SCHEDULE OF EVENTS
2007 AAS/AAPT Joint Meeting
5-10 January 2007, Seattle, Washington

The 209th Meeting of the American Astronomical Society and the 2007 Winter Meeting the American Association of Physics Teachers are being held jointly with the AAS Historical Astronomy Division and the AAS High Energy Astrophysics Division at Washington State Convention and Trade Center, Seattle, Washington.

Start Time	End Time	Event Type	Session Number	Session/Event Title	Location
Friday, January 05, 2007					
7:00 AM	03:00 PM	Attendee Services		Registration (workshops only)	South Lobby
8:00 AM	12:00 PM	AAPT Workshop	W01	Video Based Motion Analysis for Homework and Classroom	TBA
8:00 AM	12:00 PM	AAPT Workshop	W02	Building TYC/University Partnerships in Teacher Preparation	306
8:00 AM	12:00 PM	AAPT Workshop	W03	Intuitive Quantum Physics for Non-Science Majors	309
8:00 AM	12:00 PM	AAPT Workshop	W04	Grant Opportunities for Two-Year Colleges, Part 2	TBA
8:00 AM	12:00 PM	AAPT Workshop	W05	Case Studies for the Laboratory	212
8:00 AM	12:00 PM	AAPT Workshop	W06	Making Pretty Pictures: How Astronomers Make Images	211
8:00 AM	12:00 PM	AAPT Workshop	W07	Energy: What It Is, What It Isn't, and How We Know	310
8:00 AM	12:00 PM	AAPT Workshop	W08	Physics of Supernovae	307
8:00 AM	05:00 PM	AAPT Workshop	W09	Using Large Data Sets to Teach Astronomy	TBA
8:00 AM	05:00 PM	AAPT Workshop	W10	Problem Solving	213
8:00 AM	05:00 PM	AAPT Workshop	W11	InterActions in Physical Science: A Standards-based, Inquiry-oriented Middle School Curriculum	214
9:00 AM	05:00 PM	AAS Workshop		Strategies for Creating a Learner-Centered Introductory College Astronomy Course	608
10:00 AM	06:00 PM	Attendee Services		Speaker Ready Room	603-04
01:00 PM	05:00 PM	AAPT Workshop	W12	Energy in the 21st Century	TBA
01:00 PM	05:00 PM	AAPT Workshop	W13	Designing a Diagnostic Environment in the Pre-College Classroom	TBA
01:00 PM	05:00 PM	AAPT Workshop	W14	General Relativity Labs	TBA
01:00 PM	05:00 PM	AAPT Workshop	W15	Make Your Own Haunted Physics Lab	212
01:00 PM	05:00 PM	AAPT Workshop	W16	Teaching Physics to Middle School Teachers with Light and Sound Toys	204
01:00 PM	05:00 PM	AAPT Event		Area Chairs' Meeting	303
02:00 PM	04:00 PM	AAPT Tutorial	T01	Mining the Internet	208
06:00 PM	09:00 PM	AAPT Event		Executive Board I	Douglas Boardroom, Grand Hyatt

Start Time	End Time	Event Type	Session Number	Session/Event Title	Location
Saturday, January 06, 2007					
7:00 AM	09:00 PM	Attendee Services		Registration (workshops reg. am, all reg. pm)	South Lobby
8:00 AM	12:00 PM	AAPT Workshop	W17	Environmental Physics & Global Warming	TBA
8:00 AM	12:00 PM	AAPT Workshop	W18	Exploring Special and General Relativity with Interactive Curricular Material	TBA
8:00 AM	12:00 PM	AAPT Workshop	W19	A Primer for Doing Astronomy Ed. Research	213
8:00 AM	12:00 PM	AAPT Workshop	W20	Physics by Inquiry	212
8:00 AM	12:00 PM	AAPT Workshop	W21	Beyond Clickers: Using Interactive Learning Devices for Student Collaboration in the Classroom	214
8:00 AM	12:00 PM	AAPT Workshop	W22	Physics for Elementary Teachers and Physical Science for Elementary Teachers	309
8:00 AM	05:00 PM	AAPT Workshop	W23	Using Research-based Curricula and Tools to Revitalize Your Introductory Course	TBA
8:00 AM	05:00 PM	AAPT Workshop	W24	Teaching Astronomy with Technology	TBA
8:00 AM	05:00 PM	AAPT Workshop	W25	Piaget Beyond	307
8:00 AM	11:00 AM	AAPT Event		Publications Committee	303
8:30 AM	03:00 PM	AAS Splinter		NURO	606
9:00 AM	11:00 AM	AAPT Tutorial	T02	Civic Engagement and Service Learning	305
9:00 AM	11:00 AM	AAPT Tutorial	T03	Online DL Science Courses & Virtual Labs	306
9:00 AM	04:00 PM	AAS Workshop		Career Workshop	610
9:00 AM	05:00 PM	AAS Workshop		Strategies for Creating a Learner-Centered Introductory College Astronomy Course	608
9:00 AM	06:00 PM	AAS Workshop		NSF Astronomy & Astrophysics Postdoc. Fellows	605
9:30 AM	11:30 AM	AAS Workshop		ComPADRE in the K-12 Classroom	613
10:00 AM	06:00 PM	Attendee Services		Speaker Ready Room	603-04
11:30 AM	02:30 PM	AAPT Event		Resource Letters Editorial Board	209
12:00 PM	04:00 PM	AAS Workshop		EPO Programs by NASA Research Grant Awardees	609
12:30 PM	04:30 PM	AAPT Event		Executive Board II	213
01:00 PM	05:00 PM	AAPT Workshop	W26	Intermediate Mechanics Tutorials	309
01:00 PM	05:00 PM	AAPT Workshop	W27	Not Your Usual Powerpoint	TBA
01:00 PM	05:00 PM	AAPT Workshop	W28	Experiencing the Pedagogical Process	TBA
01:00 PM	05:00 PM	AAPT Workshop	W29	Exploring Easy & Effective Ways to Use PhET's Web-Based Interactive Simulations in Your Physics Course	TBA
01:00 PM	05:00 PM	AAPT Workshop	W30	The Physics Teaching Web Advisory, Online Advice for Teaching Physics	TBA
01:00 PM	05:00 PM	AAPT Workshop	W31	Cosmic Evolution: the "Astro" in Astrobiology	211
01:00 PM	05:00 PM	AAPT Workshop	W32	Tutorials in Introductory Physics	212
01:00 PM	05:00 PM	AAPT Workshop	W33	Franklin and Electrostatics	308
01:00 PM	05:00 PM	AAPT Workshop	W34	Teaching Tailored Tutorials	310
01:00 PM	03:00 PM	AAS Workshop		ComPADRE in Undergraduate Physics	613
01:00 PM	05:00 PM	AAS Workshop		Exploring Magnetism in Earth and Space Science	607
02:30 PM	05:30 PM	AAS Splinter		Astro 101	612
03:00 PM	05:00 PM	AAS Workshop		ComPADRE, AstronomyCenter	613
04:30 PM	05:30 PM	AAPT Event		Programs I	211
05:30 PM	06:30 PM	AAPT Event		Examinations Ed. Board (closed)	210
05:30 PM	06:30 PM	AAPT Event		Section Of?cers' Exchange	615

Start Time	End Time	Event Type	Session Number and Session/Event Title		Location
06:00 PM	07:00 PM	AAS Event		Undergraduate Orientation	N. Galleria Lobby - 2nd Floor
06:30 PM	07:30 PM	AAPT Event		Teacher Prep Committee	211
06:30 PM	08:00 PM	AAPT Event		Section Representatives	615
06:30 PM	08:30 PM	AAPT Event		HS Share-a-thon	6C
07:00 PM	08:00 PM	AAPT Event		Center for Astronomy Learner-centered Teaching Workshop Participant Reunion	618
07:00 PM	010:00 PM	Joint Event		Opening Reception	Grand Hyatt

Sunday, January 07, 2007

Start Time	End Time	Event Type	Session Number	Session/Event Title	Location
7:00 AM	8:00 AM	AAPT Event		First-Timers Orientation	307-08
7:30 AM	05:00 PM	Attendee Services		Registration	South Lobby
7:30 AM	06:00 PM	Attendee Services		Speaker Ready Room	603-04
8:00 AM	06:30 PM	Attendee Services		Cyber Café	South Lobby
8:15 AM	**9:45 AM**	**PLENARY**	**1**	**Opening Remarks**	**Ballroom 6**
8:30 AM	**9:20 AM**	**PLENARY**	**2**	**Space Flight: A Human Perspective**	**Ballroom 6**
9:20 AM	06:30 PM	AAPT Poster	3	Poster Session I	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	4	A Potpourri of Internal Properties of Galaxies	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	5	AGN, Starbursts, and Sub-mm Galaxies	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	6	Astrobiology and Lab Results	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	7	Black Holes	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	8	Blazars and AGN jets	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	9	Cataclysmic / Eruptive Variables / Novae	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	10	Circumstellar Disk Observations	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	11	Cosmic Microwave Background	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	12	Dark Matter	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	13	Debris Disks	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	14	Differential Rotation & Activity of Cool Dwarfs	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	15	Extragalactic ISM	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	16	The Sun	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	17	Galactic ISM I	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	18	Galactic Structures: Identi?cation & Evolution	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	19	Galaxy Evolution over Cosmic History	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	20	High Z Objects; IR, Optical Background	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	21	Gravitational Lensing	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	22	Ground-Based Instrumentation I	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	23	HAD IV	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	24	SIM Science	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	25	Solar System	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	26	Star Clusters I	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	27	Stellar Populations I	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	28	The SDSS Supernova Survey	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	29	Variable Stars	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	30	YSO / Star Formation I	Exhibit Hall 4
9:20 AM	05:00 PM	Attendee Services		Gadgets and Gizmos	South Lobby
9:20 AM	05:00 PM	Attendee Services		Job Center	Exhibit Hall 4
9:30 AM	11:00 AM	AAPT Event		Membership and Bene?ts Committee	212
10:00 AM	11:30 AM	AAS Special	31	Clickers in Astronomy Teaching	201

Start Time	End Time	Event Type	Session Number and Session/Event Title		Location
10:00 AM	11:30 AM	AAS Special	32	The SDSS Supernova Survey	204
10:00 AM	11:30 AM	HAD Special	33	HAD I	6A
10:00 AM	11:30 AM	AAS Oral	34	Accretion, Accretion Disks and Out?ows	613-14
10:00 AM	11:30 AM	AAS Oral	35	Astrobiology & The Solar System	611-12
10:00 AM	11:30 AM	AAS Oral	36	Black Holes	608-10
10:00 AM	11:30 AM	AAS Oral	37	Dark Matter, Dark Energy and Lensing	605-07
10:00 AM	11:30 AM	AAS Oral	38	Feedback and Mergers in Galaxy Evolution	3B
10:00 AM	11:30 AM	AAS Oral	39	Starburst Galaxies: Analogs of Lyman Break Galaxies?	6B
10:00 AM	11:30 AM	AAS Oral	40	Stellar Populations	3A
10:00 AM	11:30 AM	AAPT Invited	41	Integrating Mechanics with Computer Modeling	616
10:00 AM	11:30 AM	AAPT Invited	42	Physics: Something for Everyone	303
10:00 AM	11:30 AM	AAPT Special	43	Optics Education in the Middle Schools	310
10:00 AM	11:30 AM	AAPT Panel	44	Interactive Lecture Demonstrations using Physics Suite Materials	617
10:00 AM	11:30 AM	AAPT Special	45	Innovations in High School Physics, Part I	307-08
10:00 AM	11:30 AM	AAPT Oral	46	Innovations in Teaching Astronomy	615
11:30 AM	12:30 PM	AAS Splinter		HAD Business Meeting	609
11:30 AM	01:00 PM	AAPT Event		Multicultural Luncheon	618-20
11:40 AM	**12:30 PM**	**PLENARY**	**47**	**Pierce Prize in Astronomy**	**Ballroom 6**
12:30 PM	01:30 PM	AAPT Event		Nominating Committee I (closed)	508
12:30 PM	01:30 PM	AAPT Event		SI Units & Metric Ed Committee	507
12:30 PM	02:00 PM	AAS Splinter		Accessing and Using Sloan Digital Sky Survey Data	608
12:30 PM	02:30 PM	AAPT Event		PTRA Rural Regional Coordinators Meeting	208
12:45 PM	01:45 PM	AAS Town Hall		NSF Town Hall	6A
01:00 PM	02:00 PM	AAPT Crackerbarrel		How to Spend Limited Resources	615
01:00 PM	02:00 PM	AAPT Crackerbarrel		PhysicsFirst Crackerbarrel	310
01:00 PM	02:00 PM	AAPT Crackerbarrel		Professional Concerns of Junior Faculty in PER	211
01:00 PM	02:00 PM	AAPT Crackerbarrel		See Spot Run, See Spot Run from Astronomy Teaching	616
01:00 PM	02:00 PM	AAS Splinter		Committee on the Status of Women in Astronomy	613
02:00 PM	03:30 PM	AAS Special	48	Cool Astronomy For Everyone	613-14
02:00 PM	03:30 PM	AAS Special	49	Cosmic Microwave Background	6A
02:00 PM	03:30 PM	AAS Special	50	NSF Astronomy Division Senior Review Outcome	6B
02:00 PM	03:40 PM	HAD Special	51	HAD II: Case Studies in How 20th Century Observatory Directors Got Chosen	611-12
02:00 PM	03:30 PM	AAS Oral	52	AGN Populations	3A
02:00 PM	03:30 PM	AAS Oral	53	Distant Works: Cosmology, Large Scale Structure and Gravitational Waves	6E
02:00 PM	03:30 PM	AAS Oral	54	EXIST	3B
02:00 PM	03:30 PM	AAS Oral	55	ISM/Molecular Clouds	608-10
02:00 PM	03:30 PM	AAS Oral	56	Space Mission Concepts and Instrumentation	605-07
02:00 PM	03:30 PM	AAS Oral	57	Young Stellar Objects	6C
02:00 PM	03:30 PM	AAPT Oral	58	Context Rich Lab Problems	617
02:00 PM	03:30 PM	AAPT Oral	59	Innovations in High School Physics, Part II	307-08
02:00 PM	03:30 PM	AAPT Poster	60	Physics Education with Vpython	303
02:30 PM	03:30 PM	AAPT Event		Bauder Fund Committee	607
02:30 PM	03:30 PM	AAPT Event		Nomination Committee II (closed)	508
03:40 PM	**04:30 PM**	**PLENARY**	**61**	**Faint Structures in Nearby Galaxies**	**Ballroom 6**

Start Time	End Time	Event Type	Session Number	and Session/Event Title	Location
04:30 PM	06:30 PM	AAPT Event		Council	615
04:40 PM	**05:30 PM**	**PLENARY**	**62**	**The Assembly of Galaxies and Their Black Holes**	**Ballroom 6**
05:30 PM	06:30 PM	AAS Town Hall		Astronomy and Astrophysics Advisory Committee	6B
06:00 PM	08:00 PM	AAS Splinter		SIM PlanetQuest: A Space-Based Facility for Ultra-Precise Astrometry	6E
06:30 PM	08:00 PM	AAPT Invited	63	The Future of the Core Curriculum	616
06:30 PM	08:00 PM	AAPT Invited	64	When Was the Last Time 5000 College Students Gave You Feedback on Your High School Physics Course?	307-08
06:30 PM	08:00 PM	AAPT Special	65	Astronomy and the Two-Year Colleges	615
06:30 PM	07:30 PM	AAPT Special	66	Effective Features of Online Tutorials	303
06:30 PM	08:00 PM	AAPT Oral	67	High School Curriculum Issues	310
06:30 PM	08:00 PM	AAPT Oral	68	Insights into Mechanics and Sound	617
07:00 PM	**08:30 PM**	**PLENARY**	**69**	**AIP Gemant Award Lecture**	**Ballroom 6**
07:00 PM	09:00 PM	Joint Event		SPS/AAPT/AAS Undergraduate Science Evening	6A
07:00 PM	09:30 PM	AAS Splinter		NASA's Planet Finding Missions	613
08:00 PM	09:30 PM	AAPT Event		Apparatus Committee	310
08:00 PM	09:30 PM	AAPT Event		Graduate Ed Committee	214
08:00 PM	09:30 PM	AAPT Event		History and Philosophy Committee	210
08:00 PM	09:30 PM	AAPT Event		HS Committee	307-08
08:00 PM	09:30 PM	AAPT Event		Space Science and Astronomy Committee	303
08:00 PM	09:30 PM	AAPT Event		Two-Year College Committee	212
08:00 PM	09:30 PM	AAPT Event		Women in Physics Committee	615

Monday, January 08, 2007

7:00 AM	8:30 AM	AAPT Event		Retirees Breakfast	211
7:00 AM	8:30 AM	AAPT Event		Two Year College Breakfast	213
7:30 AM	06:00 PM	Attendee Services		Speaker Ready Room	603-04
8:00 AM	05:00 PM	Attendee Services		Registration	South Lobby
8:00 AM	06:30 PM	Attendee Services		Cyber Café	South Lobby
8:30 AM	**9:20 AM**	**PLENARY**	**70**	**The Coming Revolutions in Particle Physics**	**Ballroom 6**
9:20 AM	06:30 PM	AAPT Poster	71	Poster Session II	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	72	AGNs, QSOs and Active Galaxies 1	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	73	Astronomers in Public Education	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	74	Astronomy and Astrophysics with LISA	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	75	Astronomy Research by Students of All Ages and the Public	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	76	Circumstellar Disk Models	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	77	Clusters & Cosmology	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	78	Computation, Data Handling, and Image Analysis	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	79	Cool dwarfs	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	80	COSMOS	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	81	Disks Later in Life	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	82	Formation and Detection of Habitable Planets	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	83	Galactic and Extragalactic Surveys Using AzTEC	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	84	Galactic ISM II	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	85	Ground-Based Instrumentation II	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	86	LSST	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	87	M33: Our Other Neighbor	Exhibit Hall 4

Start Time	End Time	Event Type	Session Number and Session/Event Title		Location
9:20 AM	06:30 PM	AAS Poster	88	MIPSGAL	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	89	Stellar Populations III	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	90	More Supernovae	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	91	Neutron Stars	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	92	Planetary and Pre-Planetary Nebulae	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	93	Properties of Cool Giant Stars	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	94	Putting Education into Outreach	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	95	Radio Galaxy Surveys	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	96	Research in K-12 Astronomy Education for Students, Teachers, & Families both in and out of the Classroom	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	97	Sloan Digital Sky Survey	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	98	SNAP Mission	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	99	Source Surveys, Catalogs and Astrometry	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	100	Star Clusters II and HST/ACS Survey of Galactic Globular Clusters	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	101	Structure of Stellar Winds	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	102	Variable Stars and Distance Scale	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	103	White Dwarfs: Search, Survey, Study, and Understand?	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	104	X-ray to IR Observations of Compact X-ray Objects	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	105	YSO / Star Formation II	Exhibit Hall 4
9:20 AM	05:00 PM	Attendee Services		Gadgets and Gizmos	South Lobby
9:20 AM	05:00 PM	Attendee Services		Job Center	Exhibit Hall 4
9:30 AM	10:30 AM	AAPT Event		Investment Advisory Committee	507
9:30 AM	11:00 AM	Commercial Workshop		Experience Digital Physics Curriculum I	302
9:30 AM	11:00 AM	Commercial Workshop		MasteringPhysics	305
10:00 AM	11:30 AM	AAS Special	106	Education with Large Astronomical Surveys	613-14
10:00 AM	11:30 AM	AAS Special	107	The Future of Astronomy and Astrophysics at NASA	611-12
10:00 AM	11:30 AM	HAD Oral	108	HAD III	608-10
10:00 AM	11:30 AM	AAS Oral	109	AGN Variability, Interactions and Environments	3A
10:00 AM	11:30 AM	AAS Oral	110	Circumstellar Disks: Early	204
10:00 AM	11:30 AM	AAS Oral	111	Dust, Starbursts and Obscured AGN	6A
10:00 AM	11:30 AM	AAS Oral	112	Formation History of Galaxies	605-07
10:00 AM	11:30 AM	AAS Oral	113	Galaxy Clusters I	6B
10:00 AM	11:30 AM	AAS Oral	114	Nearby Galaxies and ANGST	3B
10:00 AM	11:30 AM	AAS Oral	115	Pulsars and White Dwarfs I	201
10:00 AM	11:30 AM	AAPT Invited	116	Advanced Physics in the Pre-High School AP, IB and Dual Enrollment Courses	310
10:00 AM	11:30 AM	AAPT Invited	117	The Once and Future Role of Women in Astronomy	615
10:00 AM	11:30 AM	AAPT Special	118	Nanoscale Physics in the Classroom	616
10:00 AM	11:30 AM	AAPT Special	119	Resource Collections and Communities Online through ComPADRE	303
10:00 AM	11:30 AM	AAPT Special	120	Signi?cant Advances in Low Temperature Physics	307-08
10:00 AM	11:30 AM	AAPT Oral	121	SPS Undergraduate Research Outreach	617
11:40 AM	**12:30 PM**	**PLENARY**	**122**	**Warner Prize for Astronomy**	**Ballroom 6**
12:30 PM	02:00 PM	AAS Splinter		Accessing and Using Sloan Digital Sky Survey Data	608
12:30 PM	02:00 PM	AAS Splinter		Extended FUSE Operations Beyond FY08	607
12:45 PM	01:45 PM	AAS Town Hall		NASA Town Hall	6B

Start Time	End Time	Event Type	Session Number	Session/Event Title	Location
12:45 PM	01:45 PM	AAS Town Hall		NRAO Town Meeting	6A
01:00 PM	02:00 PM	AAPT Invited	123	Presidential Address and Awards Presentation	Ballroom 6
02:00 PM	03:30 PM	AAS Special	124	Formation and Detection of Habitable Planets	611-12
02:00 PM	03:30 PM	AAS Special	125	Galactic and Extragalactic Surveys Using AzTEC	204
02:00 PM	03:30 PM	AAS Special	126	Job Applicants: Top 10 Questions You Should Ask	201
02:00 PM	03:30 PM	AAS Oral	127	Circumstellar Disks: Not So Early	608-10
02:00 PM	03:30 PM	AAS Oral	128	Education Across the Spectrum	605-07
02:00 PM	03:30 PM	AAS Oral	129	Galaxy Clusters II	6B
02:00 PM	03:30 PM	AAS Oral	130	Instrumentation for Ground-Based and Airborne Observatories	3B
02:00 PM	03:30 PM	AAS Oral	131	Pulsars and White Dwarfs II	3A
02:00 PM	03:30 PM	AAS Oral	132	UDF, GOODS and High Redshift Galaxies	613-14
02:00 PM	03:30 PM	AAS Oral	133	YSOs and Early Type Stars	6A
02:00 PM	03:30 PM	AAPT Invited	134	Recruiting the Next Generation of Physics Teachers	310
02:00 PM	03:30 PM	AAPT Invited	135	Student Dif?culties with Mathematics in Upper-Division Physics	307-08
02:00 PM	03:30 PM	AAPT Oral	136	Physics Teaching Around the World	619
02:00 PM	03:30 PM	AAPT Oral	137	Undergraduates Research Astronomy and Physics	616
02:00 PM	03:30 PM	AAPT Crackerbarrel		Professional Concerns of Women in Physics	615
02:00 PM	03:30 PM	AAPT Crackerbarrel		Double Simplex: Envisioning Particles & Interactions	618
03:30 PM	04:30 PM	AAPT Event		Nominating Committee III (closed)	608
03:40 PM	**04:30 PM**	**PLENARY**	**138**	**Hypervelocity Stars**	**Ballroom 6**
04:40 PM	**05:30 PM**	**PLENARY**	**139**	**Probing the Gas Content of Galaxy Groups**	**Ballroom 6**
06:00 PM	08:00 PM	AAPT Invited	140	Hot Topics in Nanoscience	616
06:00 PM	08:00 PM	AAPT Invited	141	Learning Sciences and Technologies: A Convergence	303
06:00 PM	08:00 PM	AAPT Invited	142	Women Using Physics: Alternative Career Paths	615
06:00 PM	08:00 PM	AAPT Special	143	Electronic Journaling: Fostering Re?ection and Building Community	310
06:00 PM	08:00 PM	AAPT Oral	144	Bringing Physics by Inquiry to K-12 Classrooms, Part I	211
06:00 PM	08:00 PM	AAPT Oral	145	Students' Use of Mathematics in Physics Contexts	307-08
06:00 PM	08:00 PM	AAPT Poster	146	Apparatus for Astronomy Education	617
06:00 PM	07:30 PM	AAS Splinter		CTIO Blanco Telescope Dark Energy Camera	611
06:00 PM	08:00 PM	AAS Splinter		Future of NASA Scienti?c Ballooning in Astronomical Research	6A
06:15 PM	09:00 PM	AAS Town Hall		Meet JWST Reception and Talks	6E
06:30 PM	07:30 PM	AAS Event		Graduate Student - Employer Networking	N. Galleria Lobby - 2nd Floor
08:00 PM	09:30 PM	AAPT Event		Educational Technologies Committee	303
08:00 PM	09:30 PM	AAPT Event		Goals Planning Meeting	210
08:00 PM	09:30 PM	AAPT Event		Interest of Senior Physicists Committee	212
08:00 PM	09:30 PM	AAPT Event		International Education Committee	214
08:00 PM	09:30 PM	AAPT Event		Laboratories Committee	211
08:00 PM	09:30 PM	AAPT Event		Minorities in Physics Committee	616
08:00 PM	09:30 PM	AAPT Event		Pre-High School Committee	615
08:00 PM	09:30 PM	AAPT Event		Professional Concerns Committee	213
08:00 PM	09:30 PM	AAPT Event		Research in Physics Ed Committee	307-08
08:00 PM	09:30 PM	AAPT Event		Science Ed for the Public Committee	620
08:00 PM	09:30 PM	AAPT Event		Undergraduate Ed Committee	617

Start Time	End Time	Event Type		Session Number and Session/Event Title	Location
Tuesday, January 09, 2007					
7:00 AM	9:00 AM	AAPT Event		Programs II	620
7:30 AM	06:00 PM	Attendee Services		Speaker Ready Room	603-04
8:00 AM	05:00 PM	Attendee Services		Registration	South Lobby
8:00 AM	06:30 PM	Attendee Services		Cyber Café	South Lobby
8:30 AM	**9:20 AM**	**PLENARY**	**147**	**Supernova Neutrino Astrophysics**	**Ballroom 6**
9:00 AM	10:00 AM	AAPT Event		Venture Fund	507
9:20 AM	06:30 PM	AAPT Poster	148	Poster Session III	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	149	AGNs, QSOs and Active Galaxies 2	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	150	And Yet More Supernovae	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	151	Binary Stars	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	152	Extrasolar Planets V: Host Stars	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	153	GLAST	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	154	Ground-Based Instrumentation III	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	155	Observations and Models of Extragalactic LMXBs	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	156	Planetary Nebulae & Supernova Remnants	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	157	Professional Development for Scientists and Educators	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	158	Properties of Hot Stars	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	159	Pulsars	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	160	SAGE	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	161	Science from the NDWFS Bootes Field	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	162	Search for Variables Through Surveys, Databases and Archives	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	163	Extrasolar Planets VI: Observed Systems	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	164	Space-Based Instrumentation I	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	165	Star Clusters III	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	166	Tests of Gravity, and Alternative Theories of Gravity	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	167	Stars, Gas and their Motions in Dwarfs and Irregulars	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	168	Stellar Populations II	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	169	Extrasolar Planets VII: Surveys	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	170	The Undergraduate Astronomy Course for Non-Majors	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	171	UDF and DEEP2	Exhibit Hall 4
9:20 AM	06:30 PM	AAS Poster	172	The Milky Way	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	173	Instrumentation and Community Analysis	Exhibit Hall 4
9:20 AM	05:00 PM	Attendee Services		Gadgets and Gizmos	South Lobby
9:20 AM	05:00 PM	Attendee Services		Job Center	Exhibit Hall 4
9:30 AM	11:00 AM	Commercial Workshop		And You Thought It Was About Homework (The way you imagined teaching could be)	305
9:30 AM	11:00 AM	Commercial Workshop		Experience Digital Physics Curriculum II	302
10:00 AM	11:30 AM	AAS Special	174	Impact of Intelligent Design and Responses to It	204
10:00 AM	11:30 AM	AAS Special	175	Observations and Models of Extragalactic LMXBs	201
10:00 AM	11:30 AM	HEAD Special	176	GLAST Science and Opportunities at All Wavelengths	611-12
10:00 AM	11:30 AM	AAS Oral	177	Andromeda All the Time	6B
10:00 AM	11:30 AM	AAS Oral	178	Dwarf Galaxies: Don't Let Their Size Fool You	3B
10:00 AM	11:30 AM	AAS Oral	179	Extrasolar Planets I	605-07
10:00 AM	11:30 AM	AAS Oral	180	Galaxy Clusters III	613-14
10:00 AM	11:30 AM	AAS Oral	181	Galaxy Evolution with DEEP2	608-10

Start Time	End Time	Event Type	Session Number	Session/Event Title	Location
10:00 AM	11:30 AM	AAS Oral	182	Novae/Cataclysmic Variables	6A
10:00 AM	11:30 AM	AAS Oral	183	SDSS and GALEX	3A
10:00 AM	11:30 AM	AAPT Panel	184	Helping Faculty/Teachers Become More Adept at Working with Under-represented Groups	615
10:00 AM	11:30 AM	AAPT Panel	185	NAEP Science 2009: Why Should Physics Teachers Care?	310
10:00 AM	11:30 AM	AAPT Special	186	1957: the Legacy of Sputnik	303
10:00 AM	11:30 AM	AAPT Special	187	Virtual Observatories	618
10:00 AM	11:30 AM	AAPT Oral	188	PER: Student Understanding and Student Reasoning	307-08
10:00 AM	11:30 AM	AAPT Oral	189	Techniques in Introductory Physics Teaching	616
10:00 AM	11:00 AM	AAPT Event		Lotze Scholarship Committee	508
11:40 AM	**12:30 PM**	**PLENARY**	**190**	**Heineman Prize Lecture**	**Ballroom 6**
12:30 PM	02:00 PM	Commercial Workshop		Begin With Special Relativity	302
12:45 PM	01:45 PM	AAS Splinter		HEAD Business Meeting	609
12:45 PM	01:45 PM	AAS Town Hall		Decadal Survey Town Hall	613
01:00 PM	02:00 PM	AAPT Crackerbarrel		Astronomy Education Research Town Hall	617
01:00 PM	02:00 PM	AAPT Crackerbarrel		High Performance Computing for Undergraduate Physics and Astronomy Education - Let's talk about it	618
01:00 PM	02:00 PM	AAPT Crackerbarrel		Physics and Society Education	619
01:00 PM	02:00 PM	AAPT Event		AAPT Town Hall Meeting	617
01:00 PM	02:30 PM	AAPT Event		Awards Committee (closed)	507
02:00 PM	03:30 PM	AAS Special	191	Next Generation Radial Velocity Planet Surveys	3B
02:00 PM	03:30 PM	AAS Special	192	SAGE: Surveying the Agents of a Galaxy's Evolution	201
02:00 PM	03:30 PM	AAS Special	193	Science from the NDWFS Bootes Field	3A
02:00 PM	03:30 PM	HEAD Special	194	Short Gamma-Ray Bursts	205
02:00 PM	03:30 PM	AAS Oral	195	AGN, Starbursts and Sub-mm Galaxies	6C
02:00 PM	03:30 PM	AAS Oral	196	Extrasolar Planets III	605-07
02:00 PM	03:30 PM	AAS Oral	197	Galaxy Clusters IV	608-10
02:00 PM	03:30 PM	AAS Oral	198	ISM/Star Formation	611-12
02:00 PM	03:30 PM	AAS Oral	199	Kinematics of Galaxies - Internal and External	204
02:00 PM	03:30 PM	AAS Oral	200	Supernovae Ia, Ib, Ic & II	613-14
02:00 PM	03:30 PM	AAPT Invited	201	Effective Mentoring of Women and Minority Students in Physics and Astronomy	615
02:00 PM	03:30 PM	AAPT Invited	202	Visualizing & Simulating the Cosmos with Computers	616
02:00 PM	03:30 PM	AAPT Panel	203	Panel on Choosing a Keypad System	303
02:00 PM	03:40 PM	AAPT Special	204	University Supervisors and Cooperating Teachers: Their Critical Roles for Student Teaching	310
02:00 PM	03:30 PM	AAPT Oral	205	Implementing Reform Instruction	307-08
02:00 PM	03:30 PM	AAPT Event		Nominating Committee IV (closed)	508
03:40 PM	**04:30 PM**	**PLENARY**	**206**	**Stardust Mission**	**Ballroom 6**
04:40 PM	**05:30 PM**	**PLENARY**	**207**	**Richtmyer Memorial Lecture**	**Ballroom 6**
07:00 PM	09:30 PM	AAS Splinter		Herschel: The Coming of Observing Opportunities	605-07
07:15 PM	09:30 PM	Joint Event		Banquet	Sheraton

Start Time	End Time	Event Type	Session Number and Session/Event Title		Location
Wednesday, January 10, 2007					
7:30 AM	04:00 PM	Attendee Services		Speaker Ready Room	603-04
8:00 AM	02:00 PM	Attendee Services		Registration	South Lobby
8:00 AM	03:30 PM	Attendee Services		Cyber Café	South Lobby
8:30 AM	**9:20 AM**	**PLENARY**	**208**	**Rossi Prize Lecture**	**Ballroom 6**
9:20 AM	04:00 PM	AAPT Poster	209	Poster Session IV	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	210	Space-Based Instrumentation II	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	211	Studying Galaxy Evolution with Nearby Galaxies	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	212	Gamma-Ray Bursts	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	213	How To ... Resources for Scientist Educators	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	214	It's All About Clear Skies	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	215	Optical Cluster Finding	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	216	Modelling Variable and Binary Stars	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	217	Starbursts & Interacting Galaxies	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	218	The 3Ts: Telescopes, Technologies and Techniques for Astronomy Education	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	219	YSO / Star Formation III	Exhibit Hall 4
9:20 AM	04:00 PM	AAS Poster	220	Fortune and Fame: Fellowships, Textbooks, Cartoons	Exhibit Hall 4
9:20 AM	12:00 PM	Attendee Services		Job Center	Exhibit Hall 4
9:20 AM	01:00 PM	Attendee Services		Gadgets and Gizmos	South Lobby
10:00 AM	11:30 AM	AAS Special	221	Biology of Astrobiology I Extremes of Earth Life	611-12
10:00 AM	11:30 AM	AAS Special	222	Optical Cluster Finding: SDSS, RCS, DEEP	613-14
10:00 AM	11:30 AM	AAS Oral	223	AGN General Properties and Relativistic Jet Acceleration.	6A
10:00 AM	11:30 AM	AAS Oral	224	CMB Theory and 21 cm Cosmology	6B
10:00 AM	11:30 AM	AAS Oral	225	COSMOS and Other Surveys	605-07
10:00 AM	11:30 AM	AAS Oral	226	Extrasolar Planets II	608-10
10:00 AM	11:30 AM	AAS Oral	227	Gamma-Ray Bursts	3B
10:00 AM	11:30 AM	AAS Oral	228	Star Clusters I	204
10:00 AM	11:30 AM	AAS Oral	229	The Supernova Legacy Survey and other SN Ia Surveys	3A
10:00 AM	11:30 AM	AAS Oral	230	Variable and Binary Stars	201
10:00 AM	11:30 AM	AAPT Invited	231	Physics in Art and Art in Physics	211
10:00 AM	11:30 AM	AAPT Special	232	Demonstrations for Teaching Astronomy	617
10:00 AM	11:30 AM	AAPT Oral	233	Bringing Physics by Inquiry to K-12 Classrooms, Part II	303
10:00 AM	11:30 AM	AAPT Oral	234	Introductory Physics Curriculum and Delivery	616
10:00 AM	11:30 AM	AAPT Oral	235	Teacher Learning	310
11:40 AM	**12:30 PM**	**PLENARY**	**236**	**Cannon Award in Astronomy**	**Ballroom 6**
12:30 PM	01:00 PM	AAPT Event		Great Book Giveaway	Exhibit Hall 4
12:30 PM	03:00 PM	AAPT Event		1st Annual AAPT Symposium on Physics Education	618-20
12:45 PM	01:45 PM	AAS Town Hall		Revealing the Hidden Nature of Space and Time (EPP2010)	609
02:00 PM	03:30 PM	AAS Special	237	Biology of Astrobiology II History of Earth's Life	611-12
02:00 PM	03:30 PM	AAS Special	238	Ground-Based Mid-IR Astronomy in the Spitzer Era	613-14
02:00 PM	03:30 PM	AAS Oral	239	AGN Jets	3B
02:00 PM	03:30 PM	AAS Oral	240	CMB-Experiments	6A
02:00 PM	03:30 PM	AAS Oral	241	Extrasolar Planets IV	605-07

Start Time	End Time	Event Type	Session Number	Session/Event Title	Location
02:00 PM	03:30 PM	AAS Oral	242	Milky Way Topics	3A
02:00 PM	03:30 PM	AAS Oral	243	SNR, Cosmic Rays and Neutron Stars	201
02:00 PM	03:30 PM	AAS Oral	244	Star Clusters II	204
02:00 PM	03:30 PM	AAPT Oral	245	Instructional Technology in Physics and Astronomy Courses	303
02:00 PM	03:30 PM	AAPT Oral	246	Physics and Society Education	617
02:00 PM	03:30 PM	AAPT Oral	247	Teacher Professional Development Programs and Assessments	310
02:00 PM	03:30 PM	AAPT Oral	248	Theoretical and Diagnostic Issues	307-08
03:40 PM	**04:30 PM**	**PLENARY**	**249**	**Oersted Medal Lecture**	**Ballroom 6**
04:40 PM	**05:30 PM**	**PLENARY**	**250**	**New Planets**	**Ballroom 6**
05:30 PM	09:30 PM	AAPT Event		Executive Board III	Douglas Boardroom, Grand Hyatt

FRIDAY

W01: Video Based Motion Analysis for Homework and Classroom

AAPT Workshop,
Friday, 8:00am-12:00pm, TBA

This workshop is for physics teachers who wish to explore the use of video-based motion analysis in a wide range of applications including the teaching laboratory, projects and homework. Participants will learn how to make digital video clips for analysis, as well as how to use video analysis for homework problems and in the classroom. We will discuss educationally effective uses of video analysis being developed in the LivePhoto Physics project, the Workshop Physics project and in other settings. Evaluation copies of analysis software, selected digital video clips and homework assignments will be provided to the participants for their use after the workshop. The software used in this workshop is available for both Mac and Windows computers. Participants in this workshop may find that some prior, hands-on experience with basic video analysis using software such as VideoPoint or VideoGraph will be helpful but is not required. (Format: Mac/PC)

W02: Building TYC/University Partnerships in Teacher Preparation

AAPT Workshop, 8:00am-12:00pm, 306

Half of our K-12 teachers begin their educations at two-year colleges. Whether you are trying to start a program at your TYC or trying to forge links between your university and TYCs in your area, you can learn new ideas and share your own at this workshop. Green River CC's Project TEACH has been hailed as a national model for teacher prep by the NSF, AAPT, AACC, and the National Association of Community College Teacher Education Programs. Hear from Project TEACH founder and physics teacher Keith Clay, Project TEACH Center Director Leslie Heizer, Central Washington University partner Bruce Palmquist, and GRCC grant-writing guru Anne Baunach how this project grew from an idea into million-dollar grants and then into an institutionalized part of our college, our partner university, and our state community and technical college system.

Chair

Keith Clay[1]
[1]*Green River Community College.*

W03: Intuitive Quantum Physics for Non-Science Majors

AAPT Workshop, 8:00am-12:00pm, 309

Our course is designed to help students with little mathematics and science background gain an understanding of some of the basic ideas and results of quantum physics. Where possible, we have students build an understanding of physics from easily observable phenomena, giving students touchstone concepts to use when dealing with more complicated topics. The course contains three instructional units in which students develop skills prerequisite to understanding quantum physics, create a "toolbox" with which to study the quantum world, and discuss applications of quantum physics. Concepts studied in the course include: superposition and interference, wave-particle duality, probability, energy, bound states, and tunneling. We use little algebra and emphasize graphical analysis and qualitative reasoning. Most material is introduced in three-hour lab-tutorial periods. The lab-tutorial includes individual, small-group, and large-group (full class) activities. Participants will work through activities, discuss instructional formats, and get a full set of lab-tutorials.

Chair

Michael Wittmann[1]
[1]*University of Maine.*

W04: Grant Opportunities for Two-Year Colleges, Part 2
AAPT Workshop, 8:00am-12:00pm, TBA

This workshop is a continuation of Grant Opportunities for Two-Year Colleges Part 1 offered at Syracuse. Participants need not have attended Part 1 in order to attend Part 2. Topics include locating funding sources, writing the proposal, building a budget, and how to revise for re-submission.

Chair
Steve Budd[1]
[1]*Springfield Technical Community College.*

W05: Case Studies for the Laboratory
AAPT Workshop, 8:00am-12:00pm, 212

Participants will be provided with four case study laboratory activities and work through one of them during the workshop. Participants will be asked to bring their own ideas for either a physics topic or case scenario to be developed into their own case. During the workshop participants will develop a first draft of the case notes and instructor notes.

Chair
Mary Creason[1]
[1]*Duke University.*

W06: Making Pretty Pictures: How Astronomers Make Images
AAPT Workshop, 8:00am-12:00pm, 211

Learn how astronomers make those great posters. LEARN TO MAKE YOUR OWN. This hands-on workshop is designed to increase students' interest in astronomy and its many wonderful images, like the Crab Nebula. We will start with the basics of image processing and then learn how to use images with different filters from The STScI Digitized Sky Survey. We will learn how to manipulate color, stack, title the data and print the image using Photoshop Elements computer program. The next step will be to use data taken at Kitt Peak National observatory from NOAO's TLRBSE program (each image is about 16 Mb fits image) to make a poster-size quality image. CD with directions/files will be distributed. Some knowledge of Photoshop Elements will be helpful but not required. If available bring USB memory stick. This workshop is a synthesis of information gained through Murdock's Partners in Science, NOAO's TLRBSE, Liftoff Summer institute.

Chair
David McDonald[1]
[1]*Sidney High School.*
Chair
Robert Teese[1]
[1]*Rochester Institute of Technology.*

W07: Energy: What It Is, What It Isn't, and How We Know
AAPT Workshop, 8:00am-12:00pm, 310

We will present a model "chapter on energy" for an introductory physics course. Then we will consider it both in parts and as a whole, showing where most such chapters currently in texts lack or differ. We will examine why they fail in the "How we know" department, why they seem unable to tell what energy "is," and how they differ due to a number of "booby traps" that have currency in the physics teaching literature. These include confusion about friction and its place in energy conservation, the fundamental role of the Work-Energy principle in our understanding of energy. We will justify teaching energy within the framework of Newtonian physics, legitimizing the derivation of energy relations from Newton's

Laws, and what this implies. The discussions are illustrated with Flash-animated snippets, contained in a CD that participants take home. Examples are worked out by participants.

Chair
Walter Scheider[1]
[1]*Cavendish Science Organization.*

W08: Physics of Supernovae
AAPT Workshop, 8:00am-12:00pm, 307

Supernovae explosions can be utilized as an exciting topic to begin a year of physics. The catastrophic destruction of stars involves topics and equations taught in physics. The electromagnetic spectrum, spectroscopy, scientific notation, gravitation, rotation, circular motion, the work-energy equation, the impulse-momentum relationship, phases of matter, and nuclear reactions are a few of the concepts that can be taught with supernovae events. This workshop will provide the materials and resources to introduce supernovae and stellar evolution into an existing physics curriculum. A PowerPoint presentation with images and animations with a separate descriptive text to introduce supernovae, and activities that range from pencil and paper to sophisticated image analysis software will be provided, along with a set of problems that use specific mathematical equations and relationships studied in a typical physics classroom. The problems will relate to supernovae, and can be inserted into an existing physics course at the instructor's discretion. This workshop is being fully subsidized by Chandra X-Ray.

Chair
Donna L. Young[1]
[1]*Tufts University.*

W09: Using Large Data Sets to Teach Astronomy
AAPT Workshop, 8:00am-5:00pm, TBA

In 2005, scientists collected more data than in all previous human history. Much of these data are online, including astronomy data for hundreds of millions of sky objects. Many of these datasets have teacher-friendly interfaces for viewing and searching their information, and many include lesson plans that guide students through the process of data discovery. I will show several projects that have tools that make data available to teachers, including the Sloan Digital Sky Survey and the National Virtual Observatory. I will also provide examples of lesson plans that teachers have designed that incorporate these data.

Chair
Jordan Raddick[1]
[1]*Johns Hopkins University.*

W10: Problem Solving
AAPT Workshop, 8:00am-5:00pm, 213

Accumulating research on problem solving in physics clearly indicates that traditional end-of-chapter numerical exercises in physics texts are not useful, and may actually be counterproductive, for helping students learn important physics concepts. The research also raises significant questions about the efficacy of such tasks for helping students develop "problem solving skills." In light of these results the natural question is: What alternative tasks can we use to help our students develop problem solving skills and a legitimate conceptual understanding? This workshop will review the research and then provide examples of several alternative tasks and their use. The alternatives presented will run a gamut from tasks which can easily be incorporated into essentially any instructor's current structure to those that require a restructuring of an instructor's pedagogy.

Chair
Thomas M. Foster[1]
[1]*Southern Illinois University Edwardsville.*

W11: InterActions in Physical Science: A Standards-based, Inquiry-oriented Middle School Curriculum
AAPT Workshop, 8:00am-5:00pm, 214

What is appropriate middle-school physical science? What content is required in middle-school to prepare students for high-school physics. Can it reflect the nature of scientific inquiry? What does the research-base tell us about the ability of the pre-high school student to learn physical science concepts? Do you work with prospective and in-service middle school science teachers and desire material that is inquiry-oriented and research based? These are some of the questions that the developers of InterActions in Physical Science considered during the development of this NSF-supported physical science curriculum. The primary aim of InterActions is to promote both a deep understanding of fundamental physical science concepts and the nature of scientific inquiry. The curriculum actively engages students in doing science by conducting interesting investigations and participating in sense-making discussions in small groups and with the whole class. InterActions achieves these goals by helping students to pose scientific questions, doing hands-on investigations, and making claims that they can support with evidence. In this session you will learn how this curriculum supports a classroom environment that engages students in doing science, learning how to make claims supported by evidence, and them persuading themselves and their peers that these claims are valid and useful ways of understanding the world around them.
Chair

Robert Poel[1]
[1] *Western Michigan University.*

Strategies for Creating a Learner-Centered Introductory College Astronomy Course
AAS Workshop, 9:00am-5:00pm, 608

The overarching goal of this workshop is to help *past workshop participants* with their obstacles to implementing a learner-centered introductory college astronomy course. Specifically, workshop participants will work to understand how students learn while engaged in learner-centered activities and what the role of the instructor is in the learner-centered class. Presenters: Edward Prather, Timothy Slater, Gina Brissenden (Univ. of Arizona, CAPER Team) *This is an advanced course. You must have participated in a past workshop to attend this workshop.* Fee: $35.00
Chair

Gina Brissenden[1]
[1] *Univ. of Arizona.*

Speaker Ready Room
Attendee Services, 10:00am-6:00pm, 603-04

See Saturday's listing for AV instructions.
Chair

Rick Matthews[1]
[1] *American Audio Video.*

W12: Energy in the 21st Century
AAPT Workshop, 1:00-5:00pm, TBA

We have found that engaging students in predictions of what form and how much energy will be used in the future is a very successful way to generate enthusiasm and further investigation of physics. Participants of this workshop will be introduced by way of experience to two different group projects that involve designing energy systems. These modeling exercises look at past energy consumption patterns and develop a plan for energy usage in the 21st Century. Other considerations such as population, costs and efficiencies are also used to further expand the discussion and decision making that takes place.

Chair
Pat Keefe[1]
[1]Clatsop Community College.

W13: Designing a Diagnostic Environment in the Pre-College Classroom
AAPT Workshop, 1:00-5:00pm, TBA

A diagnostic learning environment is one in which assessments are used to identify students' understanding and reasoning such that a teacher can decide what might be troublesome about that thinking and address the specific difficulty with targeted instruction. While many teachers assess all the time, typically this means they identify whether the student has the "right" idea, and if not, the instruction presents more of the right idea. What we mean by a diagnostic learning environment closely parallels the diagnosis and prescription that a medical doctor does. The doctor doesn't just find out that you are not healthy. She/he assesses to find out, as specifically as possible, what the trouble is and then prescribes treatment to address that specific difficulty. Participants of this workshop will learn about and experience a diagnostic learning environment. In addition, participants will learn about the Diagnoser Project's free instructional tools to help diagnose pre-college student thinking.

Chair
Stamatis Vokos[1]
[1]Seattle Pacific University.

W14: General Relativity Labs
AAPT Workshop, 1:00-5:00pm, TBA

"A new generation of lab-based tests of gravity" The workshop will take place at the NPL/CENPA building on the Univ. Washington campus, and would involve both presentations and lab tours. We will discuss tests of Einstein's Equivalence Principle, and of the Newtonian Inverse-square law at very small (less than 100 microns) and also large (orbit of the Moon) separations, as well astests involving quantum-mechanical spin. We will also give a presentation about LISA (proposed GravityWave Observatory in Space). Our experiments are primarily table-top and simple to understand without requiring much mathematical sophistication but the physics is really interesting and contemporary. Co-leaders for this workshop are Eric Adelberger, Blayan Heckel, and Jens Gundlach.

Chair
Mary Creason[1]
[1]Duke University.

W15: Make Your Own Haunted Physics Lab
AAPT Workshop, 1:00-5:00pm, 212

'Hook' younger students into the physics lab and keep their attention for an afternoon with the promise of some spooky science. Once there, they and their parents are intrigued to find out how things really work. Come learn how to put together an attractive, stimulating experience for children and parents that has the added benefit of getting your students involved in physics in a way they never anticipated. Haunted Physics Labs can be set up at any level, elementary through university. Build some of your own displays and see many more in person. A DVD with activity sheets, instructions and photographs will be provided to each participant in addition to the materials to construct some airline-friendly interactive displays. See our HPL set up at an elementary school at http://www.physics.niu.edu/~frontier/wyp/hpl_pec/index.html Support for this workshop provided by Arbor Scientific.

Chair
Patricia Sievert[1]
[1]Northern Illinois University.

W16: Teaching Physics to Middle School Teachers with Light and Sound Toys
AAPT Workshop, 1:00-5:00pm, 204

This workshop is based on a physics course for middle school teachers using toys to introduce physics concepts(and lower anxiety). The hands-on activities support a constructivist approach to teaching, emphasizing collaboration, modelling and embedded assessments. Participants will make simple toys such as kaleidoscopes and acoustical phones, receive sample toys and a copy of the book by the presenter,″Toying With Physics, II- Light an Sound.”

Chair
Karen A. Bouffard[1]
[1]*Newton's Rule, Inc..*

T01: Mining the Internet
AAPT Tutorial, 2:00-4:00pm, 208

The Internet is a rich source of science information. In this tutorial, I will demonstrate some excellent resources. In this very informal setting, we can all learn from each other. Come prepared with questions and suggestions.

Chair
Pat Viele[1]
[1]*Cornell University.*

SATURDAY

Registration (workshops am, all pm)
Attendee Services,
Saturday, 7:00am-9:00pm, South Lobby

W17: Environmental Physics & Global Warming
AAPT Workshop, 8:00am-12:00pm, TBA

An overview of the science of global climate with related classroom activities. An introduction to online research to learn the state of our understanding of global climate change will also be included. Following this will be The Thermodynamics of Clothing Unit, is a hands-on activity-based unit adaptable to teaching grades 7 – 12. The Solar House Design Project involves an understanding of Solar Geometry, and Energy Use including software to evaluate the performance of the house throughout the year. The Sustainability Unit will have your students wondering how they can best protect their future on Earth. You may bring your own laptop computer.

Chair
David Gewanter[1]
[1]*Georgetown University.*

W18: Exploring Special and General Relativity with Interactive Curricular Material
AAPT Workshop, 8:00am-12:00pm, TBA

There are many reasons to use computer-based material for teaching relativity. Both the special and general theories are full of (apparent) paradoxes and captivate students' interest in physics. Because these topics focus on abstract and unfamiliar concepts, visualization is especially valuable. This workshop will emphasis both the special and general theory and the interactive software with which you and your students can explore spacetime. Special relativity examples include: visualizing simultaneity, length contraction, time dilation, and spacetime diagrams. General relativity examples include the gravitational red shift, trajectories of particles and light rays, and the observer's view in the vicinity of non-spinning black holes. Each participant will receive a CD containing Java applets, programs, and source code developed by the Open Source Physics Project. This workshop is supported in part by NSF DUE-0442581.

Chair
Mario Belloni[1]
[1] *Davidson College.*

W19: A Primer for Doing Astronomy Education Research
AAPT Workshop, 8:00am-12:00pm, 213

Are you running an E/PO project and are concerned about the evaluation? Are you implementing a new astronomy curriculum and want more data than just student evaluations? Have you been reading astronomy education research articles with too much uncertainty about the methods and results reported? Then this is the workshop for you. This primer will introduce you to the core philosophies and methods of astronomy education research to help you become a better user and consumer of AER.

Chair
Thomas M. Foster[1]
[1] *Southern Illinois University Edwardsville.*

W20: Physics by Inquiry
AAPT Workshop, 8:00am-12:00pm, 212

This workshop focuses on how college and university physics faculty can contribute to the professional development of pre-college (K-12) teachers. Participants will have an opportunity to gain hands-on experience with instructional materials (Physics by Inquiry) designed to provide teachers with the background needed to teach physics and physical science as a process of inquiry.(1) Excerpts from a video produced by WGBH will be used to illustrate interactions between teachers and instructors during a course based on these instructional materials.(2) Participants will also gain an understanding of how physics education research has guided the design of the curriculum. In addition, there will be a discussion of various intellectual and practical issues. Volumes I and II will be provided to participants. (1) L.C. McDermott and the Physics Education Group at the University of Washington, Physics by Inquiry: An Introduction to Physics and Physical Science, Volumes I and II (Wiley, New York, 1996). Development was supported, in part, by the National Science Foundation. 2. Physics by Inquiry: A Video Resource (WGBH, Boston, 2000). Development was supported, in part, by the National Science Foundation.

Chair
Lillian McDermott[1]
[1] *University of Washington.*

W21: Beyond Clickers: Using Interactive Learning Devices for Student Collaboration in the Classroom

AAPT Workshop, 8:00am-12:00pm, 214

In this workshop participants will learn how to use a new generation of software that promotes student engagement with collaborative learning activities. For anyone excited about the promise of classroom response systems ('clickers') but frustrated by their limitations - this project offers new avenues for users and developers alike. Visit the project website http://tuples.sri.com/ for software downloads prior to the workshop. You are encouraged to bring your own laptop, Tablet PC or Windows Mobile device.

Chair
S. R. Chaudhury[1]
[1]*Christopher Newport University.*

W22: Physics for Elementary Teachers and Physical Science for Elementary Teachers

AAPT Workshop, 8:00am-12:00pm, 309

Physics for Elementary Teachers (PET) and Physical Science for Elementary Teachers (PSET) are each one-semester courses for prospective and practicing elementary teachers. Both PET and PSET engage students in four types of activities: (1) standards-based physics or physical science content, (2) nature of science, (3) learning about one's own learning, and (4) learning about the learning of elementary students. PET and PSET use a similar course pedagogy and activity sequence that is guided by research on student learning of physical science. The PET course content focuses on the themes of interactions, energy, forces and fields. PSET focuses on interactions, energy, forces and both macro and micro (small particle model) descriptions of the properties of matter. Specially designed computer simulators are used both during class and as part of web-based homework. After developing their own understanding of ideas in the PET or PSET class, students then analyze video of children discussing similar ideas in elementary classrooms. During the workshop participants will view and discuss video from college PET and PSET classrooms, and from elementary classrooms. This workshop will provide participants with a substantial introduction to both the PET and PSET curricula (with a greater emphasis on PET). *Supported in part by NSF Grant ESI-0096856. PET is published by, and PSET will be published by, It's About Time, Herff Jones Education Division.

Chair
Fred Goldberg[1]
[1]*San Diego State University.*

W23: Using Research-based Curricula and Tools to Revitalize Your Introductory Course

AAPT Workshop, 8:00am-5:00pm, TBA

This hands-on workshop is designed for those interested in making learning in their introductory courses more active within the context of lectures, labs, and recitation hours. Participants will be introduced to physics education research-based strategies for each of these components: Interactive Lecture Demonstration (ILDs), Web-Based ILDs, RealTime Physics labs, Activity Based Tutorials and Collaborative Problem-Solving Tutorials, as well as modeling and video analysis tools. The tools and software used in this workshop are available for Macintosh and Windows computers.

Chair
David Sokoloff[1]
[1]*University of Oregon.*

W24: Teaching Astronomy with Technology

AAPT Workshop, 8:00am-5:00pm, TBA

This workshop will survey a variety of educational technologies useful for engaging students in both high school and introductory college classrooms. Special emphasis will be placed on simulation usage and peer instruction. Participants will work on computers gaining familiarity with the astrophysical simulations of the Nebraska Astronomy Applet Project (NAAP) and its web-based assessment capabilities. Participants will also design peer instruction sequences to be used in the classroom using the computer-based modules of the ClassAction Project. A lighter emphasis will be placed on using computerized ranking tasks and on comparing available options for online homework, astronomy laboratories, and desktop planetariums. All participants will receive NAAP, ClassAction, and computerized ranking task materials on CD.

Chair

Kevin Lee[1]

[1]*University of Nebraska—Lincoln.*

W25: Piaget Beyond

AAPT Workshop, 8:00am-5:00pm, 307

While early work of the Swiss Genetic Epistemologist, Jean Piaget, and co-workers in Geneva was being‘rediscovered’ in the 1970’s in physics education, Piaget and his co-workers were advancing understanding of origins and development of human understanding of the world several decades beyond the works we were studying at the time. We were just grappling with Piaget’s notion of developmental‘stages,’ while Piaget and his co-workers moved beyond‘stages,’ explaining how, why and under what circumstances human understanding changes. Physics educators realized Piaget’s method of evidence collection, the individual interview, revealed the nature of interviewee understanding. Such interviews became the origins of physics education research (PER) in student conceptions. Work of the Geneva group on understanding change in human understanding has not been extensively studied in physics education and PER. This later work, with significant implications for physics learning and teaching, will be the subject of this workshop.

Chair

Dewey Dykstra, Jr.[1]

[1]*Boise State University.*

NSF Astronomy & Astrophysics Postdoctoral Fellows

AAS Workshop, 9:00am-6:00pm, 605

Chair

Nate McCrady[1]

[1]*UC, Los Angeles.*

T02: Civic Engagement and Service Learning

AAPT Tutorial, 9:00-11:00am, 305

This tutorial is aimed at those interested in improving physics education within the context of civic engagement (including service learning). During the tutorial we will describe a national dissemination program that connects science and civic engagement by teaching “through” complex, capacious, and unresolved public issues and ways to participate in its activities. We will also discuss ways to include service learning in the physics curriculum using examples from across the country, and engage in group activities that will provide a springboard for making curricular changes that will make civic engagement an integral part of the physics curriculum.

Chair

Theo Koupelis[1]

[1]*University of Wisconsin Colleges.*

T03: Online DL Science Courses & Virtual Labs
AAPT Tutorial, 9:00-11:00am, 306

Online learning will play an increasingly important role in educating tomorrow's scientists and engineers. To be both pedagogically and cost effective, the challenge of offering inquiry-based, highly interactive, asynchronous or synchronous laboratory-based courses must be met. These courses must be based on proven pedagogy and include decision-making, selection of instrumentation, data collection and analysis, the ability to make realistic mistakes and transferable lab skills. Central to the laboratory environment is the dialog between user and virtual tutor; branching based on student answers permit nearly one-to-one guidance. A back end database permits extensive research on cognitive learning. This approach can be used for Just in Time Learning (JITL), Remediation, Tutorials, Interactive Assessment and Problem-Based Learning. You will be given an account to see how this novel approach works. Participants are encouraged to bring wireless-enabled laptops.

Chair
Gerald Meisner[1]
[1]*University of North Carolina at Greensboro.*

Career Workshop
AAS Workshop, 9:00am-4:00pm, 610

Registrants for this special workshop (attendance is limited) will learn how to market themselves in today's challenging employment environment. Ms. Jennifer Giesler, program officer for mentoring programs at the Geological Society of America, will spend the morning portion (9am-12noon) of the workshop providing insight into the current job market for astronomers, how to capitalize on unique skills and abilities to land a job, unveil the interview process and discuss other topics based on questions from participants. The afternoon portion (1-4pm) of the workshop is direct one-on-one review of participant resumes with special emphasis on resume customization. The registration fee for this event is $35 and may be paid with your meeting registration.

Chair
Jennifer Giesler[1]
[1]*Geological Society of America.*

Strategies for Creating a Learner-Centered Introductory College Astronomy Course
AAS Workshop, 9:00am-5:00pm, 608

See Friday's listing for details.

ComPADRE in the K-12 Classroom
AAS Workshop, 9:30-11:30am, 613

ComPADRE is an ongoing collaboration to provide community collections and tools for sharing teaching and learning resources in Physics and Astronomy. This workshop will introduce comPADRE's network of websites, the materials it contains, submission tools for contributing resources, editorial tools for managing and reviewing materials, and, the communication tools for sharing expertise. Participants will use the ComPADRE's collections to gather content and materials for a class and share their ideas for using the materials. Topics covered include information databases submitting resources, reviewing materials, and developing new collections. depending on the interests of the audience. ComPADRE is partially funded by the National Science Foundation. ComPADRE has three two-hour sessions each focused on different audiences 1) pre-college science, 2) undergraduate physics, 3) introductory undergraduate astronomy. Participants may sign up for one, two or three sessions. Some computing facilities will be available, but participants are strongly encouraged to bring a computer to work with the collections.

Chair
Susana E. Deustua[1]
[1]*American Astronomical Society.*

Speaker Ready Room

Attendee Services, 10:00am-6:00pm, 603-04

Audiovisual Equipment Audiovisual equipment MUST be ordered via email (speakerready@aas.org) at least 24 hours prior to your presentation or personally handed to the American Audio Video technician in the speaker ready room.

VCRs/Monitors: must be ordered and cost $85. Payment may be made with registration and must be paid for by the start of the meeting.

35mm and Overhead Projectors: are free but must be ordered 24 hours in advance from the speaker ready room technician.

Microphones: Each oral session room will have two microphones: a wireless lapel microphone, and a hard mounted podium microphone. You do not need to place an order for microphones.

LCD Projectors and Laptops: will be provided in every oral session room, free of charge. YOU MAY NOT USE YOUR OWN. There will be one Mac laptop and one PC laptop in each room. You do not need to place an order to use the LCD Projector, but the following requirements must be strictly adhered to:

PRESENTATION: PowerPoint, Keynote, or Adobe Acrobat are the only accepted formats. Your presentation must be compatible with Office XP (2003) for PC or OS X for Mac. The PCs in the session rooms will be loaded with Windows XP Professional with Office XP, and the Macs will be loaded with OS X (10.46 Leopard) with Keynote and PowerPoint for Mac. All presentations must be in one of these formats.

MOVIES: Movie files should be linked to your presentation rather than embedded like a picture or drawing. If your presentation has linked files, you must copy the linked files as well as the presentation to your passoff media (see Drop Off below). QuickTime Movie files (.mov) or uncompressed Tiff files will not work as linked movies in the PC version of PowerPoint. Please convert these types of files into MPEG (.mpg, .mpeg) or AVI (.avi) formats if you wish to link them to your PowerPoint file.

LABEL: Your presentation file must be labeled with the session number, speaker number, and your last name (for example "35.03_smith"). Please double check your file name before dropping off your file.

DROP OFF: At least one day in advance of your session, bring your presentation on a CD-ROM or USB Flash Disk (PC formatted) to the Speaker Ready Room (Room 603-4).

SPEAKER READY ROOM: The Speaker Ready Room is located room 603-4. The computers in the speaker ready room and each of the session rooms are EXACTLY alike. If your presentation presents correctly in the Speaker Ready Room, it will present correctly in any Session Room. A technician will be in the Speaker Ready Room all day to assist you. Please feel free to drop by and ask questions.

IN THE SESSION: You will control your presentation on the computer in the session room. There will be a laptop for you to use. Please do not attempt to load your presentation on this laptop as it may be deleted remotely.

Questions: Prior to the meeting, contact Rick Mathews with American Audio Video, speakerready@aas.org, 703-573-6910, 703-569-6701. Onsite, a technician will be in the Speaker Ready Room (603-4) all day to assist you.

Chair
Rick Matthews[1]
[1]American Audio Video.

EPO Programs by NASA Research Grant Awardees

AAS Workshop, 12:00-4:00pm, 609

This session is intended to highlight and serve those NASA research grant awardees who have carried out programs in education and public outreach (EPO). It is also intended to provide introductory information for space scientists who have yet to get involved in EPO but are interested in doing so. The session will include oral presentations on NASA's Science Mission Directorate EPO program, current EPO grant opportunities, and ways to navigate the proposal process. It will also include contributed oral and poster presentations by NASA research grant awardees which describe their EPO programs.

Chair
William H. Waller[1]
[1]*Tufts Univ..*

W26: Intermediate Mechanics Tutorials
AAPT Workshop, 1:00-5:00pm, 309

Ongoing research in physics education has demonstrated that physics majors often do not develop a working knowledge of basic concepts in mechanics, even after standard instruction in upper-level mechanics courses. This workshop will focus on Intermediate Mechanics Tutorials (IMT), a suite of research-based materials that provides an innovative instructional approach that supplements traditional lectures. These materials are designed to address persistent student difficulties and to guide students to make appropriate connections between the physics and mathematics. Workshop participants will learn about recent results from the research and obtain firsthand experience with selected tutorials. Because intermediate mechanics courses vary in format and content from institution to institution, we will also discuss how IMT can be tailored appropriately. A copy of all IMT materials, which include conceptual, derivation, and computer-based tutorials, will be given to each participant.

Chair
Bradley Ambrose[1]
[1]*Grand Valley State University.*

W27: Not Your Usual Powerpoint
AAPT Workshop, 1:00-5:00pm, TBA

With a little imagination it is possible to use Powerpoint to produce very attractive and creative presentations for illustrating physics talks -- either classroom lectures or presentations to professional audiences. This tutorial will help you do this. It will consist of a model one hour long Powerpoint talk on "Crazy Ideas in Science," followed by a practice session, where participants try to brainstorm ideas for creating such talks in areas of interest to them.

Chair
Robert Ehrlich[1]
[1]*George Mason University.*

W28: Experiencing the Pedagogical Process
AAPT Workshop, 1:00-5:00pm, TBA

Pedagogy is a process. Unfortunately, it has been wrongfully viewed and taught as a subject matter in and of itself in the schools of education. As a result, pedagogy has come to be perceived by other professionals as largely irrelevant, sometimes even as fluff stuff. The net result is pedagogy has received a bad name. This view is a major obstacle to producing quality teachers. The workshop we are proposing is to demonstrate pedagogy as a process inseparable from the content being taught. In this case, the workshop uses computer applications as a content for providing a hands-on demonstration of pedagogy as a process for math and science teachers. This process has been analyzed into specific teaching techniques, now documented and illustrated in our book, "Color-Blind Teaching″. These techniques have been tested and validated over a long period of time with diverse students, characterized by differing academic preparations, ethnicities, socio-economic status, and cultures. The techniques have resulted in a retention rate of around 95% with diverse populations, a vast improvement over the usual retention rate of 25-40% in diverse classrooms. Most importantly, the workshop opens the door to increased teaching effectiveness, and we promise all of this without your having to abandon the time-honored and much-loved lecture method.

Chair
Daryao Khatri[1]
[1]*University of the District of Columbia.*

W29: Exploring Easy & Effective Ways to Use PhET's Web-Based Interactive Simulations in Your Physics Course
AAPT Workshop, 1:00-5:00pm, TBA

The Physics Education Technology (PhET) Project has developed over 50 simulations for teaching and learning introductory physics at the high school and college levels. These research-based simulations create animated, interactive, game-like environments that are designed to engage students in active thinking, encourage experimentation, and help develop visual and conceptual models of physical phenomena, emphasizing their connections to everyday life. The simulations are free, and can be run from the PhET website (http://phet.colorado.edu) or downloaded to a local computer for off-line use. In this workshop, participants will work with these simulations and explore how they can be used effectively in lecture, lab, and as part of homework assignments to improve both student learning and engagement.
Chair
Katherine Perkins[1]
[1]*University of Colorado at Boulder.*

W30: The Physics Teaching Web Advisory, Online Advice for Teaching Physics
AAPT Workshop, 1:00-5:00pm, TBA

The Physics Teaching Web Advisory (Pathway) is a new type of digital library. Based on state-of-the-art digital video technology, Pathway is a free online resource that provides assistance and expertise for teachers of physics. Participants will be introduced to the two primary components of Pathway' the Synthetic Interview and the searchable digital video library. The Synthetic Interview enables any teacher to have a virtual conversation with experienced physics teachers while the digital library provides access to a variety of video resources. We will show how Synthetic Interview responses are tied to the National Science Education Standards and to current literature in physics teaching. Participants will learn how both features can be valuable in their physics teaching. Supported in part by National Science Foundation under grant numbers DUE-0226157, DUE-0226219, ESI-0455772 & ESI-0455813.
Chair
Brian Adrian[1]
[1]*Kansas State University.*

W31: Cosmic Evolution: the "Astro" in Astrobiology
AAPT Workshop, 1:00-5:00pm, 211

Using astronomy applications within the context of astrobiology, learn how the search for life in the universe inspires students. This workshop will introduce you to curriculum materials in the Cosmic Evolution module from Voyages Through Time (VTT), a standards-based and nationally field-tested course developed by SETI Institute. Participants will practice inquiry based lessons on spectroscopy, gravity and stellar evolution. In addition to VTT, you will learn how a space-orbiting photometer for the NASA Kepler Mission will be used to detect potentially life-supporting planets around other stars. Participants are encouraged to bring their laptops and will receive the module valued at $100. More information can be found at website http://www.voyagesthroughtime.org/cosmic/index.html.
Chair
Mary Ann Kadooka[1]
[1]*University of Hawaii.*

W32: Tutorials in Introductory Physics
AAPT Workshop, 1:00-5:00pm, 212

Tutorials in Introductory Physics(1) is a set of instructional materials intended to supplement the lecture, textbook, and laboratory of a standard calculus-based or algebra-based introductory course. The tutorials are designed to address specific conceptual and reasoning difficulties that have been identified through research. In addition to providing hands-on experience with the curriculum, the workshop will include discussions of instructional strategies incorporated into the materials and results from assessments of student learning. Important aspects related to implementation of the tutorials will be covered, including preparation of graduate teaching assistants, undergraduate peer instructors, and post-docs. Copies of Tutorials in Introductory Physics will be provided to participants. (1) L.C. McDermott, P.S. Shaffer, and the Physics Education Group at the University of Washington, Tutorials in Introductory Physics, First Ed. (Prentice Hall, 2002). Development was supported, in part, by the National Science Foundation.

Chair

Lillian McDermott[1]
[1]*University of Washington.*

W33: Franklin and Electrostatics
AAPT Workshop, 1:00-5:00pm, 308

Benjamin Franklin's experiments and observations on electricity established not only his reputation as a scientist, but also our electrical conventions and vocabulary, and the principle of charge conservation. In his letters, Franklin builds, test, and defends his model with skill and eloquence, arguing from experiment and sharing both his wisdom and doubts, while clearly conveying his fascination with electricity. As Franklin was not formally schooled in mathematics, his theory was qualitative, and is an approachable example of hands-on and minds-on construction of a conceptual model with significant explanatory power. In this new workshop, developed by the author at the Wright Center for Science Teaching at Tufts University, working with Franklin's descriptions, we will recreate many of his experiments using modern, inexpensive equipment. Participants will receive a CD-ROM along with the workshop manual, a collection of Franklin's letters relating to electricity, and many historical pictures and illustrations. The year 2006 marked the tercentenniel of Franklin's birth. Continue the celebration! (Workshop partially supported by the Wright Center for Innovative Science Education, Tufts University)

Chair

Robert Morse[1]
[1]*Cathedral College.*

W34: Teaching Tailored Tutorials
AAPT Workshop, 1:00-5:00pm, 310

Instructors inevitably need to adapt even the best reform materials to suit their local circumstances. We offer a package of research-based, open-source, epistemologically-focused mechanics tutorials, along with the detailed information instructors need to make effective modifications and provide professional development for TAs. In particular, our tutorials are embedded with comments from the developers, advice from experienced instructors, and video clips of students working on the materials. A DVD will be provided to all participants.

Chair

Rachel Scherr[1]
[1]*University of Maryland.*

Exploring Magnetism in Earth and Space Science
AAS Workshop, 1:00-5:00pm, 607

We will present hands-on lessons, developed by the Center for Science Education at UC Berkeley's Space Sciences Laboratory, about the basics of magnetism and its connection to

electricity. Magnetism is important in understanding topics such as sunspots, solar flares, geomagnetic storms, and aurorae. Participants will map the magnetic fields around bar magnets and electrical circuits; explore how to make a coil of wire behave like a bar magnet; and discover how to generate electrical currents with nothing more than a bar magnet. Additional activities will explore the strength of magnetic fields during a solar flare, an electromagnetic induction lesson to help students understand how electrical currents in the upper atmosphere can be measured by magnetic fields on the ground, and an activity involving using the internet and computer software programs to discover how the Sun's electrical solar wind is influencing Earth's magnetic field. We seek to enhance the teacher's content knowledge as well as model pedagogical methods for improvement of their science teaching in the classroom.
Chair
Bryan J. Mendez[1]
[1]UC Berkeley.

ComPADRE in Undergraduate Physics
AAS Workshop, 1:00-3:00pm, 613

See morning ComPADRE woskshop for description.
Chair
Susana E. Deustua[1]
[1]American Astronomical Society.

Astro 101
AAS Splinter Meeting, 2:30-5:30pm, 612

Astronomy 101 is a popular elective amongst undergraduates of all backgrounds, as is demonstrated by the attendance of 250,000 students across the country in introductory astronomy courses. This session, offered at every meeting, is equally popular with their instructors. Discussions are wide ranging with specific topics selected for each session, but they always focus on What makes science/astronomy difficult for students? How do we, as instructors, adapt our specialized knowledge so that our students learn astronomy and enjoy doing so. Join us for an interactive discussion.

ComPADRE, AstronomyCenter
AAS Workshop, 3:00-5:00pm, 613

See morning ComPADRE woskshop for description.
Chair
Susana E. Deustua[1]
[1]American Astronomical Society.

Undergraduate Orientation
AAS Event, 6:00-7:00pm, N. Galleria Lobby 2nd Floor

Undergraduate students, their advisors and those interested in attracting undergraduate students to their graduate program, or undergraduate research opportunity are invited to attend this event. The Chair of the Astronomy Education Board will explain how to get the most benefit from an AAS meeting and outline how the meeting works. The leadership of the AAS will also be in attendance to answer questions and get to know the undergraduate attendees. Tickets are required and are available free of charge to all undergrads, their advisors and those offering research opportunities (or jobs) to undergraduates, through the meeting registration form and will be placed in their registration envelope. Light snacks and refreshments will be provided. Organizations hoping to recruit undergraduate students may reserve poster display space for a small fee.
Chair
Susana E. Deustua[1]
[1]American Astronomical Society.

Center for Astronomy Learner-centered Teaching Workshop Participant Reunion

AAPT Event, 7:00-8:00pm, 618

Chair
Timothy F. Slater[1]
[1]*Univ. of Arizona.*

Opening Reception

Joint Event, 7:00-10:00pm, Grand Hyatt

This opening reception is for all participants and registered guests. It will feature a cash bar and light snacks (not to be construed as dinner!). Meeting registration is being held at a separate location, the Washington State Convention and Trade Center.
Chair
Kelli L. Gilmore[1]
[1]*American Astronomical Society.*

SUNDAY

Registration

Attendee Services, Sunday, 7:30am-5:00pm, South Lobby

Chair
Laronda Boyce[1]
[1]*AAS.*

Speaker Ready Room

Attendee Services, 7:30am-6:00pm, 603-04

See Saturday's listing for AV instructions.
Chair
Rick Matthews[1]
[1]*American Audio Video.*

Cyber Café

Attendee Services, 8:00am-6:30pm, South Lobby

The Cyber Cafe, will open Sunday, opening at the beginning of the morning coffee break and closing Wednesday after the evening poster sessions. In addition to computers, there will be open lines for your laptops. There will be an open area with wireless connectivity. Please be advised that users need to bring their own wireless cards and review the connection process with their system administrators. In order to provide continuous network connectivity to all of our attendees and exhibitors, we will ask you to adhere to the following rules.

If there is a waiting line for computers, please limit your time to 15 minutes.

All attached devices will be required to be running the most up-to-date Virus Protection Software and Virus Definitions, IP Filtering, Anti-Ad and Anti-Spyware Software.

We recommend turning off automatic updates to your operating system, this will prevent bottlenecks in the network during the morning hours.

No device should be running as a server for offsite clients.

Absolutely no routers can be attached to the network without prior authorization from the AAS IT Staff.

The network will be monitored throughout the meeting and the AAS Staff reserves the right to disconnect any device that is causing overall network problems.

Chair

Scott Idem[1]
[1]*American Astronomical Society.*

001: Opening Remarks
Plenary, 8:15-8:30am, Ballroom 6

002: Space Flight: A Human Perspective
Plenary, 8:30-9:20am, Ballroom 6

Chair

Janelle M. Bailey[1]
[1]*Univ. Nevada, Las Vegas.*

002.01 **Space Flight: A Human Perspective**
Kathryn C. Thornton[1]
[1]*University of Virginia.*

003: Poster Session I
AAPT Poster, 9:20am-6:30pm, Exhibit Hall 4

003.01 **PhysicsFirst: Building Connections with a Concurrent Mathematics Course**
Boris M. Korsunsky[1]
[1]*Weston High School.*

003.02 **Building Problem-Solving Skills in PhysicsFirst Classroom**
Boris M. Korsunsky[1]
[1]*Weston High School.*

003.03 **Putting the "Spark" into Physical Science and Algebra**
Andre Dagenais[1], B. Pill[1]
[1]*Sanford School.*

003.04 **Teaching Lower Socio-Economic Students About The Electromagnetic Spectrum Uses**
Sharon R. Blauvelt[1]
[1]*Missouri State University.*

003.05 **Impulse In, Impulse Out Understanding Elastic Collisions Before Energy**
Richard G. Piccioni[1]
[1]*James A. Garfield High School.*

003.06 **Characterizing Student Experiences in Physics Competitions: The Power of Emotions**
Rachel F. Moll[1], S. Nashon[1], D. Anderson[1]
[1]*University of British Columbia, Canada.*

003.07 **Introduction to Physics of the Universe in AP Physics Classrooms**
Stephanie L. Allen[1]
[1]*Hope College.*

003.08 **Modification of Multiple-Choice Assessment Items Based on Student Feedback**
Thomas J. Regan[1]
[1]*AAAS/Project 2061.*

003.09 **Producing a Brighter Future by Changing a Trend**
Elaine Gwinn[1]
[1]*Ball State University.*

003.10 **The Illinois Pipeline Project**
Carl J. Wenning[1]
[1]*Illinois State University.*

003.11 **Efforts to Recruit Secondary STEM Teachers at Columbus State University**
Zodiac T. Webster[1], MaSST Preparation Council
[1]*Columbus State University.*

003.12 **Mentoring Beginning and Crossover Teachers**
Dale Freeland[1]
[1]*Portage Central High School.*

003.13 **Is Special Training Needed to Teach "Physics For Elementary Teachers″?**
Paul W. Zitzewitz[1], J. F. Devlin[1], R. M. Savage[1], C. M. Swift[1]
[1]*University of Michigan-Dearborn.*

003.14 **Training Future Physics Teachers at BYU: Successes in Teacher Training**
Duane B. Merrell[1], R. Beck Clark[1]
[1]*Brigham Young University.*

003.15 **A Proposal for a Research-based Constructivist Physics-and-Pedagogy Course**
Esther Zirbel[1]
[1]*Tufts University.*

003.16 **PET as a Model for Other Introductory Content Courses**
George D. Nelson[1]
[1]*Western Washington University.*

003.17 **Teacher Leaders as Intern Supervisors: Lessons from an MSP Project**
Jacob Clark Blickenstaff[1]
[1]*Western Washington University.*

003.18 **The Need and Effectiveness of Professional Development for K-12 Teachers**
Robert J. Endorf[1], K. M. Koenig[2]
[1]*University of Cincinnati,* [2]*Wright State University.*

003.19 **Orange Peel The Orange's Life Vest**
Milijana Suskavcevic[1], E. Hagedorn[1]
[1]*University of Texas at El Paso.*

003.20 **Never Fear; Scaffolding is Here: Solar Research in the Classroom**
Constance E. Walker[1], N. DeMuth[2], D. Isbell[1], S. M. Pompea[1], K. Garmany[1]
[1]*National Optical Astronomy Observatory,* [2]*El Camino College.*

003.21 **Using Case Studies to Assess the Impact of Modeling Workshops**
Jeff Saul[1], G. O'Brien[1], L. Kramer[1]
[1]*Florida International University.*

003.22 **Contrasting Inquiry and Direct Physics Instructional Designs: Examples from Dynamics**
Betty Adams[1], A. Undreiu[1], D. Schuster[1]
[1]*Western Michigan University.*

003.23 **Report on the IX Inter-American Conference on Physics Education**
Gordon J. Aubrecht, II[1], J. F. Sullivan[2]
[1]*Ohio State University at Marion,* [2]*College of Applied Science/University of Cincinnati.*

003.24 **Latin America's Presentation of "World Year of Physics 2005″**
Margarete B. Allen[1]
[1]Los Angeles Pierce College.

003.25 **A Masterclass in Particle Physics for High School Students**
Kenneth Cecire[1], T. Entwistle[2]
[1]Hampton University, [2]Ward Melville High School.

003.26 **Physics Education in Nigeria**
Jefferson L. Collier[1]
[1]ABTI-American University of Nigeria, Nigeria.

003.27 **Physics Education in Russia and in the United States**
Irina Struganova[1]
[1]Barry University.

003.28 **The Comparison Between Russian High School And American College Curricula**
Valentin Voroshilov[1]
[1]Boston University.

003.29 **Representations of Force and Motion Concepts at the Middle Level**
Thomas J. Regan[1], B. Sweeney[1], T. Willard[1], G. DeBoer[1]
[1]AAAS/Project 2061.

004: A Potpourri of Internal Properties of Galaxies
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

004.01 **A Deep HST Survey of the Prototypical Spiral Galaxy M81**
Andreas Zezas[1], J. S. Gallagher, III[2], P. Mucciarelli[3]
[1]SAO, [2]University of Wisconsin-Madison, [3]INAF-Obs. Padova & University of Padova, Italy.

004.02 **Panchromatic Tully-Fisher Relations**
Martin Meyer[1], SINGS Team
[1]STScI.

004.03 **Mapping Tidal Interactions in the M51 System**
Allison G. Noble[1], J. S. Gallagher[1], K. E. Dellenbusch[1]
[1]U. Wisconsin-Madison.

004.04 **Ultraviolet Observations of M51 with Swift/UVOT**
Sally D. Hunsberger[1], C. Gronwall[1], A. Morgan[2], S. Immler[3], T. S. Poole[4], A. A. Breeveld[4]
[1]Pennsylvania State Univ., [2]University of Cambridge, United Kingdom, [3]NASA GSFC, [4]Mullard Space Sciences Laboratory, United Kingdom.

004.05 **Spitzer IRS Spectral Maps of Spatially Resolved Molecular Hydrogen in NGC 5194**
Gregory Brunner[1], K. Sheth[2], L. Armus[2], G. Helou[2], E. Schinnerer[3], S. Vogel[4], M. Wolfire[4]
[1]Rice Univ./Spitzer Science Center, [2]Spitzer Science Center, [3]MPIA, Germany, [4]University of Maryland.

004.06 Excess 4.5 Micron Emission from SINGS Galaxies
Michael W. Regan[1], SINGS Team
[1]STScI.

004.07 **Evolution and Instability of Galactic Gas Disks inresponse to A Spiral Density-wave Potential**
Chi Yuan[1], D. C. Yen[1], H. H. Wang[1]
[1]Academia Sinica, Taiwan.

004.08 **Hydrodynamical Simulations of the Barred Spiral Galaxy NGC 6782**
Lien-Hsuan Lin[1], C. Yuan[1], R. Buta[2]
[1]*Academia Sinica, Taiwan,* [2]*Department of Physics and Astronomy, University of Alabama.*

004.09 **Star formation and figure rotation in the early-type galaxy NGC2974**
Hyunjin Jeong[1], M. Bureau[2], S. K. Yi[1], D. Krajnovic[2], R. L. Davies[2]
[1]*Yonsei University, Republic of Korea,* [2]*University of Oxford, United Kingdom.*

004.10 **A Multi-Waveband Study of the Southern Compact Group, SCG 0018-4854**
Elizabeth H. Wehner[1]
[1]*McMaster University, Canada.*

004.11 **Mapping a Low Surface Brightness Galaxy**
Kushal T. Mehta[1], K. O'Neil[2]
[1]*University of Maryland, Baltimore County,* [2]*National Radio Astronomy Observatory.*

004.12 **In Search of the Highest Velocity Dispersion Galaxies in the Universe**
Sarah B. Salviander[1], G. A. Shields[1], K. Gebhardt[1], M. Bernardi[2]
[1]*Univ. of Texas at Austin,* [2]*Univ. of Pennsylvania.*

004.13 **The Connection In Bulge Properties And The Bimodailty Of Galaxy Properties**
David B. Fisher[1], N. Drory[2]
[1]*Univ. Of Texas,* [2]*MPE Garching, Germany.*

004.14 **Revisiting the Low Metallicity Problem of the Hot ISM in X-ray Faint Early-type Galaxies**
Jimmy Irwin[1], G. R. Sivakoff[2], C. L. Sarazin[3], J. Ji[1], J. N. Bregman[1], W. G. Mathews[4]
[1]*Univ. Of Michigan,* [2]*Ohio State University,* [3]*Univ. Of Virginia,* [4]*Univ. Of California-Santa Cruz.*

004.15 **Chandra Observations of Maffei 1**
Christopher S. Reynolds[1], C. Miller[1]
[1]*Univ. Of Maryland.*

004.16 **PNLF Distances to Six Face-On Spiral Galaxies**
Kimberly A. Herrmann[1], R. Ciardullo[1], J. J. Feldmeier[2], M. Vinciguerra[1]
[1]*Penn State University,* [2]*Youngstown State University.*

004.17 **The Star Formation History in Andromeda's Diffuse Stellar Halo**
Thomas M. Brown[1], E. Smith[1], H. Ferguson[1], P. Guhathakurta[2], R. Rich[3], J. Kalirai[2], A. Renzini[4], A. Sweigart[5]
[1]*STScI,* [2]*UCSC,* [3]*UCLA,* [4]*INAF, Italy,* [5]*NASA/GSFC.*

005: AGN, Starbursts, and Sub-mm Galaxies
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

005.01 **SPIRE Multi-Color Fluctuation** *P(D)* **Analysis Below the Confusion Limit.**
Glenn T. Laurent[1], J. Glenn[1], P. R. Maloney[1], J. J. Bock[2]
[1]*University of Colorado,* [2]*Jet Propulsion Laboratory.*

005.02 **A Comparison of Effective Volumes for X-ray Surveys**
Dave J. English[1], M. Elvis[1], H. Hao[1]
[1]*Harvard-Smithsonian CfA.*

005.03 **Colour Bimodality in Powerful AGN Host Galaxies**
David Floyd[1]
[1]*STScI.*

005.04 **Cosmological History of Massive Black Hole Interactions in Triples**
Frederic A. Rasio[1], J. Fregeau[1], S. Umbreit[1], M. Volonteri[1]
[1]*Northwestern Univ..*

005.05 **Local Benchmarks for the Evolution of Major-Merger Galaxies (I)--Spitzer Observations of a K-Band Selected Sample**
C. Kevin Xu[1], Y. Cheng[1], R. Cutri[1], D. Domingue[2], Y. Gao[3], J. Huang[4], N. Lu[1], J. Mazzarella[1], W. Sun[5], J. Surace[1]
[1]*Caltech,* [2]*GCSU,* [3]*Purple Mountain, China,* [4]*CfA,* [5]*NCU, Taiwan.*

005.06 **Local Benchmarks for the Evolution of Major-Merger Galaxies (II) -- Palomar H_alpha/H_beta Observations of a K-Band Selected Sample**
Yi-Wen Cheng[1], C. K. Xu[1], N. Lu[1], R. Cutri[1], D. Domingue[2], Y. Gao[3], J. Huang[4], J. Mazzarella[1], J. Surace[1], W. Sun[5]
[1]*IPAC/Caltech,* [2]*GCSU,* [3]*Purple Mountain, China,* [4]*CfA,* [5]*National Central Univ., Taiwan.*

005.07 **Evidence for Evolution in the FIR Luminosity Function of Luminous Infrared Galaxies from Spitzer and ISO Observations of the Lockman Hole**
Bradley Jacobs[1], D. B. Sanders[1], D. Rupke[2], S. Veilleux[2], E. Le Floc'h[1], O. Ilbert[1], H. Aussel[3], Y. Taniguchi[4], M. Yun[5]
[1]*Univ. Of Hawaii,* [2]*Univ. Of Maryland,* [3]*CEA/Saclay, France,* [4]*Ehime University, Japan,* [5]*Univ. Of Massachusetts.*

006: Astrobiology and Lab Results
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

006.01 **Investigation of Anomalous Sputtering Behavior of a Ga-In Target**
Dale R. Nunn[1], D. L. Weathers[1], L. R. Burns[1], P. Kadam[1], S. Li[1]
[1]*University of North Texas.*

006.02 **Laboratory Infrared Optical Constants and Reflectance Spectra of Silicon Carbide**
Karly M. Pitman[1], A. M. Hofmeister[2], A. K. Speck[3]
[1]*NASA Jet Propulsion Laboratory, California Institute of Technology,* [2]*Dept. of Earth & Planetary Sciences, Washington University St. Louis,* [3]*Dept. of Physics & Astronomy, University of Missouri Columbia.*

006.03 **Modeling Atmospheric Effects of the September 1859 Solar Flare**
Brian Thomas[1], C. H. Jackman[2], A. L. Melott[3]
[1]*Washburn Univ.,* [2]*NASA GSFC,* [3]*University of Kansas.*

006.04 **Living with a dM Star: Evolution over Time of Dynamo Generated X-ray UV Emissions and Effects on Hosted Planets**
Edward F. Guinan[1], S. G. Engle[1], L. E. DeWarf[1], D. Schulze-Makuch[2], M. Cuntz[3], R. T. Zellem[1], V. Pettiford[1]
[1]*Villanova Univ.,* [2]*WSU,* [3]*Univ. of Texas, Arlington.*

006.05 **Evolutionary Competition Between Primitive Photosynthetic Systems: Existence of an early purple Earth?**
William B. Sparks[1], S. DasSarma[2], I. N. Reid[1]
[1]*STScI,* [2]*University of Maryland Biotechnology Institute.*

007: Black Holes
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

007.01 **The Binary Nucleus in VCC 128: A Candidate Supermassive Black Hole in a Dwarf Elliptical Galaxy**
Victor P. Debattista[1], I. Ferreras[2], A. Pasquali[3], A. Seth[4], S. De Rijcke[5], L. Morelli[6]
[1]Univ. of Washington, [2]King's College London, United Kingdom, [3]Max-Planck-Institut fur Astronomie, Germany, [4]Centre for Astrophysics, [5]Universiteit Gent, Belgium, [6]Pontificia Universidad Catolica de Chile, Chile.

007.02 **First Constraints on Black Hole Spin in Broad Iron Line AGN**
Laura Brenneman[1]
[1]Univ. of Maryland.

007.03 **The Accretion Disk of GRS 1915+105: What Makes it Go Crazy?**
David M. Rothstein[1]
[1]Cornell Univ..

007.04 **Toward Understanding the Spectral Energy Distribution of Microquasars. I. Multiwavelength Properties of XTE J1550--564**
Yongquan Xue[1], X. Wu[2], W. Cui[1]
[1]Purdue Univ., [2]Peking Univ., China.

007.05 **Active X-ray States of Black Hole Binaries: Current Overview**
Ronald A. Remillard[1], J. E. McClintock[2]
[1]MIT, [2]Harvard-Smithsonian.

007.06 **High Resolution Ultraviolet Spectroscopy of the X-ray Binary Cygnus X-1**
Adrienne E. Hunacek[1], S. D. Vrtilek[2], B. S. Boroson[2], D. Geis[3]
[1]Massachusetts Institute of Technology, [2]Harvard-Smithsonian Center for Astrophysics, [3]Georgia State University.

008: Blazars and AGN jets
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

008.01 **Collimation and Stability Properties in AGN Jets**
Masanori Nakamura[1], H. Li[1]
[1]LANL.

008.02 **Correlated Multifrequency Variability in the Blazars 3C 279 and PKS 1510-089**
Ritaban Chatterjee[1], A. P. Marscher[1], S. G. Jorstad[1], M. F. Aller[2], I. M. McHardy[3]
[1]Boston Univ., [2]Univ. Michigan, [3]Univ. Southampton, United Kingdom.

008.03 **Spitzer Observations of Cygnus A and Pictor A**
Dean C. Hines[1], G. H. Rieke[2], K. D. Gordon[2], C. L. Carilli[3], L. Armus[4], Y. Shi[2]
[1]Space Science Institute, NM Office, [2]The University of Arizona, [3]NRAO, [4]Spitzer Science Center.

008.04 **Multi-frequency VLBA Observations of Circular Polarization fromExtragalactic Radio Jets**
Daniel C. Homan[1], M. L. Lister[2], H. D. Aller[3], M. F. Aller[3], J. F. Wardle[4]
[1]Denison Univ., [2]Purdue Univ., [3]University of Michigan, [4]Brandeis University.

008.05 **Cm-band Circular Polarization Spectral Variability from Blazars: Recent Results from the UMRAO Program**
Margo F. Aller[1], H. D. Aller[1], P. A. Hughes[1]
[1]Univ. of Michigan.

008.06 **Observations of Blazar S5 0716+714 With Ground Based Telescopes and the Spitzer Infrared Space Telescope**
Jeffery Adkins[1], M. Lacy[2], A. Morton[1], T. Travagli[1], M. Mulaveesala[1], J. Santiago[1], S. Rapp[3], L. Stefaniak[4]
[1]Deer Valley High School, [2]Spitzer Science Center, [3]Linwood Holton Governor's School, [4]Allentown High School.

008.07 **Microvariabilty in Active Galactic Nuclei at 1420 MHz**
James W. Atwood[1]
[1]Morehead State Univ..

008.08 **Ejection Direction Variations in MOJAVE AGN Jets**
Matthew L. Lister[1]
[1]Purdue Univ..

008.09 **Effects of Jet Opening Angle and Velocity Structure on Blazar Parameters**
Paul J. Wiita[1], .. Gopal-Krishna[2], S. Dhurde[3], P. Sircar[4]
[1]Georgia State Univ., [2]National Centre for Radio Astronomy/TIFR, India, [3]InterUniversity Centre Astron. & Astrophys., India, [4]Dept. Physics, IIT Kanpur, India.

008.10 **Searching for TeV Blazar Candidates in the Sloan Digital Sky Survey**
David A. Barnaby[1], L. Fortson[2], G. Gyuk[2], D. Steele[2], M. Subbarao[2], M. Carini[1], J. Maune[1]
[1]Western Kentucky Univ., [2]Adler Planetarium.

008.11 **Rapid Multiwavelength Polarization Variability in the Quasar 0420-014**
Francesca D. D'Arcangelo[1], S. G. Jorstad[1], A. P. Marscher[1], P. S. Smith[2]
[1]Boston Univ., [2]Steward Obs.

008.12 **A Multi-Wavelength Study of Blazars with WIYN VERITAS IceCube**
Kirsten Larson[1], M. Bayer[2], T. Montaruli[2], D. Steele[3]
[1]The College of Wooster, [2]University of Wisconsin-Madison, [3]Adler Planetarium.

008.13 **Deep Hubble Space Telescope Imaging of the M87 Jet**
Eric S. Perlman[1], W. B. Sparks[2], J. Madrid[2], D. E. Harris[3], D. Macchetto[2], J. Biretta[2]
[1]Florida Institute of Technology, [2]Space Telescope Science Institute, [3]Smithsonian Astrophysical Observatory.

008.14 **A Large Homogeneous Sample of BL Lacs from SDSS and FIRST**
Richard M. Plotkin[1], S. F. Anderson[1]
[1]University of Washington.

008.15 **An Optical Survey of Potential Gamma-ray Sources**
Lisa R. Carpenter[1]
[1]University of Michigan.

008.16 **A Two-Fluid Plasma Shock Wave Model for the Strong Shock in Centaurus A**
Robert F. Penna[1], P. E. Nulsen[2], R. P. Kraft[2]
[1]University Of Rochester, [2]Harvard-Smithsonian Center for Astrophysics.

009: Cataclysmic / Eruptive Variables / Novae
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

009.01 **Observations of SS Cyg Quiescence to Outburst**
Krista F. White[1]
[1]Ball State Univ..

009.02 **HD 109962 The Most Massive Dwarf Nova?**
Frederick M. Walter[1], H. E. Bond[2]
[1]Stony Brook University, [2]Space Telescope Science Institute.

009.03 **Phase-Resloved Infrared Cyclotron Spectroscopy of Polars**
Ryan Campbell[1]
[1]New Mexico State Univ..

009.04 **Near Infrared Quantitative Abundance Analysis of The Secondary Stars in a Sample of CVs**
Joseph W. Wellhouse[1], T. E. Harrison[1]
[1]New Mexico State University.

009.05 **The 0.5 13 µm Spectrum of V4332 Sagittarii in 2006**
David K. Lynch[1], R. J. Rudy[1], R. W. Russell[1], S. Mazuk[1], C. C. Venturini[1], M. L. Sitko[2], H. B. Hammel[3], R. C. Puetter[4], R. B. Perry[5]
[1]The Aerospace Corporation, [2]U. Cincinnati & Space Sci. Inst., [3]Space Science Institute, [4]Univ. California, [5]NASA LaRC.

009.06 **Spitzer Space Telescope and Visible/IR Spectrophotometry of V574 Pupis (Nova Pupis 2004)**
Richard J. Rudy[1], D. K. Lynch[1], S. M. Mazuk[1], C. C. Venturini[1], R. W. Russell[1], R. C. Puetter[2], R. B. Perry[3], C. E. Woodward[4], G. J. Schwarz[5], M. F. Bode[6], A. Evans[7], T. R. Geballe[8], R. D. Gehrz[4], M. A. Greenhouse[9], P. A. Hauschildt[10], L. A. Helton[4], J. E. Lyke[11], A. Salama[12], S. N. Shore[13], S. G. Starrfield[14], J. W. Truran[15], R. M. Wagner[16]
[1]Aerospace Corp., [2]UCSD, [3]NASA, [4]University of Minnesota, [5]West Chester University, [6]John Moores University, United Kingdom, [7]Keele University, United Kingdom, [8]Gemini Observatory, [9]NASA Goddard Space Flight Center, [10]Landessternwarte, Germany, [11]Keck Observatory, [12]ESA, Spain, [13]Universita' di Pisa, Italy, [14]Arizona State University, [15]University of Chicago, [16]University of Arizona.

009.07 **A New, Bright, Short-period, Emission Line Binary in Ophiuchus**
Michele A. Stark[1], R. A. Wade[2], J. R. Thorstensen[3], C. S. Peters[3], H. A. Sheets[3], H. A. Smith[4], R. D. Miller[4], E. M. Green[5]
[1]Univ. of Wyoming, [2]Penn State Univ., [3]Dartmouth Coll., [4]Michigan State Univ., [5]Steward Obs..

009.08 **Low-State Photometry of AM Her during 2005-06**
Jeff W. Robertson[1], S. Kafka[2], K. Honeycutt[3], T. Campbell[4]
[1]Arkansas Tech University, [2]CTIO/NOAO, Chile, [3]Indiana University, [4]Whispering Pines Observatory.

009.09 **Steady-State Modeling and Possible Detection of HCl in Eta Carinae's - 513 km/s Ejecta**
Alissa S. Bans[1]
[1]Maria Mitchell Observatory.

009.10 **Population Synthesis Studies of Close Binary Systems Using a Variable Alpha: Dependence Upon the Evolutionary State of the Giant**
Michael Politano[1]
[1]Marquette Univ..

009.11 **Understanding the White Dwarfs in Intermediate Polars**
Kunegunda E. Belle[1], E. M. Sion[2]
[1]LANL, [2]Villanova University.

009.12 **The Hard X-ray Bright Magnetic Catclysmic Variable IGR J14536-5522=Swift J1453.4-5524**
Koji Mukai[1], C. Markwardt[1], J. Tueller[1], D. Buckley[2], S. Potter[2], M. Still[2], Swift/BAT team
[1]NASA's GSFC, [2]South African Astronomical Observatory, South Africa.

009.13 **Galactic Wolf-Rayet Infrared Imaging Survey**
Jill Gerke[1], D. R. Zurek[1], M. M. Shara[1], A. F. Moffat[2], N. St-Louis[2], R. Doyon[2], L. Drissen[3], C. Robert[3]
[1]American Museum of Natural History, [2]Universite de Montreal, Canada, [3]Universite Laval, Canada.

009.14 **Wind-Clumping does not Depend on Ambient Metallicity: Wolf-Rayet Stars in the SMC**
Sergey Marchenko[1], C. Foellmi[2], A. F. Moffat[3], F. Martins[4], J. Bouret[5], É. Depagne[6]
[1]Western Kentucky Univ., [2]Observatoire de Grenoble, France, [3]Universite de Montreal, Canada, [4]Max-Planck-Institut fur extraterrestrische Physik, Germany, [5]Laboratoire d'Astrophysique de Marseille, France, [6]European Southern Observatory, Chile.

009.15 **Revised Ephemerides for V1776 Cygni and QU Vulpeculae**
Michael Lujan[1], A. W. Shafter[2], K. A. Misselt[3], J. K. Reed[2], S. R. Warren[4]
[1]California Polytechnic State University, [2]San Diego State University, [3]University of Arizona, [4]University of Minnesota.

009.16 **A 2006 Spectroscopic Study of ST LMi**
R. K. Honeycutt[1], S. Kafka[2], S. B. Howell[3], J. W. Robertson[4]
[1]Indiana Univ., [2]CTIO/NOAO, Chile, [3]WIYN/NOAO, [4]Arkansas Tech Univ..

009.17 **Magnetic Activity on the Degenerate Secondary Star in EF Eri**
Styliani Kafka[1], S. B. Howell[2], F. M. Walter[3], A. Z. Bonanos[4], D. Steeghs[5]
[1]CTIO/NOAO, Chile, [2]WIYN/NOAO, [3]Stony Brook University, [4]Carnegie-DTM, [5]CfA.

009.18 **VLT Spectroscopy of Four Short Period Cataclysmic Variables**
Julie N. Skinner[1], S. B. Howell[2], E. Mason[3]
[1]University of Oklahoma, [2]WIYN/NOAO, [3]European Southern Observatory, Chile.

009.19 **XMM-Newton Observations of Three Interesting Cataclysmic Variables**
Eric J. Hilton[1], P. Szkody[1], L. Homer[2], G. Schmidt[3], A. Henden[4], S. Anderson[1], K. Mukai[5], A. Mukadam[1], L. van Zyl[6], C. Hellier[6]
[1]Univ. Of Washington, [2]Liverpool CC, United Kingdom, [3]Steward Observatory, [4]AAVSO, [5]NASA Goddard, [6]Keele University, United Kingdom.

009.20 **HET Spectroscopy of Extragalactic Novae**
Allen W. Shafter[1], E. A. Coelho[1], K. A. Misselt[2], M. F. Bode[3], M. J. Darnley[3]
[1]San Diego State University, [2]University of Arizona, [3]Liverpool JMU, United Kingdom.

009.21 **The Distance to V838 Monocerotis**
Howard E. Bond[1], W. B. Sparks[1], M. Cracraft[1], M. Afsar[2], R. Corradi[3], L. Crause[4], M. Dopita[5], A. Henden[6], Z. Levay[1], U. Munari[7], N. Panagia[1], S. Starrfield[8], B. Sugerman[9], M. Wagner[10], R. White[1]
[1]STScI, [2]Ege University, Turkey, [3]Isaac Newton Group, Spain, [4]University of Cape Town, South Africa, [5]Australian National University, Australia, [6]AAVSO, [7]Universita di Padova, Italy, [8]ASU, [9]Goucher College, [10]Large Binocular Telescope.

009.22 **Modeling Eclipses of the Novalike Variable TT Triangulum**
Steven R. Warren[1], A. W. Shafter[2], J. K. Reed[2]
[1]University of Minnesota, [2]San Diego State University.

010: Circumstellar Disk Observations
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

010.01 **The Formation and Evolution of Solar Systems: Penultimate Status Report on Results from a Spitzer Legacy Science Program**
Lynne Hillenbrand[1], FEPS Spitzer Legacy Science Team
[1]Caltech.

010.02 **A Detection of OH in the Planet Formation Regions of Circumstellar Disks**
Steinn Sigurdsson[1], A. M. Mandell[1], M. Mumma[2], G. Blake[3]
[1]Pennsylvania State Univ., [2]GSFC, [3]Caltech.

010.03 **Updated Observations of V1647 Orionis: Measuring Hα and Brγ in the Optical and Near-Infrared**
Matthew Troutman[1], S. Brittain[1], E. Gibb[2], T. Rettig[3], T. Simon[4], B. Donehew[1]
[1]Clemson University, [2]University of Missouri, [3]University of Notre Dame, [4]University of Hawaii.

010.04 **Characterizing the Disk Around the Brown Dwarf Planetary System 2MASSW J1207334-393254**
Basmah Riaz[1], J. E. Gizis[1]
[1]Univ. of Delaware.

010.05 **Sub-millimeter Interferometric Study of Circumstellar Disks Surrounding Optically Visible, Young High Mass Stars**
Manoj Puravankara[1], P. T. Ho[2], N. Ohashi[1], Q. Zhang[3]
[1]Institute of Astronomy and Astrophysics, Academia Sinica, Taiwan, [2]Smithsonian Astrophysical Observatory, [3]Harvard-Smithsonian Center for Astrophysics.

010.06 **Silica in Protoplanetary Disks**
Benjamin A. Sargent[1], W. J. Forrest[1], D. M. Watson[1], M. K. McClure[1], C. J. Bohac[1], E. Furlan[2], K. H. Kim[1], J. D. Green[1], G. C. Sloan[3]
[1]Univ. of Rochester, [2]UCLA, [3]Cornell Univ..

010.07 **Coronographic Observations of Circumstellar Disks with Subaru**
Jennifer Karr[1], M. Puravankara[1], M. Tamura[2], T. Kudo[2], N. Ohashi[1]
[1]ASIAA, Taiwan, [2]NAOJ, Japan.

010.08 **The TEXES/Gemini Survey for Protoplanetary Disk Gas**
Martin Bitner[1], M. J. Richter[2], J. H. Lacy[1], T. K. Greathouse[3], D. T. Jaffe[1], G. J. Herczeg[4], J. Najita[5], J. S. Carr[6], R. Y. Shuping[7], G. A. Blake[8], S. J. Kenyon[9], T. Currie[9], U. Gorti[7], D. Hollenbach[7]
[1]Department of Astronomy, University of Texas, Austin, [2]Department of Physics, University of California, Davis, [3]Lunar and Planetary Institute, [4]Department of Astronomy, Caltech, [5]National Optical Astronomy Observatory, [6]Naval Research Laboratory, [7]NASA Ames Research Center, [8]Division of Geological and Planetary Sciences, Caltech, [9]Harvard Smithsonian Center for Astrophysics.

010.09 **Warm HCN, C_2H_2, and CO in the Circumstellar Disk of GV Tau**
Erika Gibb[1], K. Van Brunt[1], S. D. Brittain[2], T. W. Rettig[3]
[1]Univ. of Missouri St. Louis, [2]Clemson University, [3]Univ. of Notre Dame.

010.10 **Observing Grain Growth in Protoplanetary Disks**
Sarah T. Maddison[1], D. Lommen[2], C. Wright[3], T. Bourke[4], J. Jorgensen[4], E. van Dishoeck[2], M. Burton[5], A. Hughes[1], D. Wilner[4]
[1]Swinburne University, Australia, [2]Leiden Observatory, The Netherlands, [3]UNSW@ADFA, Australia, [4]CfA, [5]UNSW, Australia.

011: Cosmic Microwave Background
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

011.01 **CBI2: Current Status**
Jonathan L. Sievers[1], CBI Collaboration
[1]CITA, Canada.

011.02 **The Q/U Imaging Experiment (QUIET)**
Michael D. Seiffert[1], QUIET Collaboration
[1]JPL.

011.03 **PAPPA: A New Generation of CMB Polarimetry**
Alan J. Kogut[1], D. T. Chuss[1], M. Devlin[2], S. Dicker[2], D. Fixsen[3], G. F. Hinshaw[1], K. Irwin[4], M. Limon[3], D. Marsden[2], S. H. Moseley[1], N. G. Phillips[3], C. Semisch[2], T. Stevenson[1], E. J. Wollack[1]
[1]NASA's GSFC, [2]University of Pennsylvania, [3]SSAI/GSFC, [4]NIST.

011.04 **Spider: Searching for the Echos of Inflation**
William C. Jones[1], Observational Cosmology Group
[1]Caltech.

011.05 **BICEP2 and SPUD: Searching for Inflation with Degree-Scale Polarimetry from the South Pole**
John Kovac[1], BICEP/SPUD collaboration
[1]California Institute of Technology.

011.06 **Search for Extragalactic Point Sources using WMAP Q-, Vand W-band Data**
Xi Chen[1], E. L. Wright[1]
[1]UC, Los Angeles.

011.07 **Primordial non-Gaussianity using CMB Temperature and Polarization Anisotropies.**
Amit P. Yadav[1], E. Komatsu[2], B. D. Wandelt[1]
[1]Univ. Of Illinois, Urban-Champaign, [2]University of Texas at Austin.

012: Dark Matter
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

012.01 **Comparing the Cosmological Critical Density of Neutralinos and Cold Dark Matter**
Sarah McMurray[1], K. Andrew[1], D. Barnaby[1], B. Bolen[1], L. Strolger[1]
[1]Western Kentucky University.

012.02 **Constraining the Angular Distribution of Satellite Galaxies Surrounding Disk-like Host Galaxies**
Jason H. Steffen[1]
[1]Fermilab.

013: Debris Disks
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

013.01 **Debris-Disk Candidates in the Open Cluster NGC 2362: An Examination of 24 Micron Stellar Excesses**
Alexander J. Shvonski[1], T. Monroe[1], C. A. Pilachowski[1]
[1]Indiana University.

013.02 **Secular Planetary Perturbations in Circumstellar Debris Disks**
Joseph M. Hahn[1], C. Capobianco,[2], P. Kalas[3], K. A. Marsh[4], C. Telesco[5]
[1]Space Science Institute, [2]Queen's University, Canada, [3]UC Berkeley, [4]NASA/JPL, [5]University of Florida.

013.03 **The Signature of Primordial Grain Growth in the Polarized Light of the AU Mic Debris Disk**
James R. Graham[1], P. Kalas[1], B. Matthews[2]
[1]UC, Berkeley, [2]NRC-HIA, Canada.

013.04 **A Search for Debris Disks around Stars with Planets**
David R. Ardila[1], A. Kospal[2]
[1]Caltech, [2]Konkoly Observatory/Caltech, Hungary.

013.05 **Spitzer's Dirty Dozen: MIPS and IRACImaging of Nearby Debris Disks**
Karl R. Stapelfeldt[1], J. C. Carson[2], K. Y. Su[3], G. H. Rieke[3], M. W. Werner[1], G. Bryden[1], C. A. Beichman[4], Spitzer MIPS Instrument Team
[1]JPL, [2]JPL/ORAU, [3]Univ. of Arizona, [4]MSC/Caltech.

013.06 **Dual Imaging Polarimetry of young stars in Rho Ophiuchus**
Catarina Ubach[1], D. Potter[1]
[1]Univ. Of Arizona.

014: Differential Rotation & Activity of Cool Dwarfs
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

014.01 **The Differential Rotation Profile of kappa1 Ceti from MOST Photometry**
Gordon A. Walker[1], B. Croll[1], R. Kuschnig[1], J. Matthews[1], A. Walker[1], S. Rucinski[2], D. Guenther[3], A. Moffat[4], D. Sassalov[5], W. Weiss[6]
[1]UBC, Canada, [2]David Dunlap Observatory, Canada, [3]St Mary's Univ., Canada, [4]Univ Montreal, Canada, [5]Harvard-Smithsonian CfA, [6]Inst. f. Ast., Wien, Austria.

014.02 **Differential Rotation in Solar-type Stars**
David H. Bruning[1]
[1]Univ. of Wisconsin-Parkside.

014.03 **Tracers of Chromospheric Structure: Observations of CaII K and Hα in M Dwarfs**
Lucianne M. Walkowicz[1], S. L. Hawley[1]
[1]University of Washington.

014.04 **Solar Physics at Evergreen: Solar Dynamo and Chromospheric MHD**
E. J. Zita[1], J. Maxwell[1], N. Song[1], M. Dikpati[2]
[1]Evergreen State College, [2]High Altitude Observatory National Center for Atmospheric Research.

015: Extragalactic ISM
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

015.01 **Spitzer View of Four Low Surface Brightness Giant Galaxies: Malin 1, UGC 6614, UGC 6879, UGC 9024**
M. N. Rahman[1], J. Howell[2], B. Buckalew[2], G. Helou[2]
[1]Caltech, [2]IPAC/Caltech.

015.02 **PDR-Produced HI in Star-Forming Regions of M33**
Jonathan S. Heiner[1], R. J. Allen[1], P. C. van der Kruit[2]
[1]STScI, [2]Kapteyn Astronomical Institute, The Netherlands.

015.03 **The Relationship of Atomic Gas and Aromatic Emission in SINGS Spiral Galaxies**
Esther Chapman[1], M. D. Thornley[2], The SINGS team
[1]Cornell College, [2]Bucknell University.

015.04 **Spitzer Observations of Extraplanar PAH Emission from Several Edge-On Galaxies**
Nicolas Lehner[1], C. Howk[1]
[1]University of Notre Dame.

015.05 **WFPC2 Imaging of the Multiphase Halos of Two Spiral Galaxies: Dust and Ionized Gas**
Katherine Rueff[1], M. Pitterle[1], A. Hirschauer[1], N. Lehner[1], C. Howk[1]
[1]Univ. of Notre Dame.

015.06 **Multiwavelength Observations of Tidally Induced Star Formation in the M81 Group**
Abigail S. Hedden[1], K. Knierman[1], T. Roelofsen[2], C. Kulesa[1], J. Feldmeier[3], V. Gorjian[4], P. Durrell[3], B. Sepulveda[5], T. Spuck[6], C. Wheeler[7]
[1]University of Arizona, Steward Observatory, [2]New Jersey Astronomy Center for Education, [3]Youngstown State University, [4]JPL, [5]Lincoln High School, [6]Oil City Area Senior High School, [7]Luther Burbank High School.

015.07 **Evidence for Outflows and a Galactic Wind in the Large Magellanic Cloud?**
J. C. Howk[1], N. Lehner[1]
[1]Univ. of Notre Dame.

015.08 **Spitzer IRS Observations of the Gaseous Halo of NGC 891**
Richard J. Rand[1], R. A. Benjamin[2], K. Wood[3]
[1]Univ. of New Mexico, [2]Univ. of Wisconsin-Whitewater, [3]Univ. of St. Andrews, United Kingdom.

015.09 **Models of the Effect of Gaseous Drag on the Accretion of Intergalactic Clouds**
Travis C. Fischer[1], R. Benjamin[1]
[1]University of Wisconsin-Whitewater.

015.10 **A PAH Deficit in Extremely Low Luminosity Galaxies**
Rongying Wu[1], D. W. Hogg[1]
[1]New York University.

015.11 **Low Frequency Turnovers of Compact Radio Sources in NGC 247**
Sara K. Schultz[1], C. K. Lacey[1]
[1]Univ. of South Carolina.

015.12 **SCONES: Determining the Warm Gas Properties of Nearby Galaxies**
Glen R. Petitpas[1], C. D. Wilson[2], A. J. Baker[3], D. Iono[4], A. B. Peck[1], K. Sakamoto[4], M. Krips[1], P. T. Ho[5], S. Matsushita[5]
[1]Harvard-Smithsonian Center for Astrophysics, [2]McMaster University, Canada, [3]Rutgers, [4]NAOJ, Japan, [5]ASIAA, Taiwan.

015.13 **Understanding the Interplay Between Star Clusters and Their Interstellar Medium Using SINGS H II Regions**
Brent A. Buckalew[1], SINGS Team
[1]Caltech/IPAC.

016: The Sun
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

016.01 **Broadband Spectroscopy of the Corona during the Total Solar Eclipse of March 29, 2006**
Sarah A. Jaeggli[1], S. R. Habbal[1], J. R. Kuhn[1], M. H. Nayfeh[2]
[1]Institute for Astronomy, Univ. of Hawaii, [2]Dept. of Physics, Univ. of Illinois at Urbana-Champaign.

016.02 **Changes in Sunspot Umbral Intensity Over Time**
Rachel MacDonald[1]
[1]University of Washington.

016.03 **Relationship Between the Radio Bursts from the Sun and Ionospheric Propagation**
Mary Lou West[1], N. Frissell[1], M. Papalos[1]
[1]Montclair State Univ..

016.04 **Coronal Loop Recognition: A Diagnostic Tool for Magnetic Field Extrapolation Models**
Julia Sandell[1], V. Kashyap[2], M. Weber[2], A. van Ballegooijen[3], E. Deluca[3], M. Bobra[3]
[1]Barnard College/Columbia University, [2]SAO/Cfa, [3]Center for Astrophysics/Smithsonian Astrophysical Observatory.

017: Galactic ISM I
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

017.01 **Imaging of Diffuse FUV Emission from the Gum Nebula with SPEAR**
Kaori Nishikida[1], R. Sankrit[1], M. Sirk[1], B. Welsh[1], K. Min[2], K. Ryu[2], J. Shinn[2], W. Han[3], D. Lee[3]
[1]Space Sciences Laboratory, UC Berkeley, [2]Korea Advanced Institute of Science and Technology, Republic of Korea, [3]Korea Astronomy and Space Science Institute, Republic of Korea.

017.02 **Properties of the Hot Diffuse Gas in our Galaxy observed with SPEAR**
Julia M. Kregenow[1], M. Sirk[2], R. Sankrit[2], C. Heiles[1], J. Edelstein[2], K. Min[3], K. Ryu[3], J. Shinn[3], W. Han[4], D. Lee[4]
[1]UC, Berkeley, [2]UC Berkeley, Space Sciences Lab, [3]KAIST, Republic of Korea, [4]KASI, Republic of Korea.

017.03 **Emission from Low Ionization Gas in the Galaxy observed with SPEAR**
Ravi Sankrit[1], E. Korpela[1], K. Seon[1], K. Nishikida[1], K. Min[2], K. Ryu[2], J. Shinn[2], W. Han[3], D. Lee[3]
[1]UC, Berkeley, [2]KAIST, Republic of Korea, [3]KASI, Republic of Korea.

017.04 **Molecular Hydrogen Fluorescence in our Galaxy Observed with SPEAR**
Jerry Edelstein[1], M. Sirk[1], J. Kregenow[1], E. Korpela[1], K. Seon[1], K. Min[2], K. Ryu[2], J. Shinn[2], W. Han[3], D. Lee[3]
[1]Space Sciences Lab, UC, [2]KAIST, Republic of Korea, [3]KASI, Republic of Korea.

017.05 **Maps of Emission from Hot Diffuse Gas in our Galaxy with SPEAR**
Eric J. Korpela[1], J. Kregenow[2], M. Sirk[1], J. Edelstein[1], J. Adolfo[1], K. Min[3], K. Ryu[3], J. Shinn[3], W. Han[4], D. Lee[4]
[1]Space Sciences Lab, UC-Berkeley, [2]Astronomy Dept, UC-Berkeley, [3]Korea Advanced Institute of Science and Technology, Republic of Korea, [4]Korea Astronomy and Space Science Institute, Republic of Korea.

017.06 **Mapping of FUV Emission Lines for the North Galactic Pole with SPEAR**
Martin M. Sirk[1], B. Y. Welsh[1], J. Edelstein[1], E. J. Korpela[1], R. Sankrit[1], K. Nishikida[1], J. Kregenow[1], K. I. Seon[1], K. W. Min[2], K. Ryu[2], J. H. Shinn[2], W. Han[3], D. H. Lee[3], U. W. Nam[3]
[1]University of California Berkeley, [2]Korea Advanced Institute of Science and Technology, Republic of Korea, [3]Korea Astronomy and Space Science Institute, Republic of Korea.

017.07 **Observation of Cosmic Far-ultraviolet Background Radiation with SPEAR**
Kwang-Il Seon[1], J. Edelstein[1], E. Korpela[1], K. Min[2], K. Ryu[2], J. Shinn[2], W. Han[1], W. Han[3], D. Lee[3]
[1]UC, Berkeley, [2]KAIST, Republic of Korea, [3]KASI, Republic of Korea.

017.08 **Intermittency of the Velocity Field Structure in Compressible MHD Turbulence**
Grzegorz Kowal[1], A. Lazarian[1]
[1]University of Wisconsin-Madison.

017.09 **Turbulence and Cosmic Ray Acceleration**
Alex Lazarian[1]
[1]Univ. of Wisconsin.

017.10 **[O I] and [C II] Emission Towards NGC 6334 A**
Nicholas Abel[1], A. Sarma[2], G. Ferland[3], T. Troland[3]
[1]University of Cincinnati, [2]Depaul University, [3]University of Kentucky.

017.11 **The Galactic Center: High-resolution Imaging and Temperature Determination of Dense Molecular Clouds**
Juergen Ott[1], A. Weiss[2], L. Staveley-Smith[3], C. Henkel[2]
[1]CSIRO Australia Telescope National Facility, Australia, [2]Max-Planck-Institut fuer Radioastronomie, Germany, [3]University of Western Australia, Australia.

017.12 **High-Resolution Study of X-ray Absorption by the Interstellar Medium**
Adrienne M. Juett[1], J. Wilms[2], N. S. Schulz[3], M. A. Nowak[3]
[1]Univ. of Virginia, [2]Univ. of Erlangen, Germany, [3]MIT.

017.13 **Highly Excited Rovibrational Rate Coefficients for H_2 + He Collisions: Relevance to H_2 Spectra in the ISM**
Teck-Ghee Lee[1], R. C. Forrey[2], S. Lepp[3], N. Balakrishnan[4], P. C. Stancil[5], D. R. Schultz[6], G. J. Ferland[7]
[1]Physics and Astronomy, University of Kentucky and Oak Ridge National Lab., [2]Department of Physics, Penn-State University, [3]Department of Physics, University of Nevada, [4]Department of Chemistry, University of Nevada, [5]Department of Physics and Astronomy and Center for Simulational Physics, The University of Georgia., [6]Physics Division, Oak Ridge National Lab., [7]Physics and Astronomy, University of Kentucky.

017.14 **A Study of the Radio Continuum Far Infrared Correlation at Small Scales in the Galaxy**
Monica I. Rodriguez-Martinez[1], R. J. Allen[1], T. Wiklind[1], L. Loinard[2]
[1]STScI, [2]CRyA-UNAM, Mexico.

017.15 **Flows, Filaments & Fragmentation:Towards a Theory of Dynamical Star Formation**
Fabian Heitsch[1], L. Hartmann[1], A. D. Slyz[2], J. E. Devriendt[3], A. Burkert[4]
[1]Univ. Of Michigan, [2]University of Oxford, United Kingdom, [3]CRAL/Observatoire de Lyon, France, [4]University Observatory Munich, Germany.

017.16 **A New View of the Light Echoes from SN 1987A**
Andrew Newman[1], A. Rest[2], N. B. Suntzeff[3], R. C. Smith[2], D. L. Welch[4], G. Damke[2], A. Zenteno[2], C. Stubbs[5], A. Garg[5], P. Challis[5], A. C. Becker[6], G. A. Miknaitis[6], A. Miceli[6], K. H. Cook[7], M. Huber[7], S. Nikolaev[7], L. Morelli[8], D. Minniti[8], A. Clocchiatti[8], J. L. Prieto[9]
[1]Washington University, [2]NOAO/CTIO, [3]Texas A & M University, [4]McMaster University, Canada, [5]Harvard University, [6]University of Washington, [7]Lawrence Livermore National Laboratory, [8]Pontifica Universidad Católica de Chile, Chile, [9]Ohio State University.

017.17 **ATCA Imaging of Dense Gas in Star-Forming Environments**
Tony H. Wong[1], J. Ott[2], S. D. Ryder[3], K. Kohno[4], R. Buta[5], M. Dahlem[6], J. B. Whiteoak[6], Y. Chin[7], M. R. Cunningham[8]
[1]U. Illinois, [2]NRAO, [3]AAO, Australia, [4]U. Tokyo, Japan, [5]U. Alabama, [6]ATNF, Australia, [7]Tamkang U., Taiwan, [8]UNSW, Australia.

017.18 **Diagnostics of Astrophysical Magnetic Fields based on AtomicAlignment and Hanle Effect**
Huirong Yan[1], A. Lazarian[2]
[1]CITA, Canada, [2]Univ. Wisconsin-Madison.

017.19 **Studying Magnetic Fields in Star Forming Regions with Aligned Atoms**
Thiem C. Hoang[1], A. Lazarian[1], K. Nordsieck[1], H. Yan[2]
[1]University of Wisconsin-Madison, [2]Canadian Institute for Theoretical Astrophysics, Canada.

017.20 **High-Mass Star Formation in Three Southern, Galactic Cores**
Georgi Chunev[1], C. Watson[1], GLIMPSE Team
[1]Manchester College.

017.21 **Interstellar Material towards the Nearby High Latitude Star eta UMa**
Priscilla C. Frisch[1], E. B. Jenkins[2], J. Aufdenberg[3], U. J. Sofia[4], D. G. York[1], J. D. Slavin[5], C. M. Johns-Krull[6]
[1]University of Chicago, [2]Princeton, [3]Embry-Riddle Aeronautical University, [4]Whitman College, [5]Harvard-Smithsonian, CfA, [6]Rice University.

017.22 **Mapping [O III] Emission in Diffuse Ionized Gas**
Rex C. Beaber[1], L. M. Haffner[1], R. J. Reynolds[1], G. J. Madsen[2]
[1]University of Wisconsin Madison, [2]Anglo-Australian Observatory, Australia.

017.23 **Density Distribution of the Warm Ionized Medium**
Alex S. Hill[1], R. J. Reynolds[1], R. A. Benjamin[2], L. M. Haffner[1]
[1]Univ. of Wisconsin-Madison, [2]Univ. of Wisconsin-Whitewater.

017.24 **Hydrogen-Dating Molecular Clouds**
Marko Krco[1], P. F. Goldsmith[2], D. Li[2]
[1]Cornell University, [2]JPL.

017.25 **Theoretical Studies of Wind Blown Nebulae around Massive Stars**
Vikram Dwarkadas[1]
[1]Univ. of Chicago.

018: Galactic Structures: Identification & Evolution
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

018.01 **Development of a Fourier Technique for Automated Spiral Galaxy Morphology**
Andrew R. Butler[1]
[1]Calvin College.

018.02 **Self-Consistent Models for Time Varying Galaxy Potentials**
Stephen Levine[1]
[1]U.S. Naval Observatory.

018.03 **The Stellar Halos of Nearby Galaxies**
Anil Seth[1], R. de Jong[2], H. Ferguson[2], J. Dalcanton[3]
[1]Harvard-Smithsonian CfA, [2]STScI, [3]U. of Washington.

018.04 **A Search for Faint, Diffuse Halo Emission in Edge-On Galaxies with Spitzer/IRAC**
Matthew Ashby[1], R. G. Arendt[2], J. L. Pipher[3], W. J. Forrest[3], M. Marengo[1], P. Barmby[1], S. P. Willner[1], J. R. Stauffer[4], G. G. Fazio[1]
[1]Harvard-Smithsonian Center for Astrophysics, [2]NASA's Goddard Space Flight Center, [3]University of Rochester, [4]Caltech/Spitzer Science Center.

018.05 **Spitzer's View on Edge-On Spiral Disks**
Benne W. Holwerda[1], R. S. de Jong[1], M. Regan[1], A. Seth[2], J. J. Dalcanton[3], E. Bell[4], S. Bianchi[5]
[1]STSCI, [2]CfA, [3]Astronomy Dept., University of Washington, [4]Max-Planck-Institut fuer Astronomie, Germany, [5]AA (Istituto di Radioastronomia/CNR), Italy.

018.06 **A WIYN Study of Optical Asymmetry in Isolated Disk Galaxies**
Alex C. Viana[1], E. M. Wilcots[1]
[1]University of Wisconsin Madison.

018.07 **The Structure of Polar Ring Galaxies UGC 7576, NGC 2685, and NGC 3718**
Christopher Q. Trinh[1], L. S. Sparke[2], J. S. Gallagher[2]
[1]University of California, Berkeley, [2]University of Wisconsin, Madison.

019: Galaxy Evolution over Cosmic History
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

019.01 **Five Thousand Galaxy Redshifts from PEARS**
Seth H. Cohen[1], R. E. Ryan, Jr.[1], S. Malhotra[1], J. E. Rhoads[1], N. P. Hathi[1], R. A. Windhorst[1], N. Pirzkal[2], C. Xu[2], PEARS Team
[1]Arizona State University, [2]Space Telescope Science Institute.

019.02 **The Size-Luminosity Relation of Disk Galaxies in EDisCS Clusters**
Stephanie M. Gogarten[1], J. J. Dalcanton[1], L. Simard[2], G. Rudnick[3], V. Desai[4], EDisCS Collaboration
[1]Univ. of Washington, [2]Herzberg Institute of Astrophysics, NRC, Canada, [3]NOAO, [4]California Institute of Technology.

019.03 **Simulated Optical Images of High Redshift Galaxies using GALEX Ultraviolet Images of Nearby Galaxies**
Bum-Suk Yeom[1], Y. Kim[1], S. Rey[1], J. Koo[1], S. Kim[1]
[1]Chungnam National University, Republic of Korea.

019.04 **Ages and Masses of Lyman Alpha Galaxies at z $\sim$ 4.5**
Steven L. Finkelstein[1], J. E. Rhoads[1], S. Malhotra[1], N. Pirzkal[2], J. Wang[3]
[1]Arizona State Univ., [2]Space Telescope Science Institute, [3]University of Science and Technology of China, China.

019.05 **The Spitzer Interacting Galaxies Survey: IRAC Evaluations of Star Formation**
Christopher R. Klein[1], M. L. Ashby[2], H. A. Smith[2], A. Zezas[2], J. L. Hora[2], M. A. Pahre[2], G. G. Fazio[2]
[1]Caltech, [2]Harvard-Smithsonian Center for Astrophysics.

019.06 **Buildup of Massive Red Galaxies at redshift z=0.3**
Morad Masjedi[1], D. W. Hogg[1], M. R. Blanton[1]
[1]New York Univ..

019.07 **The Origin and Evolution of the Mass-Metallicity Relationship for Galaxies: Results from Cosmological N-Body Simulations**
Alyson Brooks[1], F. Governato[1], C. M. Booth[2], B. Willman[3], J. P. Gardner[4], J. Wadsley[5], G. Stinson[1], T. Quinn[1]
[1]Univ. of Washington, [2]Univ. of Durham, United Kingdom, [3]Harvard-Smithsonian CfA, [4]Univ. of Pittsburgh, [5]McMaster Univ., Canada.

019.08 **Star-Forming Galaxies at z~2: Stellar, Gas and Dynamical Masses and the Mass-Metallicity Relation**
Dawn Erb[1]
[1]Harvard-Smithsonian Center for Astrophysics.

020: High Z Objects; IR, Optical Background
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

020.01 **Search for High-Redshift Quasars in the Palomar-QUEST Survey**
Anne Bauer[1], C. Baltay[1], N. Ellman[1], J. Jerke[1], D. Rabinowitz[1], A. Mahabal[2], E. Glickman[2], C. Donalek[2], S. G. Djorgovski[2]
[1]Yale University, [2]California Institute of Technology.

020.02 **A Confirmation of the Optical EBL From HST Archival Data: First Results**
Timothy Dolch[1], H. C. Ferguson[2], B. Mobasher[2], M. Stiavelli[2], S. Casertano[2], R. S. de Jong[2], M. Giavalisco[2], L. E. Bergeron[2]
[1]Johns Hopkins Univ., [2]Space Telescope Science Institute.

020.03 **Probing the CIRB with Spitzer in 3 DIRBE Dark Spots**
Louis R. Levenson[1], E. L. Wright[1]
[1]UCLA.

020.04 **The First Stars in the Universe: Mass Function and Local Chemical Signatures**
Jason Tumlinson[1]
[1]Yale University.

020.05 **Photometric Redshift Survey Forecast for Luminous Red Galaxies at z~1.0**
Xiaosheng Huang[1], D. J. Schlegel[1]
[1]Lawrence Berkeley National Laboratory.

021: Gravitational Lensing
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

021.01 **A Three-Dimensional View of the Environments of Three Strong Gravitational Lenses**
Leonidas A. Moustakas[1], P. Marshall[2], AEGIS Collaboration
[1]JPL/Caltech, [2]UCSB.

021.02 **HST ACS Observations of the Gravitational Lens B1608+656**
Sherry H. Suyu[1], R. D. Blandford[2], C. D. Fassnacht[3], L. V. Koopmans[4], P. J. Marshall[5], J. P. McKean[3], T. Treu[5]
[1]California Institute of Technology, [2]KIPAC, Stanford University, [3]University of California, Davis, [4]Kapteyn Institute, The Netherlands, [5]University of California, Santa Barbara.

021.03 **LensPerfect: Exact Massmap Solutions for Gravitationally Lensed Multiple Images**
Dan A. Coe[1], E. Fuselier[2], N. Benítez[3], T. Broadhurst[4], H. Ford[1], ACS Science Team
[1]Johns Hopkins Univ., [2]U.S. Military Academy, [3]Instituto de Astrofísica de Andalucía, Spain, [4]Tel Aviv Univ., Israel.

021.04 **A Multi-Resolution Weak Lensing Reconstruction Method**
Hossein Khiabanian[1], I. Dell'Antonio[1]
[1]Brown Univ..

021.05 **Application of Gravitational Lensing Models to the Brightest Strongly LensedLyman Break Galaxy the '8 o'clock arc'**
Elizabeth J. Buckley-Geer[1], S. S. Allam[2], D. Tucker[1], H. Lin[1], H. T. Diehl[1], J. Annis[1], J. A. Frieman[3]
[1]Fermi National Accelerator Laboratory, [2]Fermi National Accelerator Laboratory/ University of Wyoming, [3]Fermi National Accelerator Laboratory/University of Chicago.

021.06 **Weak Lensing : Ground vs. Space in the Cosmos Field**
Mansi M. Kasliwal[1], R. J. Massey[2], R. S. Ellis[2], J. Rhodes[3]
[1]Caltech (Hale Fellow of Moore Foundation), [2]Astronomy Department, Caltech, [3]Jet Propulsion Laboratory, Caltech.

021.07 **Time-Delays and Mass Models for the Quadruple Lens RXJ1131-1231**
Nicholas D. Morgan[1], C. S. Kochanek[1], E. E. Falco[2], X. Dai[1]
[1]The Ohio State University, [2]Harvard Smithsonian Center for Astrophysics.

021.08 **Mid Infrared Observations of Quasar Lenses**
Eric Agol[1], C. Kochanek[2]
[1]Univ. of Washington, [2]Ohio State University.

022: Ground-Based Instrumentation I
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

022.01 **The Dark Energy Survey Instrument**
Brenna Flaugher[1], Dark Energy Survey Collaboration
[1]Fermilab.

022.02 **The Dark Energy Survey Camera Design**
Herman P. Cease[1], DES Collaboration
[1]Fermilab.

022.03 **Front-End Electronics for the Dark Energy Survey Camera (DECam)**
Theresa M. Shaw[1], D. Huffman[1], M. Kozlovsky[1], J. Olsen[1], W. Stuermer[1], M. Barcelo[2], L. Cardiel[2], J. Castilla[3], J. DeVicente[3], G. Martinez[3], P. Moore[4], R. Schmidt[4]
[1]Fermilab, [2]IFAE, Spain, [3]CIEMAT, Spain, [4]NOAO.

022.04 **Characterication and Testing of Dark Energy Survey CCDs**
H T. Diehl[1], Dark Energy Survey Collaboration
[1]Fermilab.

022.05 **Mountaintop Software for the Dark Energy Survey**
Jon Thaler[1], T. Abbott[2], I. Karliner[1], T. Qian[1], K. Honscheid[3], W. Merritt[4], L. Buckley-Geer[4]
[1]University of Illinois (UIUC), [2]CTIO, Chile, [3]Ohio State University, [4]Fermilab.

022.06 **Application of the Dark Energy Survey Data Management System to the Blanco Cosmology Survey Data**
Chow Choong Ngeow[1], J. J. Mohr[2], W. Barkhouse[1], T. Alam[3], C. Beldica[3], D. Cai[3], G. Daues[3], P. Duda[3], J. Annis[4], H. Lin[4], D. Tucker[4], A. Rest[5], C. Smith[5], Y. Lin[6], W. High[7], S. Hansen[8], M. Brodwin[9], S. Allam[4], BCS Collaboration
[1]Univ. of Illinois, [2]Univ. of Illinois and NCSA, [3]NCSA, [4]Fermilab, [5]NOAO/CTIO, Chile, [6]Princeton University/Pontificia Universidad Católica de Chile, Chile, [7]Harvard, [8]Univ. of Chicago, [9]NASA/JPL.

022.07 **Analyzing the Focus Sensor Images for ODI at WIYN**
Robert P. Nowicki[1]
[1]Susquehanna University.

022.08 **QUOTA sees First Light at WIYN!**
Daniel R. Harbeck[1], G. Jacoby[1], D. Sawyer[1], S. Howell[2], C. Corson[2], A. Yeatts[1], B. Brondel[3], M. Hunten[2], P. Moore[4]
[1]WIYN Observatory, [2]NOAO, [3]University of Indiana, [4]NOAO, Chile.

022.09 **Fast Guiding with the Quad OTA**
Brian J. Brondel[1], D. R. Harbeck[2], S. B. Howell[2], A. Yeatts[2]
[1]Indiana University, [2]National Optical Astronomy Observatories.

022.10 **The WIYN Serendipity Project: High Speed Guide Star Photometry at the WIYNObservatory**
Lisa M. Ferrara[1], S. B. Howell[2], D. Harbeck[2], C. Bailyn[1]
[1]Yale University, [2]WIYN Observatory and National Optical Astronomy Observatory.

022.11 **The Quest for Precision Ground-Based Astronomy:The CCD/Transit Instrument with Innovative Instrumentation (CTI-II)**
John T. McGraw[1], M. R. Ackermann[1], T. Williams[1], P. C. Zimmer[1], W. H. Gerstle[1], G. F. Benedict[2], S. C. Odewahn[2], C. J. Wetterer[3], V. L. Gamiz[4], C. F. Claver[5], J. R. Pier[6], D. C. Hines[7], J. S. Schwarz[8], NESSI/CTI-II Research Group
[1]Univ. of New Mexico, [2]Univ. of Texas, [3]US Air Force Academy, [4]Air Force Research Laboratory/DE, [5]National Optical Astronomy Observatory, [6]US Naval Observatory, [7]Space Science Institute, [8]Sandia National Laboratories.

022.12 **The Unique Optical Design of the CTI-II Survey Telescope**
Mark R. Ackermann[1], J. T. McGraw[2], M. MacFarlane[3]
[1]Sandia National Laboratories, [2]University of New Mexico, [3]Optical Design Consltant.

022.13 **LCOGT.net: A Global Telescope Network to Keep Astronomers in the Dark**
Stuart F. Taylor[1], T. M. Brown[1], W. Rosing[1], R. Ross[1], J. Farrell[1]
[1]Las Cumbres Observatory Global Telescope.

022.14 **The Discovery Channel Telescope: Construction and Design Progress, January 2007**
Thomas A. Bida[1], R. L. Millis[1], B. W. Smith[1], E. W. Dunham[1], H. Marshall[1]
[1]Lowell Obs..

023: HAD IV
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

This HAD Poster Session will contiue Monday morning.

023.01 **History of the Spitzer Mission**
George Rieke[1]
[1]Univ. of Arizona.

023.02 **The Role of Eclipse Expeditions in Early French and Australian Radio Astronomy**
Wayne Orchiston[1], J. Lequeux[2], M. Pick[2], B. Slee[3], J. Steinberg[2]
[1]James Cook University, Australia, [2]Paris Observatory, France, [3]Australia Telescope National Facility, Australia.

023.03 **Seth Nicholson's First Satellite Discovery: Jupiter IX and His Orbit for It**
Donald E. Osterbrock[1]
[1]UCO/Lick Observatory.

023.04 **The Guilford-Carleton Eclipse Expedition of 1900**
Thomas R. English, III[1]
[1]Guilford Tech. Community College.

023.05 **The North American Astronomical Photographic Plate Preservation & Digitization Center Current Status**
Wayne Osborn[1], M. Castelaz[2], J. D. Cline[2], R. E. Griffin[3], T. Barker[2]
[1]Central Michigan Univ., [2]Pisgah Asronomical Research Institute, [3]Dominion Astrophysical Observatory, Canada.

023.06 *Astronomy Education Review:* **A Five-Year Progress Report**
Andrew Fraknoi[1], S. Wolff[2]
[1]Foothill College, [2]NOAO.

024: SIM Science
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

024.01 **The Exoplanet Host Star Gamma Cephei: Orbit of the Binary and Mass of the Substellar Companion**
Guillermo Torres[1]
[1]Harvard-Smithsonian, CfA.

024.02 **Astrometric Detection of Terrestrial Planets in the Habitable Zones of Nearby Stars with SIM PlanetQuest**
Joseph Catanzarite[1], M. Shao[1], A. Tanner[1], S. Unwin[1], J. Yu[1]
[1]Jet Propulsion Laboratory.

024.03 **Masses of Exoplanets from Doppler Spectroscopy and HST Astrometry**
Jacob Bean[1], B. E. McArthur[1], G. F. Benedict[1]
[1]*Univ. of Texas, Austin.*

024.04 **Clandestine Companions of Nearby Red Dwarfs**
Todd J. Henry[1], D. W. Koerner[2], W. C. Jao[1], J. P. Subasavage[1], P. A. Ianna[3], RECONS
[1]*Georgia State Univ.,* [2]*Northern Arizona University,* [3]*University of Virginia.*

024.05 **Crowded Field Astrometry with SIM**
Sridharan Rengaswamy[1], R. Allen[1]
[1]*STScI.*

025: Solar System
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

025.01 **Small Lnding Pobes for In-situ Characterization of Asteroids and Comets**
Dennis Ebbets[1], R. Dissly[1], R. Reinert[1]
[1]*Ball Aerospace & Tech. Corp..*

025.02 **Search for Satellites around Ceres**
Allyson Bieryla[1], J. W. Parker[1]
[1]*Southwest Research Institute.*

025.03 **Searching for Asteroids with 8 micron Spitzer Space Telescope Data**
Edward L. Wright[1], B. Mohlie[2]
[1]*UC, Los Angeles,* [2]*RPI.*

025.04 **Correlating Arecibo Radar and IRTF Near-Infrared Spectral Observations of 105 Artemis**
Heather M. Hanson[1], E. S. Howell[2], C. Magri[3], M. C. Nolan[2]
[1]*University of Wyoming,* [2]*Arecibo Observatory, Puerto Rico,* [3]*University of Maine at Farmington.*

025.05 **Orbits of Binary Near-Earth Asteroids from Radar Observations**
Heidi E. Brooks[1]
[1]*Reed College.*

025.06 **Differential Photometry of Asteroids 252 Clemintina, 329 Svea, 334 Chicago, 596 Scheila, 517 Edith, 521 Brixia and 713 Luscinia.**
Elise C. Jutzeler[1], E. Hausel[2], A. Burke[3], M. Leake[4]
[1]*SUNY Geneseo,* [2]*University of Wyoming,* [3]*Vassar College,* [4]*Valdosta State University.*

025.07 **Beyond the Main Belt: Properties of Solar System Objects using the Sloan Digital Sky Survey**
Shannon Schmoll[1], Z. Ivezic[1], M. Juric[2]
[1]*Univ. of Washington,* [2]*Princeton University.*

025.08 **Asteroid Families in the Sloan Digital Sky Survey Moving Object Catalog**
Alex Parker[1], Z. Ivezic[1], M. Juric[2], R. Lupton[2]
[1]*University of Washington,* [2]*Princeton University.*

025.09 **The Canada-France Ecliptic Plane Survey: Strategy, Details and Results**
R. L. Jones[1], J. Kavelaars[2], B. Gladman[3], J. Petit[4], J. Parker[5], A. Bieryla[5]
[1]*Univ. of Washington,* [2]*HIA/NRC, Canada,* [3]*Univ. of British Columbia, Canada,* [4]*Obs. de Besancon, France,* [5]*SWRI.*

025.10 **New and Improved Ephemerides of Nix and Hydra During the 1985 to 1990 Mutual Events Between Pluto and Charon**
Garrett Elliott[1], D. J. Tholen[2]
[1]The Ohio State University & Institute for Astronomy, University of Hawaii, [2]Institute for Astronomy, University of Hawaii.

025.11 **Obtaining An MPC Observatory Code For Arkansas Tech University**
Jason Ahrns[1], J. W. Robertson[1]
[1]Arkansas Tech University.

025.12 **Constraining the Rotational Period for Component C of the Periodic Comet 73P/ Schwassmann-Wachmann 3**
Shaye Storm[1], N. Samarasinha[2], B. Mueller[3], T. Farnham[4], Y. Fernandez[5], A. Kidder[6], D. Snowden[6], M. A'Hearn[4], W. Harris[6], M. Knight[4], J. Morgenthaler[6], C. Lisse[7], F. Roesler[8]
[1]MIT, [2]NOAO & PSI, [3]PSI, [4]UMD, [5]UCF, [6]U of Wash, [7]APL/JHU, [8]U of Wisc.

025.13 **Comet 73P/Schwassmann-Wachmann 3: O(1D) and H2O Production Rates**
Tanya L. Hall[1], E. J. Mierkiewicz[2], L. M. Haffner[2], F. L. Roesler[2], W. M. Harris,[3], G. J. Madsen[4]
[1]Saint Cloud State University, [2]University of Wisconsin-Madison, [3]University of Washington, [4]Anglo-Australian Observatory, Australia.

025.14 **GALEX Observations of Comet 9P/Tempel 1 During Deep Impact**
Stephan R. McCandliss[1], P. D. Feldman[1], C. M. Lisse[2], H. A. Weaver[2], M. F. A'Hearn[3]
[1]Johns Hopkins Univ., [2]JHU/APL, [3]University of Maryland.

025.15 **Wide-field spectroscopic observations of comet C/2004 Q2 (Machholz) by GALEX**
Jeffrey P. Morgenthaler[1], W. M. Harris[1], M. R. Combi[2], P. D. Feldman[3], H. A. Weaver[4]
[1]Univ. of Washington, [2]Univ. of Michigan, [3]Johns Hopkins Univ., [4]Johns Hopkins University/APL.

025.16 **The Effect of the Sun's Early Environment on the Oort Cloud and Comet Showers**
Nathan A. Kaib[1], T. Quinn[1]
[1]Univ. Of Washington.

025.17 **Distribution of Ethane and Methane Emission on Neptune**
Heidi B. Hammel[1], M. L. Sitko[1], G. S. Orton[2], T. Geballe[3], D. K. Lynch[4], R. W. Russell[4], I. de Pater[5]
[1]Space Science Institute, [2]JPL, [3]Gemini, [4]The Aerospace Corp., [5]UC Berkeley.

025.18 **Origin of the Moon**
Peter D. Noerdlinger[1]
[1]St. Mary's University, Canada.

025.19 **Velocity Resolved Observations of the Extended Lunar Sodium Tail**
Michael R. Line[1], E. J. Mierkiewicz[1], F. L. Roesler[1], L. M. Haffner[1], R. J. Oliversen[2]
[1]University of Wisconsin-Madison, [2]NASA Goddard Space Flight Center.

025.20 **Advanced Computer Modeling of the Lunar Plasma Environment in the Dynamic Terrestrial Magnetosphere**
Erika Harnett[1], R. Winglee[1], J. Halekas[2]
[1]Univ. Of Washington, [2]Univ. Of California Berkeley.

025.21 **3D Multi-Fluid Simulations of the Solar Wind Interaction with Mercury's Magnetosphere**
Ariah R. Kidder[1], R. M. Winglee[1], E. M. Harnett[1]
[1]University of Washington.

025.22 **3D Multi-fluid Simulations of Titan's Plasma Interaction**
Darci Snowden[1], R. Winglee[1]
[1]University of Washington.

026: Star Clusters I
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

026.07 **Age Distribution of Galactic Globular Clusters using HST Snapshot Photometry**
YoungDae Lee[1], S. Rey[1], Y. B. Kang[1], S. Kim[1]
[1]Chungnam National Univ., Republic of Korea.

026.08 **The Deepest UV Observations of a Globular Cluster: Preliminary Results for NGC 6681**
Jennifer L. Connelly[1], D. R. Zurek[1], M. M. Shara[1], C. Knigge[2], A. Dieball[2], K. S. Long[3]
[1]American Museum of Natural History, [2]University of Southampton, United Kingdom, [3]Space Telescope Science Institute.

026.09 **The Evolution of Horizontal Branch Stars in the Core Region of M15**
Jessica E. Castora[1], E. L. Sandquist[1]
[1]San Diego State Univ..

026.10 **The Evolved Stars of the Globular Cluster M 55**
Carlos Vargas Alvarez[1], E. Sandquist[1]
[1]San Diego State Univ..

026.11 **Washington Photometry of NGC 6441**
Joanne D. Hughes[1], G. Wallerstein[2], A. Bossi[1], W. McDougald[1], R. Covarrubias[2]
[1]Seattle Univ., [2]University of Washington.

026.12 **Spitzer Observations of Galactic Globular Clusters**
Pauline Barmby[1], M. L. Boyer[2], G. Bono[3], I. Ferraro[3], M. Marengo[1]
[1]Harvard-Smithsonian, CfA, [2]University of Minnesota, [3]INAF-Osservatorio Astronomico di Roma, Italy.

026.13 **Do the Large Magellanic Cloud and Milky Way Globular Clusters Share a Common Origin?**
Bradley E. Tucker[1], K. A. Olsen[2], B. Blum[2]
[1]Univ. Of Notre Dame, [2]Cerro Tololo Inter-American Observatory, Chile.

026.15 **CN and CH Bandstrengths in Bright Globular Cluster Red Giants**
Sarah L. Martell[1], G. H. Smith[1]
[1]UC Santa Cruz.

026.16 **Why Haven't Dense Globular Clusters Lost More Mass?**
Guido De Marchi[1], F. Paresce[2], L. Pulone[2]
[1]ESA, The Netherlands, [2]INAF, Italy.

026.17 **GRAPE6 Simulations of Star Cluster Evolution with a Hard Binary Population**
James E. Maxwell[1], H. N. Cohn[1], P. M. Lugger[1], S. D. Slavin[2]
[1]Indiana University, [2]Purdue University Calumet.

027: Stellar Populations I
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

027.01 **A Survey of Local Group Galaxies Currently Forming Stars: UBVRI Photometry of Stars in Seven Dwarfs and a Comparison with the Entire Sample**
Philip Massey[1], K. A. Olsen[2], P. W. Hodge[3], G. H. Jacoby[4], R. T. McNeill[5], R. C. Smith[6], S. B. Strong[7]
[1]Lowell Obs., [2]NOAO, Chile, [3]Univ of Washington, [4]WIYN, [5]Smith College, [6]NOAO, [7]Univ of Texas.

027.02 **Halpha Emission Line Stars in M31, M33 and Seven Local Group Dwarfs**
Reagin T. McNeill[1], P. Massey[2], K. A. Olsen[3], P. W. Hodge[4], G. H. Jacoby[5], C. Blaha[6], R. C. Smith[7], S. B. Holmes[8]
[1]Smith College, [2]Lowell Observatory, [3]NOAO, Chile, [4]University of Washington, [5]WIYN, [6]Carleton College, [7]NOAO, [8]University of Texas.

027.03 **H-alpha Photometric Survey of M33**
Cindy Blaha[1], P. Massey[2], P. Hodge[3], R. Martin[1], L. Gavilan[1], A. Adhikari[1]
[1]Carleton College, [2]Lowell Observatory, [3]University of Washington.

027.04 **The Search for Optical Counterparts to Supersoft X-ray Sources near the Nucleus of M31**
Sarah Scoles[1], B. Patel[2], R. DiStefano[3], J. Liu[3], P. Barmby[3], F. Primini[3]
[1]Agnes Scott College, [2]Tufts University, [3]Center for Astrophysics.

027.05 **The Magellanic Bridge: The Nearest Purely Tidal Stellar Population**
Jason R. Harris[1]
[1]Steward Observatory.

027.06 **Surface Brightness Fluctuations of Old Stellar Systems in UV and Optical Passbands as Population Indicators**
HyeJeon Cho[1], Y. Lee[1], S. Yoon[1]
[1]Department of Astronomy & Center for Space Astrophysics, Yonsei University, Republic of Korea.

027.07 **First Stars as a Possible Origin for the Helium-rich Population in ω Cen**
Ena Choi[1], S. K. Yi[1]
[1]Yonsei Univ., Republic of Korea.

027.08 **Measuring the Luminosity Function of Low-Mass Stars with Matched Survey Datasets**
Kevin R. Covey[1], J. J. Bochanski[2], S. L. Hawley[2], J. Davenport[2], I. Reid[3], D. Golimowski[4]
[1]Harvard Smithsonian Center for Astrophysics, [2]University of Washington, [3]Space Telescope Science Institute, [4]Johns Hopkins University.

027.09 **Substructure in the Galactic Halo**
Kenneth W. Carrell[1], R. Wilhelm[1]
[1]Texas Tech University.

027.10 **Globular Cluster Tidal Streams: An Observational Study**
William L. Powell[1], A. Lauchner[1], R. Wilhelm[1], A. McWilliam[2]
[1]Texas Tech Univ., [2]Carnegie Observatories.

028: The SDSS Supernova Survey
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

028.01 **Object Classification and Photometric Supernova Typing in the SDSS-II SN Survey**
Benjamin E. Dilday[1], SDSS-II Supernova collaboration
[1]Univ. of Chicago.

028.02 **Photometry and Light Curves for the SDSS-II SN Survey**
Jon A. Holtzman[1], SDSS-II Supernova Collaboration
[1]New Mexico State Univ..

028.03 **Follow-up Spectroscopy for the SDSS-II SN Survey**
Chen Zheng[1], SDSS-II Supernova Collaboration
[1]KIPAC.

028.04 **Core Collapse Supernova in the SDSS Supernova Survey**
David Cinabro[1]
[1]*Wayne State University.*

028.05 **Exploring the Variable Sky with SDSS**
Branimir Sesar[1], Z. Ivezic[1], R. H. Lupton[2], J. E. Gunn[2], G. R. Knapp[2], C. M. Rockosi[3], M. Juric[2], J. A. Smith[4], G. Miknaitis[4], H. Li[4], D. Tucker[4], D. J. Schlegel[5], D. Finkbeiner[6], N. Padmanabhan[2]
[1]*Univ. Of Washington,* [2]*Princeton University,* [3]*University of California,* [4]*Fermilab,* [5]*LBNL,* [6]*Harvard University.*

029: Variable Stars
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

029.01 **The Selection of RR Lyrae Stars Using POSS and SDSS**
Oliver J. Fraser[1], J. R. Barton[1], B. J. Oldfield[1], T. P. Biesiadzinski[1], D. A. Horning[2], J. A. Baerny[1], F. Kiuchi[1], D. Krogsrud[1], D. S. Longhurst[1], L. P. McCommas[1], J. A. Scheidt[1], R. Covarrubias[1], K. Covey[1], C. Laws[1], B. Sesar[1], Z. Ivezic[1]
[1]*Univ. of Washington,* [2]*Bainbridge High School.*

029.02 **Using RR Lyrae Stars to Proble the M33 Halo**
Barton J. Pritzl[1], M. Buttermore[1], A. Saha[2], E. D. Skillman[3], K. A. Venn[4], H. L. Morrison[5], E. W. Olszewski[6]
[1]*Macalester College,* [2]*NOAO,* [3]*University of Minnesota,* [4]*University of Victoria, Canada,* [5]*Case Western Reserve University,* [6]*Steward Observatory.*

029.03 **The V-R Color of RR Lyrae Stars at Minimum Light**
Andrea M. Kunder[1], B. Chaboyer[1], A. Layden[2]
[1]*Dartmouth College,* [2]*Bowling Green State University.*

029.04 **Photometric Observations of RR Lyrae Stars at Red Buttes Observatory**
Frances Rivera[1], R. Ressler[1], K. Kinemuchi[1], H. A. Smith[2]
[1]*University of Wyoming,* [2]*Michigan State University.*

029.05 **SMC RR Lyr Abundances from Ca*by* Photometry**
Scott R. Baird[1], H. A. Smith[2], S. C. Keller[3], K. H. Cook[4], A. R. Walker[5]
[1]*Benedictine College & University of Kansas,* [2]*Michigan State University,* [3]*Mount Stromlo Observatory, Australia,* [4]*Lawrence Livermore National Laboratory,* [5]*Cerro Tololo Inter-American Observatory, Chile.*

029.06 **A Photometric Study of Starspot Evolution on HIP 106231**
Robert O. Harmon[1], R. M. Roettenbacher[1]
[1]*Ohio Wesleyan University.*

029.07 **Variable Stars in the LMC Globular Cluster NGC 1754**
Charles A. Kuehn, III[1], L. Taylor[2], H. A. Smith[1], M. Catelan[3], B. J. Pritzl[4], N. De Lee[1]
[1]*Michigan State University,* [2]*Transylvania University,* [3]*Pontificia Universidad Catolica de Chile, Chile,* [4]*Macalester College.*

029.08 **The Secret Lives of Cepheids: Discovery of Strong FUV Emissions in the Classical Cepheids Polaris and beta Dor**
Scott G. Engle[1], E. F. Guinan[1], N. R. Evans[2]
[1]*Villanova Univ.,* [2]*Harvard-Smithsonian CfA.*

029.09 **Correlation of R Cassiopeia's SiO Maser Properties**
Anne Hayes[1], G. McIntosh[1]
[1]*University of Minnesota, Morris.*

029.10 **APT Observations of the Bright Cepheid HD 32456**
William Z. Taylor[1], R. J. Dukes, Jr.[1]
[1]College of Charleston.

029.11 **Frequency Determination for the Slowly Pulsating B Star, HD21071, From Combined Geneva and Stromgren Photometry**
Melissa Sims[1], R. J. Dukes, Jr.[1]
[1]College of Charleston.

029.12 **Frequency Determinations of Five Slowly Pulsating B Stars**
Joseph Bramlett[1], R. J. Dukes, Jr.[1]
[1]College of Charleston.

029.13 **Spitzer 24μ and 70μ Imagery of Symbiotic Stars with Extended Nebular Ejecta**
Bruce McCollum[1], F. C. Bruhweiler[2], G. M. Wahlgren[3], M. Eriksson[3], A. Rosas[4], E. Verner[5]
[1]IPAC/SSC, [2]CUA/GSFC, [3]Lund Obs., Sweden, [4]CUA, [5]CUA/UDC/GSFC.

029.14 **Fast-Drifting Radio Bursts Seen on the Flare Star AD Leo with the Arecibo Observatory**
Rachel A. Osten[1], T. Bastian[2]
[1]University of Maryland, [2]National Radio Astronomy Observatory.

029.15 **VLA Imaging of Cyngus X-3 Jets at 8.5 GHz**
Catherine A. Whiting[1], M. Rupen[2], A. Mioduszewski[2]
[1]University of Iowa/ NRAO, [2]NRAO.

029.17 **Photometric and Spectroscopic Observations of Two delta Scuti Variable: V919 Herculis and V927 Herculis**
Charles R. Phillips[1], E. G. Hintz[1]
[1]Brigham Young University.

029.18 **An Analysis of the Variable Star V577 Ophiuchi**
Christine Forsyth[1], E. G. Hintz[2]
[1]Bryn Mawr College, [2]Brigham Young Univ..

029.19 **Rotational Velocities of delta Scuti Variable Stars**
Tabitha C. Bush[1], E. G. Hintz[1]
[1]Brigham Young Univ..

029.20 **The Curious Case of GSC3196-641: Double-mode RR Lyrae or a Spotted Rotating Star?**
Michael Koppelman[1], R. Huziak[2], V. Petriew[3]
[1]Univ. of Minnesota, [2]Univ. of Saskatchewan, Canada, [3]American Association of Variable Star Observers.

030: YSO / Star Formation I
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

030.01 **Stellar and Circumstellar Properties of Class I Protostars**
Kelly Lockhart[1], L. Prato[2], C. M. Johns-Krull[3], J. T. Rayner[4]
[1]Rice University, Lowell Observatory, [2]Lowell Observatory, [3]Rice University, [4]Institute for Astronomy, University of Hawaii.

030.02 **An Unbiased Statistical Study of Herbig AeBe Eystems in the X-rays Using Chandra**
Murad Hamidouche[1], S. Wang[1], L. W. Looney[1]
[1]Univ. of Illinois.

030.03 **Search for Close Binaries of Herbig Ae/Be Stars**
Maria J. Cordero[1], S. Thomas[2], N. van der Bliek[3], B. Rodgers[4], G. Doppmann[4], A. Sweet[5]
[1]Pontificia Universidad Catolica de Chile, Chile, [2]UC Santa Cruz, [3]CTIO, Chile, [4]Gemini South Observatory, Chile, [5]Macalester College.

030.04 **Wide-Field NIR Polarimetry of the Orion Nebula**
Nobuhiko Kusakabe[1], M. Tamura[1], R. Kandori[1], J. Hashimoto[2], Y. Nakajima[1], T. Nagayama[3], C. Nagashima[4], T. Nagata[3], J. H. Hough[5]
[1]National Astronomical Observatory, Japan, [2]Tokyo University of Science, Japan, [3]Kyoto University, Japan, [4]Nagoya University, Japan, [5]University of Hertfordshire, United Kingdom.

030.05 *Spitzer* **IRAC and MIPS Observations toward High-mass Star Forming Regions**
Keping Qiu[1], Q. Zhang[1], R. A. Gutermuth[1], T. S. Megeath[2], H. Beuther[3], T. K. Sridharan[1], D. S. Shepherd[4], L. Testi[5], C. G. De Pree[6]
[1]Harvard-Smithsonian Center for Astrophysics, [2]University of Toledo, [3]Max-Planck-Institute for Astronomy, Germany, [4]National Radio Astronomy Observatory, [5]Osservatorio Astrofisico di Arcetri, Italy, [6]Department of Physics and Astronomy, Agnes Scott College.

030.06 **Lithium Depletion in the Beta Pictoris Moving Group**
Jennifer C. Yee[1], E. L. Jensen[1], B. E. Reaser[1]
[1]Swarthmore College.

030.07 **A Search for OH Maser Emission In Bright-Rimmed Clouds**
Kristen L. Thomas[1], L. K. Morgan[1], J. S. Urquhart[2], M. A. Thompson[3]
[1]NRAO, [2]University of Leeds, United Kingdom, [3]The University of Hertfordshire, United Kingdom.

030.08 **A Mid-Infrared Survey of Class I/Flat-Spectrum Binary/Multiple Systems**
Karl E. Haisch, Jr.[1], M. Barsony[2], M. E. Ressler[3], T. P. Greene[4]
[1]Utah Valley State College, [2]San Francisco State University, [3]NASA JPL, [4]NASA Ames Research Center.

030.09 **CO Emission from the Inner Regions of Disks with Dust Clearing**
Joanna M. Brown[1], G. A. Blake[1], C. Salyk[1], A. C. Boogert[2]
[1]Caltech, [2]AURA/NOAO-South, Chile.

030.10 **Fission of Rapidly Rotating Protostars**
Jennifer L. Lozier[1], S. Michael[2], R. H. Durisen[2], J. N. Imamura[3]
[1]Mount Union College, [2]Indiana University, [3]University of Oregon.

030.11 **Formaldehyde Emission From Protostellar Region L1448IRS3**
Claire M. Davy[1], J. Mangum[2], A. Wootten[2]
[1]Bryn Mawr College, [2]NRAO.

030.12 **A Search for Young Stellar Objects in the Horsehead Nebula**
Brendan P. Bowler[1], W. H. Waller[1], S. T. Megeath[2], B. M. Patten[3], M. Tamura[4]
[1]Tufts University, [2]University of Toledo, [3]NSF, CfA, [4]NAOJ, Japan.

030.13 **Outflow Evolution in Turbulent Clouds**
Andrew Cunningham[1], A. Frank[1], A. C. Quillen[1], E. G. Blackman[1]
[1]University of Rochester.

030.14 **Protostellar Outflows and their Influence on the Star Formation Process**
Hector G. Arce[1]
[1]Am. Museum of Natural History.

030.15 **Photometric Monitoring of the PMS Object Walker 90**
Michael D. Joner[1]
[1]Brigham Young Univ..

030.16 **The Taurus Spitzer Legacy Project**
Deborah Padgett[1], M. Fukagawa[2], L. Rebull[1], A. Noriega-Crespo[1], S. Carey[1], K. Stapelfeldt[3], L. Hillenbrand[1], T. Huard[4], S. Terebey[5], D. Hines[6], T. Brooke[1], C. McCabe[3], M. Guedel[7], G. Knapp[8], M. Audard[9], F. Menard[10], J. Monin[10], C. Dougados[10], N. Evans[11], L. Allen[4], S. Strom[12], P. Harvey[11]
[1]California Institute of Technology, [2]Nagoya University, Japan, [3]Jet Propulsion Laboratory, [4]Harvard-Smithsonian Center for Astrophysics, [5]California State University, Los Angeles, [6]Space Science Institute, [7]Paul Sherrer Institut, Switzerland, [8]Princeton University, [9]University of Geneva, Switzerland, [10]Observatoire du Grenoble, France, [11]University of Texas, [12]NOAO.

030.17 **Millimeter-Wavelength Methanol Masers in New Galactic Sources**
Jenna J. Lemonias[1], V. Strelnitski[2], P. Pratap[3]
[1]Vassar College, [2]Maria Mitchell Observatory, [3]MIT Haystack Observatory.

030.18 **Class I Methanol Masers in the DR21 Star Forming Complex**
Samantha Hoffmann[1], P. Pratap[2], V. Strelnitski[3]
[1]Texas Lutheran University and MIT Haystack Observatory, [2]MIT Haystack Observatory, [3]Maria Mitchell Observatory.

030.19 **Short-term Variations in the Class I Methanol Maser Line at 44 GHz**
Preethi Pratap[1], S. Hoffmann[1], V. Strelnitski[2]
[1]MIT Haystack Obs., [2]Maria Mitchell Observatory.

030.20 **A New Low-Mass, Pre-Main Sequence Eclipsing Binary in Orion:Precise Mass Determinations of System Components**
Phillip Cargile[1], K. G. Stassun[1], R. Mathieu[2]
[1]Vanderbilt Univ., [2]Universtiy of Wisconsin.

030.21 **Star Formation in Bright-Rimmed Clouds**
Sarah Ballard[1], L. Allen[2], R. Gutermuth[2]
[1]UC Berkeley, [2]Harvard-Smithsonian Center for Astrophysics.

Job Center
Attendee Services, 9:20am-5:00pm, Exhibit Hall 4

The AAS Job Center will be operated as normal at the Seattle Meeting Washington.

The Job Center is designed to facilitate as many informal interviews as possible. It is our hope that successful formal interviews will be the next step for everyone.

Employers: If you are planning to conduct interviews in Calgary, please let us know. Send your name, institution and position for which you will be interviewing to jobs@aas.org

Job Seekers: To participate, please submit your resume and cover sheet to jobs@aas.org at the AAS Executive Office by 15 December 2006.

For more details access, http://members.aas.org/JobReg/JRIncludes/jobcen.cfm.
Chair
Faye Peterson[1]
[1]American Astronomical Society.

Gadgets and Gizmos
Attendee Services, 9:20am-5:00pm, South Lobby

If you're interested in sharing educational materials you've developed, adapted and used, whether you're new to teaching or an old hand, this session is for you. Suitable demonstrations include interactive web tools (applets, immersive experiences, touch screens), instructional software, remote observing tools, audience response systems ("clickers"), wireless delivery of content to handheld devices, laboratory activities, planetarium programs, etc.,

etc., and, of course, real gadgets and gizmos. Only non-commercial educational products, for any level and for any audience, are appropriate for this forum. Presenters may distribute materials — print, CD, DVD — but not conduct sales.

Gadgets and Gizmos will be located in the main lobby right across from the Exhibit Hall and between the Cyber Café and the registration area. It will be open throughout the week to give everyone the opportunity for a hands-on experience. If you are interested in using this forum, or have questions about the suitability of an idea or technology, please email deustua@aas.org.

Registration: If you wish to be a presenter, please fill out the registration form at www.aas.org/meetings/gadgetregform.php. The deadline is 18 October 2006. G&G registrations received by the deadline will be included in the meeting program book. Please remember to provide a title, brief description of your demonstration to and note any specific display, space, electrical and internet requirements as well as the times you will be present. We do ask that your demonstrations be as stand alone as possible as during peak usage times internet access at the convention center can be limited. There may be a fee for internet connections and computer rentals. Presenting at G&G does not count against the one-author rule for contributed papers.

Chair
Susana E. Deustua[1]
[1]*American Astronomical Society.*

031: Clickers in Astronomy Teaching
AAS Special, 10:00-11:30am, 201

Chair
Douglas K. Duncan[1]
[1]*Univ. of Colorado.*

031.01 **Success and Failure Using Student Response Systems: "Clickers"**
Douglas K. Duncan[1]
[1]*Univ. of Colorado.*

031.02 **Clickers at UMass: a successful program of campus-wide implementation**
Stephen Schneider[1]
[1]*UMass.*

031.03 **To Click or Not to Click is Not the Question: How Research with Clickers Develops a Better Understanding of When Learning Happens in Your Classroom**
Edward Prather[1], T. F. Slater[1], G. Brissenden[1], E. F. Dokter[1]
[1]*Univ. of Arizona.*

031.04 **Interactive Learning and "Clickers"**
Alexander Rudolph[1]
[1]*California Polytechnic Univ..*

032: The SDSS Supernova Survey
AAS Special, 10:00-11:30am, 204

Chair
Joshua Frieman[1]
[1]*Fermi Nat'l. Accelerator Lab..*

032.01 **Overview of the SDSS Supernova Survey: the First Two Seasons**
Andrew C. Becker[1]
[1]*Univ. of Washington.*

032.02 **SDSS SN Hubble Diagram: First Cosmology Results**
Hubert Lampeitl[1], SDSS-II Supernova collaboration
[1]*Space Telescope Science Institute.*

032.03 **The Supernova Ia Rate at z~0.1**
Richard Kessler[1]
[1]University of Chicago.

032.04 **Peculiar Supernovae in the SDSS-II SN Survey**
Jose L. Prieto[1], SDSS-II Supernova Survey Collaboration
[1]Ohio State University.

032.05 **Studies with 'Purely Photometric' Supernovae from SDSS-II**
Masao Sako[1], SDSS-II Supernova Survey Collaboration
[1]Univ. Pennsylvania.

033: HAD I
HAD Special, 10:00-11:30am, 6A

Chair
Donald K. Yeomans[1]
[1]JPL.

033.01 **Astronomical Instruments of Ignazio Porro (1801-1875)**
Peter Abrahams[1]
[1]Independent.

033.02 **The Discovery of an 1862 Drawing of M 51, the Whirlpool Nebula**
Jay B. Holberg[1], W. Tobin[2]
[1]Univ. of Arizona, [2]Vannes, France.

033.03 **Radar and Meteors: Controversy over the Origin of Meteors in Postwar Astronomy**
Woodruff T. Sullivan, III[1]
[1]Univ. of Washington.

033.04 **Frank Ross's Early Orbits of the First Irregular Satellites of Saturn and Jupiter**
Donald E. Osterbrock[1]
[1]UCO\Lick Observatory.

034: Accretion, Accretion Disks and Outflows
AAS Oral, 10:00-11:30am, 613-14

034.02 **High Velocity Outflows in Quasars**
Paola Rodriguez[1], F. Hamann[1], D. Nestor[2]
[1]Univ. of Florida, [2]Univ. of Cambridge, United Kingdom.

034.04 **The Hard X-ray Spectral Slope as an Accretion-Rate Indicator in Radio-Quiet Active Galactic Nuclei**
Ohad Shemmer[1], W. N. Brandt[1], H. Netzer[2], R. Maiolino[3], S. Kaspi[2]
[1]Pennsylvania State University, [2]Tel Aviv University, Israel, [3]INAF Osservatorio Astrofisico di Arcetri, Italy.

034.05 **Accretion Disk Temperatures and Continuum Colors in QSOs**
Erin W. Bonning[1], G. A. Shields[2], S. Salviander[2], L. Cheng[2], K. Gebhardt[2]
[1]Obs. de Paris-Meudon, France, [2]University of Texas at Austin.

034.06 **Interpreting the Variability of Double-Peaked Emission Lines using Accretion Disk Models**
Helene Flohic[1], M. Eracleous[1]
[1]Pennsylvania State Univ..

34.01 **Revisiting Standard Helium-like X-ray Diagnostics**
Ryan Porter[1], G. Ferland[1]
[1]Univ. Of Kentucky.

34.03 **A Sptizer Infrared and Chandra X-ray study of LINERs: A Link Between Star Formation, AGN Fueling, and Mass Accretion**
Rachel Dudik[1], S. Satyapal[1], R. M. Sambruna[2], E. Dwek[2], M. Gliozzi[1]
[1]George Mason Univ., [2]Goddard Space Flight Center.

035: Astrobiology & The Solar System
AAS Oral, 10:00-11:30am, 611-12

035.01 **Near-Infrared Spectra of UV Photolyzed Astrophysical Ice Mixtures**
Perry A. Gerakines[1], C. R. Richey[1]
[1]University of Alabama at Birmingham.

035.02 **Detection of 13C Isotopomers of Molecule HC7N**
Glen Langston[1], B. Turner[1]
[1]NRAO.

035.03 **Life on Mars? Reinterpretation of the Viking Life Detection Experiments: A Possible Biogenic Origin of Hydrogen Peroxide**
Dirk Schulze-Makuch[1], J. M. Houtkooper[2]
[1]Washington State University, [2]Justus-Liebig University, Germany.

035.04 **New Exploration on What is Life?**
D. K. Perkins[1]
[1]Saratoga, CA.

035.05 **Charge-Exchange Induced X-rays in the Martian Exosphere**
Dimitra Koutroumpa[1], R. Lallement[1], R. Modolo[2], G. Chanteur[2], V. Kharchenko[3]
[1]Service D'Aéronomie, France, [2]Centre d'Etude des Environnements Terrestre et Planétaires, France, [3]Harvard-Smithsonian Center for Astrophysics.

035.06 **Science Results from the Stardust Comet Sample Return Mission: Large Scale Mixing in the Solar Nebula and the Origin of Crystalline Silicates in Circumstellar Disks**
Donald E. Brownlee[1], Stardust Mission Team
[1]Univ. of Washington.

035.07 **Simulating Supernova Injection of Short Lived Radionuclides with Consideration of the Solar Birth Environment**
Keith W. Davis[1], M. D. Leising[1]
[1]Clemson Univ..

036: Black Holes
AAS Oral, 10:00-11:30am, 608-10

036.01 **Quasi-Periodic Oscillations and Spectral Behaviour of XTE 1859+226. QPO Frequency Spectral Index Correlation and the Mass of the Central Object.**
Nikolai Shaposhnikov[1], R. Fiorito[2], L. Titarchuk[3]
[1]NASA's GSFC, [2]NASA's GSFC/UMD, [3]NASA's GSFC/GMU/NRL.

036.02 **Fundamental Parameters of Galactic Black Holes from SIM Planetquest**
Xiaopei Pan[1], S. Shaklan[1]
[1]JPL.

036.03 **Black Hole Formation in Galactic X-Ray Binaries**
Bart Willems[1], T. Fragos[1], V. Kalogera[1]
[1]Northwestern University.

036.07 **Seeing the Wiggle: High Resolution Imaging of SS433 with the VLBA**
Amy J. Mioduszewski[1], M. P. Rupen[1]
[1]NRAO.

036.08 **Recent Optical Observations of the Microquasar SS 433**
Todd C. Hillwig[1], D. Gies[2]
[1]Valparaiso Univ., [2]Georgia State Univ..

36.06 **Gravitational Waves From The Hierarchical Buildup Of Intermediate Mass Black Holes**
Miroslav Micic[1], S. Sigurdsson[1], K. Holley-Bockelmann[1], T. Abel[2]
[1]Pennsylvania State Univ., [2]Stanford University.

037: Dark Matter, Dark Energy and Lensing
AAS Oral, 10:00-11:30am, 605-07

037.01 **The Search for Dark Matter and New Physics using the Gamma Ray Large Area Space Telescope (GLAST) Large Area Telescope (LAT)**
Lawrence L. Wai[1], GLAST LAT Collaboration
[1]Kavli Institute for Particle Astrophysics and Cosmology.

037.02 **Gamma-rays from Dark Matter in the Galactic Center**
Douglas P. Finkbeiner[1]
[1]Harvard University.

037.03 **Discovery of a Dark Matter Ring in the Core of the Galaxy Cluster CL0024+17 at z=0.4**
Myungkook J. Jee[1], H. C. Ford[1], G. D. Illingworth[2], R. L. White[3], T. J. Broadhurst[4], D. A. Coe[1], G. R. Meurer[1], A. van der Wel[1], ACS Science Team
[1]Johns Hopkins Univ., [2]University of California, Santa Cruz, [3]Space Telescope Science Institute, [4]Tel Aviv University, Israel.

037.04 **Evidence for a New Force in the Dark Sector?**
Glennys R. Farrar[1], R. A. Rosen[1]
[1]New York Univ..

037.06 **Dark Energy Search: Current Status and Future Prospects**
Yun Wang[1]
[1]Univ. of Oklahoma.

037.07 **Dark Matter in Galaxy Cluster 1E0657-56: Measuring the Invisible With Gravitational Lensing**
Marusa Bradac[1], D. Clowe[2], A. Gonzalez[3], P. Marshall[1], W. Forman[4], C. Jones[4], M. Markevitch[4], S. Randall[4], T. Schrabback[5], D. Zaritsky[6]
[1]KIPAC/Stanford, [2]Ohio University, [3]University of Florida, [4]Harvard-Smithsonian Center for Astrophysics, [5]AIfA, Germany, [6]Steward Observatory.

37.05 **Simulations of Dark Matter Bound to the Solar System**
Annika Peter[1]
[1]Princeton Univ..

038: Feedback and Mergers in Galaxy Evolution
AAS Oral, 10:00-11:30am, 3B

038.01 **AGN Feedback Regulating Early-type Galaxy Evolution**
Kevin Schawinski[1], S. Khochfar[1], S. K. Yi[2], S. Kaviraj[1], GALEX Science Team
[1]Oxford Astrophysics, United Kingdom, [2]Yonsei University, Republic of Korea.

038.03 **The Evolution of the Massive Galaxy Luminosity Function Over Half of Cosmic History**
Richard J. Cool[1], D. J. Eisenstein[1]
[1]Univ. of Arizona.

038.04 **Understanding Galaxies in Pairs**
Elizabeth J. Barton[1], A. R. Zentner[2], J. S. Bullock[1], R. H. Wechsler[3]
[1]UC, Irvine, [2]KICP and U. Chicago, [3]KIPAC and Stanford University.

038.06 **The Asymmetric Relations among Galaxy Color, Structure, and Environment**
Alejandro D. Quintero[1], A. Berlind[2], M. R. Blanton[2], D. W. Hogg[2]
[1]Steward Observatory, [2]New York University.

038.07 **The Role of Galaxy Interactions and Mergers in Star Formation at z<1.3: Mid-Infrared Properties in the Spitzer First Look Survey**
Carrie Bridge[1], P. N. Appleton[2], C. J. Conselice[3], P. Choi[2], L. Armus[2], D. T. Fadda[2], S. Laine[2], F. R. Marleau[2], R. G. Carlberg[1], G. Helou[2], L. Yan[2]
[1]University of Toronto, Canada, [2]Spitzer Science Center, [3]University of Nottingham, United Kingdom.

38.02 **Star Formation and Supernova Feedback in Smoothed Particle Hydrodynamic Simulations of Galaxy Formation**
Gregory S. Stinson[1], T. Kaufmann[2], T. Quinn[1], C. Christensen[1], J. Wadsley[3], S. Kazantzidis[4]
[1]Univ. Of Washington, [2]Univ. of California, Irvine, [3]McMaster University, Canada, [4]KITP.

38.05 **Dynamic and Spatial Properties of Satellites in Isolated Galactic Systems**
Abel Diaz[1], R. Wilhelm[1]
[1]Texas Tech University.

039: Starburst Galaxies: Analogs of Lyman Break Galaxies?
AAS Oral, 10:00-11:30am, 6B

039.01 **The Young and The Dustless: Constraining the Star Formation History and Dust Content of Ultraviolet Luminous Galaxies using GALEX UV and Radio Observations**
Antara Basu-Zych[1], D. Schiminovich[1], Galex Science Team
[1]Columbia University.

039.03 **HST/STIS Spectroscopy of Ionized Gas in the M82 Starburst Core**
Linda J. Smith[1], M. S. Westmoquette[2], J. S. Gallagher, III[3], R. W. O'Connell[4], D. J. Rosario[4], R. de Grijs[5]
[1]Space Telescope Science Institute, [2]University College London, United Kingdom, [3]University of Wisconsin-Madison, [4]University of Virginia, [5]University of Sheffield, United Kingdom.

039.04 **Spitzer ISM Studies of Low Metallicity Starbursts**
Brian O'Halloran[1], S. Satyapal[1], R. Dudik[1]
[1]George Mason Univ..

39.02 **A FUSE Survey of Starburst Galaxies: Galactic Feedback from Star Formation**
John P. Grimes[1], T. Heckman[1], A. Aloisi[2]
[1]Johns Hopkins Univ., [2]Space Telescope Science Institute.

040: Stellar Populations
AAS Oral, 10:00-11:30am, 3A

040.02 **Theoretical Realization of Near-IR Photometry of Magellanic Star Clusters**
Hyun-chul Lee[1], G. Worthey[1]
[1]Washington State Univ..

040.05 **White Dwarfs in the Galaxy**
Stephane Vennes[1], A. Kawka[2]
[1]Florida Institute of Technology, [2]Astronomical Institute AV CR, Czech Republic.

40.01 **Detailed Properties of Populous Clusters in the Large Magellanic Cloud**
Aaron J. Grocholski[1], A. Sarajedini[1], A. A. Cole[2], D. Geisler[3], K. A. Olsen[4], G. P. Tiede[5], V. V. Smith[6], C. L. Mancone[1]
[1]Univ. of Florida, [2]Univ. of Minnesota, [3]Univ. de Concepcion, Chile, [4]CTIO, Chile, [5]Bowling Green State Univ., [6]US Gemini Project, Chile.

40.03 **Self-Consistent Stellar Evolution Models with Updated Physics and Variable Abundances**
Aaron L. Dotter[1], B. Chaboyer[1], E. Baron[2], J. W. Ferguson[3], D. Jevremovic[2], H. Lee[4], G. Worthey[4]
[1]Dartmouth College, [2]University of Oklahoma, [3]Wichita State University, [4]Washington State University.

40.04 **Bulge Formation Scenarios vs. the Observations**
Grant Newsham[1]
[1]The Ohio State University.

041: Integrating Mechanics with Computer Modeling
AAPT Invited, 10:00-11:30am, 616

Chair
Wolfgang Christian[1]
[1]Davidson College.

041.01 **Computation in Classical Mechanics with Easy Java Simulations (EJS)**
Anne J. Cox[1]
[1]Eckerd College.

041.02 **Introducing Computational Approaches in Intermediate Mechanics**
David M. Cook[1]
[1]Lawrence University.

042: Physics: Something for Everyone
AAPT Invited, 10:00-11:30am, 303

Chair
Kenneth Heller[1]
[1]Univ of Minnesota.

042.01 **The Physics Force Physics for Ages 6 to 106**
E. D. Dahlberg[1], C. Falco[2], I. K. Schuller[3]
[1]University of Minnesota, [2]University of Arizona, [3]University of California San Diego.

042.02 **The Science of Optics; the History of Art**
Charles M. Falco[1]
[1]University of Arizona.

042.03 **Science as Entertainment: Making of a Scientific Movie**
Ivan K. Schuller[1]
[1]UC, San Diego.

043: Optics Education in the Middle Schools
AAPT Special, 10:00-11:30am, 310

Chair
Robert T. Sparks[1]
[1]National Optical Astronomy Observatory.

043.01 **LITE, Optics, Color and Vision**
Kenneth Brecher[1]
[1]Boston University.

043.02 **Science beyond the Classroom: Hands-On Optics and the Boys and Girls Club**
Erin F. Dokter[1], C. Walker[2], C. Peruta[1], C. Ubach[1], R. Sparks[2], S. Pompea[2]
[1]University of Arizona, [2]National Optical Astronomy Observatory.

043.03 **Middle School Optics Education: Hitting the Target or Impedance Mismatch?**
Stephen M. Pompea[1], C. E. Walker[1], R. T. Sparks[1]
[1]National Optical Astronomy Observatory.

044: Interactive Lecture Demonstrations using Physics Suite Materials
AAPT Panel, 10:00-11:30am, 617

Co-presented with Ronald Thornton, Tufts Univ., and Priscilla Laws, Dickinson College The results of physics education research and the availability of microcomputer-based tools have led to the development of the activity-based Physics Suite. Most of the Suite materials are designed for hands-on learning, for example student-oriented laboratory curricula like Real-Time Physics. One reason for the success of these materials is that they encourage students to take an active part in their learning. This interactive session will demonstrate—through active audience participation—Suite materials designed to promote active learning in lecture?/Interactive Lecture Demonstrations (ILDs). The demonstrations will be drawn from energy, heat and thermodynamics, oscillations and waves, electricity and magnetism, light and optics. Results of studies on the effectiveness of this approach will be presented. This session should be of special interest to teachers of large lecture classes as well as those who teach small classes where only one computer is available.
Chair
David Sokoloff[1]
[1]University of Oregon.

045: Innovations in High School Physics, Part I
AAPT Special, 10:00-11:30am, 307-08
Chair
Thomas F. Haff[1]
[1]Issaquah High School.

045.01 **Seattle Area High School Astronomy Projects: 4 local teachers present their work with students.**
Eric C. Muhs[1]
[1]Roosevelt High School.

046: Innovations in Teaching Astronomy
AAPT Oral, 10:00-11:30am, 615
Chair
Janelle M. Bailey[1]
[1]Univ. Nevada, Las Vegas.

046.01 **Survey Instrument Probing Student Understanding of the Greenhouse Effect**
John M. Keller[1], T. F. Slater[2], E. E. Prather[2]
[1]Cal Poly San Luis Obispo, [2]University of Arizona.

046.02 **Misconceptions in Astronomy and Physics**
Andy Veh[1]
[1]Kenai Peninsula College.

046.03 **Ranking Tasks for Assessing Conceptual and Quantitative Understanding in Astronomy**
Edward E. Prather[1], T. F. Slater[1], D. Loranz[2]
[1]University of Arizona CAPER Team, [2]Truckee Meadows Community College.

046.04 **Sorting Tasks and Vocabulary-in-Context Activities for Assessing Introductory Astronomy Understanding**
Timothy F. Slater[1], D. Loranz[2], E. E. Prather[1]
[1]University of Arizona CAPER Team, [2]Truckee Meadows Community College.

046.05 **Visual Activities for Assessing Non-science Majors' Understanding in Introductory Astronomy**
Daniel Loranz[1], E. E. Prather[2], T. F. Slater[2]
[1]Truckee Meadows Community College, [2]University of Arizona CAPER Team.

046.06 **A New Chart and Teaching Materials on Cosmology from CPEP**
G Samuel Lightner[1], M. Cherney[2], G. Aubrecht[3], R. Reiland[4]
[1]Westminster College, [2]Creighton University, [3]The Ohio State University, [4]Shady Side Academy.

046.07 **Asteroids and LSST EPO**
Robert T. Sparks[1], S. K. Croft[1], S. M. Pompea[1]
[1]National Optical Astronomy Observatory.

047: Pierce Prize in Astronomy
Plenary, 11:40am-12:30pm, Ballroom 6

047.01 **Bubbles, Bow Shocks and *B* Fields: The Interplay Between Neutron Stars and Their Environments**
Bryan M. Gaensler[1]
[1]The University of Sydney, Australia; Harvard-Smithsonian Center for Astrophysics.

Accessing and Using Sloan Digital Sky Survey Data
AAS Splinter Meeting, 12:30-2:00pm, 608

Presentations of a few specific cases showing astronomers how to access data from the Sloan Digital Sky Survey, with questions and answers from Jordan Raddick and other members of the SDSS collaboration. The session will be similar to the session given at the summer meeting in Calgary.

Chair
Jordan Raddick[1]
[1]Johns Hopkins University.

NSF Town Hall
AAS Town Hall Meeting, 12:45-1:45pm, 6A

The Division of Astronomical Sciences of NSF will continue its discussion with the community at this town meeting. Staff will provide updates on the status of the NSF and Divisional budgets, highlight new and continued funding opportunities, and discuss ongoing strategic planning and coordination with other agencies. Updates will be provided on the activities of the senior review being carried out by the Division with a discussion of its recommendations should they be available at the time of the meeting. The majority of the session will be reserved for questions and discussion.

Chair
Eileen D. Friel[1]
[1]NSF.

Committee on the Status of Women in Astronomy
AAS Splinter Meeting, 1:00-2:00pm, 613

The CSWA session will focus on one specific recommendation from the list of Pasadena Recommendations. This recommendation was for the AAS to commission a longitudinal study of young women and men in astronomy, tracking both those that remain in the field and those that choose to leave. The CSWA has facilitated the formation of a group of people interested in actively working on a longitudinal study of the career paths of women in astronomy, and requested that that group use this session to provide the broader astronomical community insight into their process. The CSWA session will begin with an overview of the current status of statistics on the career paths of astronomers, and the clear need for a well-defined longitudinal study. The Longitudinal Study committee will then report on how they defined the overall goals of the study, selected an initial target group of participants, and formulated a first survey. This survey is undergoing final revisions. The study is supported by the American Institute of Physics, and the CSWA is proposing to secure additional seed funding for the first phase of the study from the AAS. There will be significant time for questions and discussion. We look forward to seeing you there!

Chair

Patricia Knezek[1]
[1]*WIYN Consortium, Inc..*

How to Spend Limited Resources
AAPT Crackerbarrel, 1:00-2:00pm, 615

Equipment budgets can be very tight, especially given the costs of educational apparatus and software. This is especially true for the high school teacher. How can you optimize your equipment budget to give you the most "bang for the buck?" Attendees are invited to bring their questions (and solutions!) about how to address this issue.

Chair

Gregory Puskar[1]
[1]*West Virginia University.*

Professional Concerns of Junior Faculty in PER
AAPT Crackerbarrel, 1:00-2:00pm, 211

Participants will interactively discuss matters of professional concerns to junior faculty in PER. Please come prepared to tell us your situation, exchange ideas, ask questions, make suggestions, share a problem, share a solution, etc.

Chair

Rachel E. Scherr[1]
[1]*University of Maryland.*

See Spot Run, See Spot Run from Astronomy Teaching
AAPT Crackerbarrel, 1:00-2:00pm, 616

In early childhood and elementary education, science topics are usually avoided by teachers, yet astronomy is among the science topics craved by their students. This crackerbarrel is for anyone who uses astronomy and space science to inspire young learners or their teachers. We will share strategies, activities, and heartbreaks.

Chair

Thomas M. Foster[1]
[1]*Southern Illinois University Edwardsville.*

PhysicsFirst Crackerbarrel
AAPT Crackerbarrel, 1:00-2:00pm, 310

This session highlights the current status of the PhysicsFirst movement as a way to engage more students in learning physics. If you have a success story, or an unsucess story, we

would like to hear about your experiences with implementing a PhysicsFirst approach at your school. Everyone is invited to join the discussion and/or present your story as a poster display.
Chair
Olga Livanis[1]
[1]Stuyvesant HS.

048: Cool Astronomy For Everyone
AAS Special, 2:00-3:30pm, 613-14
Chair
Susana E. Deustua[1]
[1]American Astronomical Society.

048.01 **Fusion Confusion: Assessing What Students Know (and Don't Know) About Stars**
Janelle M. Bailey[1], E. E. Prather[2], B. Johnson[2], T. F. Slater[2]
[1]Univ. Nevada, Las Vegas, [2]Univ. Arizona.

048.02 **Transients in 10 seconds or less: catching Gamma-Ray Bursts in the act with ROTSE**
Eli S. Rykoff[1]
[1]Univ. of Michigan.

049: Cosmic Microwave Background
AAS Special, 2:00-3:30pm, 6A
Chair
John Mather[1]
[1]NASA Goddard Space Flight Center.

049.01 **Introduction to the Cosmic Microwave Background**
Marc Kamionkowski[1]
[1]Caltech.

049.02 **CMB Anisotropies with the SZA**
Matthew Sharp[1], J. Carlstrom[1], J. Cartwright[1], C. Greer[1], D. Hawkins[2], R. Hennessy[1], M. Joy[3], J. Lamb[2], E. Leitch[4], M. Loh[1], D. Marrone[1], A. Miller[5], T. Mroczkowski[5], S. Muchovej[5], C. Pryke[1], B. Reddall[1], M. Runyan[1], D. Woody[2]
[1]KICP, U. Chicago, [2]OVRO, Caltech, [3]NASA, [4]NASA / Caltech, [5]Columbia.

049.03 **New measurements of the CMB polarization anisotropy at small angular scales from CAPMAP**
Lewis D. Hyatt[1], CAPMAP Collaboration
[1]Princeton.

049.04 **Report on BICEP's First Season Observing the Cosmic Microwave Background from South Pole**
K. W. Yoon[1], P. A. Ade[2], D. Barkats[1], J. O. Battle[3], E. M. Bierman[4], J. J. Bock[3], H. C. Chiang[1], C. D. Dowell[3], L. Duband[5], G. S. Griffin[1], E. F. Hivon[6], W. L. Holzapfel[7], V. V. Hristov[1], B. G. Keating[4], J. M. Kovac[1], C. Kuo[1], A. E. Lange[1], E. M. Leitch[3], P. V. Mason[1], H. T. Nguyen[3], N. Ponthieu[8], Y. D. Takahashi[7]
[1]California Institute of Technology, [2]University of Wales, United Kingdom, [3]Jet Propulsion Laboratory, [4]U. C. San Diego, [5]CEA, France, [6]IPAC, [7]U. C. Berkeley, [8]IAS, France.

049.05 **Status of the QUAD Experiment**
Sarah Church[1]
[1]Stanford University/KIPAC.

049.06 **The Future of CMB Polarization: Report of the CMB Task Force**
Rai Weiss[1]
[1]MIT.

049.07 **NASA CMBPOL Mission Studies**
Jamie Bock[1], G. F. Hinshaw[2], P. T. Timbie[3]
[1]NASA/JPL, [2]NASA/GSFC, [3]U. Wisconsin.

050: NSF Astronomy Division Senior Review Outcome
AAS Special, 2:00-3:30pm, 6B

Chair
Eileen D. Friel[1]
[1]NSF.

050.01 **NSF Astronomy Division Senior Review Outcome**
G W. Van Citters[1]
[1]NSF.

051: HAD II: Case Studies in How 20th Century Observatory Directors Got Chosen
HAD Special, 2:00-3:40pm, 611-12

Chair
Karl Hufbauer

051.01 **Lowell Observatory Enters the Twentieth Century—in the 1950s**
Joseph S. Tenn[1]
[1]Sonoma State Univ..

051.02 **The Evolution of the National Radio Astronomy Observatory into a User Based Observatory**
Kenneth I. Kellerman[1], E. Bouton[1]
[1]NRAO.

051.03 **Michigan Turns to Leo Goldberg**
Rudi P. Lindner[1]
[1]U. Michigan.

051.04 **A Referendum on the State of Astronomy at Harvard:** *Choosing Harlow Shapley's Successor*
David H. DeVorkin[1]
[1]Smithsonian Inst..

051.05 **Changing the Guard Slowly: Yale 1963-1975**
Virginia Trimble[1]
[1]U. C. Irvine.

052: AGN Populations
AAS Oral, 2:00-3:30pm, 3A

052.01 **The Infrared Properties of galaxies and Quasars at z~6**
Yuexing Li[1], L. Hernquist[1], D. Finkbeiner[1]
[1]Harvard-Smithsonian, CfA.

052.02 **X-ray Spectral Properties from Chandra Observations of SDSS QSOs to z=5**
Paul J. Green[1], W. A. Barkhouse[2], T. L. Aldcroft[1], D. Kim[1], A. Mossman[1], G. Richards[3], M. Weinstein[4], ChaMP Collaboration
[1]SAO, [2]UIUC, [3]Princeton, [4]PSU.

052.04 **Searching for the Sources Responsible for the Unresolved 6-8 keV Cosmic X-ray Background**
Aaron T. Steffen[1], W. N. Brandt[1], D. Alexander[2], S. Gallagher[3], B. Lehmer[1]
[1]Penn State Univ., [2]Durham University, United Kingdom, [3]UCLA.

052.05 **Swift/Burst Alert Telescope(BAT) Hard X-ray Survey**
Jack Tueller[1], C. Markwardt[2], R. Mushotzky[3], Swift Survey Team
[1]NASA's GSFC, [2]UMd/NASA/GSFC,, [3]NASA/GSFC.

052.06 **The DRaGONS Survey: A Search for High Redshift Radio Galaxies and Heavily Obscured AGNs**
Samuel Schmidt[1], A. Connolly[1], A. Hopkins[2]
[1]University of Pittsburgh, [2]University of Sydney, Australia.

052.07 **Spitzer/IRS Spectra of GOODS AGN**
Jeffrey Van Duyne[1], C. M. Urry[1]
[1]Yale University.

052.08 **Probing Faint Active Galaxies at Redshifts 6 7 and above**
Anton M. Koekemoer[1], J. Bergeron[2], D. Alexander[3], W. Brandt[4], R. Chary[5], C. Conselice[6], S. Cristiani[7], E. Daddi[8], M. Dickinson[9], D. Elbaz[8], N. Grogin[10], G. Hasinger[11], V. Mainieri[12], E. Treister[13], C. M. Urry[14]
[1]STScI, [2]IAP, France, [3]Institute of Astronomy, United Kingdom, [4]PSU, [5]Caltech, [6]University of Nottingham, United Kingdom, [7]Osservatorio di Trieste, Italy, [8]CEA, France, [9]NOAO, [10]JHU, [11]MPE, Germany, [12]ESO, Germany, [13]ESO, Chile, [14]Yale University.

52.03 **Properties of Millijansky Radio Source Hosts**
Brian Stalder[1]
[1]University of Hawaii.

053: Distant Works: Cosmology, Large Scale Structure and Gravitational Waves
AAS Oral, 2:00-3:30pm, 6E

053.01 **Discovery of Faint Radio Structures over 50 Square Degrees Down to 3 arcmin Scales near the NGP**
Philipp P. Kronberg[1], R. Kothes[2], C. J. Salter[3], P. Perillat[3]
[1]LANL, [2]DRAO, NRC Canada, Canada, [3]Arecibo Observatory.

053.04 **A Direct View of the Large-Scale Distribution of Mass, from Weak Gravitational Lensing in the HST COSMOS Survey**
Richard Massey[1], J. Rhodes[1], A. Leauthaud[2], R. Ellis[1], N. Scoville[1], A. Finoguenov[3]
[1]CalTech, [2]Laboratoire d'Astrophysique de Marseille, France, [3]Max Planck Institut fur Extraterrestrische Physik, Germany.

053.05 **Effects of Baryons and Dissipation on the Matter Power Spectrum**
Douglas Rudd[1], A. Zentner[1], A. Kravtsov[1]
[1]University of Chicago.

053.07 **Analytical and Numerical Models of Turnaround Densities in ΛCDM**
Alan Peel[1], E. Shaya[1]
[1]Univ. of Maryland.

53.03 **Crawling the Cosmic Web: An Exploration of Filamentary Structure**
Nicholas A. Bond[1], M. A. Strauss[1], R. Cen[1]
[1]Princeton Univ..

53.06 **Upper Limit Map of a Stochastic Background of Gravitational Waves**
Stefan Ballmer[1]
[1]California Institute of Technology.

054: EXIST
AAS Oral, 2:00-3:30pm, 3B

054.01 **Black Hole Finder Probe to EXIST:Surveying Black Holes in Space and Time**
Jonathan E. Grindlay[1], EXIST Team
[1]Harvard-Smithsonian, CfA.

054.02 **The Low-Energy Telescopes on EXIST**
Philip E. Kaaret[1], B. Ramsey[2], J. G. Jernigan[3], R. A. Remillard[4], R. E. Rothschild[5], J. Hong[6], J. E. Grindlay[6]
[1]Univ. of Iowa, [2]NASA/MSFC, [3]SSL/UC Berkeley, [4]MIT, [5]UCSD, [6]Harvard.

054.03 **The High Energy Telescopes on EXIST**
JaeSub Hong[1], J. E. Grindlay[1], EXIST team
[1]Harvard Univ..

054.04 **Blazars and the Cosmic Diffuse IR Background with EXIST**
Paolo S. Coppi[1], EXIST Science Team
[1]Yale Univ..

054.05 **Gamma Ray Bursts as Cosmological Probes with EXIST**
Dieter Hartmann[1], EXIST Team
[1]Clemson Univ..

054.06 **Uncovering Obscured AGN with EXIST and Other Hard X-Ray Surveys**
C. M. Urry[1], E. Treister[2], S. Virani[1]
[1]Yale Univ., [2]European Southern Observatory, Chile.

055: ISM/Molecular Clouds
AAS Oral, 2:00-3:30pm, 608-10

055.01 **Comparison of 13CO Line and Far-Infrared Continuum as a Diagnostic of Dust and Molecular Gas Physical Conditions -- Implications for the N(H2)/I(CO) Conversion Factor**
William F. Wall[1]
[1]INAOE, Mexico.

055.02 **Continuity between Magnetic Fields in GMCs and Large-scale Galactic Magnetic Fields**
Giles G. Novak[1], M. Krejny[1], H. Li[2], D. T. Chuss[3], P. G. Calisse[4]
[1]Northwestern Univ., [2]Harvard-Smithsonian Center for Astrophysics, [3]NASA-Goddard Space Flight Center, [4]Cardiff University, United Kingdom.

055.03 **Temporal Variations of Charge-Exchange induced Heliospheric X-rays: Constraints on the Local Interstellar X-ray Background**
Rosine Lallement[1], D. Koutroumpa[1], F. Acero[2], J. Ballet[2], V. Kharchenko[3], R. Pepino[3], A. Dalgarno[3]
[1]Service D'Aéronomie, France, [2]Commissariat à l'Energie Atomique, France, [3]Harvard-Smithsonian Center for Astrophysics.

055.04 **Spitzer Observations of the Lupus Molecular Cloud**
Nicholas L. Chapman[1], L. Mundy[1], N. J. Evans, II[2], c2d team
[1]Univ. of Maryland, [2]Univ. of Texas.

055.05 **The COMPLETE Calibration of 12CO and 13CO in Perseus**
Jaime E. Pineda[1], P. Caselli[1], A. A. Goodman[1], E. Rosolowsky[1], J. B. Foster[1]
[1]Harvard-Smithsonian Center for Astrophysics.

055.06 **Advancing Nebular Astrophysics through Near-Infrared Spectroscopic Mapping**
William H. Waller[1], A. Kutyrev[2], R. Silverberg[2], B. Woodgate[2], L. Allen[3]
[1]Tufts Univ., [2]NASA Goddard Space Flight Center, [3]Center for Astrophysics.

055.07 **Mapping Enrichment in M33**
Erik Rosolowsky[1], J. D. Simon[2]
[1]Harvard-Smithsonian, CfA, [2]California Institute of Technology.

056: Space Mission Concepts and Instrumentation
AAS Oral, 2:00-3:30pm, 605-07

056.01 **Flight Calibration of the Galaxy Evolution Explorer (GALEX)**
Patrick Morrissey[1], GALEX Science Team
[1]Caltech.

056.02 **Optical Performance of Designs for a Large Aperture Far-Infrared Telescope**
Paul Goldsmith[1], B. Khayatian[1], C. M. Bradford[1], M. Dragovan[1], W. Imbriale[1], R. Lee[1], C. Paine[1], H. Yorke[1], J. Zmuidzinas[1]
[1]JPL.

056.03 **Science Priorities of the RadioAstron Space VLBI Mission**
Glen Langston[1], N. Kardashev[2], International Space VLBI Collaboration
[1]NRAO, [2]Astro Space Center, Russian Federation.

056.04 **Telescope to Observe Planetary Systems (TOPS): A High Efficiency Coronagraphic 1.2-m Visible Telescope**
Olivier Guyon[1], J. R. Angel[2], C. Bowers[3], J. Burge[2], A. Burrows[2], J. Codona[2], T. Greene[4], M. Iye[5], J. Kasting[6], H. Martin[2], D. W. McCarthy[2], V. Meadows[7], M. Meyer[2], E. A. Pluzhnik[1], N. Sleep[8], T. Spears[9], M. Tamura[5], D. Tenerelli[10], R. Vanderbei[11], B. Woodgate[3], R. A. Woodruff[10], N. J. Woolf[2]
[1]Subaru Telescope, [2]University of Arizona, [3]NASA GSFC, [4]Ames Research Center, [5]National Astronomical Observatory of Japan, Japan, [6]Pennsylvania State University, [7]IPAC, [8]Stanford University, [9]LOGYX, [10]Lockheed Martin, [11]Princeton University.

056.05 **Availability of Calibration Sources for Measuring Spacecraft Angular Position with Sub-Nanoradian Accuracy**
Walid A. Majid[1], D. Bagri[1]
[1]JPL/Caltech.

056.07 **Future In-Space Operations for Astronomy**
Harley A. Thronson[1]
[1]NASA Goddard Space Flight Center.

057: Young Stellar Objects
AAS Oral, 2:00-3:30pm, 6C

057.02 **Mid-IR Spectral Survey of High Mass Protostellar Objects**
Murray F. Campbell[1], T. K. Sridharan[2], J. L. Hora[2], M. Kassis[3], H. Beuther[4], R. T. Brooks[1], S. Fung[1], L. C. Johnson[1], J. M. De Buizer[5]
[1]Colby College, [2]Center for Astrophysics, [3]Keck Observatory, [4]Max-Planck-Institut fur Astronomie, Germany, [5]Gemini Observatory, Chile.

057.05 **Gemini NIFS Integral Field Spectroscopy of YSO Environments: Spatially Extended Molecular Hydrogen Emission in the Inner 200 AU**
Tracy L. Beck[1], P. McGregor[2], M. Takami[3]
[1]Gemini North Observatory, [2]RSA&A, Australian National University, Australia, [3]Subaru Observatory.

057.06 **Application of Medical Imaging Software to the 3D Visualization of Astronomical Data**
Michelle A. Borkin[1], A. A. Goodman[2], M. Halle[3], D. Alan[1], J. Kauffmann[2]
[1]Initiative in Innovative Computing, Harvard University, [2]Initiative in Innovative Computing/ Harvard Smithsonian Center for Astrophysics, [3]Initiative in Innovative Computing/ Harvard Medical School.

57.01 **A Wide-field Search for Intermediate-age Pre-Main Sequence Stars near Taurus and Upper Scorpius**
Catherine L. Slesnick[1], J. M. Carpenter[1], L. A. Hillenbrand[1]
[1]Caltech.

57.03 **The Evolution of the Multiplicity of Young Stellar Objects**
Michael S. Connelley[1], B. Reipurth[1], A. Tokunaga[1]
[1]Univ. of Hawaii.

57.04 **The State and Evolution of Isolated Dense Molecular Cores**
Jens Kauffmann[1]
[1]Harvard-Smithsonian CfA.

058: Context Rich Lab Problems
AAPT Oral, 2:00-3:30pm, 617

Chair
Terry Singleton[1]
[1]University of Alberta, Canada.

058.01 **Undergraduate Labs for Biological Physics: Brownian Motion and Optical Trapping**
Kelvin Chu[1], A. Laughney[1], J. Williams[1]
[1]University of Vermont.

058.02 **Alternatives to Traditional Labs: a Discovery Lab Based on A***nalogy*
Mark I. Liff[1]
[1]Philadelphia University.

058.03 **Student Understanding Difficulties Research-based on Conceptual and Numerical Labs**
Sergio Flores[1]
[1]University of Juarez.

058.04 **Teaching Optics Topics in College Physics Laboratory***
Roman Y. Kezerashvili[1]
[1]Physics Department, New York City College of Technology, CUNY.

058.05 **A Laboratory on Pulse Trains, Counting Statistics, and the Central Limit Theorem for Physics Students**
David B. Pengra[1]
[1]University of Washington.

058.06 **Crafting a Gauss Gun Demonstration**
Matthew E. Blodgett[1], E. D. Blodgett[1]
[1]University of Wisconsin River Falls.

058.07 **Using a Tube of Fire to Demonstrate Various Gas and Wave Properties.**
Don B. Cameron[1]
[1]University of Denver High School.

058.08 **My Top Ten List of Labs and Demonstrations**
Paul Robinson[1]
[1]San Mateo High School.

058.09 **My Most Annoying Demonstration**
Joseph M. Mosca[1]
[1]Embry-Riddle Aeronautical University.

059: Innovations in High School Physics, Part II
AAPT Oral, 2:00-3:30pm, 307-08

Chair
Eric C. Muhs[1]
[1]Roosevelt High School.

059.01 **Keeping Seniors Engaged During The Last Week Of School**
Thomas F. Haff[1]
[1]Issaquah High School.

059.02 **Thank You for Flying the Vomit Comet**
Gregory A. DiLisi[1], R. Dempsey[2], L. A. DiLisi[3], G. Santo[4]
[1]John Carroll University, [2]Johnson Space Center, [3]Parker Hannifin Corporation Nichols Airborne Division, [4]Beaumont High School.

059.03 **Physics on Wheels: Teaching Mechanics by Riding a Bicycle**
Hezi Yizhaq[1], G. Baran[1]
[1]Environmental High School, Israel.

059.04 **High School Student Scientists Researching Pulsars at the CGWA**
Adrienne Rodriguez-Zermeno[1]
[1]University of Texas at Brownsville.

059.05 **Metricize Yourself**
Maria K. Falbo[1]
[1]Cardinal Gibbons High School.

059.06 **Mini-Labs**
Marc Kossover[1]
[1]The Jewish Community High School of the Bay.

059.07 **International Physics Summer Camp for High School Students**
Damian T. Pope[1], B. Korsunsky[2]
[1]Perimeter Institute for Theoretical Physics, Canada, [2]Weston High School.

059.08 **Student Measurements of Cosmic Rays on an International Scale**
Robert S. Peterson[1]
[1]QuarkNet/Education Office | Fermi National Accelerator Lab.

059.09 **The Next Best Thing to Having Your Own Accelerator: How QuarkNet Can Help**
Kris Whelan[1]
[1]Lawrence Berkeley National Laboratory.

060: Physics Education with Vpython
AAPT Poster, 2:00-3:30pm, 303

Chair
Ruth Chabay[1]
[1]North Carolina State University.

060.01 **Using VPython to Apply Mathematics to Physics in Mathematical Methods**
Dedra Demaree[1], J. Eagan[1], P. Finn[1], B. Knight[1], J. Singleton[1], A. Therrien[1]
[1]College of the Holy Cross.

060.02 **VPython applications for Teaching Physics**
Roberto B. Salgado[1]
[1]Syracuse University Department of Physics.

060.03 **Charming VPythong Simulations**
Eric W. Pepin[1], R. P. Olenick[1]
[1]University of Dallas.

060.04 **Visual Basic VPython Interface: Charged Particle in a Magnetic Field**
Chandra Prayaga[1]
[1]University of West Florida.

061: Faint Structures in Nearby Galaxies
Plenary, 3:40-4:30pm, Ballroom 6

061.01 **Faint Structures in Nearby Galaxies: Studies of Galaxy Formation at z=0**
Julianne Dalcanton[1]
[1]Univ. of Washington.

062: The Assembly of Galaxies and Their Black Holes
Plenary, 4:40-5:30pm, Ballroom 6

062.01 **The Assembly of Galaxies and Their Black Holes: A New Paradigm for Hierarchical Galaxy Formation?**
Rachel S. Somerville[1]
[1]Max-Planck-Institut fuer Astronomie, Germany.

Astronomy and Astrophysics Advisory Committee
AAS Town Hall Meeting, 5:30-6:30pm, 6B

The Astronomy and Astrophysics Advisory Committee (AAAC) was constituted by Congress with OMB and agency support to advise both the Congress and the three Agencies supporting astronomy and astrophysics research programs, NASA, NSF, and DOE. The enabling legislation requires the AAAC to advise on (1) the coordination of programs in astronomy and astrophysics between the three agencies, and (2) the status of the Decadal Survey and like NRC reports. The committee is required to submit an annual report to Congress and the heads of the agencies with findings and recommendations in these areas. Since this report must be submitted by March 15, input from the community at the AAS meeting in January would be most valuable and appreciated by the committee. The last discussion was very late in the day and was not well attended; the goal here is to provide a further opportunity to involve the AAS membership in discussions with the committee members and the agency representatives who can attend about a broad range of issues affecting astronomy programs at the three agencies.

Chair
Garth D. Illingworth[1]
[1]UC, Santa Cruz.

SIM PlanetQuest: A Space-Based Facility for Ultra-Precise Astrometry

AAS Splinter Meeting, 6:00-8:00pm, 6E

The President's Vision for Space Exploration calls for NASA to "conduct advanced telescope searches for Earth-like planets and habitable environments around other stars." The primary missions in these searches are Navigator Program missions - SIM PlanetQuest, and the Terrestrial Planet Finder Missions (TPF-C and TPF-I). Other observatories also play important roles in exploring the field of extrasolar planets: e.g. Kepler, Spitzer Space Telescope, JWST, the Keck and LBT Interferometers, and other ground-based observatories. In this session, we will recap some recent science results and show how the various techniques and instruments each play important roles in advancing our understanding in this rich field of research.

Chair

Stephen C. Unwin[1]
[1]*JPL.*

063: The Future of the Core Curriculum

AAPT Invited, 6:30-8:00pm, 616

Chair

Michael Theonnessen[1]
[1]*Michigan State University.*

063.01 **The Future of the Core Curriculum in Graduate Education**

Michael Thoennessen[1]
[1]*Michigan State University.*

064: When Was the Last Time 5000 College Students Gave You Feedback on Your High School Physics Course?

AAPT Invited, 6:30-8:00pm, 307-08

Chair

Wayne Fisher[1]
[1]*Myers Park High School.*

064.01 **Does Taking Physics Pay Off Later in Chemistry and Biology Courses?**

Philip M. Sadler[1], R. H. Tai[2]
[1]*Harvard-Smithsonian Center for Astrophysics,* [2]*University of Virginia.*

064.02 **High School Teaching and College Performance: Looking for Connections**

Robert H. Tai[1]
[1]*Univ. of Virginia.*

064.03 **Gender Differences in Introductory University Physics Performance: The Influence of High School Physics Preparation and Affect**

Zahra Hazari[1]
[1]*Harvard Smithsonian Center for Astrophysics.*

065: Astronomy and the Two-Year Colleges

AAPT Special, 6:30-8:00pm, 615

Chair

Theo Koupelis[1]
[1]*University of Wisconsin Colleges.*

065.01 **Community College's CAN do Research A Decade of Eclipse Expeditions**

Jon M. Saken[1]
[1]*Appalachian State Univ..*

065.02 **What's in the Neighborhood?: Using Science/Technology/Society (STS) Instructional Strategies in an Introductory Community College Astronomy Class**
Lawrence R. Kellerman[1]
[1]*Illinois Central College.*

065.03 **NASA Center for Astronomy Education: Building a Community of Practice**
Gina Brissenden[1], E. Prather[1], T. F. Slater[1], W. M. Greene[2], M. Thaller[3]
[1]*Univ. of Arizona,* [2]*JPL,* [3]*CalTech.*

065.04 **Teaching Astronomy at Lewis and Clark Community College**
David A. Cornell[1]
[1]*Principia College.*

065.05 **Free Resources for Teaching with Technology**
Michelle A. Strand[1]
[1]*Southeast Community College.*

066: Effective Features of Online Tutorials

AAPT Special, 6:30-7:30pm, 303

Chair
Gerald W. Meisner[1]
[1]*UNC Greensboro.*

066.01 **PhET's Research-based Guidelines for Design and Use of Interactive Simulations**
Katherine K. Perkins[1], W. K. Adams[1], C. E. Wieman[1], PhET Team
[1]*University of Colorado at Boulder.*

066.02 **Virtual Labs and Virtual Worlds**
Ted Boehler, Ed.D.[1]
[1]*Coastline Community College.*

066.03 **Electric Circuits in a Virtual Environment**
Gerald W. Meisner[1], H. Hoffman[2], M. Turner[3]
[1]*UNC Greensboro,* [2]*Science Lab Courseware,* [3]*Hebrew Academy.*

066.05 **Measuring Learning from hints in Web-based Socratic Tutor**
Young-Jin Lee[1], D. E. Pritchard[1]
[1]*Massachusetts Institute of Technology.*

066.06 **Impact of Inquiry-Oriented Curriculum Materials Modified to Provide Better Access for Special Needs Students**
Julia K. Olsen[1], T. F. Slater[1]
[1]*University of Arizona.*

067: High School Curriculum Issues

AAPT Oral, 6:30-8:00pm, 310

Chair
Beverly Cannon[1]
[1]*Highland Park HS.*

067.01 **Active Physics Problem Based Learning for High Schools**
Arthur Eisenkraft[1]
[1]*Univ of Massachusetts Boston.*

067.02 *Physics First*: **Why You Should Consider It at Your High School**
Alan P. Gnospelius[1]
[1]*Design and Technology Academy.*

067.03 **A TIME for Physics First in Missouri**
Meera Chandrasekhar[1], K. Manivannan[2], D. Kosztin[1], S. Torres[3]
[1]University of Missouri, [2]Missouri State University, [3]Columbia Public Schools.

067.04 **What To Do After The AP Test: How About Household Electricity?**
John P. Lewis[1]
[1]Glenbrook South High School.

067.05 **Introduction to Physics of the Universe in AP Physics Classrooms**
Stephanie L. Allen[1]
[1]Hope College.

067.06 **Using the Hypothesis Method in Learning Physics**
Genrikh Golin[1]
[1]Touro College & Franklin Delano Roosevelt HS.

067.07 **Inservice Preparation of High School Physics Teachers**
Stephen T. Thornton[1], R. A. Lindgren[1]
[1]University of Virginia.

068: Insights into Mechanics and Sound
AAPT Oral, 6:30-8:00pm, 617

Chair
G. Samuel Lightner[1]
[1]Westminster College.

068.01 **Some Aspects of the Physics of Shooting a Basketball**
John J. Fontanella[1]
[1]U. S. Naval Academy.

068.02 **Period-Speed Analysis of a Pendulum**
Barbara M. Hoeling[1], Y. Kostov[1], R. Morshed[1], P. Siegel[2]
[1]Pomona College, [2]Cal Poly Pomona.

068.03 **Optical Measurement of the Acceleration Due to Gravity**
Bill Crummett[1]
[1]Centre College.

068.04 **Why the Magnetic Levitation can be Observed only in a Constrained Case in PASCO's Magnetic Levitation Apparatus?**
Xiao Xie[1], P. P. Gu[1], Z. Y. Wang[1], Z. Xie[1]
[1]Hunan University, China.

068.05 **Wavelength Dependent End Correction for a Resonating Air Column**
Henry Kuhlman[1], C. Hansen[1]
[1]Southern Adventist University.

068.06 **Amplifier Distortion**
David Keeports[1]
[1]Mills College.

068.07 **Exact Relativistic to Non-Relativistic Transformation via an Effective Potential**
James P. Crawford[1], J. Shubila[1]
[1]Penn State University.

068.08 **New Ideas for Teaching Relativity: a unified derivation of the Doppler Effect**
Roberto B. Salgado[1]
[1]Syracuse University Department of Physics.

069: AIP Gemant Award Lecture
Plenary, 7:00-8:30pm, Ballroom 6

Dr. Jim Stith of AIP, make present the award and introduce Marcia Bartusiak. Ms. Bartusiak is the author of numerous popular books on astronomy and cosmology, including "Einstein's Unfinished Symphony," "Thursday's Universe," "Through A Universe Darkly" and most recently, "Archives of the Universe." The award is given to individuals who have linked physics to the arts and humanities. Previous winners include Philip Morrison, Freeman T. Dyson, Gerald Holton, Jeremy Bernstein, Cyril Stanley Smith, Martin Aitken, and Abraham Pais.

Chair
James J. Stith[1]
[1]American Institute of Physics.

069.01 **Einstein's Legacy to Astronomy: From Black Holes to the Expanding Universe**
Marcia Bartusiak[1]
[1]MIT.

SPS/AAPT/AAS Undergraduate Science Evening
Joint Event, 7:00-9:00pm, 6A

The AAS Education Office and the AIP/Society of Physics Students are sponsoring an "Evening with Scientists" for all undergraduates attending the AAS/AAPT Joint Meeting on Sunday Night from 7 to 9 pm. Two notable astronomers will give short (20 mins) presentations on their peresonal experiences as scientists, their perpectives on the field and their own research. Dinner, in the form of pizza, burritos and other student favorites will be provided. Undergraduates are invited to put up their posters for an hour of informal discussion with each other and the featured speakers to get a perspective on Astronomy that is often overlooked at large meetings.

Chair
Susana E. Deustua[1]
[1]American Astronomical Society.

542.002 Chair
Gary White[1]
[1]American Institute of Physics.

MONDAY

Speaker Ready Room
Attendee Services,
Monday, 7:30am-6:00pm, 603-04

See Saturday's listing for AV instructions.

Chair
Rick Matthews[1]
[1]American Audio Video.

Cyber Café
Attendee Services, 8:00am-6:30pm, South Lobby

See Sunday's listing for details.

Registration
Attendee Services, 8:00am-5:00pm, South Lobby
Chair
Laronda Boyce[1]
[1]AAS.

070: The Coming Revolutions in Particle Physics
Plenary, 8:30-9:20am, Ballroom 6
Chair
Lila Adair[1]
[1]Piedmont College.

070.01 **The Coming Revolutions in Particle Physics**
Chris Quigg[1]
[1]Fermi National Accelerator Laboratory.

071: Poster Session II
AAPT Poster, 9:20am-6:30pm, Exhibit Hall 4

071.01 **Student Exploration of Scientific Literature**
Erin K. McCamish[1], T. McKay[1], M. Geramita[1], E. Percha[1]
[1]University of Michigan.

071.02 **Inquiry-Based, Hands-on In-class Astronomy Activities**
Rebecca Lindell[1], T. Foster[1]
[1]Southern Illinois University Edwardsville.

071.03 **Innovate Use of SCALE-UP for Teaching General Education Astronomy**
Luke Keller[1], M. Rogers[1]
[1]Ithaca College.

071.04 **Promoting Stellar Writing: An Astronomy/English Learning Community**
Frank Dudish[1], R. Lacina[1]
[1]Delta College.

071.05 **An Upper-Division Astronomy Laboratory Course for Undergraduate Physics Majors**
David M. Kuehn[1], B. L. Davis[1]
[1]Pittsburg State University.

071.06 **A New Chart and Teaching Materials on Cosmology from CPEP**
G Samuel Lightner[1], M. Cherney[2], G. Aubrecht[3], R. Reiland[4]
[1]Westminster College, [2]Creighton University, [3]The Ohio State University, [4]Shady Side Academy.

071.07 **Investigating Neglected Double Stars**
R Kent Clark[1], J. M. Sanders[1], J. Guidry[1], J. Pearce[1]
[1]University of South Alabama.

071.08 **Simulating the Retention of an Atmosphere**
Kevin M. Lee[1], C. M. Siedell[1], A. N. Davis[1]
[1]University of Nebraska.

071.09 **Citizen-Scientists Monitor Light Pollution Worldwide via "GLOBE at Night"**
Constance E. Walker[1], S. M. Pompea[1], D. Isbell[1], D. Orellana[2], D. Ward[3], S. Henderson[3], K. Meymaris[3], S. Gallagher[3], D. Salisbury[4]
[1]National Optical Astronomy Observatory, [2]Centro de Apoyo a la Didáctica de la Astronomía (CADIAS), Chile, [3]UCAR, [4]CSU.

071.10 **Student-Scientists use Remote Sensing to Reach across the Equator**
Constance E. Walker[1], R. Probst[1], C. Martin[2], B. Dorame[2], D. Isbell[1], S. M. Pompea[1], H. Ochoa[3], D. Orellana[4], A. Garcia[5]
[1]National Optical Astronomy Observatory, [2]Howenstine Magnet High School, [3]Cerro Tololo Inter-American Observatory, Chile, [4]Centro de Apoyo a la Didáctica de la Astronomía (CADIAS), Chile, [5]Gemini Observatory, Chile.

071.11 **NASA's Gravity Probe B Mission: Was Einstein Right?**
Shannon K. Range[1]
[1]NASA's Gravity Probe B at Stanford University.

071.12 **Using the Astronomy Diagnostic Test to Identify Students' Preconceptual Knowledge**
Dennis M. Robbins[1], S. Tribiano[1], K. Ford[1], B. McKernan[1]
[1]Borough of Manhattan Community College.

071.13 **Interactive Lecture Experiments in Large Introductory Physics Classes**
Marina M. Milner-Bolotin[1], A. Kotlicki[1], G. Rieger[1], F. Bates[1], R. Moll[1], K. McPhee[1], S. Nashon[1]
[1]University of British Columbia, Canada.

071.14 **Web administered pre/post assessment: reliability, compliance and security**
Scott W. Bonham[1]
[1]Western Kentucky University.

071.15 **Physics Applets for Drawing in the classroom**
Scott W. Bonham[1]
[1]Western Kentucky University.

071.16 **Active Learning with Ubiquitous Presenter and Tablet PCs**
Edward Price[1], B. Simon[2]
[1]California State University, San Marcos, [2]University of California, San Diego.

071.17 **Simulation-Based e-Learning Tools for Science,Engineering, and Technology Education(SimBeLT)**
Doyle V. Davis[1], Y. Cherner[2]
[1]New Hampshire Community Technical College, [2]ATeL, LLC.

071.18 **Study of Interface Design for Engagement and Learning with Educational Simulations**
Wendy K. Adams[1], S. Reid[1], R. LeMaster[1], S. McKagan[1], K. Perkins[1], C. E. Wieman[1]
[1]University of Colorado.

071.19 **Advanced Modeling in Excel: from Water Jets to Big Bang**
Olga Ignatova[1], D. Chyzhyk[2], C. Willis[3], A. Kazachkov[1]
[1]V.Karazin Kharkiv National University, Ukraine, [2]Kharkiv National University of Radio-Electronics, Ukraine, [3]University of Northern Colorado.

071.20 **Develpoing computer program for calculating magnetic fields**
Wook Hee Koh[1], A. Koh[2]
[1]Hanseo University, Republic of Korea, [2]Irvine Valley College.

071.21 **Data Acquisition with Mathematica**
Wesley W. Bliven[1], N. Fitch[2], P. Tam[1]
[1]Humboldt State Univ, [2]University of Colorado at Boulder.

071.22 **Teaching Computational Physics Using Spreadsheets**
Jaebong Lee[1], K. Shin[1], S. Lee[1]
[1]Seoul National Univ., Republic of Korea.

071.23 **Doing Physics with Spreadsheets: Old Tricks for New Dogs**
A. John Mallinckrodt[1]
[1]Cal Poly Pomona.

071.24 **Bouncing Ball Video Analysis: The Conservation of Mechanical Energy**
Joel A. Bryan[1]
[1]*Texas A&M University.*

071.25 **Changing Student Attitudes using Andes, An Intelligent Homework System**
Brett van de Sande[1], K. VanLehn[1], D. Treacy[2], R. Shelby[2]
[1]*University of Pittsburgh,* [2]*US Naval Academy.*

071.26 **Using the Motion Visualizer Family of Programs to Enhance Classroom and On-Line Learning**
James E. Trimble, Jr[1]
[1]*University of Tennessee.*

071.27 **Choosing the Right Mixture of Techniques and Technologies**
Todd K. Timberlake[1]
[1]*Berry College.*

072: AGNs, QSOs and Active Galaxies 1
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

072.01 **Redshift Effects on the Spectroscopic Properties of Active Galaxies**
Kelly Wallenstein[1], E. C. Moran[2]
[1]*Wellesley College,* [2]*Wesleyan University.*

072.02 **Applications Of Spectral Principle Component Analysis In AGN Research: Sample Selection and Beyond**
Zhaohui Shang[1], M. Brotherton[1]
[1]*Univ. Of Wyoming.*

072.03 **Quasar Metallicities and Host Galaxy Evolution**
Simon E. Leah[1], F. W. Hamann[1]
[1]*University of Florida.*

072.04 **Quasar Environments in the Sloan Digital Sky Survey**
Amanda Haapala[1], J. Scott[1]
[1]*Towson University.*

072.05 **Magnetorotational Instability in Strongly Magnetized Plasmas**
Vladimir I. Pariev[1], V. V. Mirnov[1], S. C. Prager[1]
[1]*Univ. Of Wisconsin-Madison.*

072.06 **Discovery of Bright Quasars at Low Galactic Latitude**
Induk Lee[1], M. Im[1]
[1]*Seoul National University, Republic of Korea.*

072.07 **Clustering of z=3 AGN in MUSYC-ECDFS**
Harold Francke[1], E. Gawiser[2], P. Lira[1], S. Virani[2], E. Treister[3], C. M. Urry[2], MUSYC Collaboration
[1]*Universidad de Chile, Chile,* [2]*Yale University,* [3]*European Southern Observatory, Chile.*

072.08 **Optical Variability of Infrared Power Law-Selected Galaxies & X-ray Sources in the GOODS South Field**
Alison J. Klesman[1], V. L. Sarajedini[1]
[1]*Univ. Of Florida.*

072.09 **Intrinsic Absorption in the HST Archive I: Search for Time Variable Systems**
Catherine Grier[1], M. Hawthorn[2], R. Ganguly[3], J. C. Charlton[4], M. Eracleous[4], K. R. Sembach[5]
[1]*University of Illinois at Urbana-Champaign,* [2]*Cambridge, United Kingdom,* [3]*University of Wyoming,* [4]*Penn State,* [5]*STScI.*

072.10 **Intrinsic Absorption in the HST Archive II: Partial Covering and Associated O VI Systems**
Rajib Ganguly[1], R. S. Lynch[2], J. C. Charlton[2], M. Eracleous[2], T. M. Tripp[3], C. Palma[2], K. R. Sembach[4], T. Misawa[2], J. R. Masiero[5], N. Milutinovic[6], T. M. Jones[2]
[1]Univ. of Wyoming, [2]Penn State University, [3]UMass, [4]STScI, [5]University of Hawaii, [6]University of Victoria, Canada.

072.11 **Dust Lanes, Nuclear Dusty Disks, and Isophotal Properties as Observed by HST: What Do They Tell Us about the 3-D Structure of Elliptical Radio Galaxy Hosts?**
Grant R. Tremblay[1], M. Chiaberge[1], C. J. Donzelli[1], W. B. Sparks[1], A. C. Quillen[2]
[1]Space Telescope Science Institute, [2]Department of Physics and Astronomy, University of Rochester.

072.12 **Probing the Assembly of Massive Galaxies via Quasar Hosts at z=4**
Kim K. McLeod[1], J. Bechtold[2], B. A. McLeod[3], S. Kimmel[4], T. Sepersky[1], R. Stoll[1], A. Zangari[1]
[1]Wellesley College, [2]Univerity of Arizona, [3]Smithsonian Astrophysical Observatory, [4]Williams College.

072.13 **Monitoring Microlensing Events In the Quasar RX J1131-1231**
George Chartas[1], C. S. Kochanek[2], X. Dai[2], N. Morgan[2], G. P. Garmire[1]
[1]Penn State University, [2]The Ohio State University.

072.14 **3D Simulations of Jet Interactions with Galaxy Cluster Environments**
Sean M. O'Neill[1], T. W. Jones[1], D. Ryu[2]
[1]Univ. of Minnesota, [2]Chungnam National University, Republic of Korea.

072.15 **AGN near Weak Lensing Selected, X-ray Confirmed Galaxy Clusters**
Dara J. Norman[1], Deep Lens Survey Collaboration
[1]NOAO/CTIO.

072.16 **FeII(UV)/MgII Ratio versus Luminosity in QSOs**
Ekaterina Verner[1], F. Bruhweiler[1], B. Peterson[2]
[1]Catholic University of America, [2]Siding Spring Observatory, Australia.

072.17 **Are There Low Radiative Efficiency Accretion Disks in Low Luminosity AGN?**
Marco Chiaberge[1], D. Macchetto[2]
[1]Space Telescope Science Institute, [2]Space Telescope Science Institute ESA.

072.18 **Broad Line Regions in Low Luminosity Radio Galaxies: is the Distinction Between Broadand Narrow-Line Galaxies Real?**
Jacob Noel-Storr[1], S. A. Baum[1], C. P. O'Dea[1]
[1]Rochester Inst. of Technology.

072.19 **Optical Ensemble Variability of Low to Moderate Redshift Galaxies in the Sloan Digital Sky Survey**
Tyler D. Desjardins[1], V. L. Sarajedini[1]
[1]Univ. Of Florida.

072.20 **Study of X-ray Spectral Parameters from Large Sample of RXTE Active Galaxies**
Barbara Mattson[1], K. Weaver[1], C. Reynolds[2]
[1]NASA's GSFC, [2]University of Maryland.

072.21 **An Archival HST Survey for Ultrafaint QSOs**
Bernhard Beck-Winchatz[1], S. F. Anderson[2]
[1]DePaul University, [2]University of Washington.

072.22 **The Broadband X-Ray Spectral Features of a Sample of Seyfert 1 Galaxies**
Urmila Padmanabhan[1], K. A. Weaver[2], T. Yaqoob[1]
[1]Johns Hopkins University, [2]GSFC.

072.23 **Quantification of Quasar Environments via Absorption Spectra**
Colleen M. McIntosh[1], J. Scott[1]
[1]Towson Univ..

072.24 **Studies of Quasar Variability With the Sloan Digital Sky Survey**
Brian C. Wilhite[1], R. J. Brunner[1], B. F. Lundgren[1], C. J. Grier[1]
[1]University of Illinois.

072.25 **The Proximity Effect and the UV Background at z~4**
Jennifer E. Scott[1], J. Bechtold[2]
[1]Towson Univ., [2]University of Arizona.

072.26 **A Search for the Earliest Luminous Quasars**
Eilat Glikman[1], S. G. Djorgovski[1], A. A. Mahabal[1], M. J. Graham[1], D. Thompson[1], G. Meylan[2], A. Eigenbrod[2], F. Courbin[2]
[1]Caltech, [2]EPFL, Switzerland.

072.27 **Observation of the GZK Cutoff by the HiRes Experiment**
Stefan Westerhoff[1], B. Connolly[1]
[1]Columbia University.

073: Astronomers in Public Education
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

073.01 **The Beyond Einstein Explorers' Program (BEEP) Getting Astronomers Involved in Afterschool Activities**
Anita Krishnamurthi[1], B. Barbier[2], S. Mitchell[2], J. Lochner[3]
[1]NASA GSFC/University of Maryland, [2]NASA GSFC/SP Systems, Inc., [3]NASA GSFC/USRA.

074: Astronomy and Astrophysics with LISA
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

074.01 **LISA: Probing the Universe with Gravitational Waves**
Thomas A. Prince[1], P. Binetruy[2], J. Centrella[3], L. S. Finn[4], C. Hogan[5], G. Nelemans[6], E. S. Phinney[7], B. Schutz[8], LISA International Science Team
[1]Caltech/JPL, [2]APC College de France, France, [3]GSFC, [4]Penn State University, [5]University of Washington, [6]Radboud University Nijmegen, The Netherlands, [7]Caltech, [8]Max-Planck-Institut fur Gravitationsphysik, Germany.

074.02 **LISA Mission Architecture**
Nicholas M. Jedrich[1], R. T. Stebbins[1], J. C. Livas[1], S. M. Merkowitz[1], R. G. Mink[1]
[1]NASA.

074.03 **The LISA Pathfinder Mission**
Robin T. Stebbins[1], LISA Pathfinder Science Team
[1]NASA Goddard Space Flight Center.

074.04 **System Validation and Verification Testing for the Laser Interferometry Space Antenna (LISA)**
Jeffrey C. Livas[1], N. Jedrich[1], S. M. Merkowitz[1], R. T. Stebbins[1]
[1]NASA's GSFC.

074.05 **Cancellation of the LISA Antenna Distortions due to the Earth**
Peter L. Bender[1]
[1]JILA, Univ. of Colorado and NIST.

074.06 **Measurements of Forces Between Surfaces for LISA**
Scott E. Pollack[1], S. Schlamminger[1], C. A. Hagedorn[1], J. H. Gundlach[1]
[1]*University of Washington.*

074.07 **Modular Gravitational Reference Sensor for High Precision Astronomical Space Missions**
Ke-Xun Sun[1], G. Allen[1], S. Buchman[1], R. L. Byer[1], J. W. Conklin[1], D. B. DeBra[1], D. Gill[1], A. Goh[1], S. Higuchi[1], P. Lu[1], N. Robertson[1], A. Swank[1]
[1]*Stanford Univ..*

074.08 **Tracking Cosmological Black Hole Mergers with LISA**
Ryan N. Lang[1], S. A. Hughes[1]
[1]*MIT.*

074.09 **Modeling Binary Black Hole Mergers**
John G. Baker[1]
[1]*NASA/GSFC.*

074.10 **Observing Massive Black Hole Binaries with LISA**
Sean McWilliams[1]
[1]*NASA GSFC.*

074.11 **Population Boundaries for Evolving White Dwarf Binaries on the LISA Sensitivity Curve**
Kopparapu R. Kumar[1], V. Gokhale[1], J. Frank[1], J. E. Tohline[1]
[1]*Louisiana State Univ..*

074.12 **Tidal Effects in Inspiraling Double White Dwarfs**
Vicky Kalogera[1], B. Willems[1], B. Hansen[2]
[1]*Northwestern University,* [2]*UCLA.*

074.13 **Gravitational Waves from Cosmic Superstrings**
Craig J. Hogan[1]
[1]*Univ. of Washington.*

074.14 **The Mock LISA Data Challenges: First Results and Future Prospects**
Michele Vallisneri[1], Mock LISA Data Challenge Taskforce
[1]*Jet Propulsion Laboratory.*

074.15 **Listening to the Universe with the Laser Interferometer Space Antenna**
Neil J. Cornish[1], J. Crowder[2], E. Porter[3]
[1]*Montana State Univ.,* [2]*Jet Propulsion Laboratory,* [3]*Albert Einstein Institutue, Germany.*

074.16 **Bayesian Inference and Observations of Massive Black-hole Binaries with LISA**
Marc Van der Sluys[1], A. Stroeer[2], A. Vecchio[2], V. Kalogera[1]
[1]*Northwestern University,* [2]*Northwestern University, University of Birmingham.*

074.17 **An Application of the Hilbert-Huang Transform to the LISA Mock Data Challenge**
John K. Cannizzo[1], J. Camp[2]
[1]*NASA/GSFC/UMBC,* [2]*NASA/GSFC.*

074.18 **Coated Fused Silica Fibers for Enhanced Sensitivity Torsion Pendulum**
Kenji Numata[1]
[1]*Univ. of Maryland/NASA-GSFC.*

075: Astronomy Research by Students of All Ages and the Public
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

075.01 **The Use of a High School Observatory to Augment Our Understanding of the Metallicity Dependence of the Cepheid Period-Luminosity Relation**
James Young[1], S. Scott[1], S. Kanbur[1], A. ominsky[2], C. Ngeow[3]
[1]SUNY Oswego, [2]SOuthern Cayuga High School Observatory, [3]University of Illinois.

075.02 **The Arecibo Remote Command Center: Involving Students in Major Astronomical Research**
Andy Miller[1], A. Rodriguez-Zermeno[1], F. Jenet[1]
[1]Center for Gravitational Wave Astronomy/ Univ. Texas at Brownsville.

075.03 **Space Science Lab at PARI**
Michael W. Castelaz[1], M. Blake[1], D. Clavier[1], C. Whitworth[1], J. D. Cline[1]
[1]Pisgah Astronomical Research Inst..

075.04 **The CUREA Program at Mount Wilson**
Paula C. Turner[1], J. C. LoPresto[2], M. Simmons[3]
[1]Kenyon College, [2]Edinboro University of Pennsylvania, [3]Mount Wilson Observatory Association.

075.05 **Astrophysical and Planetary Science Research at Four Minority Institutions**
Donald K. Walter[1], L. P. Johnson[2], S. A. Austin[2], C. Salgado[3], P. A. Morris[4]
[1]South Carolina State Univ., [2]Medgar Evers College, [3]Norfolk State University, [4]University of Houston Downtown.

075.06 **Research-Infused STEM Reform at South Carolina State University**
Daniel M. Smith, Jr.[1], J. A. Anderson[1], K. Adzievski[1]
[1]South Carolina State University.

075.07 **Education and Public Outreach for Stardust@home: An Interactive Internet-based Search for Interstellar Dust**
Bryan J. Mendez[1], A. J. Westphal[1], A. L. Butterworth[1], N. Craig[1]
[1]UC Berkeley.

075.08 **THEMIS Education and Outreach Program's Involvement in Authentic Science in the classroom.**
Nahide G. Craig[1], L. M. Peticolas[1], V. Trautman[2]
[1]UC, Berkeley, [2]Petersburg City Schools.

076: Circumstellar Disk Models
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

076.01 **Accretion of Terrestrial Planets from Oligarchs in a Turbulent Disk**
Masahiro Ogihara[1], S. Ida[1], A. Morbidelli[2]
[1]Tokyo Institute of Technology, Japan, [2]Observatory of Nice, France.

076.02 **Disks in Transition Around Pre-Main Sequence Stars**
Catherine Espaillat[1], N. Calvet[1], L. Hartmann[1]
[1]University of Michigan.

076.03 **Modification of Angular Velocity Distribution by Inhomogeneous Growth of MRI in Protoplanetary Disks**
Mariko Kato[1], K. Nakamura[1], R. Tandokoro[1], M. Fujimoto[2], S. Ida[1]
[1]Tokyo Institute of Technology, Japan, [2]JAXA/ISAS, Japan.

076.04 **The behaviors of Kelvin-Helmholtz Instability in protoplanetary disks**
Yusuke Kobayashi[1], K. Nakamura[1], M. Fujimoto[1]
[1]Tokyo Institute of Technology, Japan.

076.05 **Kelvin-Helmholtz vortices induced by MRI at the inner-edge of protoplanetary disks**
Keita Nakamura[1], M. Kato[1], R. Tandokoro[2], M. Fujimoto[3], S. Ida[1], H. Yurimoto[4]
[1]Tokyo Institute of Technology, Japan, [2]FUJITSU LABORATORIES LTD., Japan, [3]ISAS/JAXA, Japan, [4]Hokkaido University, Japan.

076.06 **A Test Suite for 3D Radiative Hydrodynamics Simulations of Protoplanetary Disks**
Aaron C. Boley[1], R. H. Durisen[1], A. Nordlund[2], J. Lord[3]
[1]Indiana University, [2]NBIfA, Denmark, [3]Whitman College.

076.07 **3D Radiative Hydrodynamics Simulations of Protoplanetary Disks: A Comparison Between Two Radiative Cooling Algorithms**
Jesse W. Lord[1], A. C. Boley[2], R. H. Durisen[2]
[1]Indiana University and Whitman College, [2]Indiana University.

076.08 **Monte-Carlo SED Models Of Young Stars With Accretion Disks In Taurus-Auriga and Orion Region**
Thompson S. LeBlanc[1], K. G. Stassun[1], E. L. Jensen[2]
[1]Vanderbilt University, [2]Swarthmore College.

076.09 **Proto Planetary Disk Model Inversion Using Artificial Neural Networks**
Gerald T. Ruch, Jr.[1], D. Wooden[2], C. E. Woodward[1]
[1]Univ. of Minnesota, [2]NASA Ames.

076.10 **Simulating Protoplanetary and Debris Disk's for ALMA**
Robert L. Stone[1]
[1]Radford University and NRAO.

077: Clusters & Cosmology
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

077.01 **First Results from an HST/ACS Snapshot Survey of Intermediate Redshift, Intermediate X-ray Luminosity Clusters of Galaxies: Early Type Galaxies and Weak Lensing**
Christine Trombley[1], M. Donahue[1], S. Bruch[1], C. Conselice[2], B. McNamara[3], H. Hoekstra[4]
[1]Michigan State University, [2]University of Nottingham, United Kingdom, [3]University of Waterloo, Canada, [4]University of Victoria, Canada.

077.02 **Populations of Lyman Break Galaxies in Two Large Quasar Groups at 0.8<z<1.2**
Lutz Haberzettl[1], G. M. Williger[1], J. T. Lauroesch[1], D. Valls-Gabaud[2], C. P. Haines[3], R. G. Clowes[4], L. E. Campusano[5], R. Dave'[6]
[1]University of Louisville Department of Physics and Astronomy, [2]Observatoire Meudon, France, [3]Osservatorio Astronomico di Capodimonte, Italy, [4]University of Central Lancashire, United Kingdom, [5]Universidad de Chile, Chile, [6]University of Arizona.

077.03 **Simulation of the Magnetothermal Instability in 3D and Application to Clusters of Galaxies**
Ian J. Parrish[1], J. M. Stone[1]
[1]Princeton University.

077.04 **Discovery of Distant Galaxy Clusters in the ROX Survey**
Deborah B. Haarsma[1], M. E. Donahue[2], A. R. Butler[1], S. S. Bruch[2], M. Dickinson[3]
[1]Calvin College, [2]MSU, [3]NOAO.

077.05 **THE EVOLUTION OF WEAK MgII ABSORBERS FROM 0 < z < 2.4.**
Anand Narayanan[1], T. Misawa[1], J. C. Charlton[1], T. Kim[2]
[1]Pennsylvania State Univ., [2]Astrophysikalisches Institut Potsdam, Germany.

077.06 **First Results from the XMM/IMACS Groups Project**
John S. Mulchaey[1], Y. Shen[2], J. Rasmussen[3], T. J. Ponman[3], S. Raychaudhury[3]
[1]Carnegie Obs., [2]Princeton University, [3]University of Birmingham, United Kingdom.

077.07 **Mapping the Intergalactic Medium in Chandra Deep Fields**
Lara A. Phillips[1]
[1]Five Colleges Astronomy Department, Amherst College.

077.08 **Chandra Observations of Abell 222 & Abell 223**
David S. Davis[1], M. Henriksen[2]
[1]UMBC/NASA's GSFC, [2]UMBC.

077.09 **Evidence for Evolution in Weak MgII Absorbers at z < 1.5**
Jessica L. Evans[1], C. W. Churchill[1], M. I. Murphy[2], A. M. Widhalm[1]
[1]New Mexico State Univ., [2]University of Cambridge, United Kingdom.

077.10 **The NOAO-XCS Survey Program**
Christopher J. Miller[1], A. K. Romer[2], S. A. Stanford[3], M. Hilton[4], M. Hosmer[5], N. Merhtens[2], XCS Consortium
[1]NOAO/CTIO, Chile, [2]University of Sussex, United Kingdom, [3]Lawrence Livermoore National Laboratory, [4]Liverpool John Moores University, United Kingdom, [5]Univsersity of Sussex, United Kingdom.

077.11 **Chandra Studies of Dark Matter and Galaxy Formation: Signatures from the Intracluster Medium**
Megan Donahue[1], M. Sun[1], K. Cavagnolo[1], G. Voit[1]
[1]Michigan State Univ..

077.12 **The Stellar Populations of Ultra-Compact Dwarf Galaxies**
Arna Karick[1], M. D. Gregg[1]
[1]UC Davis/LLNL.

077.13 **Spatial Probing of MgII Absorption in ″Halo'' Gas through Adaptive Mesh Refinement Simulations of Galaxies**
Christopher W. Churchill[1], G. Kacprzak[1], D. Ceverino[1], J. Evans[1], A. Widhalm[1]
[1]New Mexico State Univ..

077.14 **Cosmic Ray Scattering in Compressible Turbulence**
Andrey Beresnyak[1], A. Lazarian[1]
[1]Univ. of Wisconsin-Madison.

077.15 **Chandra Spectral Analysis of the Intergalactic Gas in the Unusual Cluster RXJ 0419+0225**
Kristina Nyland[1], R. Dupke[1]
[1]Univ. Of Michigan.

077.16 **Sunyaev-Zel'dovich Effect Signals in Cluster Models**
Beth A. Reid[1], D. N. Spergel[1]
[1]Princeton Univ..

077.17 **The Beta Problem: The Incompatibility of X-ray and Sunyaev-Zeldovich Model Fitting**
Jack O. Burns[1], E. Hallman[1], P. Motl[2], M. Norman[3]
[1]Univ. Of Colorado at Boulder, [2]Louisana State University, [3]Univ. of California at San Diego.

077.18 **OVI and HI Around Nearby Galaxies**
Bart P. Wakker[1], B. D. Savage[1], K. R. Sembach[2]
[1]Univ. of Wisconsin, [2]Space Telescope Science Institute.

077.19 **Chandra Observation of the Cluster Environment of a WAT Radio Source in Abell 1446**
Edmund Douglass[1], E. Blanton[1], T. Clarke[2], C. Sarazin[3], M. Wise[4]
[1]Boston University, [2]NRL, [3]University of Virginia, [4]University of Amsterdam, The Netherlands.

077.20 **A Possible Mass-Density and Star Formation Density relation at z=5.7**
Peter L. Capak[1], N. Z. Scoville[1], Y. Taniguchi[2], S. Sasaki[2], S-COSMOS Team
[1]Caltech, [2]Ehime University, Japan.

077.21 **Group Analysis Reveals Previously Unrecognized Patterns in Stellar and Galactic Distributions**
Philip Mocz[1]
[1]Mililani High School.

077.22 **New Statistical Methods to Analyze the SDSS DR5 Galaxy Distribution**
Yongfeng Wu[1], D. Batuski[1], A. Khalil[1]
[1]Univ. of Maine.

077.23 **Exploring Galaxy Environments with Characteristic Field Mapping**
Shannon A. Snider[1]
[1]Michigan State University.

077.24 **A Weak Lensing Study of the Coma Cluster in SDSS**
Jeffrey Kubo[1], J. Annis[1], I. Dell'Antonio[2], H. Khiabanian[2], A. Stebbins[1]
[1]Fermi Nat'l. Accelerator Lab., [2]Brown University.

077.25 **Quantifying Galaxy Cluster Substructure**
David A. Ventimiglia[1], G. M. Voit[1], M. Donahue[1], S. Borgani[2], S. Ameglio[2]
[1]Michigan State University, [2]Università degli Studi di Trieste, Italy.

077.26 **Iron Abundance and Temperature Gradients in High Redshift Galaxy Clusters**
Steven R. Ehlert[1]
[1]Northwestern University.

077.27 **A Detection of Large-scale Intrinsic Alignments and Implications for Cosmic Shear**
Rachel Mandelbaum[1], C. M. Hirata[1], M. Ishak[2], U. Seljak[3]
[1]Institute for Advanced Study, [2]University of Texas (Dallas), [3]Princeton University.

077.28 **Constraining Lambda CDM and Brane-based Cosmologies using Gamma Ray Bursts**
Razieh Behkam[1], J. Rhoads[1]
[1]Arizona State Univ..

077.29 **Understanding a Cosmic Yardstick Simulating Neutral Hydrogen in Disk Galaxies**
Alok Singhal[1], R. Fisher[2], K. O'Neil[2], E. Murphy[3]
[1]National Radio Astronomy Observatory and University of Virginia, [2]National Radio Astronomy Observatory, [3]University of Virginia.

077.31 **The Opposite of Dark Energy: Limits on Ultralight Energy in the Early Universe**
Robert J. Nemiroff[1]
[1]Michigan Technological University.

077.32 **Cosmology with the Cluster Mass Function**
Kenneth J. Rines[1]
[1]Smithsonian Astrophysical Observatory.

078: Computation, Data Handling, and Image Analysis
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

078.01 **Theory SkyNode**
Richard P. Wagner[1], M. L. Norman[1]
[1]UC, San Diego.

078.02 **Datamining the NOAO NVO Portal: Automated Image Classification**
Pooja Vaswani[1], C. J. Miller[2], I. Barg[3], R. C. Smith[3]
[1]University of Arizona, [2]NOAO/CTIO, [3]NOAO.

078.03 **A New Telescope Control System Interface for the HET**
Brandt M. Westing[1], J. R. Fowler[2]
[1]The University of Texas Austin, [2]Hobby-Eberly Telescope/McDonald Observatory.

078.04 **VOEventNet: Event Messaging for Astronomy**
Andrew J. Drake[1], G. Djorgovski[1], M. Graham[1], R. Williams[1], A. Mahabal[1], C. Donalek[1], E. Glikman[1], J. Bloom[2], T. Vastrand[3], R. White[3], D. Rabinowitz[4], C. Baltay[4]
[1]Caltech, [2]UCB, [3]LANL, [4]Yale.

078.05 **Real-time Transients from Palomar-QUEST Synoptic Sky Survey**
Ashish A. Mahabal[1], A. Drake[1], S. G. Djorgovski[1], C. Donalek[1], E. Glikman[1], M. J. Graham[1], R. Williams[1], C. Baltay[2], D. Rabinowitz[2], A. Bauer[2], N. Ellman[2], R. Lauer[2], PQ team (Caltech, Yale, NCSA, Indiana, ...)
[1]Caltech, [2]Yale University.

078.06 **SEDBuilder: A Federating Tool for the Virtual Observatory**
August A. Muench[1], D. Floyd[2], T. Murphy[3], P. Prema[4], R. Sinha[5]
[1]Smithsonian Astrophysical Observatory, [2]STSCI, [3]University of Sydney, Australia, [4]Institute of Astronomy, United Kingdom, [5]IUCAA, India.

078.07 **Status of the CDS Services, SIMBAD, VizieR and Aladin**
Francoise Genova[1], M. G. Allen[1], O. Bienayme[1], T. Boch[1], F. Bonnarel[1], L. Cambresy[1], S. Derriere[1], P. Dubois[1], P. Fernique[1], G. Landais[1], S. Lesteven[1], C. Loup[1], A. Oberto[1], F. Ochsenbein[1], A. Schaaff[1], B. Vollmer[1], M. Wenger[1], M. Louys[2], E. Davoust[3], G. Jasniewicz[4]
[1]Obs. de Strasbourg, France, [2]LSIIT, France, [3]LAT, France, [4]GRAAL, France.

078.08 **An Implementation of the VO Spectrum Model**
Kelly McCusker[1]
[1]Harvard-Smithsonian Center for Astrophysics.

078.09 **How to Find More Supernovae with Less Work: Object Classification Techniques for Difference Imaging**
Stephen J. Bailey[1], G. Aldering[1], C. Aragon[1], S. Bongard[1], M. Childress[1], S. Loken[1], P. Nugent[1], S. Perlmutter[1], K. Runge[1], R. Scalzo[1], R. Romano[1], R. Thomas[1], B. Weaver[1], C. Baltay[2], A. Bauer[2], D. Herrera[2], D. Rabinowitz[2], E. Pecontal[3], G. Rigaudier[3], P. Antilogus[4], S. Gilles[4], R. Pain[4], R. Pereira[4], C. Buton[5], Y. Copin[5]
[1]Lawrence Berkeley National Laboratory, [2]Yale University, [3]Centre de Recherche Astronomique de Lyon, France, [4]Laboratoire de Physique Nucleaire et de Haute Energies de Paris, France, [5]Institut de Physique Nucleaire de Lyon, France.

078.10 **Arecibo Observatory and the National Virtual Observatory**
Isobel Ojalvo[1]
[1]Rensselaer Polytechnic Institute.

078.11 **Moletai Meeting on CCD Strömvil Photometry**
A. G. D. Philip[1], R. P. Boyle[2], R. Janusz[2]
[1]ISO and Union College, [2]Vatican Observatory.

078.12 **Bayesian Source Separation for PAH Spectra**
Duane F. Carbon[1], M. K. Tse[2], K. H. Knuth[3]
[1]NASA/Ames Research Center, [2]University of Albany (SUNY), [3]University at Albany (SUNY).

079: Cool dwarfs
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

079.01 **Spitzer Observations of Substellar Companions**
Sonali J. Shukla[1], P. Lowrance[2], J. Kirkpatrick[3]
[1]Vanderbilt University / Spitzer Science Center, California Institute of Technology, [2]Spitzer Science Center, California Institute of Technology, [3]Infrared Processing and Analysis Center, California Institute of Technology.

079.02 **Activity and Kinematics of Ultracool Dwarfs Including Flare Observations**
Sarah J. Schmidt[1], K. L. Cruz[2]
[1]University of Washington, [2]American Museum of Natural History.

079.03 **Discovery of a Nearby, Very Young L Dwarf**
Dagny Looper[1], J. Kirkpatrick[2], R. Cutri[2], T. Barman[3], T. Roellig[4], M. Cushing[5]
[1]Univ. Of Hawaii, [2]Caltech/IPAC, [3]Lowell Observatory, [4]NASA-Ames, [5]Univ. of Arizona.

079.04 **A Custom Near-IR Filter for Finding Young Brown Dwarfs**
Katelyn N. Allers[1], M. Liu[1]
[1]Univ. Of Hawaii.

079.05 **Recent Results of the NIRSPEC Brown Dwarf Spectroscopic Survey**
Emily L. Rice[1], I. S. McLean[1], L. Prato[2], M. R. McGovern[3], A. J. Burgasser[4], J. Kirkpatrick[5], S. S. Kim[6]
[1]UCLA, [2]Lowell Observatory, [3]Antelope Valley College, [4]MIT, [5]IPAC/Caltech, [6]Kyung Hee University, Republic of Korea.

080: COSMOS
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

080.01 **The Luminosity Function of COSMOS Radio Sources**
Timothy Paglione[1], V. Smolcic[2], E. Schinnerer[2], K. Salvador[3], P. Ciliegi[4], M. Bondi[4], S. Tribiano[5]
[1]CUNY-York College, [2]MPIA, Germany, [3]AMNH, [4]INAF, Italy, [5]CUNY-BMCC.

080.02 **The Faint End Slope Of Starburst Galaxy Luminosity Functions In The COSMOS 2-Square Degree Field**
Charles Liu[1], P. Capak[2], B. Mobasher[3], T. A. Paglione[4], R. M. Rich[5], N. Z. Scoville[2], S. M. Tribiano[6], N. Tyson[7], COSMOS Collaboration
[1]CUNY College of Staten Island, [2]Caltech, [3]STScI, [4]CUNY York College, [5]UCLA, [6]CUNY BMCC, [7]AMNH.

080.03 **The COSMOS Survey: New Data Releases**
Patrick L. Shopbell[1], P. Capak[1], N. Scoville[1], COSMOS Team
[1]Caltech.

080.04 **A Multiwavelength Study of Millimeter Galaxies in the Bolocam-COSMOS Survey**
James E. Aguirre[1], Bolocam-COSMOS Collaboration
[1]NRAO Jansky Fellow at the University of Colorado, Boulder.

080.05 **The VLA-COSMOS 1.4 GHz Survey: The Properties of the Faint Radio Population and Star Formation Rates**
Vernesa Smolcic[1], E. Schinnerer[1], C. Carilli[2], M. Scodeggio[3], P. Franzetti[3], K. Jahnke[1], A. Martinez-Sansigre[1], M. Salvato[4], G. Zamorani[5]
[1]Max-Planck Inst. fur Astronomie, Germany, [2]NRAO, [3]IASF INAF, Italy, [4]California Institute of Technology, [5]L'Istituto Nazionale di Astrofisica, Italy.

080.06 **The Chandra COSMOS Survey**
Martin Elvis[1], C-COSMOS Team
[1]Harvard-Smithsonian CfA.

081: Disks Later in Life
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

081.01 **Mid-infrared Spectra of PAH Emission in Herbig AeBe Stars**
Luke D. Keller[1], G. C. Sloan[2], S. Shah[1], N. Chitrakar[1], W. J. Forrest[3], B. Sargent[3], D. M. Watson[3], A. Li[4], J. Najita[5], C. H. Chen[5], J. D. Green[3], T. F. Herter[2], P. D'Alessio[6], N. Calvet[7], L. Hartman[7], J. R. Houck[2]
[1]Ithaca College, [2]Cornell University, [3]University of Rochester, [4]University of Missouri, [5]NOAO, [6]UNAM, Mexico, [7]University of Michigan.

081.02 **Spectroscopy of the Post-AGB Disk around HR 4049**
Kenneth H. Hinkle[1], S. D. Brittain[2], D. L. Lambert[3]
[1]NOAO, [2]Clemson University, [3]University of Texas.

081.03 **Periodic Variations in the Emission Lines of Zeta Tauri**
Shellie L. Huether[1], K. S. Bjorkman[2]
[1]Univ. of Missouri-Rolla, [2]Univ. of Toledo.

081.04 **Be Star Spectra: Disk Variability and Radial Velocity Variations**
Erika Grundstrom[1], D. R. Gies[1], T. S. Boyajian[1], S. J. Williams[1], D. W. Wingert[1]
[1]Georgia State Univ..

081.05 **Probing the Circumstellar Disks of Be Stars with Contemporaneous Optical and IR Spectroscopy**
Karen S. Bjorkman[1], E. N. Hesselbach[1], J. P. Wisniewski[2], J. E. Bjorkman[1]
[1]Univ. of Toledo, [2]NASA GSFC.

081.06 **Mid-Infrared Spectra of Circumsteller Dust Debris around Main-sequence A and Late B Type Stars**
Farisa Morales[1], M. Werner[1], G. Bryden[1], C. Beichman[1], K. Su[2], G. Rieke[2]
[1]JPL/Caltech, [2]U of A.

082: Formation and Detection of Habitable Planets
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

082.01 **Is the Binary-Planetary System of Gamma Cephei Dynamically Full?**
Joseph Castro[1], N. Haghighipour[1]
[1]Institute for Astronomy, University of Hawaii.

082.02 **Habitable Planetary Systems (un)like our own: Which of the Known Extra-Solar Systems Could Harbor Earth-like Planets?**
Sean Raymond[1], A. Mandell[2], S. Sigurdsson[2]
[1]Univ. of Colorado, [2]Pennsylvania State University.

082.03 Laboratory demonstration of coronagraph imaging for the detection of Earth-like planets
John T. Trauger[1], W. A. Traub[1]
[1]JPL.

083: Galactic and Extragalactic Surveys Using AzTEC
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

083.01 **AzTEC: A New Millimeter-Wave Camera**
Jason Austermann[1], P. A. Ade[2], J. J. Bock[3], J. Glenn[4], S. R. Golwala[5], S. Kim[6], P. D. Mauskopf[2], T. A. Perera[1], C. R. Predmore[7], C. Roberts[1], K. S. Scott[1], G. W. Wilson[1]
[1]Univ. Of Massachusetts, Amherst, [2]Cardiff University, United Kingdom, [3]Jet Propulsion Laboratory, [4]University of Colorado, Boulder, [5]Caltech, [6]Sejong University, Republic of Korea, [7]Predmore Associates.

083.02 **Optimizing AzTEC Data Reduction for Extracting Point-like Objects**
Thushara Perera[1], J. Austermann[1], C. Battersby[1], C. Roberts[1], K. S. Scott[1], G. W. Wilson[1], M. S. Yun[1]
[1]Univ. Of Massachusetts Amherst.

083.03 **AzTEC Observations of the SHADES Fields**
Kimberly S. Scott[1], AzTEC/SHADES group
[1]Univ. Of Massachusetts.

083.04 **The Star Formation History of SHADES Sources**
Itziar Aretxaga[1], SHADES consortium and AzTEC team
[1]INAOE, Mexico.

083.05 **Milli-Jansky Sources in GOODS-N Detected with JCMT/AzTEC**
James D. Lowenthal[1], I. Aretxaga[2], J. Austermann[3], E. Chapin[4], K. Coppin[4], M. Crowe[4], L. Frey[4], A. Gibb[4], M. Halpern[4], D. H. Hughes[2], T. Perera[3], A. Pope[4], D. Scott[4], K. Scott[3], G. Wilson[3], M. S. Yun[3]
[1]Smith College, [2]INAOE, Mexico, [3]University of Massachusetts, [4]University of British Columbia, Canada.

083.06 **Nature of the 1100 Micron AzTEC-COSMOS Sources**
Min Su Yun[1], J. Aguirre[2], I. Aretxaga[3], J. Austermann[1], J. Bock[4], G. Fazio[5], J. Huang[5], D. Hughes[3], Y. Kang[6], S. Kim[6], J. Lowenthal[7], C. Ma[8], P. Mauskopf[9], T. Perera[1], D. Sanders[8], K. Scott[1], N. Scoville[4], G. Wilson[1], I. Yoon[1]
[1]Univ. of Massachusetts, [2]Univ. of Colorado/NRAO, [3]INAOE, Mexico, [4]Caltech, [5]SAO, [6]Sejong University, Republic of Korea, [7]Smith College, [8]Univ. of Hawaii, [9]Cardiff University, United Kingdom.

083.07 **A 1.1mm AzTEC Survey Tracing Accelerated Galaxy Formation Towards a Protocluster at z~3.8**
David H. Hughes[1], A. Montana[1], I. Aretxaga[1], M. Plionis[1], A. Porras[1], J. Wagg[1], E. Gaztanaga[2], J. Huang[3], G. Fazio[3], G. Wilson[4], M. Yun[4], J. Lowenthal[5], T. Perera[4], J. Austermann[4], K. Scott[4], J. Dunlop[6], R. Ivison[6], J. Stevens[7], I. Smail[8], P. Appleton[9]
[1]Instituto Nacional de Astrofisica, Optica y Electronica, Mexico, [2]IEEC, Spain, [3]Center for Astrophysics, [4]University of Massachusetts, [5]Smith College, [6]Institute of Astronomy, Royal Observatory, United Kingdom, [7]University of Hertfordshire, United Kingdom, [8]University of Durham, United Kingdom, [9]IPAC.

083.08 **Joint Analysis of the Full AzTEC Sub-Millimeter Galaxy Data Set**
Grant Wilson[1], P. Ade[2], I. Aretxaga[3], J. Austermann[1], J. Bock[4], D. Hughes[3], Y. Kang[5], S. Kim[5], J. Lowenthal[6], P. Mauskopf[2], T. Perera[1], K. Scott[1], M. Yun[1]
[1]University of Massachusetts, [2]Cardiff University, United Kingdom, [3]INAOE, Mexico, [4]California Institute of Technology, [5]Sejong University, Republic of Korea, [6]Smith College.

083.09 **AzTEC Observations of 1.1 mm Emission from the Orion Nebula**
Sungeun Kim[1], I. Aretxaga[2], J. Austermann[3], J. Bock[4], D. Hughes[2], J. Lowenthal[5], P. Mauskopf[6], T. Perera[3], K. Scott[3], G. Wilson[3], I. Yoon[3], S. Youn[1], M. Yun[3]
[1]Sejong Univ., Republic of Korea, [2]INAOE, Mexico, [3]UMass, [4]Caltech, [5]Smith College, [6]Cardiff, United Kingdom.

083.10 **Constraints on the Star-forming Content of Extreme Molecular Cloud Environments using AzTEC**
Toby Moore[1], J. Allsopp[1], AzTEC Instrument Team
[1]Liverpool John Moores University, United Kingdom.

084: Galactic ISM II
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

084.01 **An Upper Limit on Anomalous Dust Emission at 31~GHz in the Diffuse Cloud [LPH96]201.663+1.643**
Clive Dickinson[1]
[1]Caltech/JPL.

084.02 **A Study of the ρ Oph Cloud: Mapping the Stars and the Distribution and Motions of the Interstellar Gas**
Theodore P. Snow[1], J. D. Destree[1], D. E. Welty[2]
[1]Univ. of Colorado, [2]Univ. of Chicago.

084.03 **Laboratory Analysis of Carbon Dioxide Ice Mixtures in Support of Observations from the Spitzer Space Telescope**
Douglas White[1], P. Gerakines[1]
[1]University of Alabama at Birmingham.

084.04 **The Halo's Hot Gas, as Revealed by a Shadowing Observation of its O VI Resonance Line Emission**
Robin L. Shelton[1], E. B. Jenkins[2], S. M. Sallmen[3]
[1]University of Georgia, [2]Princeton University, [3]University of Wisconsin La Crosse.

084.05 **Distances of Four High-Galactic Latitude Molecular Clouds**
Sharon L. Montgomery[1], C. E. Rombach[1], C. Y. Birney[1], D. N. Burrows[2]
[1]Clarion University, [2]Pennsylvania State University.

084.06 **New Maps of the 3-D Distribution of Cold and Warm Interstellar Gas within 500pc**
Barry Welsh[1], R. Lallement[2], J. Vergely[2]
[1]UC, Berkeley, [2]Service d'Aeronomie, CNRS, France.

084.07 **Radio and Recombination Lines from a Thermal Spur associated with the HII Region S54 : A Model to explain the Observational Results**
Diana E. Azcarate[1]
[1]Inst. Argentino de Radioastronomia, Argentina.

084.08 **Observational Evidence for X-ray Induced Plasma Damping of Grain Alignment**
Bengt-Goran Andersson[1]
[1]Johns Hopkins Univ..

084.09 **The Dynamical Structure of the Local Interstellar Medium**
Seth Redfield[1], J. L. Linsky[2]
[1]Univ. of Texas, [2]JILA and Univ. of Colorado.

084.10 **OH Study of the Massive Star-Forming Region IRAS 19111+1048**
Knicole Colon[1]
[1]The College of New Jersey.

084.11 **Dissipation and Heating in Supersonic MHD Turbulence**
M. Nicole Lemaster[1], J. M. Stone[1]
[1]Princeton Univ..

084.12 *Spitzer* **Observations of HD 34078 and IC 405: Bow Shock and Mid-IR Emission Variations**
Kevin France[1], S. R. McCandliss[2], R. E. Lupu[2]
[1]CITA / U Toronto, Canada, [2]JHU.

084.13 **Intrinsic Stellar Color and Reddening with the Sloan Digital Sky Survey**
Jennifer G. Boyles[1], K. A. Larson[1], Z. Ivezic[2]
[1]Western Washington University, [2]University of Washington.

084.14 **Analyzing the X-Ray Dust Halo and Extinction Toward X Per**
Lynne A. Valencic[1], R. K. Smith[2]
[1]NASA's GSFC, [2]Johns Hopkins University.

084.15 **High Resolution Observations of the Interstellar Medium Along the Future Solar Trajectory**
Ryland T. Brooks[1], S. Redfield[2]
[1]Colby College, [2]Univ. of Texas.

084.16 **H_2/PAH emissions in the shocks and UV dominated regions of the embedded young cluster NGC2316**
Thangasamy Velusamy[1], W. D. Langer[1], D. Li[1]
[1]JPL/Caltech.

084.17 **Correlations between Tracers of Dense Molecular Gas and Star Formation Rate in GMCs**
Hongjun Ma[1], Y. Gao[1], J. Wu[2]
[1]Purple Mountain Observatory, China, [2]Harvard-CfA.

084.18 **Probing the Dust Structure in the LMC with Light Echoes**
Guillermo J. Damke[1], A. Rest[1], A. Newman[2], N. B. Suntzeff[3], R. C. Smith[1], D. L. Welch[4], A. Zenteno[1], C. Stubbs[5], A. Garg[5], P. Challis[5], A. C. Becker[6], G. A. Miknaitis[6], A. Miceli[6], K. H. Cook[7], M. Huber[7], S. Nikolaev[7], L. Morelli[8], D. Minniti[8], A. Clocchiatti[8], J. Prieto[9]
[1]NOAO/CTIO, [2]Washington University, [3]Texas A&M University, [4]McMaster University, Canada, [5]Harvard University, [6]University of Washington, [7]Lawrence Livermore National Laboratory, [8]Pontificia Universidad Catolica de Chile, Chile, [9]Ohio State University.

084.19 **The Non-Linear Relationship between Silicate Absorption Depth and IR Extinction in Dense Clouds**
Jean E. Chiar[1], Y. Pendleton[2], K. Ennico[2], A. Boogert[3], T. Greene[2], C. Lada[4], T. Roellig[2], A. Tielens[2], M. Werner[5], D. Whittet[6]
[1]SETI Institute, [2]NASA Ames, [3]AURA/NOAO-Gemini South, Chile, [4]SAO, [5]IPAC, [6]Rensselaer Polytechnic Institute.

084.20 **The Photo-Dissociation Region Surrounding HR 5171AB**
Michael T. Schuster[1], M. Marengo[1], J. L. Hora[1], R. D. Gehrz[2], R. M. Humphreys[2], G. Fazio[1]
[1]Harvard-Smithsonian, CfA, [2]University of Minnesota.

084.21 **The effects of Geometry, Dust and Magnetic Fields upon Strong-line Abundance Indicators in HII Regions**
Humeshkar B. Nemala[1], G. J. Ferland[1]
[1]University of Kentucky.

084.22 **Numerical Simulations of Interstellar Gas with a Variable Continuum Source**
Gary J. Ferland[1], W. J. Henney[2], R. J. Williams[3]
[1]Univ. of Kentucky, [2]Centro de Radioastronomia y Astrofisica, Universidad Nacional Autonoma de Mexico, Mexico, [3]AWE, United Kingdom.

084.23 **Recent FUSE Observations of Diffuse O VI Emission in the Galactic Interstellar Medium**
William V. Dixon[1], R. Sankrit[2]
[1]Johns Hopkins University, [2]University of California, Berkeley.

084.24 **A Comparative Study of Velocity Statistics of Hydrodynamic and Magnetohydrodynamic Turbulence**
Nicholas Hall[1], G. Kowal[1], A. Lazarian[1], J. Cho[2]
[1]University of Wisconsin Madison, [2]Chungnam National University, Republic of Korea.

085: Ground-Based Instrumentation II
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

085.01 **The 21-Meter Space Tracking Antenna and Radio Telescope at Morehead State University**
Thomas Pannuti[1], B. K. Malphrus[1], M. Combs[1], J. Kruth[1], J. W. Atwood[1]
[1]Morehead State Univ..

085.02 **Atacama Large Millimeter Array Low Noise Analysis**
Manasseh O. Obi[1]
[1]Idaho State University.

085.03 **MUSTANG: A 90 GHz Bolometer Array for the Green Bank Telescope**
Brian S. Mason[1], S. Dicker[2], P. Korngut[1], D. Benford[3], M. Devlin[2], K. Irwin[4], H. Moseley[3], MUSTANG collaboration
[1]NRAO, [2]UPenn, [3]NASA GSFC, [4]NIST.

085.04 **Research Experience for Teachers at Green Bank: High-Precision Calibration, Baselines and Nonlinearities with the GBT**
Shelly Hynes[1], R. J. Maddalena[2], C. Figura[3]
[1]Louisiana School for Math, Science and the Arts, [2]National Radio Astronomy Observatory, [3]Wartburg College.

085.05 **Potential Astronomy Applications of Large Deep Space Network Arrays**
Dayton L. Jones[1], T. B. Kuiper[1], W. A. Majid[1]
[1]Jet Propulsion Laboratory.

085.06 **Ionospheric Phase Errors and Corrections at 1 m Wavelength**
William D. Cotton, Jr.[1], J. Uson[1]
[1]NRAO.

085.07 **A Web-based Portable RFI Monitor for LWA Site Selection**
Robert L. Mutel[1], T. Jaeger[1], G. Taylor[2]
[1]Univ. of Iowa, [2]Univ. of New Mexico.

085.08 **The Mileura Widefield Array**
Colin J. Lonsdale[1], International MWA partnership
[1]MIT.

085.09 **Construction of a Novel Interferometric Array of Small Radio Telescopes**
Dalit Engelhardt[1], P. Timbie[2]
[1]Boston University, [2]University of Wisconsin-Madison.

085.10 **Effectiveness of the Correlator Field of View Weighting Technique in Source Attenuation**
Dylan R. Nelson[1], S. S. Doeleman[2], C. J. Lonsdale[2], D. Oberoi[2], R. Cappallo[2]
[1]University of California Berkeley, [2]Massachusetts Institute of Technology, Haystack Observatory.

085.11 **First Astronomical Imaging Spectroscopy Obtained with a Multiplexed Superconducting Bolometer Array**
Dominic J. Benford[1], J. G. Staguhn[1], T. J. Ames[1], C. A. Allen[1], J. A. Chervenak[1], C. R. Kennedy[2], S. Lefranc[3], S. F. Maher[1], S. H. Moseley[1], F. Pajot[3], C. Rioux[3], R. A. Shafer[1], G. M. Voellmer[1]
[1]NASA / GSFC, [2]Notre Dame, [3]IAS, France.

085.12 **An Innovative Multicolor Submillimeter Camera Using Microwave Kinetic Inductance Detectors**
James A. Schlaerth[1], P. K. Day[2], J. Gao[3], J. Glenn[1], S. Golwala[3], S. Kumar[3], H. G. LeDuc[2], B. A. Mazin[2], H. T. Nguyen[2], J. E. Vaillancourt[3], A. Vayonakis[3], J. Zmuidzinas[3]
[1]University of Colorado, [2]Jet Propulsion Laboratory, [3]California Institute of Technology.

085.13 **Development of A Protype Infrared Exoplanet Tracker for All Sky Extrasolar Planet Survey**
Pengcheng Guo[1], J. Ge[1], S. Mahadevan[1], L. Ramsey[2]
[1]Univ. of Florida, [2]The Pennsylvania State University.

085.14 **Exploring Precision Radial Velocities in the NIR: PRVS Pathfinder**
Lawrence W. Ramsey[1], S. Bongiorno[1], L. Engel[1], S. Redman[1], A. Wolszczan[1], H. R. Jones[2], J. Barnes[2]
[1]Penn State Univ., [2]University of Hertfordshire, United Kingdom.

085.15 **The Tunable Spatial Heterodyne Spectrometer (TSHS): A High-Resolution Spectral Sensor for Broadband Studies of Diffuse Targets in the UV-Visible.**
Walter M. Harris[1], O. Dawson[1], L. Giersch[1]
[1]Univ. of Washington.

086: LSST
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

086.01 **The LSST System**
Donald Sweeney[1], J. A. Tyson[2], LSST Collaboration
[1]LSST Corporation, [2]University of California, Davis.

086.02 **LSST Survey Strategy**
Zeljko Ivezic[1], A. J. Tyson[2], M. A. Strauss[3], S. Kahn[4], C. Stubbs[5], P. Pinto[6], K. Cook[7], LSST Collaboration
[1]Univ. of Washington, [2]Univ. of California, Davis, [3]Princeton University, [4]Stanford University, [5]Harvard University, [6]Univ. of Arizona, [7]Lawrence Livermore National Laboratory.

086.03 **Science Opportunities with the LSST**
Michael A. Strauss[1], LSST Collaboration
[1]Princeton Univ..

086.04 **LSST Survey Strategy: Cadence Design and Simulation**
Philip A. Pinto[1], K. H. Cook[2], F. Delgado[3], M. Miller[4], L. Denneau[5], A. Saha[4], P. A. Gee[6], J. A. Tyson[6], Z. Ivezic[7], LSST Collaboration
[1]Steward Observatory, University of Arizona, [2]Lawrence Livermore National Laboratory, National Optical Astronomy Observatory, [3]Cerro Tololo Inter-American Observatory, Chile, [4]National Optical Astronomy Observatory, [5]Univ. of Hawaii Institute for Astronomy, [6]Univ. of California/Davis, [7]Univ. of Washington.

086.05 **Calibration of LSST Instruments and Data**
David Burke[1], T. Axelrod[2], C. Claver[3], J. Frank[4], K. Gilmore[1], Z. Ivezic[5], V. Krabbendam[3], D. Monet[6], P. O'Connor[4], J. Oliver[7], E. Olszewski[2], P. Pinto[2], A. Saha[3], C. Smith[3], C. Stubbs[7], P. Takacs[4], J. A. Tyson[8]
[1]Stanford Linear Accelerator Center, [2]Steward Observatory, [3]National Optical Astronomy Observatory, [4]Brookhaven National Laboratory, [5]University of Washington, [6]U.S. Naval Observatory, [7]Harvard-Smithsonian Center for Astrophysics, [8]University of California.

086.06 **Calibrating Photometric Redshifts for LSST**
Jeffrey Newman[1], A. J. Connolly[2], J. A. Tyson[3], M. Schneider[3], V. E. Margoniner[3], D. M. Wittman[3], H. Aihara[4], S. Miyazaki[5], LSST Collaboration
[1]U.C. Berkeley, [2]U. Washington, [3]U.C. Davis, [4]U. Tokyo, Japan, [5]NAOJ-Subaru.

086.07 **The LSST Data Products**
Tim S. Axelrod[1], R. Allsman[2], A. Becker[3], J. Becla[4], A. Connolly[3], K. Cook[5], J. Gray[6], A. Jagatheesan[7], J. Kantor[2], M. Nieto-Santisteban[8], S. Nikolaev[5], R. Owen[3], R. Pike[9], R. Plante[10], N. Silvestri[3], C. Smith[11], A. Szalay[8], A. Thakar[8], J. A. Tyson[12], LSST Collaboration
[1]Steward Observatory / LSSTC, [2]LSSTC, [3]U Washington, [4]SLAC, [5]LLNL, [6]Microsoft Research, [7]SDSC, [8]JHU, [9]Google, [10]NCSA, [11]NOAO, [12]UCD.

086.08 **Four LSST probes of Dark Energy**
J. A. Tyson[1], H. Zhan[1], L. Knox[1], LSST Collaboration
[1]UC, Davis.

086.09 **Cosmology with Photometric Baryon Acoustic Oscillation Measurements**
Hu Zhan[1], A. J. Hamilton[2], L. Knox[1], J. A. Tyson[1], LSST Collaboration
[1]UC Davis, [2]JILA, U. Colorado.

086.10 **Weak Lensing with LSST**
David M. Wittman[1], B. Jain[2], M. Jarvis[2], L. Knox[1], V. Margoniner[1], M. Takada[3], J. Tyson[1], H. Zhan[1], LSST Weak Lensing Science Collaboration
[1]UC, Davis, [2]U. Penn, [3]Tohoku University, Japan.

086.11 **Supernova Science and Cosmology with the LSST**
W. M. Wood-Vasey[1], P. Pinto[2], L. Wang[3], H. Zhan[4], Y. Wang[5], LSST Supernova Science Collaboration
[1]Harvard-Smithsonian, CfA, [2]Steward Observatory, University of Arizona, [3]Texas A&M, [4]UC Davis, [5]University of Oklahoma.

086.12 **Gravitationally Lensed Quasars Lessons from SDSS and Predictions for LSST**
R. D. Blandford[1], M. Oguri[1], P. Marshall[2], E. A. Baltz[1], M. Bradac[1], C. D. Fassnacht[2], LSST collaboration
[1]SLAC, [2]University of California.

086.13 **Transients and Variables**
Shrinivas Kulkarni[1], A. Becker[2], J. S. Bloom[3], K. H. Cook[4], S. Kahn[5], T. Tyson[3], LSST Transient Object Collaboration
[1]Caltech, [2]U. Washington, [3]UC, [4]Lawrence Livermore National Laboratory, [5]Stanford University.

086.14 **AGN Science with the LSST**
Niel Brandt[1], LSST AGN Science Collaboration
[1]Penn State Univ..

086.15 **Mapping the Milky Way with LSST**
James Bullock[1], C. M. Rockosi[2], Z. Ivezic[3], A. Saha[4], LSST Milky Way Science Collaboration
[1]University of California Irvine, [2]University of California Santa Cruz, [3]University of Washington, [4]Space Telescope Science Institute.

086.16 **Stellar Populations with the LSST**
Abhijit Saha[1], K. Olsen[2], LSST Stellar Populations Collaboration
[1]NOAO, [2]Cerro Tololo Inter-American Observatory, Chile.

086.17 **LSST: Taking Inventory of the Solar System**
Steven R. Chesley[1], A. J. Connolly[2], A. W. Harris[3], Z. Ivezic[4], J. Kubica[5], LSST Solar System Science Collaboration
[1]JPL, [2]Univ. Pittsburgh, [3]Space Sci. Inst., [4]Univ. Wash., [5]Carnegie Mellon Univ..

086.18 **An Overview of the LSST Telescope and Site**
Chuck F. Claver[1], V. L. Krabbendam[1], J. Andrew[1], J. Barr[1], J. Burge[2], W. Gressler[1], D. Neill[1], S. Olivier[3], D. Phillion[3], J. Sebag[1], L. Seppala[3], R. Upton[1], LSST Collaboration
[1]NOAO, [2]University of Arizona, Steward Observatory, [3]LLNL.

086.19 **The Baseline Design of the LSST Camera**
Steven Kahn[1], LSST Collaboration
[1]Stanford University / Stanford Linear Accelerator Center.

086.20 **The LSST Sensor Development Program**
Veljko Radeka[1], J. C. Geary[2], K. Gilmore[3], M. Nordby[3], J. A. Tyson[4], J. Oliver[5], D. Figer[6], C. Stubbs[7]
[1]Brookhaven National Laboratory, [2]Smithsonian Astrophysical Observatory, [3]Stanford Linear Accelerator Center, [4]University of California, Davis, [5]Harvard University, [6]Rochester Institute of Technology, [7]Harvard-Smithsonian Center for Astrophysics.

086.21 **LSST Camera Electronics**
Paul O'Connor[1], J. Oliver[2], J. Geary[3], R. Van Berg[4], V. Radeka[1]
[1]Brookhaven National Laboratory, [2]Harvard University, [3]Smithsonian Astrophysical Observatory, [4]University of Pennsylvania.

086.22 **Maximizing Observations in the Large Synoptic Survey Telescope Cadence Simulator (OpSim) and Uncovering Its Abilities: Evaluating The Search for Variable Stars**
Casey R. Coffey[1], A. Saha[2], M. Miller[2]
[1]Westminster College, [2]National Optical Astronomy Observatory.

087: M33: Our Other Neighbor
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

087.01 **Chandra ACIS Survey of M33 (ChASeM33): A Deep X-ray Survey of theNearest Face-on Spiral**
Paul P. Plucinsky[1], M. Sasaki[1], T. J. Gaetz[1], B. Williams[2], K. S. Long[3], R. P. Kirshner[1], W. Pietsch[4], F. Haberl[4], D. J. Helfand[5], J. P. Hughes[6], P. F. Winkler[7], W. P. Blair[8], P. Ghavamian[8], R. J. Edgar[1], T. G. Pannuti[9], T. Mazeh[10], A. Shporer[10], D. Breitschwerdt[11], L. Bianchi[8], M. A. de Avillez[12], D. Thilker[8], R. K. Smith[13], J. E. Grindlay[1], K. Kuntz[8], R. Tuellmann[14]
[1]Harvard-Smithsonian, CfA, [2]University of Washington, [3]Space Telescope Science Institute, [4]Max Planck Institut fuer Extraterrestriche Physik, Germany, [5]Columbia University, [6]Rutgers University, [7]Middlebury College, [8]Johns Hopkins University, [9]Morehead State University, [10]Tel Aviv University, Israel, [11]University of Vienna, Austria, [12]University of Evora, Portugal, [13]NASA GSFC & The Johns Hopkins University, [14]Ruhr-University Bochum, Germany.

087.02 **Chandra ACIS Survey of M33 (ChASeM33): The X-ray Point Source Population of M33**
Manami Sasaki[1], B. Williams[2], P. P. Plucinsky[1], W. Pietsch[3], T. J. Gaetz[1], K. S. Long[4], T. Mazeh[5], A. Shporer[5], F. Haberl[3], T. G. Pannuti[6], P. Ghavamian[7], L. Bianchi[7], A. Tolea[7], ChASeM33 team
[1]CfA, [2]University of Washington, [3]Max-Planck Institute for Extraterrestrial Physics, Germany, [4]STScI, [5]Tel Aviv University, Israel, [6]Morehead State University, [7]JHU.

087.03 **Chandra ACIS Survey of M33 (ChASeM33): Supernova Remnants**
Knox S. Long[1], P. Winkler[2], W. P. Blair[3], P. Ghavamian[3], J. P. Hughes[4], T. J. Gaetz[5], D. J. Helfand[6], R. P. Kirshner[5], T. G. Pannuti[7], P. P. Plucinski[5], M. Sasaki[5], ChASEM33 team
[1]STScI, [2]Middlebury College, [3]JHU, [4]Rutgers Univ., [5]Harvard-Smithsonian CfA, [6]Columbia Univ., [7]Morehead State Univ..

087.04 **Chandra ACIS Survey of M33 (ChASeM33): X-ray Imaging and Spectroscopy of M33SNR21, the Brightest X-ray Supernova Remnant in M33**
Terrance J. Gaetz[1], J. P. Hughes[2], W. P. Blair[3], P. F. Winkler[4], P. Ghavamian[3], K. S. Long[5], T. G. Pannuti[6], B. Williams[7], R. J. Edgar[1], P. P. Plucinsky[1], M. Sasaki[1], R. P. Kirshner[8], M. Avillez[9], D. Breitschwerdt[10], ChASeM33 team
[1]SAO/CfA, [2]Rutgers University, [3]JHU/CAS, [4]Middlebury College, [5]STScI, [6]SSC/Morehead State University, [7]Univ. Washington, [8]Harvard/CfA, [9]Univ. Evora, Portugal, [10]Univ. Wien, Austria.

087.05 **Stellar Populations of the Disk of M33**
Roberto J. Avila[1], J. A. Holtzman[1], D. R. Garnett[2], A. Sarajedini[3]
[1]New Mexico State Univ., [2]Steward Observatory, UofA, [3]University of Florida.

087.06 **A Spectroscopic Study of M31 dSphs - Kinematics, Chemical Abundances, and Radial Distributions in And I, II, and III**
Steven R. Majewski[1], J. Kalirai[2], M. Geha[3], P. Guhathakurta[2], K. Gilbert[2], J. Ostheimer[1], R. Patterson[1]
[1]Univ. of Virginia, [2]University of California, [3]HIA, Canada.

088: MIPSGAL
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

088.01 **MIPSGAL I & II: A Survey of the Inner Galactic Plane at 24 and 70 Microns, The Mosaics**
Sean J. Carey[1], A. Noriega-Crespo[1], D. R. Mizuno[2], S. Shenoy[1], R. Paladini[1], K. E. Kraemer[3], T. A. Kuchar[2], F. R. Marleau[1], S. D. Price[3], D. L. Padgett[1], R. Indebetouw[4], J. G. Ingalls[1], B. Ali[5], G. B. Berriman[5], F. Boulanger[6], R. M. Cutri[5], W. B. Latter[5], P. Martin[7], M. Miville-Deschenes[6], S. Molinari[8], L. M. Rebull[1], R. F. Shipman[9], L. Testi[10]
[1]Spitzer Science Center / Caltech, [2]Boston College, [3]Air Force Research Laboratory, [4]University of Virginia, [5]IPAC / Caltech, [6]IAS, France, [7]CITA, Canada, [8]Istituto Fisica Spazio Interplanetario, Italy, [9]SRON, The Netherlands, [10]Arcetri Observatory, Italy.

088.02 **Data processing of MIPSGAL 24 micron images**
Donald R. Mizuno[1], A. Noriega-Crespo[2], D. L. Padgett[2], S. J. Carey[2], R. Paladini[2], S. Shenoy[2], K. Kraemer[3], T. Kuchar[1], F. Marleau[2], S. Price[3]
[1]Boston College, [2]Spitzer Science Center, [3]Air Force Research Laboratory.

088.03 **The MIPSGAL 24 Micron Point Source Catalog: Preliminary Results**
Sachindev S. Shenoy[1], F. Marleau[1], D. Mizuno[2], S. J. Carey[1], A. Noriega-Crespo[1], K. E. Kraemer[3], S. D. Price[3], T. A. Kuchar[2], D. L. Padgett[1], R. Paladini[1]
[1]SSC Caltech, [2]Boston College, [3]Air Force Research Laboratory.

088.04 **Data Processing of MIPSGAL 70 Micron Images**
Roberta Paladini[1], D. Frayer[1], A. Noriega-Crespo[1], S. Carey[1], D. Mizuno[2], S. Shenoy[1], K. Kramer[2], T. Kuchar[2], F. Marleau[1], S. Price[2], D. Padgett[1], J. Ingalls[1]
[1]SSC/Caltech, [2]Air Force Research Laboratory.

088.05 **Dusty Sculptures in the MIPSGAL Survey**
Nicolas Flagey[1], A. Noriega-Crespo[2], S. Carey[2], MIPSGAL Team
[1]Institut d'Astrophysique Spatiale, Orsay, FRANCE & Spitzer Science Center, [2]Spitzer Science Center.

088.06 **The Astronomical Zoo in MIPSGAL I and II**
Thomas A. Kuchar[1], D. Mizuno[1], S. Shenoy[2], R. Paladini[2], K. Kraemer[3], S. Price[3], F. Marleau[2], D. Padgett[2], R. Indebetouw[4], J. Ingalls[2], B. Ali[2], B. Berriman[2], F. Boulanger[5], R. Cutri[2], W. Latter[2], M. Miville-Deschenes[5], S. Molinari[6], L. Rebull[2], L. Testi[7], R. Shipman[8], P. Martin[9], S. Carey[2], A. Noriega-Crespo[2]
[1]Boston College, [2]Spitzer Science Center, [3]Air Force Research Laboratory, [4]University of Virginia, [5]Université Paris Sud, France, [6]Istituto di Fisica dello Spazio Interplanetario, Italy, [7]Osservatorio Astrofisico di Arcetri, Italy, [8]Netherlands Institute for Space Research, The Netherlands, [9]University of Toronto, Canada.

089: Stellar Populations III
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

089.01 *FUSE* **Observations of the Unprecedentedly Deep "Quiescent" Magnetic Activity State of alpha Centauri A**
Jennifer M. Carton[1], L. E. DeWarf[1], E. F. Guinan[1]
[1]Villanova U..

089.02 **Results from the Nearby Stars (NStars) Program: Candidate Solar Twinsand Chromospheric Diversity in G and K dwarfs**
Richard O. Gray[1], C. J. Corbally[2], R. F. Garrison[3], M. T. McFadden[1], A. A. O'Donoghue[4], E. J. Bubar[5]
[1]Appalachian State Univ., [2]Vatican Obs. Research Group, [3]David Dunlap Obs., Canada, [4]St. Lawrence Univ., [5]Clemson Univ..

089.03 **Global Simulations of the Magnetorotational Instability in a Spherical Geometry**
Kaitlin M. Kratter[1], L. J. Dursi[2], U. Pen[2]
[1]Univ. of Toronto, Canada, [2]CITA, Canada.

089.04 **Time Variation in the Magnetic Activity of Cool Stars**
Andrew A. West[1], J. T. Wright[1], G. W. Marcy[1], M. Agueros[2], L. M. Walkowicz[3], E. J. Hilton[3], S. L. Hawley[3], J. J. Bochanski[3], K. R. Covey[4]
[1]UC, Berkeley, [2]Columbia University, [3]University of Washington, [4]CfA.

089.05 **The Old Feeble Coronae of Solar-like Dwarf Stars in the Arcturus Moving Group**
Alexander Brown[1], E. Hodges-Kluck[1], T. R. Ayres[1], G. M. Harper[1]
[1]Univ. of Colorado.

089.06 **The Age-Activity Relation for M dwarfs Using 25,000 SDSS Spectra**
Suzanne L. Hawley[1], A. A. West[2], J. J. Bochanski[1], K. R. Covey[3]
[1]Univ. of Washington, [2]Univ. of California, [3]CfA.

089.07 **Flare Rate Analysis of M-Dwarf Lightcurves**
Adam F. Kowalski[1], E. J. Hilton[1], A. C. Becker[1], S. L. Hawley[1]
[1]University of Washington.

089.08 **Simulations of Convection and Magnetism in Fully Convective Stars**
Matthew K. Browning[1], G. Basri[1]
[1]UC Berkeley.

090: More Supernovae
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

090.01 **Targeting Supernovae in Very High Redshift Galaxy Clusters with HST: Preliminary Results**
Kyle Barbary[1], S. Perlmutter[2], G. Aldering[1], K. S. Dawson[1], G. Goldhaber[1], N. Kuznetsova[1], J. Meyers[1], D. Rubin[1], D. J. Schlegel[1], A. L. Spadafora[1], N. Suzuki[1], R. Amanullah[3], E. Linder[3], C. Lidman[4], M. Kowalski[5], T. Hattori[6], N. Kashikawa[6], A. Fruchter[7], V. Fadeyev[8], M. Doi[9], Y. Ihara[9], K. Konishi[9], T. Morokuma[9], N. Takanashi[9], N. Yasuda[9]
[1]LBNL, [2]UC-Berkeley, [3]SSL, [4]ESO, Chile, [5]Humbolt U. Berlin, Germany, [6]NAOJ, Japan, [7]STScI, [8]UCSC, [9]U Tokyo, Japan.

090.02 **A Probabilistic Approach to Classifying Supernovae Using Photometric Information**
Brian Connolly[1], N. Kuznetsova[2]
[1]Columbia University, [2]Lawrence Berkeley National Lab.

090.03 **Combining Supernova Datasets for Cosmological Measurements**
David Rubin[1], M. Kowalski[2], S. Perlmutter[3], G. Aldering[1], R. Amanullah[4], K. Barbary[1], K. S. Dawson[1], G. Goldhaber[1], N. Kuznetsova[1], J. Meyers[1], D. J. Schlegel[1], A. L. Spadafora[1], M. Strovink[1], N. Suzuki[1], A. Conley[5], V. Fadeyev[6], A. Goobar[7], I. Hook[8], C. Lidman[9], R. Pain[10], P. Ruiz-Lapuente[11], L. Wang[12], Supernova Cosmology Project
[1]LBNL, [2]Humboldt University, Germany, [3]UC Berkeley, [4]SSL, [5]University of Toronto, Canada, [6]UCSC, [7]Stockholm University, Sweden, [8]University of Oxford, United Kingdom, [9]ESO, Chile, [10]IN2P3, France, [11]University of Barcelona, Spain, [12]Texas A&M.

090.04 **The Carnegie Supernova Project: First Results From the High-Redshift Campaign**
Christopher R. Burns[1], P. Wyatt[1], W. Freedman[1]
[1]Carnegie Observatories.

090.05 **CfA Nearby Supernova Ia Light Curves and Exploring Correlations Between Light Curve Shape And Host Galaxy Type**
Malcolm Hicken[1], P. Berlind[1], S. Blondin[1], M. Calkins[1], P. Challis[1], G. Esquerdo[1], C. Hergenrother[1], R. Kirshner[1], D. Latham[1], M. Modjaz[1], M. Wood-Vasey[1], A. Rest[2], T. Matheson[3]
[1]Harvard-Smithsonian, CfA, [2]CTIO, Chile, [3]NOAO.

090.06 **First Two Years: Infrared Light Curves of Type Ia Supernovae with the Peters Automated Infrared Imaging Telescope (PAIRITEL)**
Andrew S. Friedman[1], W. M. Wood-Vasey[1], M. Modjaz[1], R. Kirshner[1], J. S. Bloom[2], C. H. Blake[1], A. H. Szentgyorgyi[1], E. E. Falco[1], D. Starr[2], M. Skrutskie[3]
[1]Harvard-CfA, [2]University of California, Berkeley, [3]University of Virginia.

090.07 **Effects of Gravitational Lensing on SNe Discovered Behind Massive Galaxy Clusters**
Mark Wagner[1], T. Pritchard[1], K. Dawson[1], X. Huang[1], S. Perlmutter[1], G. Smoot, III[1], N. Suzuki[1], Supernova Cosmology Project
[1]LBNL.

090.08 **SALT2: Using Distant Supernovae to Improve the Use of Type Ia Supernovae as Distance Indicators**
Julien Guy[1], SNLS Collaboration
[1]LPNHE IN2P3/ CNRS, France.

090.09 **Photometric Calibration of the Supernova Legacy Survey Fields**
Nicolas Regnault[1], SNLS Collaboration
[1]LPNHE IN2P3 CNRS, France.

090.10 **Resolving Supernovae, H_0, and the Equation of State with HST**
Louis-Gregory Strolger[1], A. C. Rohde[1], M. J. Gorski[1], A. G. Riess[2], H. Lampeitl[2], H. C. Ferguson[2], A. R. Martel[2]
[1]Western Kentucky Univ., [2]Space Telescope Science Institute.

090.11 **Constraints on Dark Energy from the ESSENCE Supernova Survey**
Gajus A. Miknaitis[1], W. Wood-Vasey[2], ESSENCE team
[1]Fermi National Accelerator Lab., [2]CfA/Harvard.

091: Neutron Stars
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

091.01 **Measurement of Orbital Decay in the Double Neutron Star Binary PSR B2127+11C**
Bryan A. Jacoby[1], P. B. Cameron[2], F. A. Jenet[3], S. B. Anderson[2], R. N. Murty[4], S. R. Kulkarni[2]
[1]Naval Research Laboratory, [2]California Institute of Technology, [3]University of Texas at Brownsville, [4]Harvard University.

091.02 **Isolated Neutron Stars: Magnetic Fields, Distances, and Spectra**
David L. Kaplan[1], M. H. van Kerkwijk[2]
[1]MIT, [2]University of Toronto, Canada.

091.03 **Properties of Rotating Neutron Stars Using Density Dependent Relativistic Hadron Field Theory**
Philip Rosenfield[1], F. Weber[1], H. Lenske[2]
[1]San Diego State Univ., [2]Institut fur Theoretische Physik, Universitat Giessen, Germany.

091.04 **New Insights into Atoll X-Ray Binaries: Fourier Resolved Spectroscopy of 4U 1728-34**
Chris R. Shrader[1], D. Kazanas[1], P. Reig[2], I. Papidakis[2]
[1]NASA's GSFC, [2]University of Crete, Greece.

092: Planetary and Pre-Planetary Nebulae
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

092.01 **Probing Nucleosynthesis in Intermediate Mass Stars via Planetary Nebulae Abundances**
Jackie Milingo[1], J. K. Teske[2], R. B. Henry[3], K. B. Kwitter[4], S. P. Souza[4]
[1]Gettysburg College, [2]American University, [3]University of Oklahoma, [4]Williams College.

092.02 **The Radio Evolution of NGC7027**
R. A. Perley[1], A. Zijlstra[2], P. van Hoof[3]
[1]NRAO, [2]Department of Physics, UMIST, United Kingdom, [3]Royal Observatory of Belgium, Belgium.

092.03 **Far-UV Temperature Diagnostics for Hot Central Stars of Planetary Nebulae**
George Sonneborn[1], R. Iping[2], J. Herald[3]
[1]NASA's GSFC, [2]NASA's GSFC & CUA, [3]Johns Hopkins University.

092.04 **The Hubble Catalog of Planetary and protoPlanetary Nebulae**
Bruce Balick[1], K. Pomeroy[1], S. Hayward[1], J. Baerny[1]
[1]Univ. of Washington.

092.05 **Spitzer IRS Spectral Observations of the 21 and 30 Micron Emission Features in Several Galactic Proto-Planetary Nebulae**
Bruce J. Hrivnak[1], K. Volk[2], S. Kwok[3]
[1]Valparaiso Univ., [2]Gemini Obs., [3]Univ. Hong Kong, China.

092.06 **Chandra X-ray Detection of a Shocked Polar Jet in the Symbiotic Mira System Hen 2-104**
Rodolfo Montez, Jr.[1], J. H. Kastner[1], R. Sahai[2]
[1]Rochester Institute of Technology, [2]JPL/Caltech.

092.07 **Deuterium Astration in the Planetary Nebula Sh 2-216?**
Cristina M. Oliveira[1], P. Chayer[1], H. W. Moos[1], J. W. Kruk[1], T. Rauch[2]
[1]Johns Hopkins Univ., [2]Universitat Tubigen, Germany.

092.08 **The Ejection of Jets and Tori in Proto-Planetary Nebulae**
Patrick J. Huggins[1]
[1]New York University.

093: Properties of Cool Giant Stars
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

093.01 **The Wilson-Bappu Effect Fifty Years Later**
Rachel A. Matson[1], R. E. Stencel[1]
[1]University of Denver.

093.02 **Abundances of Extremely Metal-Poor Stars, aNnew HIRES Sample**
David K. Lai[1], M. Bolte[2], J. A. Johnson[3], S. Lucatello[4]
[1]UC, Santa Cruz, [2]UC, Santa Cruz/UCO Lick, [3]Ohio State University, [4]INAF-Osservatorio Astronomico di Padova, Italy.

093.03 **The Abundances of Na, Mg, & Al in the Hyades: Giants, Dwarfs, and Mixing**
Simon C. Schuler[1], J. R. King[2], L. The[2]
[1]NOAO/CTIO, Chile, [2]Clemson University.

093.04 **Heavy Element Abundances in the Photospheres of Cool Supergiants**
Glenn M. Wahlgren[1], M. Lundqvist[2], K. G. Carpenter[3]
[1]CUA/NASA-GSFC, [2]Lund Observatory, Sweden, [3]NASA-GSFC.

093.05 **Brighter Still! A Summary of Photometric Data from the HST Eta Carinae Treasury Project**
John C. Martin[1], K. Davidson[2], M. D. Koppelman[2], R. M. Humphreys[2]
[1]University of Illinois Springfield, [2]University of Minnesota.

093.06 **Late-Type Red Supergiants: Too Cool for the Clouds?**
Emily M. Levesque[1], P. Massey[2], K. A. Olsen[3], B. Plez[4]
[1]Institute for Astronomy, University of Hawaii, [2]Lowell Observatory, [3]CTIO, NOAO, Chile, [4]GRAAL, Universite de Montepellier II, France.

093.07 **A Search for Companions to AGB Stars**
Krzysztof Findeisen[1], R. Sahai[2], A. Gil de Paz[3], C. Sanchez Contreras[4]
[1]Cornell University, [2]Jet Propulsion Laboratory, Caltech, [3]Universidad Complutense de Madrid, Spain, [4]Instituto de Estructura de la Materia, CSIC, Spain.

093.09 **A Spitzer Survey of Mass Losing Stars in the Galactic Bulge**
Raghvendra Sahai[1], M. Stute[1], M. Morris[2], I. Glass[3], J. Blommaert[4], M. Groenewegen[4], M. Schultheis[5], A. Omont[6], K. Kraemer[7]
[1]JPL, [2]UCLA, [3]SAAO, South Africa, [4]K.U.Leuven, Belgium, [5]Observatoire de Besancon, France, [6]IAP, France, [7]AFRL.

094: Putting Education into Outreach
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

094.01 **Collaboration for Education with the Apple Learning Interchange**
Patrick A. Young[1], T. Zimmerman[2], K. A. Knierman[3]
[1]Los Alamos National Laboratory, [2]Apple Computer, [3]Steward Observatory.

094.02 **Astronomy in the Digital Universe**
Bernard M. Haisch[1], J. Lindblom[1], Y. Terzian[2]
[1]Digital Universe Foundation, [2]Cornell University.

094.03 **Opportunitites for Scientist Participation in Chandra Education and Public Outreach**
Kathleen Lestition[1], P. Edmonds[1], K. Kowal-Arcand[1], M. Watzke[1]
[1]SAO.

094.04 **Astro-Science Workshop: Education and Public Outreach at the Adler Planetarium**
Lauren R. Grodnicki[1], M. Hammergren[2], A. Puckett[1]
[1]Univ. of Chicago, [2]Adler Planetarium.

094.05 **Solar Education and Outreach at Columbus State University's Mead Observatory**
Michael Johnson[1], J. Hood[1], S. T. Cruzen[1]
[1]Columbus State University.

094.06 **The SNAP Education and Public Outreach Program**
Lynn R. Cominsky[1], P. Plait[1], S. Silva[1], SNAP Collaboration
[1]Sonoma State Univ..

094.07 **The Sky is the Limit: Benefits from Partnering with the Project ASTRO National Network!**
Constance E. Walker[1], D. Zevin[2], W. van der Veen[3], A. Fraknoi[4], R. Wilson[1], S. Gurton[2], V. White[2], C. Clemens[5], J. Harvey[6]
[1]National Optial Astronomy Observatory, [2]Astronomical Society of the Pacific, [3]New Jersey Astronomy Center for Education, [4]Foothill College & ASP, [5]Harvard-Smithsonian Center for Astrophysics, [6]Gemini Observatory.

094.08 **Space Science Outreach in the Virtual World of Second Life**
Anthony W. Crider[1], International Spaceflight Museum
[1]Elon University.

094.09 **The Sunnel: Engaging Visitors in Solar Research via a Tunnel Through the Sun**
Nora H. DeMuth[1], C. E. Walker[2]
[1]El Camino College, [2]National Optical Astronomy Observatory.

094.10 **Slackerpedia Galactica**
Aaron Price[1], M. Koppelman[2], M. Robinson[3], D. L. Welch[4], T. Searle[5], R. Turner[5]
[1]AAVSO/Tufts University, [2]University of Minnesota, [3]Swinburne University of Technology, Australia, [4]McMaster University, Canada, [5]AAVSO.

094.11 **"It's Our Universe": Astronomy Outreach in Appalachian Ohio**
Mangala Sharma[1], G. Eberts[1], M. Hartwick[2], L. Miller[3]
[1]Ohio Univ, [2]Southeast Ohio Astronomical Society, [3]Athens Public Library.

094.12 **Arecibo Observatory for All**
Gloria M. Isidro[1], C. A. Pantoja[1], P. Bartus[1], C. La Rosa[1]
[1]University of Puerto Rico.

094.13 **Effectively Engaging Family Groups in Learning Astronomy**
Jacob Noel-Storr[1]
[1]Rochester Inst. of Technology.

095: Radio Galaxy Surveys
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

095.01 **The Arecibo Legacy Fast ALFA Survey: HI Sources in the Northern Virgo Cluster Region**
Rebecca A. Koopmann[1], ALFALFA Consortium
[1]*Union College.*

095.02 **The Arecibo Legacy Fast ALFA HI Survey: The Rich Galaxy Group Zwicky 1400+0949**
Thomas J. Balonek[1], B. M. Walsh[1], ALFALFA Consortium
[1]*Colgate Univ..*

095.03 **A Neutral Hydrogen Survey of the NGC 7332 Region with the Arecibo L-band Feed Array**
Robert F. Minchin[1], E. Momjian[1], L. Cortese[2], K. L. O'Neil[3], P. A. Henning[4], J. I. Davies[2], AGES Team
[1]*Arecibo Obs.,* [2]*Cardiff University, United Kingdom,* [3]*National Radio Astronomy Observatory,* [4]*University of New Mexico.*

095.04 **The ALFA Zone of Avoidance Survey: Results from the Precursor Observations**
Chris M. Springob[1], P. A. Henning[2], B. Catinella[3], F. Day[2], R. Minchin[3], E. Momjian[3], B. Koribalski[4], K. L. Masters[5], E. Muller[4], C. Pantoja[6], M. Putman[7], J. L. Rosenberg[8], S. Schneider[9], L. Staveley-Smith[10]
[1]*Naval Research Laboratory,* [2]*Univ. of New Mexico,* [3]*National Astronomy and Ionosphere Center,* [4]*Australia Telescope National Facility, Australia,* [5]*Harvard-Smithsonian, CfA,* [6]*Univ. of Puerto Rico,* [7]*Univ. of Michigan,* [8]*George Mason Univ.,* [9]*Univ. of Massachusetts,* [10]*Univ. of Western Australia, Australia.*

096: Research in K-12 Astronomy Education for Students, Their Teachers, and Their Families both in and out of the Classroom
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

096.01 **The Search: for Life Beyond Earth**
Neal E. Hurlburt[1], J. Blair[2], S. Lubbs[2], D. Miller[2]
[1]*Lockheed Martin Corp.,* [2]*Evergreen Valley High School.*

096.02 **Stones from the Sky: Introducing Middle School Students to Meteorites**
Angela R. Sarrazine[1], E. Albin[1]
[1]*Fernbank Science Center.*

096.03 **Education and Public Outreach using Venus Express**
Rosalyn A. Pertzborn[1], S. S. Limaye[1], H. Y. Pi[1]
[1]*University of Wisconsin.*

096.04 **The eXtreme Universe: A Portable Planetarium Program**
Philip Plait[1], S. Silva[1], T. Graves[1], J. Reed[1], L. Cominsky[1]
[1]*Sonoma State Univ..*

096.05 **Demystifying Scientific Data**
Esther A. Santos[1], P. Nassiff[2], P. Pratap[3]
[1]*Nashua High School South,* [2]*Burlington High School,* [3]*MIT Haystack Observatory.*

096.06 **The Impact of Science Graduate Students in Urban Science Classrooms: The SFOS Program at Cal State Los Angeles**
Susan Terebey[1], D. Mayo[1]
[1]*Cal. State Univ. at Los Angeles.*

096.07 **How Astronomers Can Help Prepare Future Teachers**
Christine Shupla[1], L. Ruberg[2], T. F. Slater[3], G. Schultz[4]
[1]Lunar & Planetary Institute, [2]CET, Wheeling Jesuit University, [3]University of Arizona CAPER Team, [4]Center for Science Education, UC Berkeley.

097: Sloan Digital Sky Survey
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

097.01 **Environments of Low-Redshift Merging Galaxies**
Christina Ignarra[1], M. R. Blanton[1]
[1]New York University.

097.02 **A Search for Low Surface Brightness Galaxies in the Ultraviolet with GALEX**
Ted K. Wyder[1], GALEX Science Team
[1]Caltech.

097.03 **Active Galaxies in Redshift Surveys**
Pietro Reviglio[1], D. Helfand[1]
[1]Columbia Univ..

097.04 **Constraints on the Stellar Initial Mass Function from the Integrated Light Properties of Galaxies in the Sloan Digital Sky Survey**
Erik A. Hoversten[1], K. Glazebrook[2]
[1]Johns Hopkins Univ., [2]Swinburne University, Australia.

097.05 **The Clustering Properties of UV-selected Galaxies at Low Redshift from GALEX-SDSS Data**
Sebastien Heinis[1], T. Budavari[1], A. Szalay[1], M. Neyrinck[2], I. Szapudi[2], B. Milliard[3], S. Arnouts[3], GALEX Team
[1]Johns Hopkins Univ., [2]University of Hawaii, [3]Laboratoire d'Astrophysique de Marseille, France.

097.06 **Arecibo Survey of HI Emission from Disk Galaxies at Intermediate Redshift**
Barbara Catinella[1], M. P. Haynes[2], J. P. Gardner[3], A. J. Connolly[3], R. Giovanelli[2]
[1]NAIC-Arecibo Obs., [2]Center for Radiophysics and Space Research and NAIC, Cornell Univ., [3]Pittsburgh Univ..

097.07 **The Star Formation History of Early-Type Galaxies**
Vaishali Bhardwaj[1], M. Blanton[2]
[1]UC Berkeley, [2]NYU.

097.08 **Dust Lanes as Markers of the Mass Transition in Edge-on Galaxies**
Mirela Obric[1], A. A. West[2], J. Dalcanton[1]
[1]University of Washington, [2]University of California, Berkeley.

097.09 **A Multi-Wavelength Catalog of Radio Objects Detected by NVSS and FIRST, and (some by) WENSS, GB6, and SDSS**
Amy E. Kimball[1], Z. Ivezic[1]
[1]Univ. of Washington.

097.10 **Reconstruction of SDSS Nearby Galaxies**
Laura K. Kushner[1], M. Obric[1], A. A. West[2], J. Dalcanton[1]
[1]University of Washington, [2]University of California, Berkeley.

097.11 **Correlation of Galaxy Types in the 2MASS Redshift Survey with 2MASS/SDSS Colors and HI Content**
Ferah Munshi[1], K. L. Masters[2], J. Huchra[2]
[1]University of California, Berkeley, [2]Center for Astrophysics, Harvard University.

097.12 **Improvement in the SDSS Photometric Calibration for Red Stars**
James R. Davenport[1], J. Bochanski[1], K. Covey[2], S. Hawley[1]
[1]Univ. Of Washington, [2]Harvard.

097.13 **Minor Galaxy Interactions in the SDSS**
Deborah Freedman Woods[1], M. J. Geller[2]
[1]Harvard Univ., [2]SAO.

098: SNAP Mission
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

098.01 **SNAP Telescope Performance for Weak Lensing Surveys**
Michael Lampton[1], M. Sholl[1], P. Jelinsky[1], H. Stabenau[2], SNAP Collaboration
[1]UC, Berkeley, [2]University of Pennsylvania.

098.02 **Characterization of LBNL SNAP CCD's: Quantum efficiency, reflectivity, and point-spread function**
Donald E. Groom[1], C. J. Bebek[1], M. Fabricius[1], J. A. Fairfield[1], A. Karcher[1], W. F. Kolbe[1], N. A. Roe[1], J. Steckert[1]
[1]Lawrence Berkeley Nat'l Lab..

098.03 **Current-Integrating Amplifier and Computer Interface for SNAP Photodiode Readout**
Stephen J. Battazzo[1], B. Adams[2], M. Gebhard[2], N. Mostek[2], S. Mufson[2]
[1]Indiana University (REU)/University of Oregon, [2]Indiana University.

098.04 **SNAP Focal Plane Development**
Chris Bebek[1], SNAP Collaboration
[1]LBNL.

098.05 **Auxiliary Science with SNAP Surveys**
Timothy McKay[1], SNAP collaboration
[1]Univ. of Michigan.

098.06 **SNAPsim: A Software Package for Simulating of Astronomical Observations**
Alex G. Kim[1], SNAP Collaboration
[1]LBNL.

098.07 **SNAP: The Power of Supernovae, Weak Lensing, and Space**
Eric Linder[1], SNAP Collaboration
[1]Berkeley Lab/UC Berkeley.

098.08 **Computation and Data Product Model for the SNAP Mission**
William Carithers[1], G. E. Kushner[1]
[1]LBNL.

098.09 **The SNAP Mission Overview**
Patrick Jelinsky[1], SNAP Collaboration
[1]UC, Berkeley.

098.10 **Near Infrared Detectors for SNAP: Towards Precision Photometry**
Michael Schubnell[1], SNAP Collaboration
[1]Univ. of Michigan.

098.11 **A Monochromatic Illumination and Cryogenic Calibration System for SNAP Calibration Studies**
Stuart Mufson[1], N. Mostek[1], C. R. Bower[1], S. S. Allam[2], C. J. Bebek[3], R. C. Bohlin[4], S. Deustua[5], S. M. Kent[2], M. L. Lampton[6], M. Richmond[7], D. T. Tucker[2], B. E. Woodgate[8], SNAP Collaboration
[1]Indiana Univ., [2]FNAL, [3]LBNL, [4]STScI, [5]AAS, [6]UC Berkeley, [7]RIT, [8]GSFC.

098.12 **Effects of Zero Points Calibration Uncertainties in Dark Energy Supernova Surveys**
Lorenzo Faccioli[1], A. G. Kim[1], R. Miquel[2]
[1]Lawrence Berkeley National Laboratory, [2]ICREA / IFAE, Spain.

098.13 **Observational Cadence vs. Exposure Time Trade-off for Supernova Surveys**
Natalia Kuznetsova[1], SNAP Simulation Team
[1]Lawrence Berkeley National Lab.

098.14 **Packaging for SNAP CCDs**
Charles Baltay[1], A. Bauer[1], W. Emmet[1], T. Hurteau[1], D. Rabinowitz[1], A. Szymkowiak[1], C. Bebek[2], K. Dawson[2], J. Emes[2], D. Groom[2], S. Holland[2], A. Karcher[2], B. Kolbe[2], N. Roe[2], T. Diehl[3], M. Demarteau[3], P. Derwent[3], B. Bigelow[4]
[1]Yale University, [2]Lawrence Berkeley National Lab, [3]Fermi National Lab, [4]University of Michigan.

098.15 **Radiation Tolerance of SNAP CCDs**
Koki Takasaki[1], SNAP collaboration
[1]UC, Berkeley.

098.16 **Calibration of Interference Filter Transmission using Light Emitting Diodes**
Nick J. Mostek[1], S. L. Mufson[1], C. R. Bower[1], S. S. Allam[2], C. J. Bebek[3], R. C. Bohlin[4], S. Deustua[5], S. M. Kent[2], M. L. Lampton[6], M. Richmond[7], D. L. Tucker[2], B. E. Woodgate[8], SNAP Collaboration
[1]Indiana Univ., [2]FNAL, [3]LBNL, [4]STScI, [5]AAS, [6]UC Berkeley, [7]RIT, [8]GSFC.

098.17 **Critical Parameters for Supernova Cosmology**
Lifan Wang[1], K. Kannan[1], A. Kim[2]
[1]Texas A&M University, [2]Lawrence Berkeley National Laboratory.

098.18 **Development of Spectrophotometric Standards to Support the SNAP**
J. Allyn Smith[1], R. C. Bohlin[2], S. E. Deustua[3], S. S. Allam[4], S. M. Kent[4], M. L. Lampton[5], N. Mostek[6], S. L. Mufson[6], M. W. Richmond[7], G. Smadja[8], D. L. Tucker[4], B. Woodgate[9], SNAP Collaboration
[1]Austin Peay State Univ., [2]STScI, [3]AAS, [4]Fermilab, [5]UC Berkeley, [6]Indiana Univ., [7]R.I.T., [8]IPN-CNRS, France, [9]NASA-GSFC.

098.19 **Dark Energy Science Constraints on Calibration: Design of the SNAP Calibration System**
Susana E. Deustua[1], S. Allam[2], R. Bohlin[3], S. Kent[4], M. L. Lampton[5], N. Mostek[6], S. L. Mufson[6], M. Richmond[7], J. A. Smith[8], D. Tucker[4], B. Woodgate[9], G. Smadja[10], SNAP Collaboration
[1]American Astronomical Society, [2]Fermi National Laboratory, [3]STScI, [4]FNAL, [5]LBNL, [6]Indiana University, [7]RIT, [8]Austin Peay, [9]NASA's GSFC, [10]Institut de Physique Nucleair de Lyon, France.

098.20 **The SNAP Integral Field Spectrograph**
Roger F. Malina[1], A. Ealet[2], E. Prieto[3], M. Aumeunier[4], A. Bonissent[2], C. Cerna[2], G. Smadja[5], SNAP Collaboration
[1]LAM, CNRS, France, [2]CPPM, CNRS, France, [3]LAM, CNRS, France, [4]LAM/CPPM, CNRS, France, [5]IPNL, CNRS, France.

099: Source Surveys, Catalogs and Astrometry
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

099.01 **Time-Series Data and the Virtual Observatory**
Mark Huber[1], A. Drake[2], K. Vivas[3], D. Gasson[4], K. Cook[1], S. Nikolaev[1]
[1]LLNL, [2]Caltech, [3]CIDA, Venezuela, [4]NOAO.

099.02 **Basic Stellar Parameters for SIM Planet Quest Reference Grid Stars**
Dmitry Bizyaev[1], V. V. Smith[1], K. Cunha[1]
[1]*NOAO.*

099.03 **Milliarcsecond Accurate Astrometry for Extension of the ICRF in the Southern Hemisphere**
Alan L. Fey[1], R. Ojha[1], K. Johnston[1], D. Jauncey[2], J. Reynolds[2], A. Tzioumis[2], J. Lovell[2], J. Quick[3], G. Nicolson[3], S. Ellingsen[4], P. McCulloch[4]
[1]*U.S. Naval Obs.,* [2]*Australia Telescope National Facility, CSIRO, Australia,* [3]*Hartebeesthoek Radio Astronomy Observatory, South Africa,* [4]*School of Mathematics and Physics, Australia.*

099.04 **Atmospheric Gravity Waves as a Source of Anomalous Refraction Observed in High Precision Astrometry**
Suzanne Taylor[1], J. McGraw[1], J. Pier[2], P. Zimmer[1]
[1]*University of New Mexico,* [2]*USNO Flagstaff Station.*

099.05 **ALPACA: An Inexpensive but Uniquely Powerful Imaging Survey Telescope**
Arlin P. Crotts[1], ALPACA Consortium
[1]*Columbia Univ..*

099.06 **OT060420 and the Systematic Automated All-sky Search for Bright Optical Transients**
Lior Shamir[1], R. Nemiroff[1]
[1]*Michigan Tech.*

099.07 **Improved UBVR$_{\mathbf{CI\ C}}$ to u'g'r'i'z' Transformation Equations: Updated Main Sequence and Giant Star Relations**
Eric J. Hausel[1], D. Allen[2], C. Rodgers[1], R. Canterna[1], M. Pierce[1], J. A. Smith[3]
[1]*University of Wyoming,* [2]*Lowell Observatory,* [3]*Austin Peay State University.*

099.08 **New DDO Photometric Equatorial Standard Stars Between 9.0 < M_{48} < 16.0: Preliminary Results**
Christopher T. Rodgers[1], R. Canterna[1], D. Allen[2], E. Hausel[1], J. A. Smith[3]
[1]*Univ. of Wyoming,* [2]*Lowell Observatory,* [3]*Austin Peay State University.*

100: Star Clusters II and HST/ACS Survey of Galactic Globular Clusters
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

100.01 **M82 at the Highest Resolution**
William D. Vacca[1], A. M. Gilbert[2], J. R. Graham[3], N. McCrady[4]
[1]*SOFIA-USRA,* [2]*IGPP-LLNL,* [3]*UC Berkeley,* [4]*UCLA.*

100.02 **Old Globular Clusters in Nearby Dwarf Irregular Galaxies**
Iskren Georgiev[1], P. Goudfrooij[1], T. H. Puzia[2], M. Hilker[3]
[1]*STScI,* [2]*Herzberg Institute of Astrophysics, Canada,* [3]*ESO, Germany.*

100.03 **Searching for the Young Super-Star Clusters in NGC 3627**
Adam Ginsburg[1]
[1]*Rice University / NRAO.*

100.04 **Properties of Globular Cluster Populations of Early-Type E+A Galaxies**
Aparna Maybhate[1], P. Goudfrooij[1], F. Schweizer[2], T. Puzia[1], D. Carter[3]
[1]*STScI,* [2]*Carnegie Observatories,* [3]*Liverpool John Moores University, United Kingdom.*

100.05 **Resolved Massive Stellar Clusters in Nearby Starburst Galaxies**
Andrea M. Gilbert[1], W. D. Vacca[2]
[1]*IGPP-LLNL,* [2]*SOFIA-USRA.*

100.06 **Multi-band Photometry of Globular Cluster Systems**
Sooyoung Kim[1], S. Yoon[1], H. Kim[1]
[1]Yonsei University, Republic of Korea.

100.07 **Imaging of Globular Clusters in NGC 4365 with IRAC on the Spitzer Space Telescope**
Andrew R. Esselman[1], S. E. Zepf[2], A. Kundu[2], M. Hempel[2]
[1]Whitman College, [2]Michigan State University.

100.08 **The Cluster Formation Function in Galaxies**
Paul W. Hodge[1], K. Krienke[2]
[1]Univ. of Washington, [2]Seattle Pacific University.

100.09 **The HST/ACS Survey of Galactic Globular Clusters: Overview and New Photometry for Nine Clusters**
Ata Sarajedini[1], J. Anderson[2], A. Aparicio[3], L. Bedin[4], B. Chaboyer[5], A. Dotter[5], M. Hempel[1], I. R. King[6], S. R. Majewski[7], A. Marin-Franch[1], A. Milone[8], N. E. Paust[9], G. Piotto[8], I. N. Reid[9], A. Rosenberg[3], M. Siegel[10]
[1]Univ. of Florida, [2]Rice University, [3]IAC, Spain, [4]ESO, Germany, [5]Dartmouth College, [6]Univ. of Washington, [7]Univ. of Virginia, [8]Univ. of Padova, Italy, [9]STScI, [10]Univ. of Texas.

100.10 **The HST/ACS Survey of Galactic Globular Clusters: New Stellar Evolution Tracks, Isochrones and Luminosity Functions**
Brian C. Chaboyer[1], A. Dotter[1], E. Baron[2], J. Ferguson[3], D. Jevremovic[2], A. Sarajedini[4]
[1]Dartmouth College, [2]University of Oklahoma, [3]Wichita State University, [4]University of Florida.

100.11 **The HST/ACS Survey of Galactic Globular Clusters: Luminosity Functions**
Nathaniel Paust[1], I. Reid[1], I. King[2], A. Aparicio[3], G. Piotto[4]
[1]STScI, [2]Department of Astronomy, University of Washington, [3]Departamento de Astrofisica, Universidad de La Laguna: and Instituto de Astrofisica de Canarias, Spain, [4]Dip. di Astronomica, Univ. degli stui di Padova, Italy.

100.12 **The HST/ACS Survey of Galactic Globular Clusters: The Sagittarius Dwarf Spheroidal System**
Michael Siegel[1], S. R. Majewski[2], A. Sarajedini[3], B. Chaboyer[4], A. Rosenberg[5]
[1]University of Texas, [2]University of Virginia, [3]University of Florida, [4]Darmouth College, [5]Instituto de Astrofisica de Canarias, Spain.

100.13 **The HST/ACS Survey of Galactic Globular Clusters: Relative Ages**
Alfred Rosenberg[1], A. Marín-Franch[2], A. Aparicio[1], G. Piotto[3], B. Chaboyer[4], A. Sarajedini[2]
[1]Instituto de Astrofísica de Canarias, Spain, [2]Department of Astronomy, University of Florida, [3]Astronomy Department, Padova University, Italy, [4]Department of Physics and Astronomy, Dartmouth College.

100.14 **The HST/ACS Survey of Galactic Globular Clusters: Absolute Ages of Selected Clusters**
Iain N. Reid[1], J. Anderson[2], A. Aparicio[3], B. Chaboyer[4], A. Dotter[4], G. Piotto[5], A. Marin-Franch[6], A. Rosenberg[7]
[1]STScI, [2]Rice University, [3]Instituto Astrofisica de Canarias, Spain, [4]Dartmouth College, [5]Universita di Padova, Italy, [6]University of Florida, [7]Instituto de Astrofisica de Canarias, Spain.

101: Structure of Stellar Winds
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

101.01 **The dM/dt of O-rich OH/IR Stars is Strongly Modulated**
B. M. Lewis[1]
[1]Arecibo Obs..

101.02 **Observations of Post-Asymptotic Giant Branch Objects in the Magellanic Clouds with the Spitzer Infrared Spectrograph**
Kathleen E. Kraemer[1], G. C. Sloan[2], J. Bernard-Salas[2], E. Peeters[3], P. R. Wood[4], S. D. Price[1], J. Cami[3], J. R. Houck[2], M. P. Egan[5], S. Guiles[2]
[1]Air Force Research Lab, [2]Cornell University, [3]University of Western Ontario, Canada, [4]Mt. Stromlo Observatory, Australia, [5]National Geospatial-Intelligence Agency.

101.03 **Synthesis of Observables from Numerical Simulations of Magnetized Hot-Star Winds**
Stephen St. Vincent[1], D. H. Cohen[1], A. ud-Doula[2], R. H. Townsend[2], S. P. Owocki[2]
[1]Swarthmore College, [2]Bartol Research Institute, University of Delaware.

101.04 **X-ray Emission Line Profiles from Clump Bow Shocks in Stellar Winds**
Alexander Burke[1], R. Ignace[2], J. P. Cassinelli[3]
[1]Vassar College, [2]East Tennessee State University, [3]University of Wisconsin.

101.05 **High Resolution Radio Observations of the Nebulae of Luminous Blue Variable Stars**
Allison Mercer[1], M. Chizek[1], C. C. Lang[1], D. F. Figer[2], P. Najarro[3]
[1]Univ. of Iowa, [2]Rochester Institute of Technology, [3]CSIC, Spain.

101.06 **Velocity Structure in the Chromosphere and Wind of VV Cephei**
Wendy H. Bauer[1], P. D. Bennett[2], A. Brown[3]
[1]Wellesley College, [2]Eureka Scientific, [3]CASA, University of Colorado.

101.07 **Multi-dimensional Simulations of Helium Shell Flash Convection**
Robert M. Hueckstaedt[1], B. Freytag[2], F. Herwig[3], F. Timmes[1]
[1]Los Alamos National Laboratory, [2]Centre de Recherche Astronomique de Lyon Ecole Normale Supérieure, France, [3]Keele Astrophysics Group, School of Physical and Geographical Sciences, Keele University, United Kingdom.

101.08 **The 3D Morphology of VY CMa**
Terry J. Jones[1], R. M. Humphreys[1], A. Helton[1], G. Wallerstein[2], G. Herbig[3]
[1]Univ. of Minnesota, [2]Univ. of Washington, [3]Institute for Astronomy.

101.09 **VY Canis Majoris: The Astrophysical Basis of Its Luminosity**
Robert D. Gehrz[1], R. M. Humphreys[1], T. J. Jones[1]
[1]Univ. of Minnesota.

101.10 **VLBA Observations of the SiO Masers in the Eruptive Variable V838 Monocerotis**
Mark J. Claussen[1], H. E. Bond[2], S. Starrfield[3], K. H. Healy[3]
[1]NRAO, [2]STScI, [3]Arizona State University.

101.11 **Observations of the 6 Centimeter Lines of OH in OH/IR Stars and Star Forming Regions**
Laura K. Zschaechner[1], V. L. Fish[2], L. O. Sjouwerman[2], Y. M. Pihlstrom[3], M. J. Claussen[2]
[1]University of Montana, [2]National Radio Astronomy Observatory, [3]University of New Mexico.

101.12 **Joint VLBA/VLTI Observations of the Mira Variable GX Mon**
David A. Boboltz[1], M. Wittkowski[2], K. Ohnaka[3], T. Driebe[3]
[1]USNO, [2]ESO, Germany, [3]MPIfR, Germany.

102: Variable Stars and Distance Scale
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

102.01 **Hubble Space Telescope Fine Guidance Sensor Parallaxes of Galactic Cepheid Variable Stars: Period-Luminosity Relations and Applications**
George F. Benedict[1], B. E. McArthur[1], M. W. Feast[2], T. G. Barnes[3], T. E. Harrison[4], R. J. Patterson[5], J. W. Menzies[6], J. L. Bean[1], W. L. Freedman[7]
[1]Univ. of Texas, Austin, [2]University of Capetown, South Africa, [3]National Science Foundation, [4]New Mexico State University, [5]Univ. of Virginia, [6]South African Astronomical Observatory, South Africa, [7]Carnegie Institution.

102.02 **A Theoretical Investigation into Period-Color relations for Cepheids in the Small Magellanic Cloud**
Shashi Kanbur[1], C. Ngeow[2], G. Feiden[1]
[1]SUNY at Oswego, [2]University of Illinois.

102.03 **A Testimator Based Approach to Investigate the Non-linearity of the LMC Cepheid Period-Liminosity Relation**
Richard Stevens[1], A. Nanthakumar[1], C. Ngeow[2], S. Kanbur[1]
[1]SUNY Oswego, [2]University of Illinois.

102.04 **A Theoretical Investigation into the Properties of RR Lyraes at Maximum and Minimum Light.**
Greg Feiden[1], S. Kanbur[1], R. Szabo[2], C. Ngeow[3]
[1]SUNY Oswego, [2]University of Florida, [3]University of Illinois.

102.05 **An Empirical Investigation of the Effect of Metallicityon Linear vs. Non-linear Cepheid Period-Luminosity relations.**
Daniel Crain[1], S. kanbur[1], C. Ngeow[1]
[1]SUNY Oswego.

102.06 **A Cepheid Distance to the Coma Cluster: Initial Progress Report**
Michael Gregg[1], K. Cook[2], L. Macri[3], D. Alves[1], D. Welch[4], P. Stetson[5], J. Mould[3]
[1]UC, Davis, [2]LLNL/NOAO, [3]NOAO, [4]Macmaster University, Canada, [5]DAO, Canada.

102.07 **Improving the Distance Scale: NICMOS and ACS/HRC observations of Cepheids in the Maser Galaxy NGC 4258**
Lucas M. Macri[1], K. Stanek[2], D. Bersier[3], L. Greenhill[4], M. Reid[4]
[1]NOAO, [2]OSU, [3]Liverpool JMU, United Kingdom, [4]CfA.

103: White Dwarfs: Search, Survey, Study, and Understand?
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

103.01 **White Dwarf Kinematics vs Mass**
Chris Wegg[1], E. S. Phinney[1]
[1]Caltech.

103.02 **The Search for White Dwarfs in the Sandage Two-color Survey of the Galactic Plane**
Howard H. Lanning[1], S. Lepine[2]
[1]NOAO, [2]Dept. of Astrophysics, Div. of Physical Sciences, American Museum of Natural History.

103.03 **Improved Photometric Distances for White Dwarfs**
Jay B. Holberg[1], E. M. Sion[2], T. D. Oswalt[3]
[1]Univ. of Arizona, [2]Villanova University, [3]Florida Institute of Technology.

103.04 **The Space Motions of DQ White Dwarfs**
Ralph Wasatonic[1], E. Sion[1], G. McCook[1], J. Holberg[2]
[1]Villanova University, [2]University of Arizona.

103.05 **The Hunt for Nearby White Dwarfs**
John P. Subasavage, Jr.[1], P. Bergeron[2], T. J. Henry[1], P. Dufour[2], N. C. Hambly[3], T. D. Beaulieu[1], RECONS
[1]Georgia State University, [2]University of Montreal, Canada, [3]University of Edinburgh, United Kingdom.

103.06 **Meet Your Local White Dwarf Neighbors: A Census of the 20 pc Sample**
Sean Foran[1], E. Sion[1], J. Holberg[2], G. McCook[1]
[1]Villanova University, [2]University of Arizona.

103.07 **FUSE Observations of the Very Cool DB White Dwarf GD408**
Pierre Chayer[1], S. Desharnais[2], F. Wesemael[2], J. W. Kruk[1]
[1]Johns Hopkins Univ., [2]University of Montreal, Canada.

103.08 **Kinematical and Statistical Study of Magnetic White Dwarfs**
Edward M. Sion[1], R. Wasatonic[1], G. McCook[1], J. Holberg[2]
[1]Villanova Univ., [2]Univ. Arizona.

103.09 **G29-38: Mode Identification**
Susan E. Thompson[1]
[1]Colorado College.

103.10 **FUSE Observation of the Ultra-Massive White Dwarf GD 50**
Jean Dupuis[1], P. Chayer[2], S. Vennes[3], V. Hénault-Brunet[4]
[1]Canadian Space Agency, Canada, [2]Johns Hopkins University, [3]Florida Institute of Technology, [4]McGill University, Canada.

103.11 **A New Look at GD358: Using Nonlinear Light Curves to Constrain Convection**
Judith L. Provencal[1], H. Shipman[1], M. Montgomery[2], Whole Earth Telescope Team
[1]Univ. Of Delaware Delaware Asteroseismic Research Center, [2]University of Texas.

103.12 **Quantifying Turbulence: A Nonlinear Approach**
Nada Jevtic[1], J. S. Schweitzer[2]
[1]Richard Stockton College, [2]University of Connecticut.

104: X-ray to IR Observations of Compact X-ray Objects
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

104.01 **Shedding New Light on the Stellar Graveyard: Compact Objects in the Mid-IR**
Magaretha L. Pretorius[1], S. Wachter[1], D. Hoard[1]
[1]California Institute of Technology.

104.02 **Radio Emission Signatures of the Crab Pulsar's High Frequency Interpulse**
Timothy H. Hankins[1], J. A. Eilek[1]
[1]New Mexico Tech..

104.03 **Multi-Wavelength Studies of Potential X-ray Counterparts to Unidentified EGRET Gamma-Ray Sources**
Mallory Roberts[1]
[1]Eureka Scientific.

105: YSO / Star Formation II
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

105.01 **Characterizing Star Formation Activity in Infrared Dark Cloud Cores**
Edward T. Chambers[1], J. M. Jackson[1], J. M. Rathborne[2], R. Simon[3]
[1]Boston University, [2]Harvard-Smithsonian Center for Astrophysics, [3]Universitat zu Koln, Germany.

105.02 **Infrared Spectroscopy of Low Mass Stars in the Cepheus A Star Forming Region**
Eric S. Boyd[1], A. Steinhauer[1], E. Lada[2]
[1]SUNY Geneseo, [2]University of Florida.

105.03 **Current Star Formation in the Perseus and Ophiuchus Molecular Clouds**
Jes K. Jorgensen[1], D. Johnstone[2], H. Kirk[3], P. C. Myers[1], Y. L. Shirley[4], L. E. Allen[1]
[1]Harvard-Smithsonian Center for Astrophysics, [2]Herzberg Institute of Astrophysics, [3]University of Victoria, [4]Steward Observatory.

105.04 **HST NICMOS Polarization Observations of Massive YSOs**
Janet P. Simpson[1], M. G. Burton[2], S. W. Colgan[1], A. S. Cotera[3], E. F. Erickson[1], D. C. Hines[4], B. A. Whitney[4]
[1]NASA/Ames Research Center, [2]University of New South Wales, Australia, [3]SETI Institute, [4]Space Science Institute.

105.05 **Spectroscopic Investigation of Companion Stars in Herbig AeBe Binary Systems**
Anne Sweet[1], B. Rodgers[2], G. Doppmann[2], N. van der Bliek[3], S. Thomas[3], M. J. Cordero[1]
[1]CTIO REU, Chile, [2]Gemini Observatory, Chile, [3]CTIO, Chile.

105.06 **Observations and Models of Very Low Luminosity Objects Discovered with the Spitzer Space Telescope**
Michael M. Dunham[1]
[1]The University of Texas at Austin.

105.07 **Star Formation in the Small Magellanic Cloud: the young star cluster NGC 602**
Antonella Nota[1], L. R. Carlson[2], E. Sabbi[3], M. Sirianni[1], J. L. Hora[4], M. Meixner[3], M. Clampin[5], J. Gallagher, III[6], S. Oey[7], A. Pasquali[8], L. J. Smith[9], M. Tosi[10], R. Walterbos[11]
[1]STScI/ESA, Space Telescope Operation Division, [2]JHU, [3]STScI, [4]Harvard/CfA, [5]NASA/Goddard, [6]University of Wisconsin, [7]University of Michigan, [8]MPIA, Germany, [9]University College London, United Kingdom, [10]INAF-Oservatorio Astronomico di Bologna, Italy, [11]New Mexico State University.

105.08 **The Effect of Varied Initial Conditions on the Evolution of Protoplanetary Disks**
Scott A. Michael[1], R. H. Durisen[1], A. C. Boley[1]
[1]Indiana Univ..

105.09 **Radiative Transfer Model Fitting of Hubble NICMOS Data for the Class I Protostar TMC-1A (IRAS 04365+2535)**
Susan Terebey[1]
[1]Cal. State Univ. at Los Angeles.

105.10 **Statistics of Turbulence Probed by Water Masers in Star Forming Regions**
Benjamin H. Ripman[1], V. Strelnitski[1]
[1]Maria Mitchell Observatory.

105.11 **Multiplicity and the Nature of Companions in Herbig Ae/Be Systems**
Bernadette Rodgers[1], N. van der Bliek[2], S. Thomas[3], G. Doppmann[4]
[1]Gemini Obs., Chile, [2]NOAO CTIO, Chile, [3]UCO Lick Observatory, [4]NOAO.

105.12 **Monte Carlo Simulations Of The Rotational Evolution Of PMS Stars**
Lucas A. Cieza[1], N. Baliber[2], N. Counselor[1]
[1]Univ. Of Texas, Austin, [2]Univ. Of California at Santa Barbara.

105.13 **Spitzer Observations of YSO's in the Witch Head Nebula (IC 2118)**
Tim S. Spuck[1], M. T. Heath[1], L. M. Rebull[2], T. E. Roelofsen Moody[3], B. Sepulveda[4], E. Sharma[4], C. Weehler[5], S. P. Weiser[1]
[1]Oil City Area Sr. High School, [2]SSC/JPL/Caltech, [3]New Jersey Astronomy Center for Education, [4]Lincoln High School, [5]Luther Burbank High School.

105.14 **The Velocity Field and the Spatial Distribution of the "Hot Spots" in Methanol Masers: a Statistical Study**
Phuongmai N. Truong[1], B. H. Ripman[2], V. Strelnitski[3]
[1]Texas A&M Univ., [2]Bowdoin College, [3]Maria Mitchell Obs..

105.15 **Spitzer Imaging of NGC 2467: Evidence for Triggered Low-Mass Star Formation in HII Region Environments**
Keely D. Snider[1], J. J. Hester[1], S. J. Desch[1], K. R. Healy[1], J. Bally[2]
[1]Arizona State Univ., [2]University of Colorado.

105.16 **Self-Gravitational Collapse Of A Slowly Rotating Interstellar Gas Cloud**
John K. Wall[1]
[1]Retired.

105.17 **Spitzer Observations of Massive Protostars Associated with Methanol Masers**
Audrey E. Simmons[1], S. L. Skinner[1], M. Guedel[2]
[1]Univ. of Colorado, [2]Paul Scherrer Inst., Switzerland.

105.18 **Large Magnetic Fields and OH Maser Motions in W75 N**
Vincent L. Fish[1], M. J. Reid[2]
[1]NRAO Jansky Fellow, [2]Harvard-Smithsonian Center for Astrophysics.

105.19 **New Young Stellar Aggregates in Perseus as Revealed by the Spitzer/MIPS c2d Legacy Program**
Luisa M. Rebull[1], K. Stapelfeldt[2], c2d team
[1]SSC/Caltech/JPL, [2]JPL.

105.20 **Cluster Formation in Isolation: Spitzer's View of Bok Globule CB 34**
Dawn E. Peterson[1], R. A. Gutermuth[2], M. F. Skrutskie[1], S. T. Megeath[3], J. L. Pipher[4], L. E. Allen[2], P. C. Myers[2]
[1]Univ. of Virginia, [2]Harvard-Smithsonian Center for Astrophysics, [3]Univ. of Toledo, [4]Univ. of Rochester.

105.21 **The Near-IR to Submillimeter Opacity Ratio toward Low-mass Star-forming Cores**
Yancy L. Shirley[1], T. L. Huard[2], A. M. Stutz[1], D. J. Wilner[2], K. M. Pontoppidan[3], L. G. Mundy[4], N. J. Evans II[5]
[1]Univ. of Arizona, [2]CfA, [3]Caltech, [4]Univ. of Maryland, [5]Univ. of Texas.

105.22 **Variations in the Extinction Law, Ice Abundance, and Dust Grains in Molecular Cloud Cores**
Tracy L. Huard[1], K. M. Pontoppidan[2], A. Boogert[3], C. Knez[4], Y. L. Shirley[5]
[1]Harvard-Smithsonian CfA, [2]Caltech, [3]NOAO Gemini Science Center, Chile, [4]University of Maryland, [5]Steward Observatory.

Job Center
Attendee Services, 9:20am-5:00pm, Exhibit Hall 4

Gadgets and Gizmos
Attendee Services, 9:20am-5:00pm, South Lobby

See Sunday's listing for details.

Chair
Susana E. Deustua[1]
[1]American Astronomical Society.

Experience Digital Physics Curriculum I
Commercial Workshop, 9:30-11:00am, 302

View and experiment with a new digital physics textbook and virtual physics labs. Learn how a fully integrated digital physics curriculum can aid your instruction. Application of multi-learning styles and inquiry-based learning in a self-paced package provide students with the opportunity to experiment and explore.
Chair
Mark Bretl[1]
[1]*Kinetic Books.*

MasteringPhysics
Commercial Workshop, 9:30-11:00am, 305

With more than 80,000 users for calculus-based physics alone, MasteringPhysics is the most widely used physics homework and tutorial system in the world. Its unprecedented popularity is due to two unique advantages. First, MasteringPhysics is the most sophisticated h/w system available‘ allowing for multi-part, multi-step free-response problems, an unmatched variety of wrong-answer feedback, individualized help (comprising hints or simpler sub-problems upon request), all driven by the largest metadatabase of student problem-solving in the world. Secondly, MasteringPhysics is the most educationally proven system‘ 8 years in development and testing, NSF-sponsored published research (and subsequent studies) shows that the system has dramatic educational results with correlated gains in class finals of up to 8 times that from traditional hand-graded homework, and gains in conceptual understanding (as measured using the FCI) higher than that from group problems.

Our workshop will explain how to introduce MasteringPhysics into your course quickly and easily, the benefits to you and your students, the latest physics education research using the system, even guidelines for authoring your own problems and possible research techniques. We welcome anyone who is interested in new ways to offer more effective tutoring and testing in their calculus- and algebra/trig-based physics courses.
Chair
Claire Masson[1]
[1]*Pearson Education.*

106: Education with Large Astronomical Surveys
AAS Special, 10:00-11:30am, 613-14
Chair
Carol A. Christian[1]
[1]*STScI.*

106.01 **Education / Outreach with Large Surveys Overview**
Carol A. Christian[1]
[1]*STScI.*

106.02 **LSST Survey Data Models for EPO Interaction**
Kirk Borne[1]
[1]*GMU / LSST / QSS Group Inc..*

106.03 **Hands on Universe Applications**
Carl Pennypacker[1]
[1]*Lawrence Berkeley Lab..*

106.04 **Teacher Education**
Vivian Hoette[1]
[1]*Yerkes Observatory.*

106.05 **LSST EPO Plans & Challenges**
Suzanne Jacoby[1]
[1]*LSST Corporation.*

106.06 **Education with SDSS Data: Activities and Lessons Learned**
M. J. Raddick[1]
[1]JHU.

106.07 **The Challenges of Using Virtual Observatories in the Classroom**
Robert T. Sparks[1]
[1]NOAO.

106.08 **Introducing High School Science Teachers to Quasar Research Using the Cyberinfrastructure**
Michelle Nichols (Yehling)[1], L. Fortson[1]
[1]Adler Planetarium & Astronomy Museum.

106.09 **The Amateurs' Love Affair with Large Datasets**
Aaron Price[1], S. H. Jacoby[2], A. Henden[3]
[1]AAVSO/Tufts University, [2]LSST Corporation, [3]AAVSO.

107: The Future of Astronomy and Astrophysics at NASA
AAS Special, 10:00-11:30am, 611-12

Chair
Jack O. Burns[1]
[1]Univ. of Colorado at Boulder.

107.01 **CAPP Panel Discussion: The Future of Astronomy & Astrophysics at NASA**
Jack O. Burns[1]
[1]Univ. of Colorado at Boulder.

108: HAD III
HAD Oral, 10:00-11:30am, 608-10

Session begins with a very brief introduction to posters.
Chair
Sara Schechner[1]
[1]Harvard U..

108.01 **The Tunguska Event and the History of Near-Earth Objects**
Donald K. Yeomans[1]
[1]JPL.

108.02 **Einstein's Jury - The Race to Test Relativity**
Jeffrey Crelinsten[1]
[1]The Impact Group, Canada.

108.03 **The Numbers of Scientific Papers Depend Only on the Numbers of Scientists**
Helmut A. Abt[1]
[1]Kitt Peak National Obs..

108.04 **Quasars and the Caltech-Carnegie Connection**
Edward R. Waluska[1]
[1]James Cook University, Australia.

109: AGN Variability, Interactions and Environments
AAS Oral, 10:00-11:30am, 3A

109.01 **Discovery of a Probable Triple Quasar**
Stanislav G. Djorgovski[1], F. Courbin[2], G. Meylan[2], D. Sluse[2], D. Thompson[3], A. Mahabal[1], E. Glikman[1]
[1]Caltech, [2]EPFL, Switzerland, [3]LBTO.

109.02 **The X-ray Variability of Seyfert Galaxies**
Kevin Marshall[1]
[1]Georgia State Univ..

109.03 **Monitoring of a Dramatically Variable C IV Mini-BAL in the Quasar HS1603+3820**
Toru Misawa[1], M. Eracleous[1], J. C. Charlton[1], N. Kashikawa[2]
[1]Penn State Univ., [2]National Astronomical Observatory of Japan, Japan.

109.05 **Reverberation Mapping of the BLRG 3C390.3**
Matthias Dietrich[1], B. M. Peterson[1]
[1]The Ohio State University.

109.06 **HCN Observations of Four High Redshift Galaxies and QSOs**
Yu Gao[1], C. Carilli[2], P. Vanden Bout[3], P. Solomon[4]
[1]Purple Mountain Observatory, China, [2]NRAO-AOC, [3]NRAO-CV, [4]University at Stony Brook.

109.07 **Radially-Inflowing Molecular Gas Deposited by a X-ray Cooling Flow**
Jeremy Lim[1], Y. Ao[2], V. Dinh[1]
[1]ASIAA, Taiwan, [2]Purple Mountain Observatory, Chinese Academy of Sciences, China.

109.08 **Intergalactic Metal Pollution at the Highest Observable Redshifts**
Emma V. Ryan-Weber[1], M. Pettini[1], P. Madau[2]
[1]IoA, Cambridge, United Kingdom, [2]University of California, Santa Cruz.

110: Circumstellar Disks: Early
AAS Oral, 10:00-11:30am, 204

110.01 **High-Resolution Imaging and Modeling of Circumstellar Debris: Architectures of Planetary Systems**
Michael Fitzgerald[1], P. Kalas[1], J. R. Graham[1], G. Duchêne[2], C. Pinte[2]
[1]UC Berkeley, [2]Laboratoire d'Astrophysique, Observatoire de Grenoble, France.

110.02 **SiO Outflow Observations of Young Massive Stellar Objects with Linearly Distributed Methanol Maser Emission**
James M. De Buizer[1], R. Redman[2], P. Feldman[2], S. Longmore[3], J. Caswell[4]
[1]Gemini Obs., Chile, [2]NRC/HIA, Canada, [3]UNSW, Australia, [4]ATNF, Australia.

110.03 **The Likelihood of Supernova Enrichment of Circumstellar Disks**
Jonathan P. Williams[1]
[1]Univ. of Hawaii.

110.04 **New Debris Disks Around Solar-Type Stars Imaged with the HST/ACS Coronagraph**
John E. Krist[1], K. Stapelfeldt[1], G. Bryden[1], C. Chen[2]
[1]JPL, [2]NOAO.

110.05 **Modeling Scattered Light Images from a Planet-Forming Disk**
Hannah Jang-Condell[1], A. P. Boss[1]
[1]Carnegie Inst. of Washington.

111: Dust, Starbursts and Obscured AGN
AAS Oral, 10:00-11:30am, 6A

111.01 **The Revealing Dust: Mid-infared Diagnostics of Nuclear Activity in Hickson Compact Groups**
Sarah Gallagher[1], K. E. Johnson[2], A. E. Hornschemeier[3], J. C. Charlton[4], J. E. Hibbard[5]
[1]UCLA, [2]UVA, [3]GSFC, [4]PSU, [5]NRAO.

111.02 **The Top 15 Luminous Obscured Quasars: SED, Luminosity and Absorption Properties**
Mari Polletta[1], D. Weedman[2], C. Lonsdale[1], S. Hoenig[3], H. Smith[1], J. Houck[4]
[1]UC, San Diego, [2]Department of Astronomy, Cornell University, [3]Max-Planck-Institut fur Radioastronomie, Germany, [4]IRS Science Center, Center for Radiophysics & Space Research, Cornell University.

111.03 **The Nature of Dust-Reddened Quasars**
Tanya Urrutia[1], R. R. Becker[1], M. Lacy[2], M. D. Gregg[1]
[1]UC, Davis, [2]Spitzer Science Center, Caltech.

111.04 **A HCN and HCO+ Multi-transition Line Survey in Active Galaxies: AGN versus Starburst Environments**
Melanie Krips[1], R. Neri[2], S. Garcia-Burillo[3], F. Combes[4], S. Martin[1], A. Eckart[5], G. Petitpas[1], A. Peck[1]
[1]Harvard-Smithsonian Center for Astrophysics, SMA project, [2]IRAM, France, [3]OAN, Spain, [4]LERMA, France, [5]University of Cologne, Germany.

111.05 **Using X-rays to Probe the Physical Properties of Astrophysical Dust**
Andreea Petric[1], F. Paerels[1]
[1]Columbia Univ..

111.06 **Dust within Central Regions of Seyfert Galaxies**
Rajesh P. Deo[1]
[1]Georgia State Univ..

112: Formation History of Galaxies
AAS Oral, 10:00-11:30am, 605-07

112.01 **The Current Mass Function of Galaxies**
Michael Pierce[1], R. C. Berrington[1]
[1]Univ. Of Wyoming.

112.02 **High Resolution Optical Velocity Fields of LSB Galaxies and the Density Profiles of Dark Matter Halos**
Rachel Kuzio de Naray[1]
[1]Univ. Of Maryland.

112.03 **Structure and Formation of Massive Galaxies with Old Stellar Populations at z=1.5**
Elizabeth J. McGrath[1], A. Stockton[1]
[1]Inst. for Astronomy.

112.04 **New Constraints on the History of Star Formation of Elliptical Galaxies**
Ricardo P. Schiavon[1], G. J. Graves[2], R. W. O'Connell[1], S. M. Faber[2]
[1]Univ. of Virginia, [2]University of California.

112.05 **The Spatial Distributions of Globular Cluster Systems**
Eric Peng[1], M. Takamiya[2], P. Cote[1], M. J. West[3], J. P. Blakeslee[4], L. Ferrarese[1], A. Jordan[5], S. Mei[6]
[1]NRC-HIA, Canada, [2]University of Hawaii, [3]Gemini Observatory, Chile, [4]Washington State University, [5]ESO, Germany, [6]l'Observatoire de Paris, France.

112.06 **An X-ray, IR, and Submillimeter Flare of Sagittarius A***
Daniel P. Marrone[1], F. K. Baganoff[2], M. Morris[3], J. M. Moran[4], A. Ghez[3], S. Hornstein[3], D. Dowell[5], M. W. Bautz[2], G. R. Ricker[2], W. N. Brandt[6], G. P. Garmire[6], J. Lu[3], K. Matthews[7], G. Bower[8], J. Zhao[4], R. Rao[9]
[1]Univ. Of Chicago, [2]MIT Kavli Institute, [3]UCLA, [4]Harvard-Smithsonian CfA, [5]JPL, [6]Penn State University, [7]Caltech, [8]UC Berkeley, [9]ASIAA, Taiwan.

112.07 **Flaring Activity of SgrA*: Adiabatic Expansion of Nonthermal Plasma**
Farhad Yusef-Zadeh[1], M. Wardle[2], D. A. Roberts[3], C. O. Heinke[1], C. D. Dowell[4], W. D. Cotton[5], G. C. Bower[6], F. K. Baganoff[7]
[1]Northwestern Univ., [2]Macquarie University, Australia, [3]Northwestern Univ. & Adler Planetarium, [4]Cal Tech, [5]NRAO, [6]UC Berkeley, [7]MIT.

113: Galaxy Clusters I
AAS Oral, 10:00-11:30am, 6B

113.01 **Hydrodynamic Models of AGN Feedback in Cooling Core Clusters**
John C. Vernaleo[1], C. S. Reynolds[1]
[1]Univ. of Maryland.

113.02 **Color and Morphological Evolution in Galaxy Clusters since z ~ 1.5**
Mark Brodwin[1], P. Eisenhardt[1], A. H. Gonzalez[2], A. Stanford[3], D. Stern[1], S. Perlmutter[4], SCP, NDWFS, IRAC, FLAMEX, AGES
[1]JPL/Caltech, [2]University of Florida, [3]UC Davis, [4]UC Berkeley.

113.03 **Characteristics of Megaparsec-scale Structures in the Horologium-Reticulum Supercluster of Galaxies**
Matthew C. Fleenor[1], J. A. Rose[1], W. A. Christiansen[1], M. Johnston-Hollitt[2], R. W. Hunstead[3], W. Saunders[4]
[1]University of North Carolina, [2]University of Tasmania, Australia, [3]Sydney University, Australia, [4]Anglo-Australian Observatory, Australia.

113.04 **A Robust Estimator of the Small Scale Galaxy Correlation Function**
Nikhil Padmanabhan[1], M. White[2], D. J. Eisenstein[3]
[1]Lawrence Berkeley National Laboratory, [2]University of California, Berkeley, [3]University of Arizona.

113.05 **Search for Fossil Groups using NVO Technologies**
Walter A. Santos, Jr.[1], O. Lopez-Cruz[2], D. Lindler[3], T. Tamura[4], C. Mendes de Oliveira[1], L. Sodre, Jr.[1]
[1]Astronomy Institute University of Sao Paulo, Brazil, [2]INAOE, Mexico, [3]Sigma Space Corporation, [4]ISAS/JAXA, Japan.

113.06 **Mapping the Local Density and Velocity Fields**
David J. Radburn-Smith[1]
[1]STScI.

114: Nearby Galaxies and ANGST
AAS Oral, 10:00-11:30am, 3B

114.01 **The ACS Nearby Galaxy Survey Treasury: Overview**
Julianne Dalcanton[1]
[1]Univ. of Washington.

114.02 **The ACS Nearby Galaxies Survey Treasury: Recovering Spatially Resolved Recent Star Formation Histories**
Evan D. Skillman[1], ANGST team
[1]Univ. of Minnesota.

114.03 **The ACS Nearby Galaxies Survey Treasury: First Age and Metallicity Distributions**
Benjamin F. Williams[1], J. Dalcanton[1], D. Weisz[2], A. Dolphin[3], A. Seth[4], E. Skillman[2], R. Covarrubias[1], J. Harris[3], ANGST team
[1]Univ. of Washington, [2]University of Minnesota, [3]Steward Observatory, [4]CfA.

114.04 **The ACS Nearby Galaxies Survey Treasury: The Recent Star Formation History of DDO 06**
Daniel R. Weisz[1], ANGST team
[1]Univ. of Minnesota.

114.05 **Modes of Star Formation in an Early Universe Laboratory: An HST/ACS Survey of Hickson Compact Groups**
Jane C. Charlton[1], S. C. Gallagher[2], C. Gronwall[1], J. English[3], P. R. Durrell[4], R. Chandar[5], K. E. Johnson[6], W. N. Brandt[1], D. M. Elmegreen[7], M. Eracleous[1], G. P. Garmire[1], J. E. Hibbard[8], P. Hickson[9], A. E. Hornschemeier[10], S. Hunsberger[1], K. A. Knierman[11], A. Maybhate[12], C. Mendes de Oliveira[13], J. S. Mulchaey[5], C. Palma[1], B. C. Whitmore[12], A. I. Zabludoff[11], S. G. Zonak[14]
[1]Penn State Univ., [2]UCLA, [3]U. Manitoba, Canada, [4]Youngstown State Univ., [5]OCIW, [6]Univ. of Virginia, [7]Vassar College, [8]NRAO, [9]Univ. of British Columbia, Canada, [10]NASA Goddard, [11]Univ. of Arizona, [12]STScI, [13]Univ. of Sao Paulo, Brazil, [14]Univ. of Maryland.

114.06 **The Star Formation Rate Density of the Local Universe from SINGG**
Daniel Hanish[1], G. R. Meurer[1], SINGG Team
[1]Johns Hopkins Univ..

114.07 **The Stellar Populations in the Outer Banks of Massive Disk Galaxies**
Roelof De Jong[1], GHOSTS team
[1]STScI.

115: Pulsars and White Dwarfs I
AAS Oral, 10:00-11:30am, 201

115.01 **A New Analytical Model for Bulk and Thermal Comptonization in Accretion Powered X-Ray Pulsars**
Peter A. Becker[1], M. T. Wolff[2]
[1]George Mason University, [2]Naval Research Laboratory.

115.02 **Probing Binary Evolution Using the Pulsar Fossil Record**
Robert D. Ferdman[1], I. H. Stairs[1], M. Kramer[2], M. A. McLaughlin[3], A. Faulkner[2], D. C. Backer[4], P. Demorest[4], D. J. Nice[5], M. Burgay[6], F. Camilo[7], N. D'Amico[6], G. Hobbs[8], D. R. Lorimer[3], A. G. Lyne[2], R. Manchester[8], A. Possenti[6]
[1]University of British Columbia, Canada, [2]Jodrell Bank Observatory, United Kingdom, [3]West Virginia University, [4]University of California, [5]Bryn Mawr College, [6]INAF, Italy, [7]Columbia University, [8]ATNF, Australia.

115.03 **X-ray Emission from Millisecond Pulsars**
Slavko Bogdanov[1]
[1]Harvard University.

115.04 **New XMM Observations of the Accreting Millisecond X-ray Pulsar SAX J1808.4-3658 in Quiescence**
Craig O. Heinke[1], R. Wijnands[2], P. G. Jonker[3], R. E. Taam[1]
[1]Northwestern Univ., [2]University of Amsterdam, The Netherlands, [3]Utrecht University, The Netherlands.

115.05 **The Distribution of Ages, Magnetic Fields and Spin Periods of Millisecond Pulsars**
Bulent Kiziltan[1], S. E. Thorsett[1]
[1]Department of Astronomy & Astrophysics, U.of California, Santa Cruz.

115.06 **Big, Smart Dishes to Find Thousands of New Radio Pulsars**
Joeri van Leeuwen[1]
[1]UC, Berkeley.

115.07 **The External Pollution of GD 362: The Bulk Composition of an Extra-Solar Asteroid?**
Carl Melis[1], D. Koester[2], B. Zuckerman[1], B. Hansen[1], M. Jura[1]
[1]UC, Los Angeles, [2]University of Kiel, Germany.

116: Advanced Physics in the Pre-High School AP, IB and Dual Enrollment Courses
AAPT Invited, 10:00-11:30am, 310

Chair
Paul Hickman[1]
[1]Science Education Consultant.

117: The Once and Future Role of Women in Astronomy
AAPT Invited, 10:00-11:30am, 615

Chair
Jill Marshall[1]
[1]UT at Austin.

117.01 **Dorrit Hoffleit: A Century of being a Woman in Astronomy**
Dorrit Hoffleit[1], P. L. Gay[2]
[1]Yale University, [2]Southern Illinois University Edwardsville.

117.02 **Women in Physics and Astronomy**
Rachel Ivie[1]
[1]American Institute of Physics.

117.03 **The Progress, Status, and "Roles" of Women in Astronomy**
Lynne Hillenbrand[1]
[1]Caltech.

118: Nanoscale Physics in the Classroom
AAPT Special, 10:00-11:30am, 616

Chair
Paul W. Zitzewitz[1]
[1]University of Michigan-Dearborn.

118.01 **National Center for Learning and Teaching in Nanoscale Science and Engineering (NCLT)**
Nicholas Giordano[1]
[1]Purdue University.

118.02 **Resource Materials for Nanoscale Science and Technology Education**
George Lisensky[1]
[1]Beloit College.

118.03 **Small Talk: Conversations about Nanotechnology through Podcasts**
Stephanie V. Chasteen[1], P. Doherty[1]
[1]Exploratorium Teacher Institute.

118.04 **Nanoscale Physics Inquiry Activities**
Jill N. Johnsen[1]
[1]Exploratorium.

119: Resource Collections and Communities Online through ComPADRE

AAPT Special, 10:00-11:30am, 303

Chair
Bruce Mason[1]
[1]OU.

119.01 **Overview of the Student Collection on ComPADRE**
David Donnelly[1]
[1]Texas State University San Marcos.

119.02 **AstronomyCenter.org: Your Online Destination for Astronomy Education Resources**
Gina Brissenden[1], S. Deustua[2]
[1]Univ. of Arizona, [2]American Astronomical Society.

119.03 **Physics To Go: an Outreach Digital Library**
Edward V. Lee[1]
[1]American Physical Society.

119.04 **The Physics Front: Resources for High School Physics & Physical Science Teachers**
Cathy M. Ezrailson[1]
[1]Texas A&M University.

120: Significant Advances in Low Temperature Physics

AAPT Special, 10:00-11:30am, 307-08

Chair
Warren Hein[1]
[1]AAPT.

120.01 **Absolute Zero**
Russell J. Donnelly[1], D. Sheibley[2], M. Belloni[2], D. Stamper-Kurn[3], W. F. Vinen[4]
[1]University of Oregon, [2]Davidson College, [3]UC, Berkeley, [4]University of Birminham, United Kingdom.

120.02 **Ultracold Quantum Gases**
Daniel Stamper-Kurn[1]
[1]University of California, Berkeley.

120.03 **Significant Advances in Low Temperature Physics**
William F. Vinen[1]
[1]University of Birmingham, UK, United Kingdom.

121: SPS Undergraduate Research Outreach

AAPT Oral, 10:00-11:30am, 617

Chair
Gary White[1]
[1]American Institute of Physics.

121.01 **SPS Intern Contributions to ComPADRE and SOCK**
Katherine N. Zaunbrecher[1]
[1]University of Louisiana at Lafayette.

121.02 **Astronomy and Education**
Kristen Greenholt[1], S. Deustua[2]
[1]Society of Physics Students, [2]American Astronomical Society.

121.03 **Studying a Quantum 'Bounce'**
David L. Sheibley[1], M. Belloni[1]
[1]*Davidson College.*

121.04 **Microsized Objects in Optical Tweezers with Orbital Angular Momentum**
Kyle A. Brandenburg[1]
[1]*Xavier University.*

121.05 **True Color Holography with Three Wavelengths**
Jeremy R. Swearingen[1]
[1]*Xavier University.*

121.06 **The Effects of Magnetic Fields on Cooling Fans**
Raphael G. Cherney[1]
[1]*Brownell-Talbot School.*

121.07 **Evaluation of a Novel Design for an Electrostatic Quadrupole Triplet Ion Beam Lens**
L. R. Burns[1], J. D. Bouas[1], S. Matteson[1], D. L. Weathers[1]
[1]*Ion Beam Modification and Analysis Laboratory (IBMAL) — University of North Texas.*

121.08 **Packets in the Classical Asymmetric Infinite Square Well**
Robert W. Correll[1]
[1]*Davidson College.*

121.09 **Sonoluminescence at Carthage: Sound into Light**
Lukas K. Swanson[1], D. Arion[1], K. Crosby[1]
[1]*Carthage College.*

122: Warner Prize for Astronomy
Plenary, 11:40am-12:30pm, Ballroom 6

122.01 **The Formation of The Solar System and The Origin of Planetary Spins**
Re'em Sari[1]
[1]*Caltech.*

Extended FUSE Operations Beyond FY08
AAS Splinter Meeting, 12:30-2:00pm, 607

The FUSE satellite has made a remarkable recovery from attitude control problems in late 2004. The scientific instrument remains healthy, and provides a unique capability for far-UV spectroscopy that will not be duplicated in the foreseeable future. We seek community input on an operations concept that would extend FUSE operations at reduced costs beyond the current mission horizon of September 2008. What are the primary science drivers for this time frame? What level of operations are required to support the science? The results of these discussions will likely drive automation and development of concept decisions in the upcoming months as we bring the concept to NASA for consideration.
Chair
William P. Blair[1]
[1]*John Hopkins University.*

Accessing and Using Sloan Digital Sky Survey Data
AAS Splinter Meeting, 12:30-2:00pm, 608

Presentations of a few specific cases showing astronomers how to access data from the Sloan Digital Sky Survey, with questions and answers from Jordan Raddick and other members of the SDSS collaboration. The session will be similar to the session given at the summer meeting in Calgary.
Chair
Jordan Raddick[1]
[1]*Johns Hopkins University.*

NRAO Town Meeting
AAS Town Hall Meeting, 12:45-1:45pm, 6A

This Town Meeting will inform the AAS membership about the status of key NRAO science operations and construction projects. Brief presentations will update the membership regarding: (a) Atacama Large Millimeter Array (ALMA) construction and planning for the North American ALMA Science Center; (b) Expanded Very Large Array (EVLA) construction and science commissioning; (c) science operations and instrument development plans at the Green Bank Telescope (GBT); and (d) science operations and instrument development at the Very Long Baseline Array (VLBA). At least half of the Town Meeting will be allocated for answering audience questions.

Chair
K Y. Lo[1]
[1]*NRAO.*

123: Presidential Address and Awards Presentation
AAPT Invited, 1:00-2:00pm, Ballroom 6

1:00 Presentation by Richard Peterson of Distinguished Service Citations to the following recipients:

Robert Beichner, North Carolina State Univ.

John Mallinckrodt, California State Polytechnic Univ

Deborah Rice, Kirkwood High School

Paul Stokstad, PASCO scientific

David and Christine Vernier, Vernier Software

1:15 Presentation of Melba Newell Phillips Award to Clifford Swartz

1:25 Presentation by James Stith of the American Institute of Physics Science Writing Award for a Work Aimed at Chileren to David Garrison, Shannon Hunt, and Jude Isabella, Editors of YES! Magazine

1:30 Presentation by Earl Blodgett of the SPS Outstanding Chapter Advisor Award to James Borgardt

1:35 Presidential Address by Kenneth Heller

Chair
Richard Peterson[1]
[1]*Bethel Univ..*

124: Formation and Detection of Habitable Planets
AAS Special, 2:00-3:30pm, 611-12

Chair
Nader Haghighipour[1]
[1]*Univ. of Hawaii.*
Chair
Karen J. Meech[1]
[1]*Inst. for Astronomy.*

124.01 **The Limits of Organic Life in Planetary Systems**
John Baross[1]
[1]*University of Washington.*

124.02 **What Comets Tell us About Prebiotic Chemistry in Protoplanetary Disks**
Karen Meech[1]
[1]*Institute for Astronomy, University of Hawaii.*

124.03 **Planetary Environmental Signatures for Habitability and Life**
Victoria Meadows[1]
[1]Spitzer Science Center.

124.04 **Detection of Habitable Planets**
Wesley A. Traub[1]
[1]JPL.

124.05 **Habitable Planet Formation; A Review of Current Status**
Nader Haghighipour[1]
[1]Institute for Astronomy, University of Hawaii.

124.06 *Kepler* **Mission Development**
William J. Borucki[1], D. Koch[1], N. Batalha[2], T. Brown[3], D. Caldwell[4], J. Christensen-Dalsgaard[5], E. Dunham[6], T. Gautier[7], J. Geary[8], R. Gilliland[9], J. Jenkins[4], D. Latham[8], D. Monet[10]
[1]NASA/Ames Research Center, [2]San Jose State University, [3]Las Cumbres Observatory, [4]SETI Institute, [5]Aarhus University, Denmark, [6]Lowell Observatory, [7]Jet Propulsion Lab, [8]Smithsonian Astrophysical Observatory, [9]Space Telescope Science Institute, [10]U.S. Naval Observatory.

125: Galactic and Extragalactic Surveys Using AzTEC
AAS Special, 2:00-3:30pm, 204

Chair
Gary Davis[1]
[1]Joint Astronomy Centre.

125.01 **Session Overview and AzTEC Instrument Performance**
Grant Wilson[1], P. A. Ade[2], I. Aretxaga[3], J. Austermann[1], J. J. Bock[4], D. Hughes[3], Y. Kang[5], S. Kim[5], J. Lowenthal[6], P. Mauskopf[2], K. Scott[1], M. Yun[1]
[1]University of Massachusetts, [2]Cardiff University, United Kingdom, [3]INAOE, Mexico, [4]California Institute of Technology, [5]Sejong University, Republic of Korea, [6]Smith College.

125.02 **AzTEC Observations of the SHADES Fields at λ=1.1mm**
Mark Halpern[1], J. Dunlop[2], SHADES and AzTEC consortia
[1]University of British Columbia, Canada, [2]Institute for Astronomy, United Kingdom.

125.03 **AzTEC COSMOS Survey**
Min Su Yun[1], P. A. Ade[2], I. Aretxaga[3], J. Austermann[1], J. J. Bock[4], D. Hughes[3], Y. Kang[5], S. Kim[5], J. Lowenthal[6], P. Mauskopf[2], K. Scott[1], G. Wilson[1]
[1]Univ. of Massachusetts, [2]Cardiff University, United Kingdom, [3]INAOE, Mexico, [4]California Institute of Technology, [5]Sejong University, Republic of Korea, [6]Smith College.

125.04 **A Deep AzTEC Map of the GOODS-North Field**
Douglas Scott[1], E. Chapin[1], I. Aretxaga[2], J. Austermann[3], K. Coppin[1], M. Crowe[1], L. Frey[1], A. Gibb[1], M. Halpern[1], D. Hughes[2], Y. Kang[4], S. Kim[4], J. Lowenthal[5], T. Perera[3], A. Pope[1], K. Scott[3], G. Wilson[3], M. Yun[3]
[1]University of British Columbia, Canada, [2]INAOE, Mexico, [3]University of Massachusetts, [4]Sejong University, Republic of Korea, [5]Smith College.

125.05 **An AzTEC 1.1mm Survey of a Highly-biased Extragalactic Field Tracing Accelerated Galaxy Formation at z~3.8 towards 4C41.17**
David Hughes[1], P. A. Ade[2], I. Aretxaga[1], J. Austermann[3], J. J. Bock[4], J. Dunlop[5], E. Gaztanagal[1], R. Ivison[5], Y. Kang[6], S. Kim[6], J. Lowenthal[7], P. Mauskopf[2], A. Montana[1], M. Plionis[1], K. Scott[3], I. Smail[8], J. Stevens[9], J. Wagg[1], G. Wilson[3], M. Yun[3]
[1]Instituto Nacional de Astrofisica, Optica y Electronica, Mexico, [2]Cardiff University, United Kingdom, [3]U. Massachusetts, [4]Caltech, [5]Institute of Astronomy, Royal Obs., United Kingdom, [6]Sejong University, Republic of Korea, [7]Smith College, [8]University of Durham, United Kingdom, [9]University of Hertfordshire, United Kingdom.

126: Job Applicants: Top 10 Questions You Should Ask
AAS Special, 2:00-3:30pm, 201

Chair
Anita Krishnamurthi[1]
[1]NASA's GSFC.

126.002 Chair
Kirk Borne[1]
[1]George Mason University.

126.01 **AAS Committee on Employment Panel Introduction**
Kirk Borne[1], M. N. Fanelli[2], L. J. Storrie-Lombardi[3], A. Krishnamurthi[4]
[1]George Mason University, [2]Texas Christian Univ., [3]Caltech, [4]NASA's GSFC.

127: Circumstellar Disks: Not So Early
AAS Oral, 2:00-3:30pm, 608-10

127.01 **HST/ACS Coronagraphic Observations of the HD 163296 Circumstellar Disk**
John P. Wisniewski[1], M. Clampin[1], C. Grady[2], D. Ardila[3], H. Ford[4], D. Golimowski[4], G. Illingworth[5], J. Krist[6], HST ACS Science Team
[1]NASA GSFC, [2]Eureka Scientific/NASA GSFC, [3]Spitzer Science Center, [4]JHU, [5]Lick Observatory, [6]JPL.

127.02 **The Circumstellar Environment of HD 97048: *HST*/ACS Scattered-Light Imaging and Dust Modeling**
Ryan L. Doering[1], M. Meixner[2], S. T. Holfeltz[2], J. E. Krist[3], D. R. Ardila[4], I. Kamp[5], M. C. Clampin[6], S. H. Lubow[2]
[1]Univ. of Illinois, Urbana, [2]STScI, [3]Jet Propulsion Laboratory, [4]Spitzer Science Center/IPAC, [5]ESA/STScI, [6]NASA Goddard Space Flight Center.

127.03 **Models of Be Star Disks Constrained by Long-baseline Interferometry**
Christopher Tycner[1], C. E. Jones[2], T. A. Sigut[2], L. Thomson[2], A. Molak[2]
[1]U.S. Naval Observatory, [2]Univ. of Western Ontario, Canada.

127.04 **Observations of Intermediate Mass Stars and their Circumstellar Environments with Nulling Interferometry**
Wilson M. Liu[1]
[1]Univ. of Arizona.

127.05 **Infrared Emission from Aliphatic and Aromatic Hydrocarbons in Cool Radiative Environments**
Gregory C. Sloan[1], M. Jura[2], W. W. Duley[3], K. E. Kraemer[4], L. D. Keller[5], B. A. Sargent[6], A. Li[7], J. Bernard-Salas[1], W. J. Forrest[6], J. D. Green[6], C. J. Bohac[6], D. M. Watson[6], J. R. Houck[1]
[1]Cornell Univ., [2]UCLA, [3]Univ. Waterloo, Canada, [4]Air Force Research Lab., [5]Ithaca College, [6]Univ. Rochester, [7]Univ. Missouri.

128: Education Across the Spectrum
AAS Oral, 2:00-3:30pm, 605-07

128.01 **Johannes Kepler's Intelligent Design**
Paul M. Wallace[1]
[1]Berry College.

128.02 **Is Debunking Intelligent Design an Effective Approach to Teaching?**
Alex Storrs[1], T. F. Slater[2], CAPER team
[1]Towson Univ., [2]Univ. of Arizona.

128.03 **And now... Equations!**
Ran Sivron[1]
[1]*Baker Univ..*

128.04 **Using Streaming Video in Delivery of an On-Line Astronomy Course**
Terrence F. Flower[1]
[1]*College of St. Catherine.*

128.05 **"Workshop Astronomy" at Dickinson College**
Windsor A. Morgan, Jr.[1]
[1]*Dickinson College.*

128.06 **Integrating Observatories and Planetaria into Survey Astronomy Laboratory Curricula**
Michael N. Fanelli[1]
[1]*Texas Christian Univ..*

128.07 **A Study of 8th Grade Students Learning the Moon's Phases Using Various Multimedia Platforms**
Timothy Young[1], M. Guy[1]
[1]*Univ. of North Dakota.*

129: Galaxy Clusters II
AAS Oral, 2:00-3:30pm, 6B

129.01 **The Clustering of Galaxy Groups: Dependence on Mass and Other Properties**
Andreas A. Berlind[1]
[1]*New York Univ..*

129.02 **The Equilibrium Structure of Dark Matter Halos in a Λ-Dominated Universe**
Michael T. Busha[1], A. E. Evrard[1], F. C. Adams[1]
[1]*Univ. Of Michigan.*

129.03 **Environment, Kinematics, & Star Formation History of Infalling [OII] Emitters in z=0.4 cluster Abell 851**
Taro Sato[1], C. L. Martin[1]
[1]*UC, Santa Barbara.*

129.04 **Simulating Cosmic Reionization from Pop II and III Stars**
Hy Trac[1], R. Cen[1]
[1]*Princeton University.*

129.05 **A z=0.45 DLA With Only Weak MgII Absorption?**
Therese Jones[1], J. C. Charlton[1], A. C. Mshar[1], G. J. Ferland[2], P. C. Stancil[3]
[1]*Penn State Univ.,* [2]*University of Kentucky,* [3]*University of Georgia.*

129.06 **From Galaxy Clustering to Dark Matter Clustering**
Jaiyul Yoo[1], D. H. Weinberg[1]
[1]*The Ohio State Univ..*

130: Instrumentation for Ground-Based and Airborne Observatories
AAS Oral, 2:00-3:30pm, 3B

130.01 **The Hertz/SMT Submillimeter Polarimeter**
David T. Chuss[1], D. J. Benford[1], S. H. Moseley[1], J. G. Staguhn[1], G. M. Voellmer[1], E. J. Wollack[1], M. Krejny[2], G. Novak[2], C. Y. Drouet d'Aubigny[3], D. R. Golish[3], C. Kulesa[3], C. K. Walker[3], R. F. Loewenstein[4]
[1]NASA's GSFC, [2]Northwestern University, [3]University of Arizona, [4]Yerkes Observatory, University of Chicago.

130.02 **SHARP: The SHARC-II polarimeter at the Caltech Submillimeter Observatory**
John E. Vaillancourt[1], M. Attard[2], C. D. Dowell[3], R. H. Hildebrand[4], M. Houde[2], L. Kirby[4], M. Krejny[5], H. Li[6], G. Novak[5], H. Shinnaga[7]
[1]Caltech, [2]U. Western Ontario, Canada, [3]JPL/Caltech, [4]U. Chicago, [5]Northwestern, [6]Harvard-Smithsonian CfA, [7]CSO.

130.03 **Gemini North Laser Adaptive Optics Performance: First Science Data**
Chadwick A. Trujillo[1], F. Rigaut[1], D. Gratadour[1], M. Bec[1], T. Beck[1], S. Chan[1], A. Matulonis[1], G. Trancho[1], B. Walls[1], A. Stephens[1], M. Boccas[1], K. Grace[1], P. Gundu[1], C. d'Orgeville[1], M. Sheehan[1], J. White[1], K. White[1], R. Wyman[1], G. Herriot[2], J. Veran[2]
[1]Gemini Obs., [2]NRC-HIA, Canada.

130.04 **Progress Report on GISMO, a 2 mm Bolometer Camera Optimized for the Study of High Redshift Galaxies**
Johannes Staguhn[1], D. Benford[1], C. Allen[1], S. Moseley[1], T. Ames[1], R. Arendt[1], W. Brunswig[2], D. Chuss[1], E. Dwek[1], A. Kovacs[3], S. Maher[1], C. Marx[1], T. Miller[1], S. Navarro[2], E. Sharp[1], A. Sievers[2], G. Voellmer[1], E. J. Wollack[1]
[1]NASA's GSFC, [2]IRAM, Spain, [3]MPIfR, Germany.

130.05 **A Survey of 3.3 Micron PAH Emission Using FLITECAM**
Erin C. Smith[1]
[1]UCLA.

130.06 **High Contrast and Extreme AO Experiments on the Palomar Hale Telescope**
Gene Serabyn[1]
[1]JPL.

131: Pulsars and White Dwarfs II
AAS Oral, 2:00-3:30pm, 3A

131.01 **Spitzer Space Telescope Observations of SGR and AXP Environments**
Stefanie Wachter[1], C. Kouveliotou[2], S. Patel[3], D. Figer[4], P. Woods[5]
[1]Caltech, [2]MSFC, [3]NSSTC/USRA/MSFC, [4]Rochester Institute of Technology, [5]Dynetics.

131.02 **Deep Searches for Radio Pulses and Bursts from AXPs**
Fronefield Crawford, III[1], J. W. Hessels[2], V. M. Kaspi[3]
[1]Franklin & Marshall College, [2]Astronomical Institute "Anton Pannekoek", University of Amsterdam, The Netherlands, [3]McGill University, Canada.

131.03 **Observational Implications of a Fall-back Crust around a Quark-nova Compact Remnant: Application to AXPs and SGRs**
Denis A. Leahy[1], R. Ouyed[1], B. Niebergal[1]
[1]Univ. of Calgary, Canada.

131.04 **Proper Motion of Compact Objects**
Patrick B. Cameron[1], S. R. Kulkarni[1]
[1]Caltech.

131.05 **SPITZER IRS Spectroscopy of Highly-Obscured X-ray Binaries**
Dae-Sik Moon[1], D. L. Kaplan[2], W. T. Reach[3], F. A. Harrison[4], J. Lee[5]
[1]University of Toronto, Canada, [2]MIT, [3]Spitzer Science Center, [4]Caltech, [5]UCLA.

131.06 **Cool Companions of White Dwarfs from 2MASS**
D W. Hoard[1], S. Wachter[1], L. K. Sturch[2], A. M. Widhalm[3], K. P. Weiler[4], J. W. Wellhouse[3], M. Gibiansky[2]
[1]California Institute of Technology, [2]Harvey Mudd College, [3]New Mexico State University, [4]DePaul University.

131.07 **Pulsar Timing and Gravitational Wave Detection: Current Status and Future Prospects**
Fredrick Jenet[1]
[1]Center for Gravitational Wave Astronomy/Univ. of Texas at Brownsville.

131.08 **Energetic Outflows from Young Neutron Stars**
Joseph Gelfand[1]
[1]Harvard Univ..

132: UDF, GOODS and High Redshift Galaxies
AAS Oral, 2:00-3:30pm, 613-14

132.01 **Evolution of the Rest-Frame UV LF from z~8 to z~4**
Rychard Bouwens[1], G. D. Illingworth[1]
[1]UC, Santa Cruz.

132.02 **Spitzer/IRAC Confirmation of z850-dropout Galaxies in the Hubble Ultra Deep Field: Stellar Masses and Ages at z~7**
Ivo F. Labbe[1], R. Bouwens[2], G. Illingworth[2], M. Franx[3]
[1]OCIW, [2]UCSC/Lick, [3]Leiden Observatory, The Netherlands.

132.03 **16 micron Imaging of the GOODS Fields**
Harry I. Teplitz[1], R. Chary[1], J. W. Colbert[1], B. Siana[1], D. Elbaz[2], M. Dickinson[3], C. Papovich[4]
[1]Spitzer Science Center, [2]Saclay, France, [3]NOAO, [4]UA.

132.04 **Exploring the Optical and Infrared Evolution of Galaxies Since z=1**
Jason Melbourne[1]
[1]UC, Santa Cruz.

132.05 **Revisiting the Hubble Sequence : Comparative Studies with Sloan Digital Sky Survey and the Hubble Ultra Deep Field**
Preethi Nair[1], R. G. Abraham[1]
[1]University of Toronto, Canada.

132.06 **Discovery of a galaxy at redshift 6.96 and its implications on galaxy formation era**
Masanori Iye[1], K. Ota[2], N. Kashikawa[1]
[1]National Astronomical Obs., Japan, [2]University of Tokyo, Japan.

132.07 **The Advanced Camera Galaxy Redshift Survey**
Brenda L. Frye[1], N. Benitez[2], D. Coe[2], H. Ford[3], D. Bowen[4], G. Illingworth[5], P. Guhathakurta[5], M. Franx[6], ACS Science Team
[1]Dublin City Univ., Ireland, [2]Instituto de Astrofisica de Andalucia, Spain, [3]Johns Hopkins University, [4]Princeton University, [5]University of California at Santa Cruz, [6]Leiden University, Netherlands Antilles.

132.08 **IRAC-selected Extremely Red Objects in the GOODS Fields**
Haojing Yan[1], GOODS Team
[1]Carnegie Observatories.

133: YSOs and Early Type Stars
AAS Oral, 2:00-3:30pm, 6A

133.01 **Molecular Clouds and Star Formation: A Multi-wavelength Study of Perseus, Serpens, and Ophiuchus**
Melissa Enoch[1]
[1]*Caltech.*

133.02 **SMA Observations of IRDC Cores: An Active Hot Core and a Quiescent Cold Core**
James M. Jackson[1], J. Rathborne[2], E. Chambers[1], Q. Zhang[2], R. Simon[3]
[1]*Boston Univ.,* [2]*Center for Astrophysics,* [3]*University of Cologne, Germany.*

133.03 **VLBA Determination of the Distance to Taurus and Ophiuchus with 1% Precision**
Laurent Loinard[1]
[1]*Centro de Radioastronomia y Astrofisica, UNAM, Mexico.*

133.04 **Long-term Infrared Variability of FU Oriand EX Lup-type Stars**
Agnes Kospal[1], P. Abraham[2], D. Ardila[3]
[1]*Konkoly Observatory/Caltech,* [2]*Konkoly Observatory, Hungary,* [3]*Caltech.*

133.05 **X-ray Variability in the Young Massive Triple θ^2 Ori A**
Norbert S. Schulz[1], P. Testa[1], D. P. Huenemoerder[1], K. Ishibashi[1], C. R. Canizares[1]
[1]*Kavli Institute for Astrophysics and Space Research, MIT.*

133.06 **Metallicity-Induced Fragmentation and the Transition from Pop III to Pop II**
Britton D. Smith[1], S. Sigurdsson[1]
[1]*Pennsylvania State Univ..*

133.07 **Quantitative Analysis of Resolved X-ray Emission Line Profiles of O Stars**
David H. Cohen[1], M. A. Leutenegger[2], A. ud-Doula[3], S. P. Owocki[3]
[1]*Swarthmore College,* [2]*Columbia University,* [3]*Bartol Research Institute, University of Delaware.*

134: Recruiting the Next Generation of Physics Teachers
AAPT Invited, 2:00-3:30pm, 310

Chair
Paul Hickman[1]
[1]*Science Education Consultant.*

134.01 **Recruiting the Next Generation of Physics Teachers: National Concerns**
Theodore Hodapp[1]
[1]*American Physical Society.*

135: Student Difficulties with Mathematics in Upper-Division Physics
AAPT Invited, 2:00-3:30pm, 307-08

Chair
Edward Redish[1]
[1]*University of Maryland.*

135.01 **Easing the Transition to Upper-division Physics**
Corinne Manogue[1], Paradigms in Physics
[1]*Oregon State University.*

135.02 **Investigating Student Connections Between Mathematics and Thermal Physics**
John R. Thompson[1]
[1]*University of Maine.*

135.03 **Students' Construction of Understanding of Abstract Vector Spaces**
Thomas J. Bing[1]
[1]University of Maryland.

136: Physics Teaching Around the World
AAPT Oral, 2:00-3:30pm, 619

Chair
Gordon Ramsey[1]
[1]Argonne Nat'l Lab..

136.01 **Teaching Gravitational Wave Astronomy in China**
Robert J. Stone[1]
[1]University of Texas-Brownsville.

136.02 **Fifth Global Colloquium on Engineering Education**
Gerhard L. Salinger[1]
[1]National Science Foundation.

136.03 **A Model for Bilingual Physics Teaching: "The Feynman Lectures "**
Heqing W. Metzner[1]
[1]Tangshan Teachers College Physics Department, China.

136.04 **Implementing active-learning strategies to improve physics learning in Latin America**
Hugo Alarcon[1], G. Zavala[1], R. Fernandez[2], J. Benegas[3]
[1]Tecnológico de Monterrey, Campus Monterrey, Mexico, [2]Universidad Catolica del Norte, Chile, [3]Universidad Nacional de San Luis, Argentina.

136.05 **A Masterclass in Particle Physics for High School Students**
Kenneth Cecire[1], T. Entwistle[2]
[1]Hampton University, [2]Ward Melville High School.

136.06 **Assessing Teaching Med-Nursing Physics Replacing Introductory Physics in Nursing College**
Wen-Ruey Wang[1], Y. Lin[1], K. Chen[1]
[1]Central Taiwan University of Science and Technology, (CTUST), Taichung, Taiwan, Taiwan.

136.07 **Ten Years of GLAPHI Method Developing Scientific Research Abilities**
Hector R. Vega-Carrillo[1]
[1]Universidad Autonoma de Zacatecas, Mexico.

137: Undergraduates Research Astronomy and Physics
AAPT Oral, 2:00-3:30pm, 616

Chair
Chris D. Impey[1]
[1]Univ. of Arizona.

137.01 **Demonstration of Electrostatic Orbits in Weightlessness**
John Janeski[1], K. Andring[1], S. Banerjee[1], D. Campbell[1], D. Keedy[1], B. Hoffmeister[1], S. Quinn[1]
[1]Rhodes College.

137.02 **Building the CHEPREO Undergraduate Learning Community**
Laird H. Kramer[1], G. O'Brien[1], P. Pamela[1], J. M. Saul[1]
[1]Florida International University.

137.03 **SiO Maser Monitoring at the University of Minnesota, Morris**
Gordon McIntosh[1]
[1]University of Minnesota, Morris.

137.04 **Correlation of R Cassiopeia's SiO Maser Properties**
Anne Hayes[1], G. McIntosh[1]
[1]*University of Minnesota, Morris.*

137.05 **Orbital Parameters of R Aquarii**
Gustav Rustan[1], G. McIntosh[1]
[1]*University of Minnesota, Morris.*

137.06 **Superhumps and Period Variability of V795 Her**
Daniel R. Malutich[1], R. P. Olenick[1], I. B. Voloshina[2]
[1]*University of Dallas,* [2]*Moscow State University, Russian Federation.*

Professional Concerns of Women in Physics Crackerbarrel
AAPT Crackerbarrel, 2:00-3:30pm, 615

Chair
Dean Hudek[1]
[1]*Brown University.*

138: Hypervelocity Stars
Plenary, 3:40-4:30pm, Ballroom 6

138.01 **Hypervelocity Stars Ejected from the Galactic Center**
Warren R. Brown[1]
[1]*Smithsonian Astrophysical Observatory.*

139: Probing the Gas Content of Galaxy Groups: A Radio Perspective
Plenary, 4:40-5:30pm, Ballroom 6

139.01 **Probing the Gas Content of Galaxy Groups: A Radio Perspective**
Eric M. Wilcots[1]
[1]*Univ. of Wisconsin.*

140: Hot Topics in Nanoscience
AAPT Invited, 6:00-8:00pm, 616

Chair
Melissa Eblen-Zayas[1]
[1]*Carleton College.*

140.01 **Nanoelectronic Devices What We Can Do and Why It's Fun**
Douglas Natelson[1]
[1]*Rice University.*

140.02 **Atomic Scale Friction and Microscale Machines: These Squeaky Wheels will get no Grease.**
Jacqueline Krim[1]
[1]*North Carolina State University.*

140.03 **Voyage at the Nanoscale**
Gregory J. Salamo[1]
[1]*University of Arkansas.*

141: Learning Sciences and Learning Technologies: A Convergence

AAPT Invited, 6:00-8:00pm, 303

Chair

S. R. Chaudhury[1]
[1]Christopher Newport University.

141.01 **The Mathematics of Motion in Middle School: Findings from a Large Scale Study**
Jeremy Roschelle[1]
[1]SRI International.

141.02 **Supporting Classroom Interaction with Networked Tablet PCs**
Richard Anderson[1]
[1]Univ. of Washington.

141.03 **Technology-Enhanced Learning in Science (TELS)**
Marcia Linn[1]
[1]UC, Berkeley.

141.04 **Understanding the Atomic-Scale World with the Molecular Workbench**
Robert F. Tinker[1]
[1]The Concord Consortium.

142: Women Using Physics: Alternative Career Paths

AAPT Invited, 6:00-8:00pm, 615

Chair

Margaret Hill[1]
[1]Southeast Missouri State University.

142.01 **Reflections on a Career in Radio Science**
Irene C. Peden[1]
[1]University of Washington.

142.02 **Women Using Physics: Alternate Career Paths, The Private Sector**
Jessica Tams[1]
[1]FUN Technologies.

142.03 **Physics in Aerospace and Military Applications**
Hong Tat[1]
[1]Boeing Company.

143: Electronic Journaling: Fostering Reflection and Building Community

AAPT Special, 6:00-8:00pm, 310

Chair

Ingrid Novodvorsky[1]
[1]University of Arizona.

143.01 **Connecting Master Teachers to Build a Community of Support for Teachers of Physics**
Paul Hickman[1], M. Fetters[2]
[1]Science Education Consultant, [2]Western Michigan University.

143.02 **Interactive, Collaborative, Electronic Learning Logs in the Physics Classroom**
Chris Gosling[1]
[1]Saranac Lake High School / SUNY Buffalo State.

144: Bringing Physics by Inquiry to K-12 Classrooms, Part I

AAPT Oral, 6:00-8:00pm, 211

Chair
Peter Shaffer[1]
[1]*Univ. of Washington.*

144.01 **Teaching Inquiry Science in the Elementary-school Classroom**
Dan Jordan[1], D. L. Messina[2], L. C. McDermott[2]
[1]*Olympic View Elementary School,* [2]*University of Washington.*

144.02 **Bringing Inquiry Science to K-5 Classrooms**
Paula L. Schachtel[1], D. L. Messina[2], L. C. McDermott[2]
[1]*Seattle Public Schools,* [2]*University of Washington.*

144.03 **Teaching Inquiry Science in the Middle-school Classroom**
Eleanor I. Martino[1], D. L. Messina[2], L. C. McDermott[2]
[1]*Seattle Country Day School,* [2]*University of Washington.*

144.04 **Assessing an inquiry-oriented mechanics unit for high school students**
Michael P. O'Byrne[1], M. R. Stetzer[2], L. C. McDermott[2]
[1]*Interlake High School,* [2]*University of Washington.*

144.05 **Adapting an Inquiry-oriented Kinematics Curriculum for High School Students***
Matthew D. Randall[1], M. R. Stetzer[2], L. C. McDermott[2]
[1]*College of Education, University of Washington,* [2]*University of Washington.*

144.06 **An Inquiry-oriented Mechanical Waves Unit for High School Students***
Thomas J. Knapton[1], R. G. Piccioni[1], M. Kryjevskaia[2], L. C. McDermott[2]
[1]*Garfield High School,* [2]*University of Washington.*

144.07 **Adapting an electric circuits curriculum for the high school classroom**
Scot A. Hovan[1], M. R. Stetzer[2], L. C. McDermott[2]
[1]*Mahtomedi High School,* [2]*University of Washington.*

145: Students' Use of Mathematics in Physics Contexts

AAPT Oral, 6:00-8:00pm, 307-08

Chair
Francis Tam[1]
[1]*Frostburg State Univ..*

145.01 **Do We Need Remedial College Math Courses?**
Anne O. Hughes[1], D. Khatri[1]
[1]*University of the District of Columbia.*

145.02 **Equations In Science: Are They Hindering the Development of Reasoning Skills?**
Suzanne White Brahmia[1]
[1]*Rutgers University.*

145.03 **Connecting Math and Motion: A Covariational Approach**
Robert J. Culbertson[1], A. S. Thompson[1]
[1]*Arizona State University.*

145.04 **Principles of Covariation in the Introductory Physics Classroom**
Adam S. Thompson[1], R. J. Culbertson[1]
[1]*Arizona State University.*

145.05 **Teaching Kinematics as a Way to understand Calculus and Graphs**
Genaro Zavala[1], H. Alarcon[1]
[1]Tecnologico de Monterrey, Mexico.

145.06 **Student Understanding of Probability and Introductory Statistical Physics in Upper-division Courses on Thermal Physics**
Michael E. Loverude[1]
[1]California State University Fullerton.

145.07 **Student Solutions to First-Order Differential Equations in Intermediate Mechanics**
Michael C. Wittmann[1], K. E. Black[1]
[1]University of Maine.

145.08 **Using Mathematics to Inform Conceptual Reasoning about Quantum Tunneling**
Jeffrey T. Morgan[1], M. C. Wittmann[2]
[1]University of Northern Iowa, [2]University of Maine.

146: Apparatus for Astronomy Education
AAPT Poster, 6:00-8:00pm, 617

Chair
M. A. H. Klassen[1]
[1]Swarthmore College.

146.01 **Teaching Astronomy at Columbus State University using Small Radio Telescopes**
Zodiac T. Webster[1]
[1]Columbus State University.

146.02 **Experimental and Theoretical Challenges of Creating Electrostatic Orbits in Weightlessness**
Kevin W. Andring[1], B. Hoffmeister[1], S. Banerjee[1], J. Janeski[1], S. Quinn[1], D. Keedy[1], D. Campbell[1]
[1]Rhodes College.

146.03 **Using Microsoft PowerPoint as an Astronomical Image Analysis Tool**
Bernhard Beck-Winchatz[1]
[1]DePaul University.

146.04 **Simulating the Nature of Science: Cosmology Distilled**
Tim Erickson[1]
[1]eeps media.

CTIO Blanco Telescope Dark Energy Camera
AAS Splinter Meeting, 6:00-7:30pm, 611

The 0.5 Gpixel Dark Energy Camera is expected to be commissioned on the Blanco telescope in 2010. With a 2 degree diameter field and red- sensitive CCDs it will provide a major increase in capability over the present Mosaic Imager. The camera will come with SDSS g,r,i,z filters which will be used to carry out the Dark Energy Survey, this can be thought of as a “super Sloan” imaging survey of 5000 sq. degrees of the southern sky. In this meeting the capabilities of the camera and the data products resulting from the Dark Energy Survey will be briefly described. Community comment is sought: in particular input is desired on what additional filters should be provided, so that a priority list can be developed.

Chair
Alistair R. Walker[1]
[1]CTIO.

Future of NASA Scientific Ballooning in Astronomical Research
AAS Splinter Meeting, 6:00-8:00pm, 6A

Since the dawn of space science, scientific ballooning has been a key research tool and advances in the capability of ballooning can keep it at the forefront of research. Balloon payloads can incorporate cutting edge technologies that are not yet ready for a space mission. Balloon platforms provide a cost effective means to test and demonstrate these new technologies in a space environment. Ballooning has often been the pathfinder major space missions and made early results available years in advance. Balloon payloads have also been one of the most important training grounds for the next generation of instrumentalists. The purpose of this session is to update the community on new developments in the balloon program and seek input from the community on the future for this important community resource.

Chair
Jack Tueller[1]
[1]*NASA's GSFC.*

Meet JWST Reception and Talks
AAS Town Hall Meeting, 6:15-9:00pm, 6E

Northrop Grumman, Goddard Space Flight Center, and the Space Telescope Science Institute are pleased to invite you to a reception and series of talks to allow you to meet many of the key people responsible for the development of the James Webb Space Telescope (JWST) and to hear them discuss compelling aspects of the mission. The reception will be held in the lobby of Room 6E at 6:15-7:00pm Monday evening, January 8. The JWST talks are from 7-8pm, and then the reception continues from 8-9pm.

The organized presentations will cover JWST's scientific promise and technology challenges. These will include introductions by Maureen Heath, Northrop Grumman VP for Civil Space, and Ed Weiler, GSFC Director. John Mather, JWST Senior Project Scientist and Nobel Laureate, will speak on lessons learned from COBE and the Science of JWST. Bob Giampaoli, Northrop Grumman Chief Engineer, will describe the challenges of deploying the JWST optics and sunshield. Mark Clampin, Observatory Project Scientist, will present the status of the key enabling technologies. Comments and questions will be welcome.

Tours of the JWST full scale model will be held throughout the four day AAS meeting. Tours will not be given during the Meet JWST Event.

Chair
Peter Stockman[1]
[1]*STScI.*

Graduate Student Employer Networking
AAS Event, 6:30-7:30pm, N. Galleria Lobby 2nd Floor

Graduate students and those hoping to recruit them for employment in research, academia or industry are welcome to attend this evening networking event. The chair of the Employment Committee will be present to discuss the activities of the employment committee and how graduate students can benefit from them as well as briefly introducing the recruiters present. Tickets are required and are available free of charge to grad students and recruiters through the meeting registration form and will be placed in their registration envelope. Light snacks and refreshments will be provided. Organizations hoping to recruit graduate students may reserve poster display for a small fee. Contact aas@aas.org for further details.

Chair
Anita Krishnamurthi[1]
[1]*NASA's GSFC.*

TUESDAY

Speaker Ready Room
Attendee Services, Tuesday, 7:30am-6:00pm, 603-04

See Saturday's listing for AV instructions.
Chair
Rick Matthews[1]
[1]*American Audio Video.*

Registration
Attendee Services, 8:00am-5:00pm, South Lobby
Chair
Laronda Boyce[1]
[1]*AAS.*

Cyber Café
Attendee Services, 8:00am-6:30pm, South Lobby

See Sunday's listing for details.

147: Supernova Neutrino Astrophysics
Plenary, 8:30-9:20am, Ballroom 6

147.01 **Supernova Neutrino Astrophysics and Associated Nucleosynthesis**
Wick Haxton[1]
[1]*University of Washington.*

Venture Fund
AAPT Event, 9:00-10:00am, 507

148: Poster Session III
AAPT Poster, 9:20am-6:30pm, Exhibit Hall 4

148.01 **Exploring Systematic Error With Digital Video**
M. A. H. Klassen[1], P. C. Bloom[2]
[1]*Swarthmore College,* [2]*North Central College.*

148.02 **100% Online College Physics at Chemeketa Community College**
Erik L. Jensen[1]
[1]*Chemeketa Community College.*

148.03 **Effect of a Web-based Tutoring System on Introductory Physics Students***
Tom Carter[1], T. Smith[2], M. Wittman[2]
[1]*College of DuPage,* [2]*University of Maine.*

148.04 **Bibliographic Research Projets**
Carlos Delgado[1]
[1]*Community College of Southern Nevada.*

148.05 **Characteristics of the General Physics student population.**
Gary L. Hunt[1]
[1]*Boise State University.*

148.06 **Intervention activities to improve the reasoning ability of students at risk in introductory physics**
Vincent P. Coletta[1], J. Phillips[1]
[1]*Loyola Marymount University.*

148.07 **Bachelor of Science in Medical Physics Program at Ryerson University**
Tetyana Antimirova[1]
[1]*Ryerson University, Canada.*

148.08 **Does it Matter Where You Sit?**
Brian A. Pyper[1], S. Thompson[1]
[1]*BYU-Idaho.*

148.09 **Peer-assessment of Homework Using Rubrics**
Sahana Murthy[1]
[1]*Massachusetts Institute of Technology.*

148.10 **Seeing Physics Outside the Classroom Through Journal Writing**
J. Johanna Hopp[1]
[1]*University of Wisconsin Stout.*

148.11 **Path Integral Understanding in the Context of the Electromagnetic Theory**
Maria D. Gonzalez[1]
[1]*NMSU.*

148.12 **Using Case Studies in Calculus-based Physics**
Debora M. Katz[1]
[1]*USNA.*

148.13 **Results From the CHEPREO Undergraduate Learning Community**
Laird H. Kramer[1], G. O'Brien[1], P. Pamela[1], J. M. Saul[1]
[1]*Florida International University.*

148.14 **Preparation for Physics Redux**
Edward Adelson[1]
[1]*The Ohio State University.*

148.15 **Fostering Critical Thinking in a First Year Seminar Course**
Jennifer Blue[1], B. A. Taylor[1], J. Yarrison-Rice[1]
[1]*Miami University.*

148.16 **Crash Videos Spark Inelastic Collisions Interest**
George R. Bart[1]
[1]*Truman College.*

148.17 **Interactive Low Tech Lecture Demonstrations for Introductory Physics**
Marina M. Milner-Bolotin[1]
[1]*University of British Columbia, Canada.*

148.18 **Using Students' Design Tasks to Develop Scientific Abilities***
Xueli Zou[1]
[1]*California State University, Chico.*

148.19 **Reflection Shadows: An Unusual Example for Elementary Ray Optics**
Lee C. Widmer[1]
[1]*University of Cincinnati.*

148.20 **The Effect of Uncertainty Focused Laboratory Instruction on Undergraduate Students**
Kwangmoon Shin[1], J. Lee[1], Y. Kang[1], S. Lee[1]
[1]Seoul National University, Republic of Korea.

148.21 **Measuring Systematic Errors With Curve Fits**
Mark E. Rupright[1]
[1]Florida Atlantic University.

148.22 **Opto-Mechanical Integration**
Jenny Magnes[1], D. Burt[1], J. Hartke[1]
[1]U.S. Military Academy.

148.23 **Extending the Rubber Band Lab for Upper Division Thermodynamics Courses.**
Stephen C. Hall[1], K. T. Gimre[1], K. H. Gimre[1], E. A. Townsend[1]
[1]Pacific University.

148.24 **Teaching Electromagnetic Waves in College Physics Laboratory**
Roman Y. Kezerashvili[1], L. Leng[1]
[1]Physics Department, New York City College of Technology, CUNY.

148.25 **Sensitive Altimeter; A Basic Electronics Project for Undergraduates**
Harry E. Bates[1], J. Klupt[1], C. Bolling[1], M. J. Earle[1], B. P. Hofmann[1], J. Osman[1], J. L. Sunderland[1], M. Vincent[1]
[1]Towson University.

148.26 **Classical Mechanics Laboratory**
Juliet W. Brosing[1]
[1]Pacific University.

148.27 **Static Friction Unsung Hero of Everyday Introductory Biomechanics**
Nancy Beverly[1]
[1]Mercy College.

148.28 **The Scientific Method in a Cup**
Bradley W. Carroll[1], M. B. More[1]
[1]Weber State University.

148.29 **Building a Gravitational Analogy of Electric Circuits Using LEGOs®**
James J. Butler[1], E. A. Townsend[2]
[1]Pacific University, [2]National Institute of Standards and Technology.

148.30 **A 2006 SPS Summer Intern's Experiences, Reflections, and Future Ambitions**
Ann Deml[1]
[1]University of Wisconsin River Falls.

149: AGNs, QSOs and Active Galaxies 2
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

149.01 **Redshift Studies of Scintillating and Non-scintillating Extragalactic Radio Sources: Direct Detection of the Ionized Intergalactic Medium?**
Roopesh Ojha[1], T. Pursimo[2], D. L. Jauncey[3], J. E. Lovell[3], J. Macquart[4], M. S. Dutka[5]
[1]USNO, [2]Nordic Optical Telescope, Spain, [3]ATNF, Australia, [4]Caltech, [5]University of Maryland.

149.02 **Scintillating and Nonscintillating AGNs: Their Structure and Intergalactic Scattering**
T. J. Lazio[1], R. Ojha[2], A. Fey[2], L. Kedziora-Chudczer[3], J. Cordes[4], D. Jauncey[5], J. Lovell[5]
[1]NRL, [2]USNO, [3]U. Sydney, Australia, [4]Cornell U., NAIC, [5]ATNF, Australia.

149.03 **Radio Emission on Subparsec Scales from the Intermediate-Mass Black Hole in NGC4395**
J. M. Wrobel[1], L. C. Ho[2]
[1]NRAO, [2]OCIW.

149.04 **Bayesian Quasar Classification in the Optical/Mid-IR**
Gordon T. Richards[1], R. Brunner[2], A. Gray[3], M. Lacy[4], A. Myers[2], R. Nichol[5], R. Riegel[3]
[1]Drexel Univ., [2]Illinois, [3]Georgia Tech, [4]SSC, [5]Portsmouth, United Kingdom.

149.05 **A Relation Between the Mid-Infrared [NeV]λ14.3μm and [NeIII]λ15.6μm Lines in Active Galactic Nuclei**
Charles R. Lawrence[1], V. Gorjian[1], K. Cleary[1], M. W. Werner[1]
[1]JPL.

149.06 **Mid-Infrared Silicate Features as an Indicator of the Dust Density Distribution in ULIRGs**
Matthew Sirocky[1], N. A. Levenson[1], M. Elitzur[1], H. W. Spoon[2], J. Marshall[2]
[1]U. of Ky, [2]Cornell.

149.07 **Searching for Mid-Infrared AGN Variability in Spitzer's IRAC Calibration Field**
Lauren B. Hund[1], M. L. Ashby[2], J. L. Hora[2], J. Surace[3]
[1]Furman University, [2]Harvard-Smithsonian Center for Astrophysics, [3]Spitzer Science Center, Caltech.

149.08 **Modeling of IR Emission from Externally Heated Dust Clouds**
Moshe Elitzur[1], A. E. Kimball[2], Z. Ivezic[2], M. Nenkova[3]
[1]Univ. of Kentucky, [2]Univ. of Washington, [3]Seneca College, Canada.

149.09 **Red AGNs: Dust Absorption or Intrinsic Continuum Difference?**
Monica Young[1], M. Elvis[2], G. Risaliti[3]
[1]Boston Univ., Center for Astrophysics, [2]Center for Astrophysics, [3]Center for Astrophsyics, INAF–Osservatorio Astronomico di Arcetri.

149.10 **Decomposing Dusty Galaxies: Probing the Nature of the Obscured Energy Source in ULIRGs**
Jason A. Marshall[1], L. Armus[2], V. Charmandaris[3], H. Spoon[1], V. Desai[4], T. L. Herter[1]
[1]Cornell Univ., [2]Spitzer Science Center, [3]Univ. of Crete, Greece, [4]Caltech.

149.11 **Gemini Observations of Mid-IR Emission from the Nucleus of Centaurus A**
James T. Radomski[1], C. Packham[2], N. A. Levenson[3], E. Perlman[4], L. L. Leeuw[5], H. Matthews[6], R. Mason[7], J. M. De Buizer[1], C. M. Telesco[2], M. Orduna[2]
[1]Gemini Observatory, Chile, [2]University of Florida, [3]University of Kentucky, [4]University of Maryland, Baltimore County, [5]Rhodes University, South Africa, [6]Herzberg Institute of Astrophysics, Canada, [7]Gemini Observatory.

149.12 **Characterization of the Baldwin Effect for AGN in the Mid Infrared**
Mark Keremedjiev[1], L. Hao[2]
[1]University of Florida, [2]Cornell University.

149.13 **Optical Color Selection of Faint AGN in the COSMOS Field**
Caitlin M. Casey[1], C. D. Impey[1]
[1]Steward Observatory, University of Arizona.

149.14 **Preliminary SEDs of TypeI AGNs of COSMOS Survey**
Heng Hao[1], M. Elvis[2], D. English[2], J. R. Trump[3], P. Capak[4], M. Brusa[5], V. Mainieri[5], M. Salvato[4], S. Gezari[4], D. Schiminovich[6], N. Scoville[4], C. Impey[3], J. Huchra[1]
[1]Harvard Univ., [2]CfA, [3]University of Arizona, [4]California Institute of Technology, [5]Max Planck-Institut fur Extraterrestrische Physik, Germany, [6]Columbia University.

149.15 **The Spectral Energy Distributions of Normal and Weakly-Active Galaxies**
John K. Parejko[1], A. Constantin[1], M. S. Vogeley[1], F. Hoyle[2]
[1]Drexel Univ., [2]Widener Univ..

149.16 **Multiwavelength Properties of Radio-loud Quasars**
Brendan P. Miller[1], N. Brandt[1], D. P. Schneider[1]
[1]Penn State Univ..

149.17 **Multiwavelength Observations of the Dwarf Seyfert 1 Galaxy POX 52**
Carol E. Thornton[1], A. J. Barth[1], L. C. Ho[2], R. E. Rutledge[3], J. E. Greene[4]
[1]UC Irvine, [2]Carnegie Observatories, [3]McGill University, Canada, [4]Princeton University.

149.18 **Measuring Accelerations in Water Vapor Megamasers using the Hough Transform**
Destry R. Saul[1], J. Braatz[2]
[1]UC Berkeley / NRAO, [2]NRAO.

149.19 **Time Variation in OH Megamaser Emission and Absorption toward Radio Supernovae in Arp 220**
Katherine R. de Kleer[1], C. J. Lonsdale[1], P. J. Diamond[2], C. J. Lonsdale[3], G. Smith[4], H. Thrall[2]
[1]MIT Haystack Observatory, [2]Jodrell Bank Observatory, United Kingdom, [3]California Institute of Technology, [4]University of California, San Diego.

149.20 **Triggering AGN Through Gravitational Perturbations: An Example of a Student Project Using SDSS-DR5**
Richard F. Gelderman[1], S. McMurray[1], S. Smith[1]
[1]Western Kentucky Univ..

150: And Yet More Supernovae
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

150.01 **Optical/UV Properties of High-z Supernovae Ia**
Ryan J. Foley[1], ESSENCE Collaboration
[1]UC, Berkeley.

150.02 **Circles on the Sky: Confirmation of a Light Echo from the Type Ia Supernova 1995E**
Peter M. Garnavich[1], J. L. Quinn[2], K. Krisciunas[1]
[1]Univ. of Notre Dame, [2]Central Michigan University.

150.03 **Direct Analysis of Spectra of the Unusual Type Ib Supernova 2005bf**
Jerod T. Parrent[1], D. Branch[1], M. Troxel[1], D. Casebeer[1], D. Jeffery[1], E. Baron[1], A. V. Filippenko[2]
[1]Univ. of Oklahoma, [2]Univ. of California Berkeley.

150.04 **Uncertainties in Supernova Yields**
Patrick A. Young[1], C. L. Fryer[1]
[1]Los Alamos National Laboratory.

150.05 **Determining the Type, Redshift, and Phase of a Supernova Spectrum**
Stephane Blondin[1], M. E. Salvo[2], J. L. Tonry[3]
[1]Harvard-Smithsonian, CfA, [2]RSAA, ANU, Australia, [3]IfA.

150.06 **Generating Pulsar Spin in Supernovae**
John M. Blondin[1], A. Mezzacappa[2]
[1]North Carolina State Univ., [2]Oak Ridge National Laboratory.

150.07 **Near-Explosion Lightcurves of SNe Ia from the SuperMACHO Survey**
Arti Garg[1], C. W. Stubbs[1], P. Challis[1], W. Wood-Vasey[1], S. Blondin[1], M. E. Huber[2], K. Cook[2], S. Nikolaev[2], A. Rest[3], R. Smith[3], K. Olsen[3], N. B. Suntzeff[4], C. Aguilera[3], J. L. Prieto[5], A. Becker[6], A. Miceli[6], G. Miknaitis[7], A. Clocchiatti[8], D. Minniti[8], L. Morelli[8], D. L. Welch[9]
[1]Harvard Univ., [2]Lawrence Livermore National Laboratory, [3]Cerro Tololo Inter-American Observatory/NOAO, Chile, [4]Texas A and M, [5]Ohio State University, [6]University of Washington, [7]Fermi National Accelerator Laboratory, [8]Universidad Catolica, Chile, [9]McMaster Uniersity, Canada.

150.08 **Imaging and Spectroscopy of Ancient Supernovae Light Echoes in the LMC**
Douglas L. Welch[1], A. Rest[2], R. C. Smith[2], K. Olsen[2], A. Zenteno[2], C. Aguilera[2], G. Damke[2], N. B. Suntzeff[3], T. Matheson[4], M. Bergmann[5], C. Stubbs[6], A. Garg[6], P. Challis[6], A. C. Becker[7], A. Miceli[7], R. Covarrubias[7], G. A. Miknaitis[8], J. Prieto[9], M. Huber[10], S. Nikolaev[10], K. H. Cook[10], D. Minniti[11], A. Clocchiatti[11], L. Morelli[11], A. Newman[12]
[1]McMaster Univ., Canada, [2]CTIO/NOAO, Chile, [3]TAMU, [4]NOAO, [5]Gemini, Chile, [6]Harvard, [7]U. Washington, [8]FNAL, [9]Ohio State, [10]IGPP/LLNL, [11]PUC, Chile, [12]Washington U..

150.09 **The Discovery of an Eruptive Variable in the LMC with Light Echoes**
R. Chris Smith[1], A. Rest[1], N. B. Suntzeff[2], D. L. Welch[3], G. Damke[1], A. Zenteno[1], C. Stubbs[4], A. Garg[4], A. Newman[5], A. Becker[6], G. Miknaitis[7], A. Miceli[6], K. H. Cook[8], S. Nikolaev[8], L. Morelli[9], D. Minniti[9], A. Clocchiatti[9], J. Prieto[10]
[1]NOAO/CTIO, [2]Texas A&M University, [3]McMaster University, Canada, [4]Harvard University, [5]Washington University, [6]University of Washington, [7]Fermilab, [8]LLNL, [9]Pontificia Universidad Catolica de Chile, Chile, [10]Ohio State University.

150.10 **A Survey for Ancient Supernova Light Echoes in the Milky Way Galaxy**
Armin Rest[1], N. B. Suntzeff[2], R. C. Smith[1], D. L. Welch[3], G. Damke[1], A. Zenteno[1], C. Stubbs[4], A. Garg[4], P. Challis[4], A. Newman[5], A. C. Becker[6], G. A. Miknaitis[6], A. Miceli[6], K. H. Cook[7], M. Huber[7], S. Nikolaev[7], L. Morelli[8], D. Minniti[8], A. Clocchiatti[8], J. Prieto[9]
[1]NOAO/CTIO, [2]Texas A&M University, [3]McMaster University, Canada, [4]Harvard University, [5]Washington University, [6]University of Washington, [7]Lawrence Livermore National Laboratory, [8]Pontificia Universidad Catolica de Chile, Chile, [9]Ohio State University.

150.11 **Shock Wave Stability in Core Collapse Supernovae**
F. D. Swesty[1], E. S. Myra[1]
[1]SUNY-Stony Brook.

150.12 **Galactic Analogs of the Rings around SN1987A and the Implication thatLBVs are Supernova Progenitors**
Nathan Smith[1]
[1]University of California, Berkeley.

150.13 **Light Curves of Supernova/Gamma-Ray Bursts**
Dean L. Richardson[1]
[1]Denison Univ..

150.14 **Subluminous Type Ia Supernovae in the Supernova Legacy Survey**
Santiago Gonzalez[1], A. Howell[1], M. Sullivan[1], A. Conley[1], R. Carlberg[1], Supernova Legacy Survey
[1]University of Toronto, Canada.

150.15 **Optical Observations of SN 1999aa**
Thea N. Steele[1], R. J. Foley[1], A. V. Filippenko[1], W. Li[1]
[1]University of California, Berkeley.

150.16 **The Nearby Supernova Factory**
Benjamin A. Weaver[1], G. Aldering[1], C. Aragon[1], S. Bailey[1], S. Bongard[1], M. J. Childress[1], S. Loken[1], P. Nugent[1], S. Perlmutter[1], R. Romano[1], K. Runge[1], R. Scalzo[1], R. C. Thomas[1], C. Baltay[2], A. Bauer[2], D. Herrera[2], D. Rabinowitz[2], E. Pécontal[3], G. Rigaudier[3], P. Antilogus[4], S. Gilles[4], R. Pain[4], R. Pereira[4], C. Buton[5], Y. Copin[5]
[1]Lawrence Berkeley National Laboratory, [2]Department of Physics, Yale University, [3]Centre de Recherche Astronomique de Lyon, France, [4]Laboratorie de Physique Nucléaire et des Hautes Energies, France, [5]Institut de Physique Nucléaire de Lyon, France.

150.17 **Verification Tests for Numerical 2-D Radiation-Hydrodynamics as Applied toa Core-Collapse Supernova Code**
Eric S. Myra[1], F. D. Swesty[1]
[1]SUNY-Stony Brook.

150.18 **Propagation of the First Flames in Type Ia Supernovae**
L. J. Dursi[1], M. Zingale[2]
[1]Univ. Of Toronto, Canada, [2]SUNY Stony Brook.

150.19 **The Spatial Correlation of Type Ia Supernovae with Local StarFormation as Measured with GALEX**
James D. Neill[1], GALEX Science Team
[1]California Institute of Technology.

150.20 **Detailed Spectral Analysis of the Type Ib Supernova 1999dn**
Wesley R. Ketchum[1], E. Baron[1]
[1]University of Oklahoma.

150.21 **The Laminar Flame Speedup by Neon-22 Enrichment in White Dwarf Supernovae**
David A. Chamulak[1], E. F. Brown[1], F. X. Timmes[2]
[1]Department of Physics and Astronomy and the Joint Institute for Nuclear Astrophysics, Michigan State University, [2]Thermonuclear Applications, X-2, Los Alamos National Laboratory.

150.22 **Steady-State Modeling and Possible Detection of HCl in Eta Carinae's - 513 km/s Ejecta**
Alissa S. Bans[1]
[1]Maria Mitchell Observatory.

150.23 **A Hubble Space Telescope WFPC-2 Optical Survey of Dust in the Crab Nebula**
Allison M. Loll[1], J. Hester[1], R. Sankrit[2], W. Blair[3]
[1]Arizona State Univ., [2]U.C. Berkeley, [3]Johns Hopkins University.

150.24 **Optical Photometry of Supernovae Using the KAIT Pipeline**
Mohan Ganeshalingam[1]
[1]UC Berkeley Astonomy Dept.

150.25 **Multidimensional Simulations of Mixing in Zero-Metallicity Supernovae**
Candace M. Church[1], A. Heger[2], S. Woosley[1]
[1]UC, Santa Cruz, [2]Los Alamos National Laboratory.

151: Binary Stars
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

151.01 **A Radial Velocity Study of Hot Subdwarf Stars with Composite Spectra**
Richard A. Wade[1], M. A. Stark[2]
[1]Penn State Univ., [2]Univ. Wyoming.

151.02 **The Eclipsing Binary MY Cygni**
Rebecca Tucker[1], J. R. Sowell[1], R. M. Williamon[2]
[1]Georgia Tech, [2]Emory.

151.03 **Analysis of the Spitzer/MIPS24 Light Curve of the M-Dwarf Eclipsing Binary GU Boo**
Kaspar von Braun[1], G. T. van Belle[1], D. R. Ciardi[1], S. Wachter[1], D. W. Hoard[1]
[1]Caltech.

151.04 **Measurements of Position Angle and Separation of Selected Binary Stars**
Rafael J. Muller[1], J. C. Cersosimo[1], V. J. Miranda[1], C. Martinez[1], D. Centeno[1], L. Rivera[1]
[1]Univ. of Puerto Rico, Humacao.

151.05 **A Light Curve Study and Analysis of the Short-Period Contact Binary XZ Leonis**
Jeffrey J. Massura[1], B. J. Hrivnak[1], W. Lu[1]
[1]Valparaiso University.

151.06 **Photometric Investigation of the Eclipsing Binary Star BX Dra**
Shaukat N. Goderya[1], T. Sykes[1]
[1]Tarleton State Univ..

151.07 **FUSE Observations of the Be/X-ray Binary 4U 1145-617(V801 Cen, HD1022567)**
Rosina Iping[1], G. Sonneborn[1]
[1]NASA's GSFC.

151.08 **Massive Star Multiplicity: The Cepheids U Aql and W Sgr**
Nancy R. Evans[1], D. Massa[2]
[1]SAO, [2](NASA's GSFC, SGT, Inc.

151.09 **Photometric Studies of Two Active Contact Binaries: GSC 2766-0775 and GSC 0619-0232**
Ronald G. Samec[1], H. A. Chamberlain[1], C. M. Labadorf[1], R. McKenzie[1], W. Van Hamme[2], D. R. Faulkner[3]
[1]Bob Jones Univ., [2]Florida International Univ., [3]Univ. of S. Carolina.

151.11 **HST Observations of Astrophysically Important Visual Binaries**
Gail Schaefer[1], H. E. Bond[1], M. Barstow[2], M. Burleigh[2], R. L. Gilliland[1], T. M. Girard[3], D. H. Gudehus[4], J. B. Holberg[5], E. Nelan[1]
[1]Space Telescope Science Institute, [2]University of Leicester, United Kingdom, [3]Yale University, [4]Georgia State University Research Foundation, [5]University of Arizona.

151.12 **The Light Curve and Parameters of Eclipsing Binary System FL Orionis**
Daniel B. Caton[1], A. B. Smith[1]
[1]Appalachian State Univ..

151.13 **Five New Low-Mass Eclipsing Binary Systems**
Jeffrey L. Coughlin[1], M. López-Morales[2], J. S. Shaw[3]
[1]Emory University, [2]Carnegie Institution of Washington, [3]University of Georgia.

151.14 **Light Curve Analysis for W UMa-Type Eclipsing Binary Star Systems**
Scott Henderson[1], N. Peach[1], T. Olsen[1]
[1]Lewis & Clark College.

151.15 **Orbital Parameters of R Aquarii**
Gustav Rustan[1], G. McIntosh[1]
[1]University of Minnesota, Morris.

152: Extrasolar Planets V: Host Stars
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

152.01 **Investigating the Rotation Periods of Exoplanet Host Stars**
Elaine K. Simpson[1], S. Baliunas[1], G. Henry[2]
[1]Harvard-Smithsonian, CfA, [2]Tennessee State University.

152.02 **Atmospheric Properties of Brown Dwarfs**
Lauren J. McCarthy[1], K. L. Cruz[2]
[1]Barnard College/AMNH, [2]AMNH.

152.03 **Determining Stellar Parameters With a Fixed Delay Interferometer**
Roger Cohen[1], S. Mahadevan[1], J. Ge[1]
[1]University of Florida.

152.04 **Characterization of Gravitational Microlensing Planetary Host Stars**
David P. Bennett[1], J. Anderson[2], B. S. Gaudi[3]
[1]Univ. of Notre Dame, [2]Rice University, [3]The Ohio State University.

153: GLAST
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

153.01 **The Gamma-ray Large Area Space Telescope (GLAST) Mission**
Steven M. Ritz[1], P. F. Michelson[2], C. Meegan[3], J. E. Grindlay[4], GLAST Mission Team
[1]GSFC & University of MD, [2]Stanford University, [3]MSFC and NSSTC, [4]Harvard University.

153.02 **The Large Area Telescope (LAT) on the Gamma-ray Large Area Space Telescope (GLAST)**
Toby H. Burnett[1], GLAST LAT Team
[1]University of Washington.

153.03 **GLAST Large Area Telescope Multiwavelength Studies: An Invitation to Coordinated Observations**
Kent S. Wood[1], D. J. Thompson[2], R. A. Cameron[3], GLAST Collaboration
[1]NRL, [2]NASA-GSFC, [3]SLAC.

153.04 **Gamma-Ray Pulsar Candidates for GLAST**
David J. Thompson[1], D. A. Smith[2], D. Dumora[2], L. Guillemot[2], D. Parent[2], T. Reposeur[2], J. E. Grove[3], R. W. Romani[4], S. E. Thorsett[5], GLAST LAT Collaboration
[1]NASA's GSFC, [2]CEN Bordeaux-Gradignan, France, [3]NRL, [4]Stanford, [5]UCSC.

153.05 **Studying Gamma-ray Blazars with the GLAST-LAT**
Benoit Lott[1], LAT Blazar Science Working Group
[1]SLAC/CENBG.

153.06 **Prospects for Observations of Microquasars with GLAST**
Richard Dubois[1]
[1]Stanford Linear Accelerator Center.

153.07 **Observing GRBs with the GLAST LAT Telescope**
Julie E. McEnery[1], GLAST LAT GRB science working group
[1]NASA's GSFC.

153.08 **Future GLAST Observations of Supernova Remnants and Pulsar Wind Nebulae**
Stefan Funk[1], GLAST LAT Collab. Pulsars, SNR and Plerions group
[1]SLAC.

153.09 **GLAST Large Area Telescope Performance Monitoring and Calibrations**
Anders W. Borgland[1]
[1]SLAC.

153.10 **The GLAST LAT Instrument Science Operations Center**
Robert A. Cameron[1], GLAST LAT ISOC
[1]Stanford Univ..

153.11 **GLAST User Support**
David L. Band[1], GLAST Science Support Center
[1] *University of Maryland, Baltimore County.*

153.12 **The GLAST Science Support Center**
Thomas E. Stephens[1], GLAST Science Support Center
[1] *NASA's GSFC/RSIS.*

153.13 **GLAST Data Access and Analysis Software**
Donald J. Horner[1], GLAST Science Support Center
[1] *NASA's GSFC.*

153.14 **Beyond the Event Horizon: Education with Black Holes**
Sarah Silva[1], P. Plait[1], L. Cominsky[1]
[1] *Sonoma State Univ. NASA GLAST E/PO.*

153.15 **On the Problem of Detecting Quantum-Gravity Based Photon Dispersion in Gamma-ray Bursts**
Jeffrey D. Scargle[1], J. P. Norris[2], J. T. Bonnell[3]
[1] *NASA/Ames Research Center,* [2] *University of Denver,* [3] *NASA/GSFC/USRA.*

154: Ground-Based Instrumentation III
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

154.01 **Pisgah Astronomical Research Institute**
J. D. Cline[1], M. Castelaz[1], D. Clavier[1]
[1] *Pisgah Astronomical Research Inst..*

154.02 **The Apache Point Observatory Lunar Laser-ranging Operation: Testing General Relativity with Millimeter-precision Measurements of the Earth-Moon Separation.**
James B. Battat[1], T. W. Murphy[2], E. G. Adelberger[3], C. D. Hoyle[3], R. J. McMillan[4], E. Michelsen[2], K. Nordtvedt[5], A. Orin[2], C. W. Stubbs[1], H. E. Swanson[3]
[1] *Harvard Univ.,* [2] *University of California San Diego,* [3] *University of Washington,* [4] *Apache Point Observatory,* [5] *Northwest Analysis.*

154.03 **The McDonald Observatory Skycam Project**
Michael A. Gully-Santiago[1]
[1] *Boston University.*

154.04 **ALE: Astronomical LIDAR for Extinction**
Peter C. Zimmer[1], J. T. McGraw[1], G. Gimmestad[2], D. Roberts[2], J. Stewart[2], M. Dawsey[3], J. Fitch[1], J. Smith[1], A. Townsend[1], B. Black[1]
[1] *Univ. of New Mexico,* [2] *Georgia Tech Research Institute,* [3] *Univ. of Arizona.*

154.05 **A GRB Optical Afterglow Automatic Response Telescope on Skynet**
Adam B. Smith[1], D. B. Caton[1], L. Hawkins[1]
[1] *Appalachian State Univ..*

154.06 **A New Sky Brightness Monitor**
David L. Crawford[1], D. McKenna[2]
[1] *IDA,* [2] *Vatican Observatory.*

154.07 **Brightness of Clouds at Night over a City**
R. H. Garstang[1]
[1] *Univ. of Colorado.*

154.08 **Performance of the Visiting Instrument TEXES on Gemini North**
Andrew J. Kruger[1], J. H. Lacy[2], D. T. Jaffe[2], M. J. Richter[1], T. K. Greathouse[3], M. Bitner[2], P. Segura[4], W. Moller[4], T. R. Geballe[5], K. Volk[5]
[1]Department of Physics, University of California, [2]Department of Astronomy, University of Texas, [3]Lunar and Planetary Institute, [4]McDonald Observatory, University of Texas, [5]Gemini Observatory.

154.09 **bHROS: Year One**
Steven J. Margheim[1]
[1]Gemini Observatory, Chile.

154.10 **The Gemini Planet Imager Apodized Pupil Lyot Coronagraph**
Remi Soummer[1], A. Sivaramakrishnan[1], B. R. Oppenheimer[1], B. A. Macintosh[2], GPI team
[1]American Museum of Nautral History, [2]LLNL.

154.11 **A Proposed GLAO System for Gemini**
David R. Andersen[1], Gemini GLAO Feasibility Study Team
[1]Herzberg Institute of Astrophysics, Canada.

154.12 **Preliminary Optical and Mechanical Designs for a 2.2 Degree Diameter PrimeFocus Corrector for the Blanco 4 Meter Telescope**
Stephen M. Kent[1], R. Bernstein[2], B. Bigelow[2], F. Leger[1], A. Stefanik[1], T. Abbott[3], D. Brooks[4], P. Doel[4], B. Flaugher[1], M. Gladders[5], A. Walker[3], S. Worswick[4]
[1]Fermi Nat'l. Accelerator Lab., [2]U. of Michigan, [3]CTIO/AURA, Chile, [4]University College London, United Kingdom, [5]U. of Chicago.

154.13 **Observating Techniques with the IRMOS MEMS Spectrometer**
John W. MacKenty[1], M. A. Greenhouse[2], R. G. Ohl[2], M. Robberto[1]
[1]STScI, [2]NASA/GSFC.

154.14 **Astrometric Calibration of Digitized Wide-Field Photographic Plates**
Peter B. Boyce[1], P. N. Truong[1]
[1]Maria Mitchell Association.

154.15 **2.1 meter (82 inch) Slip Ring By-Pass Project**
Corby B. Bryan[1]
[1]Texas Tech University.

155: Observations and Models of Extragalactic LMXBs
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

155.01 **Low-Mass X-ray Binary Models for NGC3379 and NGC4278**
Tassos Fragos[1], V. Kalogera[1], K. Belczynski[2], D. Kim[3], G. Fabbiano[4], L. Angelini[5], R. L. Davies[6], J. S. Gallagher[7], A. R. King[8], S. Pellegrini[9], G. Trinchieri[10], S. F. Zepf[11], A. Zezas[4]
[1]Northwestern University, Department of Physics and Astronomy, [2]New Mexico State University, [3]Harvard-Smothsonian Center for Astrophysics, [4]Harvard-Smithsonian Center for Astrophysics, [5]Laboratory for High Energy Astrophysics, NASA Goddard Space Flight Center, [6]University of Oxford, United Kingdom, [7]Astronomy Department, University of Wisconsin, [8]University of Leicester, United Kingdom, [9]Dipartimento di Astronomia, Universita' di Bologna, Italy, [10]INAF-Observatorio Astronomico di Brera, Italy, [11]Department of Physics and Astronomy, Michigan State University.

155.02 **X-ray Binaries in the Fornax Local Group Dwarf**
Roy E. Kilgard[1], R. Soria[1], A. H. Prestwich[1], V. Kalogera[2]
[1]SAO, [2]Northwestern University.

155.03 **X-ray Binary Populations in Normal elliptical Galaxies**
Nicola J. Brassington[1], G. Fabbiano[1], D. Kim[1], L. Angelini[2], R. Davies[3], J. Gallagher[4], V. Kalogera[5], A. King[6], S. Pellegrini[7], G. Trinchieri[8], S. Zepf[9], A. Zezas[1]
[1]CfA, [2]GSFC, [3]University of Oxford, United Kingdom, [4]University of Wisconsin, [5]Northwestern University, [6]University of Leicester, United Kingdom, [7]Bologna University, Italy, [8]INAF-OABr, Italy, [9]Michigan State University.

155.04 **Low-Luminosity XLF in Normal Elliptical Galaxies**
Dong-Woo Kim[1], G. Fabbiano[1], N. J. Brassington[1], V. Kalogera[2], A. R. King[3], S. Pellegrini[4], G. Trinchieri[5], S. E. Zepf[6], A. Zezas[1], L. Angelini[7], R. L. Davies[8], J. S. Gallagher[9]
[1]Harvard-Smithsonian, CfA, [2]Northwestern University, [3]University of Leicester, United Kingdom, [4]Universita di Bologna, Italy, [5]INAF Osservatorio, Italy, [6]Michigan State University, [7]NASA Goddard Space Flight Center, [8]University of Oxford, United Kingdom, [9]University of Wisconsin.

156: Planetary Nebulae & Supernova Remnants
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

156.01 **Discovery of Multiple Coaxial Rings in the Bipolar Nebula Hb12**
Sun Kwok[1], C. Hsia[2]
[1]University of Hong Kong, China, [2]National Central University, Taiwan.

156.02 **Planetary Nebulae and Stellar Kinematics in Interacting Spiral Galaxy M82**
Lent C. Johnson[1], R. H. Mendez[2], A. M. Teodorescu[2]
[1]Colby College & Institute for Astronomy, University of Hawaii, [2]Institute for Astronomy, University of Hawaii.

156.03 **Balmer Ratios and Molecular Hydrogen in M27**
Roxana E. Lupu[1], S. R. McCandliss[1], K. France[2]
[1]Johns Hopkins University, [2]CITA/ University of Toronto, Canada.

156.04 **Planetary Nebulae in the Large Magellanic Cloud: Results from MCELS**
Alfredo Zenteno[1], R. C. Smith[2], A. Rest[1], S. Points[1], R. Leiton[1], C. Aguilera[1], D. Shaw[2], P. F. Winkler[3]
[1]CTIO/NOAO, Chile, [2]NOAO, [3]Middlebury University.

156.05 **A More Complete Sample of Planetary Nebulae in the Small Magellanic Cloud: Results from MCELS**
Joseph W. Coish[1], E. C. Galle[2], P. F. Winkler[3], R. C. Smith[4], MCELS Team
[1]Haverford College, [2]Center for Astrophysics and Middlebury College, [3]Middlebury College, [4]NOAO.

156.06 **High-resolution X-ray Imaging and Spectroscopy of the Planetary Nebula BD +30 3639**
Young Sam Yu[1], J. Kastner[1], J. Houck[2], E. Behar[3], R. Nordan[3], N. Soker[3]
[1]Center for imaging science, Rochester Inst. Of Technology, [2]Kavli Institute, Massachusetts Institute of Technology, [3]Department of physics, Technion-Israel Institute of Technology, Israel.

156.07 **K-Band Spectroscopy of the Extragalactic Planetary Nebula Hen 2-436**
Jessica L. Wood[1], H. L. Dinerstein[1], T. R. Geballe[2], N. C. Sterling[3]
[1]Univ. of Texas at Austin, [2]Gemini Observatory, [3]NPP Fellow, NASA Goddard Space Flight Center.

156.08 **Properties of Planetary Nebulae: NGC2022**
Renee C. Mateluna Perez[1], H. Monteiro[2], J. Richards[3], H. E. Schwarz[4]
[1]Univ. de Concepcion, Chile, [2]Georgia State University, [3]Carnegy Mellon University, [4]Cerro Tololo Inter-American Observatory, Chile.

156.09 **A Search for Gas-Phase Zirconium in s-process Enriched Planetary Nebulae**
Harriet L. Dinerstein[1], J. H. Lacy[1], K. Sellgren[2], N. C. Sterling[3]
[1]Univ. of Texas, Austin, [2]Ohio State Univ., [3]NPP Fellow, NASA Goddard Space Flight Center.

156.10 **Searching for the Missing Galactic Planetary Nebulae: A Pilot [S III] Imaging Survey**
Joshua H. Shiode[1], D. P. Clemens[1], K. A. Janes[1], A. Pinnick[1], B. Taylor[1]
[1]Boston University.

156.11 **A Multi-Wavelength Investigation of Newly Discovered Supernova Remnants in the Large Magellanic Cloud**
Matthew Klimek[1], S. D. Points[2], C. Smith[2]
[1]Rutgers University, [2]CTIO, Chile.

156.12 **Modeling the Crab Synchrotron Nebula by Including Radiative Losses in Flow Dynamics**
Joseph P. Foy[1], J. Hester[1]
[1]Arizona State Univ..

156.13 **Spitzer Observations of Supernova Remnant N49 in the LMC**
Tea Temim[1], C. E. Woodward[1], E. F. Polomski[1], R. D. Gehrz[1]
[1]Univ. of Minnesota.

156.14 **The N19 HII Complex in the SMC: Multiple Supernova Remnants Forming a Proto-Superbubble?**
Rosa N. Williams[1], Y. H. Chu[1], C. H. Chen[1], R. A. Gruendl[1], S. D. Points[2], R. C. Smith[2]
[1]Univ. of Illinois at Urbana-Champaign, [2]Cerro-Tololo Inter-American Observatory, Chile.

156.15 **Balmer-Dominated Supernova Remnants Revisited**
Richard McCray[1], K. Heng[1]
[1]JILA, University of Colorado.

156.16 **Expanding Ejecta in the Core-Collapse Supernova Remnant G292.0+1.8, Cas A's Older Cousin**
Karl Twelker[1], C. N. Reith[1], P. F. Winkler[1], K. S. Long[2]
[1]Middlebury College, [2]STScI.

156.17 **A Deep Chandra Observation of Kepler's Supernova Remnant: A Type Ia Supernova with Circumstellar Interaction**
Stephen P. Reynolds[1], K. J. Borkowski[1], C. Badenes[2], J. P. Hughes[2], U. Hwang[3], J. M. Laming[4], J. M. Blondin[1]
[1]North Carolina State Univ., [2]Rutgers U., [3]NASA/GSFC, [4]NRL.

156.18 **A Deep Chandra Observation of the O-Rich SNR 0540-69.3 in the LMC**
Sangwook Park[1], J. Hughes[2], P. Slane[3], D. Burrows[1], K. Mori[4]
[1]Pennsylvania State Univ., [2]Rutgers Univ, [3]CfA, [4]Univ of Miyazaki, Japan.

156.19 **X-Ray Imaging and Spectroscopy of Oxygen-Rich Ejecta in N132D**
Kazimierz J. Borkowski[1], S. P. Hendrick[2], S. P. Reynolds[1]
[1]North Carolina State Univ., [2]Millersville Univ..

156.20 **Investigation of the Vela X Emission**
Stephanie M. LaMassa[1], P. Slane[1], O. de Jager[2]
[1]Center for Astrophysics, [2]Potchefstroom University, South Africa.

156.21 **Optical Imaging and Spectroscopy of the Galactic Supernova Remnant 3C58**
Robert A. Fesen[1], G. Rudie[1], A. Hurford[1], A. Soto[1]
[1]Dartmouth College.

157: Professional Development for Scientists and Educators
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

157.01 **The ASP: Programs to Inspire Educators**
Anna Hurst[1], S. Gurton[1], M. Bennett[1], M. Berendson[1], M. Gibbs[1]
[1]*Astronomical Society of the Pacific.*

157.02 **An Online Hands-On Program for Middle-School Science Teachers**
Stephen Schneider[1], K. Davis[1]
[1]*UMass.*

157.03 **Strategies for Professional Development for Educators**
Matthew Bobrowsky[1], D. A. Smith[1], B. Eisenhamer[1], NASA Origins E/PO Leads
[1]*STScI.*

157.04 **Teaching Astronomy Graduate Students About Teaching at the 101 Level**
Erika Grundstrom[1], D. R. Gies[1], J. W. Wilson[1]
[1]*Georgia State Univ..*

157.05 **The NASA Center for Astronomy Education (CAE): 2007 College Astronomy Teaching Excellence Workshops**
Gina Brissenden[1], E. E. Prather[1], T. F. Slater[1], W. M. Greene[2], M. Thaller[3]
[1]*Univ. of Arizona,* [2]*Navigator, JPL,* [3]*Spitzer, Cal Tech.*

157.06 **Impact of the CAE Astronomy Teaching Excellence Workshop Program**
Erin F. Dokter[1], E. E. Prather[1], G. Brissenden[1], T. F. Slater[1], W. M. Greene[2], M. Thaller[3]
[1]*Univ. of Arizona,* [2]*JPL Navigator,* [3]*Caltech, Spitzer.*

157.07 **Deciphering Stars: A Professional Development Workshop for Teachers**
Mary Kay Hemenway[1], S. Redfield[1]
[1]*U. Texas-Austin.*

158: Properties of Hot Stars
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

158.01 **Xatlas: An Online Archive of Chandra Hot Star Gratings Observations**
Owen Westbrook[1], N. R. Evans[1], S. J. Wolk[1], J. Nichols[1], V. L. Kashyap[1], P. J. Mendygral[2], W. L. Waldron[3]
[1]*Harvard-Smithsonian, CfA,* [2]*University of Minnesota,* [3]*Eureka Scientific, Inc.*

158.02 **Searching for Hidden Wolf-Rayet Stars in the Galaxy 15 New Wolf-Rayet Stars**
Lucy J. Hadfield[1], S. D. van Dyk[2], P. W. Morris[3], J. D. Smith[4], A. P. Marston[5]
[1]*The Univerity Of Sheffield, United Kingdom,* [2]*Spitzer Science Center, IPAC, CALTECH,* [3]*NASA Herschel Science Center, IPAC, CALTECH,* [4]*Steward Observatory,* [5]*ESA/ESAC, Spain.*

158.03 **Chandra Spectroscopy of the Hot Star Beta Cru and the Discovery of a Pre-Main Sequence Companion**
Michael A. Kuhn[1], D. H. Cohen[1], E. L. Jensen[1], M. Gagne[2]
[1]*Swarthmore College,* [2]*West Chester University.*

159: Pulsars
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

159.01 **The Torque-luminosity Relation and Possible Glitches in Three X-ray Binary Systems**
Michael J. Stark[1], D. Meral[1], A. Baykal[2], J. H. Swank[3]
[1]*Lafayette College,* [2]*Middle East Technical University, Turkey,* [3]*NASA's Goddard Space Flight Center.*

159.02 **New Pulsars in the Globular Cluster M28**
Ingrid H. Stairs[1], S. Begin[1], S. Ransom[2], P. Freire[3], J. Hessels[4], J. Katz[5], V. Kaspi[6], F. Camilo[7]
[1]Univ. of BC, Canada, [2]NRAO, [3]NAIC, [4]University of Amsterdam, The Netherlands, [5]University of Virginia, [6]McGill University, Canada, [7]Columbia University.

159.03 **Discovery and Timing of Eight New Millisecond Pulsars in NGC 6440 and NGC 6441**
Paulo Freire[1], S. M. Ransom[2], S. Begin[3], I. H. Stairs[3], J. W. Hessels[4]
[1]Arecibo Observatory, [2]NRAO, [3]University of British Columbia, Canada, [4]McGill University, Canada.

159.04 **A New Technique for the Characterization of Radio Pulsar Polarization Profiles**
Samuel Rodarte, Jr.[1], W. van Straten[1]
[1]Center for Gravitational Wave Astronomy; The University of Texas at Brownsville.

159.05 **Discovery of an Energetic Young Pulsar Candidate Coincident with a TeV Gamma-ray Source.**
David J. Helfand[1], E. V. Gotthelf[1], D. Semler[1], F. Camilo[1], R. H. Becker[2], R. L. White[3]
[1]Columbia Astrophysics Lab., [2]University of California, Davis, [3]Space Telescope Science Institute.

159.06 **Timing Pulsars in Globular Cluster NGC6441**
Lucille H. Frey[1], S. Ransom[2]
[1]Case Western Reserve University, [2]National Radio Astronomy Observatory.

159.07 **Population Synthesis of Radio and Gamma-ray Millisecond Pulsars from the Galactic Plane**
Sarah A. Story[1], P. L. Gonthier[1], B. D. Clow[1], A. K. Harding[2]
[1]Hope College, [2]NASA Goddard Space Flight Center.

159.08 **First Results from a Galactic Center Search for Pulsars and Transients:A Rotating Radio Transient Candidate**
Julia S. Deneva[1], J. M. Cordes[1], T. J. Lazio[2], R. Bhat[3], S. Chatterjee[4], S. M. Ransom[5], G. Bower[6], W. Vlemmings[7], P. Demorest[6], D. C. Backer[6]
[1]Cornell University, [2]NRL, [3]Swinburne University, Australia, [4]University of Sydney, Australia, [5]NRAO, [6]University of California, Berkeley, [7]Jodrell Bank Observatory, United Kingdom.

159.09 **Updated Timing Parameters of two Massive Binary Pulsars: J0621+1002 and J0751+1807**
Laura Kasian[1], I. H. Stairs[1], D. J. Nice[2]
[1]Univ. Of British Columbia, Canada, [2]Bryn Mawr College.

159.10 **Circumpulsar Asteroids: Inferences from Nulling Statistics and High Energy Correlations**
Ryan Shannon[1], J. M. Cordes[1]
[1]Cornell University.

159.11 **Application of Typological Sequencing for the Classification of Radio Pulsar Profiles**
Rossina B. Miller[1], F. Jenet[1]
[1]Center for Gravitational Wave Astronomy/ University of Texas at Brownsville.

159.12 **Population Statistics of Normal Isolated, Radio and Gamma-ray Pulsars from the Galactic Plane**
Peter L. Gonthier[1], S. A. Story[1], B. D. Clow[1], A. K. Harding[2], I. A. Grenier[3]
[1]Hope College, [2]NASA Goddard Space Flight Center, [3]CEA/Saclay & University of Paris VII, France.

159.13 **Numerical Simulations of Bulk and Thermal Comptonization in X-Ray Pulsar Accretion Columns**
Kenneth D. Wolfram[1], P. A. Becker[2], M. T. Wolff[1]
[1]Naval Research Laboratory, [2]George Mason Uninversity.

159.14 **The Radio Properties and Magnetic Field Configuration in Pulsar Wind Nebula G54.1+0.3**
Cornelia C. Lang[1], F. Lu[2], Q. D. Wang[3], K. I. Clubb[1]
[1]Univ. of Iowa, [2]IHEP, China, [3]Univ. of Mass.

160: SAGE
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

160.01 **Dust Processing Near Sites of High-Mass Star Formation in the Large Magellanic Cloud**
Sacha Hony[1], S. Madden[1], D. Rubin[1], M. S. Oey[2], F. Galliano[3], B. Whitney[4], M. Meade[5], B. Babler[5], R. Indebetouw[6], J. Hora[7], K. Gordon[8], C. Engelbracht[8], B. For[9], M. Block[8], K. Misselt[8], M. Meixner[10], U. Vijh[10], C. Leitherer[10]
[1]Service d'Astrophysique, CEA, France, [2]University of Michigan, Department of Astronomy, [3]NASA Goddard Space Flight Center, [4]Space Science Institute, [5]University of Wisconsin, [6]University of Virginia, [7]Harvard-Smithsonian/CfA, [8]University of Arizona, [9]University of Texas, [10]STScI.

160.02 ***SST/SAGE* and *HST* Study of Stellar Populations and Star Formation around NGC 1850 in the LMC**
Nino Panagia[1], M. Romaniello[2], R. Gilmozzi[2], G. De Marchi[3], M. Meixner[1], U. Vijh[1], C. Leitherer[1], B. Whitney[4], M. Meade[5], B. Babler[5], R. Indebetouw[6], J. Hora[7], K. Gordon[8], C. Engelbracht[8], B. For[9], M. Block[8], K. Misselt[8], SAGE Group
[1]STScI, [2]ESO, Germany, [3]ESA/ESTEC, The Netherlands, [4]Space Science Institute, [5]U. Wisconsin, [6]U.Virginia, [7]CfA, [8]U. Arizona, [9]U. Texas.

160.03 **Mass Loss from Evolved Stars in LMC Clusters**
Sean Points[1], K. Olsen[1], R. Blum[2], B. Whitney[3], M. Meade[4], B. Babler[4], R. Indebetouw[5], J. Hora[6], K. Gordon[7], C. Engelbracht[7], B. For[8], M. Block[7], K. Misselt[7], M. Meixner[9], U. Vijh[9], C. Leitherer[9], S. Srinivasan[9]
[1]CTIO/NOAO, Chile, [2]NOAO, [3]Space Science Institute, [4]Univ Wisconsin, [5]Univ Virginia, [6]Harvard-Smithsonian/CfA, [7]Univ Arizona, [8]Univ Texas, [9]STScI.

160.04 **Crystalline Silicates around Asymptotic Giant Branch Stars in the Large Magellanic Cloud**
Francisca Markwick-Kemper[1], C. Dijkstra[2]
[1]Univ. of Manchester, United Kingdom, [2]Univ. of Missouri.

160.05 **The Mass Loss Return From Evolved Stars to the LMC: Empirical Relations For Excess Emission at 8 and 24 μm**
Sundar Srinivasan[1], M. Meixner[2], U. Vijh[2], C. Leitherer[2], K. Volk[3], F. Markwick-Kemper[4], R. D. Blum[5], J. R. Mould[5], K. A. Olsen[6], S. Points[6], B. A. Whitney[7], M. Meade[8], B. Babler[8], R. Indebetouw[4], J. L. Hora[9], K. Gordon[10], C. Engelbracht[10], B. For[11], M. Block[10], K. Misselt[10]
[1]Johns Hopkins University, [2]Space Telescope Science Institute, [3]Gemini Observatory, [4]University of Virginia, [5]National Optical Astronomy Observatory, [6]Cerro Tololo Inter-American Observatory, Chile, [7]Space Science Institute, [8]University of Wisconsin, [9]Harvard-Smithsonian Center for Astrophysics, [10]University of Arizona, [11]University of Texas.

160.06 **Variable Sources in Large Magellanic Cloud using the SAGE Survey**
Uma P. Vijh[1], M. Meixner[1], S. Srinivasan[2], B. Babler[3], M. Block[4], C. Engelbracht[4], B. -. For[4], K. Gordon[4], J. Hora[5], R. Indebetouw[6], C. Leitherer[1], M. Meade[3], K. Misselt[4], B. Whitney[7]
[1]STScI, [2]JHU, [3]U. Wisconsin, [4]U. Arizona, [5]Harvard/CfA, [6]U. Virginia, [7]SSI.

160.07 **Modelling Evolved Stars Detected by the Spitzer LMC Survey (SAGE)**
Kevin Volk[1], M. Meixner[2], S. Srinivasan[2], F. Markwick-Kemper[3], B. Whitney[2], R. D. Blum[4], M. Meade[5], B. Babler[5], R. Indebetouw[6], J. Hora[7], K. Gordon[8], C. Engelbracht[8], B. For[9], M. Block[8], K. Misselt[8], U. Vijh[2], C. Leitherer[2], SAGE Team
[1]Gemini Observatory, [2]Space Telescope Science Institute, [3]University of Manchester, United Kingdom, [4]National Optical Astronomical Observatory, [5]Univeristy of Wisconsin, [6]Univeristy of Virginia, [7]Harvard-Smithsonian Center for Astrophysics, [8]Steward Observatory, [9]University of Texas.

160.08 **Spitzer/SAGE Observations of Planetary Nebulae in the Large Magellanic Cloud**
Joseph L. Hora[1], M. Cohen[2], M. Meixner[3], R. D. Blum[4], B. Whitney[5], R. G. Ellis[6], M. Meade[7], B. Babler[7], R. Indebetouw[8], K. Gordon[9], C. Engelbracht[9], B. For[10], M. Block[9], K. Misselt[9], U. Vijh[3], C. Leitherer[3]
[1]Harvard-Smithsonian CfA, [2]Univ. Calif. Berkeley, [3]STScI, [4]NOAO, [5]Space Science Institute, [6]Brown Univ., [7]Univ. of Wisconsin, [8]Univ. of Virginia, [9]Univ. of Arizona, [10]Univ. of Texas.

160.09 **Star Formation Tracers and Dust Emission in the Large Magellanic Cloud**
Karl D. Gordon[1], C. Engelbracht[1], M. Meixner[2], B. Whitney[3], M. Block[1], M. Meade[4], B. Babler[4], B. For[5], R. Indebetouw[6], U. Vijh[2], J. Hora[7], K. Misselt[1], C. Leitherer[2], SAGE Legacy Team
[1]Univ. of Arizona, [2]Space Telescope Science Institute, [3]Space Science Institute, [4]Univ. of Wisconsin, [5]Univ. of Texas, [6]Univ. of Virginia, [7]Harvard-Smithsonian/CfA.

160.10 **Spitzer SAGE Observations of Young Stellar Objects in the Large Magellanic Cloud**
Barbara Whitney[1], M. Sewilo[2], R. Indebetouw[3], T. Robitaille[4], M. Meixner[5], U. Vijh[5], S. Srinivasan[6], M. Meade[2], B. Babler[2], E. Churchwell[2], J. Hora[7], K. Gordon[8], C. Engelbracht[8], B. For[9], M. Block[8], K. Misselt[8], C. Leitherer[5], A. Kawamura[10], T. Onishi[10], A. Mizuno[10], Y. Fukui[10]
[1]Space Science Institute, [2]University of Wisconsin, [3]University of Virginia, [4]Univ. of St. Andrews, United Kingdom, [5]Space Telescope Science Institute, [6]JHU, [7]Harvard-Smithsonian/CfA, [8]Univ. of Arizona, [9]Univ. of Texas, [10]Nagoya University, Japan.

160.11 **Star Formation Activity in Giant Molecular Clouds in the LMC**
Toshikazu Onishi[1], A. Kawamura[1], Y. Fukui[1], T. Minamidani[1], Y. Mizuno[1], N. Mizuno[1], A. Mizuno[1], M. Meixner[2], U. Vijh[2], C. Leitherer[2], B. Whitney[3], M. Meade[4], B. Babler[4], R. Indebetouw[5], J. Hora[6], K. Gordon[7], C. Engelbracht[7], B. For[8], M. Block[7], K. Misselt[7], S. Madden[9], J. Bernard[10], R. Paladini[11], SAGE team
[1]Nagoya University, Japan, [2]STScI, [3]Space Science Institute, [4]University of Wisconsin, [5]University of Virginia, [6]Harvard-Smithsonian/CfA, [7]University of Arizona, [8]University of Texas, [9]CEA, France, [10]CNRS, France, [11]IPAC/Caltech.

160.12 *Spitzer* **Spectroscopy of Stellar Feedback on Circumstellar Gas and Dust in 30 Doradus, the Nearest Super-Star Cluster**
Genevieve E. de Messieres[1], R. Indebetouw[1], B. Babler[2], F. Boulanger[3], C. Engelbracht[4], F. Galliano[5], K. Gordon[4], J. Hora[6], S. Madden[7], M. Meade[2], M. Meixner[8], J. D. Smith[4], L. Smith[9], X. Tielens[10], U. Vijh[8], M. Werner[11], M. Wolfire[12]
[1]University of Virginia, [2]University of Wisconsin, [3]Institut d'Astrophysique Spatiale, France, [4]University of Arizona, [5]NASA Goddard Space Flight Center, [6]Center for Astrophysics, [7]CEA, France, [8]Space Telescope Science Institute, [9]University College London, United Kingdom, [10]NASA Ames Research Center, [11]Jet Propulsion Laboratory, [12]University of Maryland.

160.13 **Viewing SAGE selected LMC Star Formation with Hubble Vision**
Lynn R. Carlson[1], M. Meixner[2], C. A. Gill[3], J. Harris[4], U. Vijh[2], M. Sewilo[5], B. Whitney [6], B. Babler[5], M. Block[4], C. Engelbracht[4], B. For[7], K. Gordon[4], J. L. Hora[8], R. Indebetouw[9], C. Leitherer[2], M. Meade[5], K. Misselt[4], SAGE team
[1]JHU, [2]STScI, [3]Loyola College, [4]U. Arizona, [5]U. Wisconsin, [6]SSI, [7]U. Texas, [8]Harvard/CfA, [9]U. Virginia.

160.14 **The Spitzer SAGE Survey of the Large Magellanic Cloud: Characteristics of the Epoch 1 IRAC and MIPS-24 Source Lists**
Margaret Meixner[1], B. Whitney[2], K. Gordon[3], B. Babler[4], M. Block[3], M. Cohen[5], C. Engelbracht[3], B. For[6], J. Hora[7], R. Indebetouw[8], C. Leitherer[1], M. Meade[4], K. Misselt[3]
[1]STScI, [2]Space Sciences Institute, [3]University of Arizona, [4]University of Wisconsin, [5]University of California, [6]University of Texas, [7]Harvard/CfA, [8]University of Virginia.

160.15 **Molecular Clouds and Star Formation in the Magellanic System by NANTEN**
Akiko Kawamura[1], T. Onishi[1], T. Minamidani[1], Y. Mizuno[1], N. Mizuno[1], A. Mizuno[1], Y. Fukui[1], M. Meixner[2], U. Vijh[2], C. Leitherer[2], B. Whitney[3], M. Meade[4], B. Babler[4], R. Indebetouw[5], J. Hora[6], K. Gordon[7], C. Engelbracht[7], B. For[8], M. Block[7], K. Misselt[7], S. Madden[9], J. Bernard[10], R. Paladini[11], W. Reach[11], SAGE team
[1]Nagoya University, Japan, [2]STScI, [3]Space Science Institute, [4]University of Wisconsin, [5]University of Virginia, [6]Harvard-Smithsonian/CfA, [7]University of Arizona, [8]University of Texas, [9]CEA, France, [10]CNRS, France, [11]IPAC.

161: Science from the NDWFS Bootes Field
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

161.01 **Mid-Infrared Properties of X-ray Sources**
Varoujan Gorjian[1], M. Brodwin[1], C. S. Kochanek[2], S. Murray[3], D. Stern[1], K. Brand[4], P. Eisenhardt[1], M. Ashby[3], P. Barmby[3], M. J. Brown[4], A. Dey[4], W. R. Forman[3], B. T. Jannuzi[4], C. Jones[3], A. Kenter[3], M. A. Pahre[3], J. C. Shields[5], M. W. Werner[1]
[1]JPL, [2]Ohios State University, [3]CfA, [4]NOAO, [5]Ohio University.

161.02 **Optical and IR Diagnostics of Radio Sources in the Bootes Field**
Steve Croft[1], W. van Breugel[1], W. de Vries[2], IRAC Shallow Survey Team, NDWFS Team
[1]UC Merced / LLNL, [2]UC Davis / LLNL.

161.03 **A Large Population of Infrared-Selected, Obscured AGN in the Bootes Field**
Christine Jones[1], R. Hickox[1], S. Murray[1], W. Forman[1], M. Brodwin[2], XBootes, IRAC Shallow Survey, NDWFS, AGES Teams
[1]Harvard-Smithsonian, CfA, [2]NASA/JPL.

161.04 **IRS Spectroscopy of z=2 Star-forming ULIRGs in the NDWFS Bootes Field**
Baruch T. Soifer[1], V. Desai[1], A. Dey[2], B. Jannuzi[2], L. Armus[3], H. Teplitz[3], K. Brand[4], E. Le Floc'h[5], D. Weedman[6], J. Houck[6]
[1]Caltech, [2]NOAO, [3]SSC/Caltech, [4]STScI, [5]IFA/U. Hawaii, [6]Cornell U..

161.05 **Clusters of Galaxies in the First Half of the Universe from the IRAC Shallow Survey**
Peter R. Eisenhardt[1], M. Brodwin[1], A. Gonzalez[2], S. A. Stanford[3], D. Stern[1], P. Barmby[4], A. Dey[5], M. J. Brown[6], J. Huang[4], B. T. Jannuzi[5], M. A. Pahre[4]
[1]JPL/Caltech, [2]U. Florida, [3]IGPP/UC-Davis, [4]Harvard, [5]NOAO, [6]Princeton University.

161.06 **Mid-Infrared Selection of Brown Dwarfs and High-Redshift Quasars**
Daniel Stern[1], J. D. Kirkpatrick[2], IRAC Shallow Survey Team
[1]JPL/ Caltech, [2]IPAC/ Caltech.

161.07 **Searching for Brown Dwarfs in the Spitzer/IRAC Shallow Survey**
Massimo Marengo[1], L. E. Allen[1], M. L. Ashby[1], B. M. Patten[2], M. C. Sanchez[3], IRAC Shallow Survey Collaboration
[1]Harvard-Smithsonian CfA, [2]Harvard-Smithsonian CfA / NSF, [3]Harvard University.

161.08 **X-ray Bright Optically Normal Galaxies (XBONGs) in the XBootes Field**
Michael Anderson[1], S. Murray[2], C. Jones[2], A. Kenter[2], B. Forman[2], R. Hickox[2]
[1]University of Michigan, [2]Harvard-Smithsonian Center for Astrophysics.

161.09 **Low Resolution Spectral Templates for Galaxies from 0.2--10 microns**
Roberto Assef[1]
[1]The Ohio State University.

161.10 **An Hα Objective Prism Survey in the NDWFS Boötes Field**
Caryl Gronwall[1], J. E. Young[1], J. J. Salzer[2], J. L. Rosenberg[3]
[1]Penn State Univ., [2]Wesleyan University, [3]Harvard-Smithsonian Center for Astrophysics.

162: Search for Variables Through Surveys, Databases and Archives
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

162.01 **Combined NSVS/2MASS Database Search For Cool Algols and Eclipsing Subdwarf B Stars**
Nicole Kelley[1], J. S. Shaw[2]
[1]University of California, Berkeley, [2]University of Georgia.

162.02 **LGSAO Imaging of STEPS Astrometric Candidates**
Sloane Wiktorowicz[1], S. R. Kulkarni[1], S. H. Pravdo[2], S. B. Shaklan[2]
[1]Caltech, [2]Jet Propulsion Laboratory.

162.03 **Recovering Long-Term Lightcurves from the Harvard Plates: A Search for Eclipsing Binaries in M44**
Michael S. Shaw[1], J. E. Grindlay[2], S. Laycock[2]
[1]Massachusetts Institute of Technology, [2]Harvard-Smithsonian, CfA.

162.04 **The American Association of Variable Star Observers (AAVSO)**
Travis Searle[1], M. Templeton[1], A. Price[1], A. Henden[1]
[1]AAVSO.

162.05 **The AAVSO International Database**
Rebecca Turner[1], A. Price[1], M. Templeton[1], E. O. Waagen[1], A. Henden[1]
[1]AAVSO.

162.06 **The Precision of Visual Estimates of Variable Stars**
Aaron Price[1], G. Foster[2], B. Skiff[3], A. Henden[2]
[1]AAVSO/Tufts University, [2]AAVSO, [3]Lowell Observatory.

162.07 **A Bright Stellar Variability Survey in the NGC 6811 Region**
Arne A. Henden[1], A. Price[1], S. Howell[2]
[1]AAVSO, [2]WIYN/NOAO.

162.08 **RR Lyrae Stars in the SDSS-II Supernova Survey**
Nathan M. De Lee[1], H. A. Smith[1], T. C. Beers[2], D. M. Bramich[3], S. Vidrih[3], D. B. Zucker[3], Z. Ivezic[4]
[1]Michigan State Univ., [2]Michigan State Univ. & JINA, [3]Institute of Astronomy, Cambridge, United Kingdom, [4]Univ. of Washington.

162.09 **GNAT Student Follow-Up Pilot Project**
Noll S. Roberts[1], N. Jaggi[1], C. Milne[1]
[1]Cuesta College.

162.10 **Revisited The Draco Dwarf Spheroidal Galaxy Variable Star Population**
Karen Kinemuchi[1], H. C. Harris[2], H. A. Smith[3], N. Silbermann[4], L. Snyder[3], A. P. LaCluyze[5], C. L. Clark[3]
[1]Univ. of Wyoming, [2]US Naval Observatory Flagstaff, [3]Michigan State University, [4]SSC/Caltech, [5]University of North Carolina.

162.11 **Light Curves of Newly Discovered Variable Stars from ROTSE-I Observations**
Douglas I. Hoffman[1], T. E. Harrison[1], B. J. McNamara[1], T. W. Vestrand[2]
[1]New Mexico State Univ., [2]Los Alamos National Laboratory.

162.12 **The FUSE Survey of Algol-Type Interacting Binary Systems**
Geraldine J. Peters[1], B. Andersson[2], T. B. Ake[2], R. Sankrit[2]
[1]Univ. of Southern California, [2]Johns Hopkins University.

162.13 **An Update on the Radial Velocity Survey in Cygnus OB2**
Daniel C. Kiminki[1], H. A. Kobulnicky[1], K. Kinemuchi[1], J. S. Irwin[2], C. L. Fryer[3], R. C. Berrington[1], B. Uzpen[1], A. J. Monson[1], M. A. Pierce[1], S. E. Woosley[4]
[1]Univ. of Wyoming, [2]Univ. of Texas, [3]Los Alamos National Laboratories, [4]University of California Santa Cruz.

162.14 **Variable Stars in the Lepine List of Nearby Stars**
Melvin Blake[1], J. McNutt[2]
[1]Pisgah Astronomical Research Institute, [2]University of North Carolina Asheville.

162.15 **Burrell-Optical-Kepler Survey (BOKS) I: Survey Description**
John J. Feldmeier[1], S. Howell[2], P. Harding[3], C. Mihos[3], C. Rudick[3], W. Sherry[4], T. Lee[5], C. Knox[3], D. Ciardi[6], K. von Braun[6], M. Everett[7], M. Proctor[8], G. van Belle[6]
[1]Youngstown State Univ., [2]NOAO/WIYN, [3]CWRU, [4]NSO, [5]NOAO, [6]MSC, [7]PSI, [8]LPL.

162.16 **Burrell-Optical-Kepler Survey (BOKS) II: Early Variability Results**
Steve B. Howell[1], J. Feldmeier[2], K. van Braun[3], M. Everett[4], C. Mihos[5], P. Harding[5], C. Knox[5], W. Sherry[6], T. Lee[7], D. Ciardi[3], C. Rudick[5], M. Proctor[8], G. van Belle[3]
[1]WIYN/NOAO, [2]YSU, [3]MSC, [4]PSI, [5]CWRU, [6]NSO, [7]NOAO, [8]LPL.

162.17 **WIYN Open Cluster Study Long-term Monitoring: NGC 2141**
Allison M. Widhalm[1], S. Kafka[2]
[1]USC, CTIO, New Mexico State University, [2]CTIO, Chile.

162.18 **New Close Binary Systems from the SDSS-I (Data Release Five) and the Orbital Periods for a Subset of Close White Dwarf + M Dwarf Systems**
Nicole M. Silvestri[1], S. L. Hawley[1], L. C. Dang[2], D. A. Krogsrud[1], K. Smoke[1], M. A. Wolfe[1], L. Mannikko[1]
[1]Univ. of Washington, [2]NASA GSFC.

162.19 **Discovery of WD+M Binaries in the Sloan Digital Sky Survey**
Robert L. da Silva[1]
[1]LBNL.

162.20 **Optically Variable RASS X-ray Sources in the Northern Sky Variability Survey**
Sara Gettel[1], E. Rykoff[2], T. McKay[2]
[1]Pennsylvania State University, [2]University of Michigan.

162.21 **Eclipsing Binaries in the Galactic Bulge from SWEEPS Data**
Kailash C. Sahu[1], T. E. Smith[1], W. Clarkson[1]
[1]STScI.

162.22 **Multicolor Oservations of the Type II Cepheid Prototype W Virginis**
Matthew R. Templeton[1], A. A. Henden[1], T. Crawford[1], R. James[1], M. Bonnardeau[1], D. Wells[1]
[1]AAVSO.

163: Extrasolar Planets VI: Observed Systems
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

163.01 **Interferometric Observations of the Transiting Planet HD 189733 with the CHARA Array**
Ellyn K. Baines[1], G. T. van Belle[2], H. A. McAlister[1], T. A. ten Brummelaar[1], D. H. Berger[3], N. H. Turner[1], P. J. Goldfinger[1]
[1]Georgia State Univ., [2]Michelson Science Center, [3]Univ. of Michigan.

163.02 **Infrared Phase Variations of Hot Jupiters**
Nicolas B. Cowan[1], E. Agol[1], D. Charbonneau[2]
[1]Univ. of Washington, [2]Center for Astrophysics.

163.03 **Eccentricities of Extrasolar Planets and Implications for Planet Formation Theory**
Eric B. Ford[1]
[1]Harvard-Smithsonian Center for Astrophysics.

163.04 **A Possible Planet Around a White Dwarf**
Fergal Mullally[1], D. Winget[1]
[1]Univ. of Texas, Austin.

163.05 **MOST Spacebased Photometry of Transiting Exoplanet Systems**
Jason Rowe[1], J. M. Matthews[1], E. Miller-Ricci[2], S. Seager[3], D. Sasselov[2], R. Kuschnig[1], D. B. Guenther[4], A. F. Moffat[5], M. Rucinski[6], G. A. Walker[1], W. Weiss[7]
[1]Univ. of B.C, Canada, [2]Harvard-Smithsonian Center of Astrophysics, [3]Carnegie Department of Terrestrial Magnetism, [4]St. Mary's University, Canada, [5]Université de Montréal, Canada, [6]University of Toronto, Canada, [7]Institut für Astronomie, Universität Wien Türkenschanzstrasse, Austria.

164: Space-Based Instrumentation I
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

164.01 **Steps Toward a UV/Optical Interferometer in Space: FIT & SIFFT**
Kenneth G. Carpenter[1], R. G. Lyon[1], A. Liu[1], P. Dogoda[2], P. Petrone[2], D. Mozurkewich[3], D. Miller[4], S. Mohan[4], P. Stahl[5]
[1]NASA's GSFC, [2]Sigma Space, [3]Seabrook Eng., [4]MIT, [5]NASA's MSFC.

164.02 **CALISTO: A Far-Infrared Observatory for the Next Decade**
Harold W. Yorke[1], P. F. Goldsmith[1], C. M. Bradford[1], J. Zmuidzinas[1], C. Paine[1], M. Dragovan[1], C. M. Satter[1], A. E. Nash III[1], R. A. Lee[1], B. Khayatian[1], A. R. Girerd[1], S. J. MacLellan[1]
[1]Jet Propulsion Laboratory, California Institute of Technology.

164.03 **Cryogenic Telescope, Scanner, and Imaging Optics for the Wide-field Imaging Survey Explorer (WISE)**
Mark Schwalm[1], A. Akerstrom[1], M. Barry[1], J. Guregian[1], F. LaMalva[1], P. Laquidara[1], G. Perron[1], D. Sampath[1], V. Ugolini[1]
[1]L-3 Communications SSG-Tinsley.

164.04 **Scientific Promise and Instrument Concepts for a Background-Limited Infrared-Submillimeter Spectrograph (BLISS) for SPICA**
Charles Bradford[1], BLISS and SPICA teams
[1]Caltech/ JPL.

164.05 **CASTER A Concept for a Black Hole Finder Probe based on the Use of New Scintillator Technologies**
Mark L. McConnell[1], P. Bloser[1], J. Macri[1], J. Ryan[1], G. Case[2], M. Cherry[3], T. Guzik[3], B. Schaefer[3], J. G. Stacy[2], J. P. Wefel[3], R. M. Kippen[4], W. T. Vestrand[4], R. S. Miller[5], W. Paciesas[5], K. Hurley[6], J. Cravens[7]
[1]Univ. of New Hampshire, [2]Louisiana State University / Southern University, [3]Louisiana State University, [4]Los Alamos National Laboratory, [5]Univ. of Alabama Huntsville, [6]Univ. of California Berkeley, [7]Southwest Research Institute.

164.06 **New Worlds Observer: Mission Overview**
Charles F. Lillie[1], J. W. Arenberg[1], W. C. Cash[2], R. P. Samuele[1], A. S. Lo[1]
[1]Northrop Grumman Space Technology, [2]University of Colorado.

164.07 **Absolute Time Calibration for the Chandra X-ray Observatory**
Arnold H. Rots[1]
[1]Harvard-Smithsonian CfA.

164.08 **Design and Lab Demonstration of the PIAA/Binary-Mask Hybrid Coronagraph**
Shinichiro Tanaka[1], O. Guyon[1], E. Pluzhnik[1]
[1]Subaru Telescope.

164.09 **Experimental Demonstration of Wavefront Estimation in a Shaped-Pupil Coronagraph**
Ruslan Belikov[1], A. Give'on[2], E. Cady[1], J. Kay[1], L. Pueyo[1], N. J. Kasdin[1]
[1]Princeton Univ., [2]Caltech University.

164.10 **Wavefront Compensation for High Contrast Imaging in the Presence of Fresnel Effects**
Laurent A. Pueyo[1], J. Kasdin[1]
[1]Princeton University.

164.11 **STARCaL: A Tunable Laser in Space for Telescope Calibration and Atmospheric Studies**
Justin Albert[1], W. Burgett[2], S. Deustua[3]
[1]Univ. of Victoria, Canada, [2]Institute for Astronomy, [3]American Astronomical Society.

164.12 **Selective Deposition of Thin Films for Future X-ray Optics**
Amy M. Colon[1], R. Bruni[2], S. Sheldon[2], S. Romaine[2]
[1]Hunter College CUNY, [2]Harvard Smithsonian Center for Astrophysics.

164.13 **Dynamics of an Occulter Based Planet Finding Telescope**
Egemen Kolemen[1], J. Kasdin[1]
[1]Princeton University.

164.14 **The Lost Flux Method: A New Algorithm for Improving the Precision of Space-Based Near-Infrared Stellar Photometry with Lossy Detectors**
Kenneth J. Mighell[1]
[1]NOAO.

164.15 **Closed-loop Wavefront Correction for High-contrast Imaging: The "Peak-A-Boo" Algorithm.**
Amir Give'on[1], J. Kasdin[2], S. Shaklan[3], R. Vanderbei[2]
[1]Caltech Univ., [2]Princeton University, [3]JPL.

165: Star Clusters III
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

165.01 **Using Open Clusters to Trace the Local Milky Way Rotation Curve and Velocity Field**
Peter M. Frinchaboy[1], S. R. Majewski[2]
[1]Univ. of Wisconsin-Madison, [2]Univ. of Virginia.

165.02 **WIYN Tip-Tilt Module Observations of the Old Open Cluster NGC 1193**
Myra J. Stone[1], C. F. Claver[2], K. J. Mighell[2]
[1]University of Georgia, [2]National Optical Astronomy Observatory.

165.03 **WIYN Open Cluster Study: Precision UBVRI CCD Photometry of the Open Cluster NGC 2420**
Aaron J. Steinhauer[1], N. Lauffenburger[1], J. Hughto[1], C. P. Deliyannis[2], K. Croxall[2], A. Sarajedini[3]
[1]SUNY Geneseo, [2]Indiana University, [3]University of Florida.

165.04 **WIYN Open Cluster Study: Precision UBVRI CCD Photometry of the Open Cluster NGC 2506**
Joseph Hughto[1], N. Lauffenburger[1], A. Steinhauer[1], C. P. Deliyannis[2], K. Croxall[2], A. Sarajedini[3]
[1]SUNY Geneseo, [2]Indiana University, [3]University of Florida.

165.05 **The Red Buttes Observatory's Wide-Field Telescope's ZAMS Project**
Ronald W. Canterna[1], M. MacDonald[1], D. Allen[1], E. Hausel[1], M. Pierce[1], C. T. Rodgers[1]
[1]Univ. of Wyoming.

165.06 **The Dolidze 27 and Alessi 10 Open Star Clusters**
Rosalie C. McGurk[1], M. W. Castelaz[2]
[1]University of Washington, [2]Pisgah Astronomical Research Institute.

165.07 **WIYN Open Cluster Study: Binary Orbits and Tidal Circularization in NGC 6819**
Meagan B. Morscher[1], R. D. Mathieu[2], S. Kaeppler[2], K. T. Hole[2], S. Meibom[3]
[1]University of Wisconsin-Milwaukee, [2]University of Wisconsin-Madison, [3]Harvard-Smithsonian Center for Astrophysics.

165.08 **WIYN Open Cluster Study: Signature(s) of Main Sequence Lithium Depletion Mechanism(s) from Subgiants of the Old (6-7Gyr) Open Cluster NGC 188**
Walter Trentadue[1], K. V. Croxall[1], A. Gill[2], C. P. Deliyannis[1], J. R. King[3], L. J. Hainline[4]
[1]Indiana University, [2]Indiana University and Brown University, [3]Clemson University, [4]Caltech.

165.09 **WIYN Open Cluster Study: Lithium Abundances in Dwarf Stars of the Old (6-7Gyr) Open Cluster NGC 188**
Amandeep Gill[1], K. V. Croxall[2], W. Trentadue[2], C. P. Deliyannis[2], J. R. King[3]
[1]Indiana University and Brown University, [2]Indiana University, [3]Clemson University.

165.10 **WIYN Open Cluster Study: Lithium in the Young and Metal-Poor Cluster M36**
Kevin V. Croxall[1], J. Cummings[1], C. P. Deliyannis[1], A. Steinhauer[2]
[1]Indiana Univ., [2]SUNY Geneseo.

165.11 **The Composition of the Old, Metal-Rich Open Cluster, NGC 6791**
Elizabeth Jensen[1], A. M. Boesgaard[2], C. P. Deliyannis[3]
[1]Smith College, [2]University of Hawaii, [3]Indiana University.

165.12 **The Search for Low Amplitude Pulsational Variable Stars in Six Open Clusters**
Eric G. Hintz[1], M. B. Rose[2]
[1]Brigham Young Univ., [2]Utah State University.

165.13 **Variable Star Search in the Open Cluster NGC 6659**
William Gray[1], E. G. Hintz[2]
[1]Utah Valley State College, [2]Brigham Young Univ..

165.14 **A Search for Variable Stars in the Field of NGC 7092 (M39)**
Sarah Schuff[1], E. G. Hintz[1], M. D. Joner[1]
[1]Brigham Young University.

166: Tests of Gravity, and Alternative Theories of Gravity
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

166.01 **The Implication of MOND for Dark Haloes**
Yi-Cheng Huang[1], A. Kosowsky[1]
[1]*Univ. Of Pittsburgh.*

166.02 **Solar System tests DO rule out 1/R gravity**
Tristan L. Smith[1], A. L. Erickcek[1], M. Kamionkowski[1]
[1]*Caltech.*

166.03 **Testing Alternative Theories of Gravity with Long Term Pulsar Timing**
K.J. Lee[1], F. Jenet[1]
[1]*Center for Gravitational Wave Astronomy / University of Texas at Brownsville.*

166.04 **21st Century Gravity**
Tom Van Flandern[1]
[1]*Meta Research.*

167: Stars, Gas and their Motions in Dwarfs and Irregulars
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

167.01 **Magnetic Fields in Irregular Galaxies: NGC 4214**
Amanda A. Kepley[1], E. M. Wilcots[1], T. Robishaw[2], C. Heiles[2], E. Zweibel[1]
[1]*Univ. of Wisconsin-Madison,* [2]*University of California-Berkeley.*

167.02 **Evidence for Tidal Heating in the Dynamics of LMC Carbon Stars and Red Supergiants**
Knut A. Olsen[1], P. Massey[2]
[1]*NOAO,* [2]*Lowell Observatory.*

167.03 **Kinematics of the dE Galaxy IC 225**
Gwen C. Rudie[1], B. W. Miller[2]
[1]*Dartmouth College,* [2]*Gemini Observatory, Chile.*

167.04 **An Examination of Kinematic Properties of Dwarf Irregular Galaxies**
Elizabeth A. Adams[1], L. van Zee[1]
[1]*Indiana University.*

167.05 **Outer Disks of Dwarf Irregular Galaxies: Stars and Gas**
Deidre A. Hunter[1], B. G. Elmegreen[2], E. Anderson[3]
[1]*Lowell Obs.,* [2]*IBM T. J. Watson Research Center,* [3]*Northern Arizona University.*

167.06 **An Interaction Induced Transformation of I Zw 18? New Results from A-Array VLA Observations**
Liese van Zee[1], J. M. Cannon[2], E. D. Skillman[3]
[1]*Indiana Univ.,* [2]*Wesleyan Univ.,* [3]*Univ. of Minnesota.*

167.07 **Investigation of Star Formation in Dwarf Iffedular Galaxies Using Ultra-violet Photometry**
Bonnie C. Ludka[1], D. Hunter[2]
[1]*James Madison University,* [2]*Lowell Observatory.*

167.08 **Oxygen Abundances in Starbursting Transition Dwarfs**
Kate Dellenbusch[1], J. S. Gallagher[1], P. M. Knezek[2]
[1]*University of Wisconsin,* [2]*WIYN Consortium, Inc..*

167.09 **A Spitzer/IRAC Census of the Asymptotic Giant Branch Populations in Local Group Dwarfs**
Dale C. Jackson[1], E. D. Skillman[1], R. D. Gehrz[1], E. Polomski[1], C. E. Woodward[1]
[1]*Univ. of Minnesota.*

167.10 **Diffraction Limited Imaging of the Stellar Population of IC 10 with Laser Guide Star Adaptive Optics and the Hubble Space Telescope**
Christopher Sheehy[1], W. D. Vacca[1], J. R. Graham[1]
[1]University of California, Berkeley.

167.11 **High Resolution Mapping of Expanding Shells in IC10**
Joyce E. Coppock[1], E. M. Wilcots[2]
[1]Duke University, [2]University of Wisconsin-Madison.

168: Stellar Populations II
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

168.01 **Hafnium and the R-Process in the Sun and Metal-Poor Stars**
Christopher Sneden[1], J. E. Lawler[2], E. A. Den Hartog[2], Z. E. Labby[2], J. J. Cowan[3], I. Ivans[4]
[1]Univ. of Texas, [2]Univ. of Wisconsin, [3]Univ. of Oklahoma, [4]Carnegie Obs. & Princeton Univ..

168.02 **Isotopic Abundances of Eu, Ba, and Sm in Metal-Poor Stars**
Ian U. Roederer[1], C. Sneden[1], J. E. Lawler[2], J. S. Sobeck[1], C. A. Pilachowski[3], J. J. Cowan[4]
[1]Univ. of Texas at Austin, [2]Univ. of Wisconsin, [3]Indiana Univ., [4]Univ. of Oklahoma.

168.03 **Revisiting Zirconium: New Abundance Determinations with Improved Oscillator Strengths**
Debra L. Burris[1], M. Jones[1], R. Nichols[1]
[1]Univ. of Central Arkansas.

168.04 **Lanthanum and Europium Abundances in a Large Sample of Galactic Disk Dwarf Stars**
Jennifer A. Simmerer[1], C. B. Stringer[1], B. W. Carney[1]
[1]Univ. North Carolina, Chapel Hill.

168.05 **Lithium Production in Asymptotic Giant Branch Stars**
Julie Krugler[1], M. Shetrone[2], C. Charbonnel[3]
[1]Michigan State University, [2]McDonald Observatory, [3]Laboratoire d'Astrophysique de l'Observatoire Midi-Pyrenees, France.

168.06 **Beryllium in Extremely Metal Deficient Stars**
Jeffrey Rich[1], A. Boesgaard[1]
[1]University of Hawaii Institute for Astronomy.

168.07 **Metallicity in the Solar Neighborhood Out to 60pc**
Roggie H. Boone, III[1], J. R. King[1], D. R. Soderblom[2]
[1]Clemson Univ., [2]Space Telescope Science Institute.

168.08 **The Most Metal-Poor Candidates in SDSS-I DR-5**
Timothy C. Beers[1], Y. Lee[1], T. Sivarani[1], B. Marsteller[1], J. Krugler[1], R. Wilhelm[2], C. Allende Prieto[3], J. Norris[4], J. Johnson[5], I. Ivans[6], B. Yanny[7], C. Rockosi[8], H. Morrison[9], H. J. Newberg[10], J. Knapp[11]
[1]Michigan State Univ. / JINA, [2]Texas Tech, [3]Univ. of Texas, [4]Australian National Univ., Australia, [5]Ohio State Univ., [6]OCIW / Princeton Univ., [7]FermiLab, [8]Lick Observatory, UCSC, [9]Case Western, [10]Rensselaer Polytechnic Institute, [11]Princeton Univ..

168.09 **A Search for Evidence of an Abundance Gradient in the Galactic Halo Based on Stars from SDSS-I DR-5**
Daniela Carollo[1], T. C. Beers[2], Y. S. Lee[2], T. Sivarani[2], C. Allende Prieto[3], J. Norris[4], J. A. Munn[5], M. Chiba[6]
[1]INAF-OATO & JINA (MSU), Italy, [2]Michigan State Univ. / JINA, [3]Univ. of Texas, [4]Australian National University, Australia, [5]USNO, [6]Tohoku Univ., Japan.

168.10 **High-Resolution Calibration of the SDSS/SEGUE Spectroscopic Analysis Pipeline**
T. Sivarani[1], T. C. Beers[2], Y. Lee[2], J. Krugler[2], R. Wilhelm[3], C. Allende Prieto[4], C. Sneden[4], D. L. Lambert[4], M. Shetrone[4], J. Johnson[5], I. Ivans[6], C. Rockosi[7], D. Lai[7], H. Morrison[8], W. Aoki[9]
[1]Michigan State Univ. & Joint Institute for Nuclear Astrophysics (JINA), [2]Michigan State Univ. & JINA, [3]Texas Tech, [4]Univ. of Texas, [5]Ohio State Univ., [6]Carnegie Observatories & Princeton Univ., [7]UCSC, [8]Case Western, [9]NAOJ, Japan.

168.11 **A New Calibration of [Fe/H] and [C/Fe] Estimates for Medium-Resolution Spectra of Carbon-Enhanced Metal-Poor Stars**
Catherine R. Kennedy[1], T. C. Beers[1], B. Marsteller[1], T. Sivarani[1], S. Rossi[2], B. Plez[3], T. Masseron[4], S. Lucatello[5]
[1]Michigan State Univ. / JINA, [2]IAG, Univ. of Sao Paolo, Brazil, [3]Univ. of Montpellier, France, [4]Ohio State Univ., [5]INAF-OAPD, Italy.

168.12 **Evidence that R Coronae Borealis Stars Evolve from a White Dwarf Merger rather than a Final Helium Shell Flash**
Geoffrey C. Clayton[1], T. R. Geballe[2], F. Herwig[3], C. Fryer[4], E. Tenenbaum[5], M. Asplund[6]
[1]Louisiana State Univ., [2]Gemini Observatory, [3]Keele University, United Kingdom, [4]Los Alamos National Laboratory, [5]University of Arizona, [6]Mount Stromlo Obs., Australia.

168.13 **Dust at Low Metallicity: Spitzer Observations of AGB Stars in NGC 6822**
Schuyler D. Van Dyk[1], F. Kemper[2], A. Speck[3], R. Szczerba[4], M. Meixner[5], E. Peeters[6], T. Ueta[7]
[1]SSC/Caltech, [2]U. Manchester, United Kingdom, [3]U. Missouri, [4]NCAC, Poland, [5]STScI, [6]SETI Institute, [7]NASA Ames/SOFIA.

168.14 **Infrared Identification of Herbig AeBe stars in the Small Magellanic Cloud**
Sweta Shah[1], L. D. Keller[1], N. Chitrakar[1]
[1]Ithaca College.

168.15 **The SDSS-II/SEGUE Spectroscopic Parameter Pipeline**
Young S. Lee[1], T. C. Beers[1], S. Thirupathi[1], R. Wilhelm[2], C. Allende Prieto[3], J. E. Norris[4], P. R. Fiorentin[5], C. A. Bailer-Jones[5], SEGUE Calibration Team
[1]Michigan State Univ., [2]Texas Tech Univ., [3]Univ. of Texas, [4]Austrailian National Univ., Australia, [5]Max Planck Institute for Astronomy, Germany.

169: Extrasolar Planets VII: Surveys
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

169.01 **Observation of Transiting Extrasolar Planets and Gamma-ray Bursts with Robotic Telescopes**
Jay Fisher[1], T. R. Young[1]
[1]Univ. Of North Dakota.

169.02 **An Extrasolar Planet Transit Search in NGC 188**
Laura Portscheller[1], B. Kelly[1], K. Kinemuchi[1], C. Kobulnicky[1]
[1]University of Wyoming.

169.03 **Planet Detection and Simulations from Multi-Object Spectrograph Surveys**
Stephen R. Kane[1], D. P. Schneider[2], J. Ge[1]
[1]University of Florida, [2]Pennsylvania State University.

169.04 **Exoplanet Tracker Observations with a Monolithic Fixed-Delay Interferometer: First Steps Towards Long-term Stability**
Scott W. Fleming[1], S. Mahadevan[1], X. Wan[1], C. Dewitt[1], A. Hariharan[1], D. McDavitt[1], J. van Eyken[1], J. Ge[1]
[1]University of Florida.

169.05 **Monitoring the Long-term Radial Velocity Stability of the New Generation Multi-object Keck Exoplanet Tracker at the Sloan Telescope**
Kaike Pan[1], S. Snedden[1], J. Ge[2], J. van Eyken[2], S. W. Fleming[2], S. Kane[2], C. Warner[2]
[1]*APO-NMSU,* [2]*UF.*

169.06 **Latest Results from the Multi-Object Keck Exoplanet Tracker**
Julian C. Van Eyken[1], J. Ge[1], X. Wan[1], B. Zhao[1], A. Hariharan[1], S. Mahadevan[1], C. DeWitt[1], P. Guo[1], R. Cohen[1], S. W. Fleming[1], J. Crepp[1], C. Warner[1], S. Kane[1], F. Leger[2], K. Pan[3]
[1]*Univ. of Florida,* [2]*Fermilab,* [3]*Apache Point Observatory.*

169.07 **Measuring Precise Stellar Barycentric Radial Velocities with a Dispersed Fixed-Delay Interferometer: Implications for a Multi-Object Survey**
Suvrath Mahadevan[1], J. van Eyken[1], J. Ge[1], C. Dewitt[1], S. Fleming[1], R. Cohen[1], J. Crepp[1], A. vanden Heuvel[1]
[1]*University of Florida.*

169.08 **Eclipse Mapping of Hot Jupiters**
Emily Rauscher[1], K. Menou[1], S. Seager[2], D. Deming[3]
[1]*Columbia University,* [2]*Carnegie Institution of Washington,* [3]*NASA Goddard Space Flight Center.*

169.09 **Simulations of Exoplanet Spectroscopy with JWST**
Matthew Johnson[1], J. Valenti[2]
[1]*Wesleyan Univ.,* [2]*STScI.*

169.10 **New Worlds Observer: Optical Simulation**
Tiffany M. Glassman[1], A. Lo[1], W. Cash[2]
[1]*Northrop Grumman Space Technology,* [2]*University of Colorado.*

169.11 **New Worlds Observer: Orbit and Sky Coverage**
Amy Lo[1], R. Malmstrom[1], T. Guilmette[1]
[1]*Northrop Grumman Corporation.*

169.12 **On the Feasibility of Detecting UV Auroral Emission from Extrasolar Giant Planets (EGPs)**
Michele Cash[1], E. Agol[1]
[1]*University of Washington.*

169.13 **Spectral Bandwidth: A Key TPF Challenge for Achieving Adequate SNR**
Martin C. Noecker[1], S. Kilston[1]
[1]*Ball Aerospace & Tech. Corp..*

169.14 **Characterization of Exoplanet Orbits Using a Monte Carlo Bayesian Analysis**
Jonathan Arenberg[1], T. Schuman[1], A. Lo[1]
[1]*Northrop Grumman.*

169.15 **The PIAA Coronagraph Prototype: First Laboratory Results.**
Eugene Pluzhnik[1], O. Guyon[1], S. Colley[1], B. Gallet[1], S. Ridgway[2], R. Woodruff[3], S. Tanaka[1], M. Warren[4]
[1]*Subaru Telescope, NAOJ,* [2]*NOAO,* [3]*Lockheed Martin Space Corporation,* [4]*Axsys Technologies, Inc.*

170: The Undergraduate Astronomy Course for Non-Majors
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

170.01 **How Are Students' Interests in Astronomy Affected by Doing Projects in ASTR 101 at a Two Year College?**
Noella L. D'Cruz[1]
[1]*Joliet Junior College.*

170.02 **For a Better Grade in Astronomy, Write About It**
Ana M. Larson[1], N. Kool[1], C. Beyer[1]
[1]*Univ. Of Washington.*

170.03 **Is the Promise of Space Worth the Price? College Students Weigh In**
Jo Eliza Pitesky[1], J. Turner[2]
[1]*JPL,* [2]*UCLA Department of Physics and Astronomy.*

170.04 **Use of Clickers in Introductory Astronomy Courses at California State University Sacramento**
Christopher L. Taylor[1]
[1]*California State University, Sacramento.*

170.05 **The Story of Astronomy: An Activities-Based, Historical Approach to Classroom Instruction**
Alan W. Hirshfeld[1]
[1]*Univ. of Mass., Dartmouth.*

170.06 **A Spectrum is Worth a Thousand Pictures**
Richard F. Gelderman[1]
[1]*Western Kentucky Univ..*

170.07 **The Astronomy Workshop: Computer Assisted Learning Tools with Instructor Support Materials and Student Activities**
Grace Deming[1], D. Hamilton[1], M. Hayes-Gehrke[1]
[1]*Univ. of Maryland.*

170.08 **Calibrated Peer Review Essays Increase Confidence in Self-assessment**
Lauren Likkel[1]
[1]*Univ. of Wisconsin - Eau Claire.*

170.09 **Astro 001 through an Interactive, Multimedia Science Fiction Story**
Christopher Palma[1], J. C. Charlton[1], N. Tr'Ehnl[1], K. A. Herrmann[1], A. Narayanan[1]
[1]*Penn State Univ..*

170.10 **Course Components for Large Astronomy Lectures**
Michael Stage[1], S. Schneider[1]
[1]*Univ. of Massachusetts.*

170.11 **CAPER Team Innovations in Teaching and Learning in ASTRO 101**
Timothy F. Slater[1], E. E. Prather[1], J. M. Bailey[2], E. Bardar[3], G. Brissenden[1], E. F. Dokter[1], D. Hudgins[4], J. Keller[5]
[1]*Univ. of Arizona,* [2]*Univ. of Nevada Las Vegas,* [3]*Boston Univ.,* [4]*Rockhurst Univ.,* [5]*Cal Poly.*

171: UDF and DEEP2
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

171.01 **Lyman-alpha Emitters in the HUDF: A Population of Low Mass, Star Forming Galaxies**
Norbert Pirzkal[1], S. Malhotra[2], J. E. Rhoads[2], C. Xu[1]
[1]*STScI,* [2]*Arizona State University.*

171.02 **Surface Brightness Properties of z~4-6 Galaxies in the HUDF**
Nimish P. Hathi[1], R. A. Jansen[1], S. H. Cohen[1], R. A. Windhorst[1], S. Malhotra[1], J. Rhoads[1]
[1]*Arizona State Univ..*

171.03 **The Unresolved Stellar Populations of Galaxies in the HUDF**
Russell E. Ryan, Jr.[1], R. A. Jansen[1], S. H. Cohen[1], R. A. Windhorst[1]
[1]Arizona State Univ..

171.04 **Emission Line Galaxies in PEARS: A 2-D Detection Method**
Amber Straughn[1], G. Meurer[2], J. Gardner[3], S. Malhotra[1], N. Pirzkal[4], N. Hathi[1], S. Cohen[1], R. A. Windhorst[1], J. Rhoads[1], C. Xu[4], C. Gronwall[5], PEARS Team
[1]Arizona State University, [2]Johns Hopkins University, [3]Goddard Space Flight Center, [4]Space Telescope Science Institute, [5]Pennsylvania State University.

171.05 **The Luminosity Function of Lyα Emitters at z=3.1**
Robin Ciardullo[1], C. Gronwall[1], T. Hickey[1], E. Gawiser[2], J. J. Feldmeier[3], MUSYC Collaboration
[1]Penn State Univ., [2]Yale Univ., [3]Youngstown State Univ..

171.06 **Evolutionary Behaviour in the HOD from the VVDS Data**
Ummi Abbas[1], O. Le Fevre[1], S. deLaTorre[1], C. Marinoni[1], VVDS collaboration
[1]Laboratoire D'Astrophysique Marseille, France.

171.07 **A GALEX Imaging Search for Lyman Continuum Emission at z~1 in the EGS**
Peter G. Friedman[1], T. A. Small[1], J. M. Deharveng[2], B. Milliard[2], GALEX Science Team
[1]Caltech, [2]Laboratoire d'Astrophysique de Marseille, France.

171.08 **Measuring the Star Formation Rate of the Universe at z~1 from H-alpha with Multi-Object Near-Infrared Spectroscopy**
Andrew J. Bunker[1], M. Doherty[2], R. Sharp[3], I. Parry[4], G. Dalton[5], I. Lewis[6]
[1]Univ. of Exeter, United Kingdom, [2]European Southern Observatory, Germany, [3]Anglo-Australian Observatory, Australia, [4]Institute of Astronomy, Univ. of Cambridge, United Kingdom, [5]Rutherford-Appleton Laboratory & Astrophysics, Univ. of Oxford, United Kingdom, [6]Astrophysics, Univ. of Oxford, United Kingdom.

171.09 **Constraining the Interaction History of Galaxies Over 4 Gyr**
Kyle Penner[1], S. Jogee[1], GEMS collaboration
[1]University of Texas at Austin.

171.10 **Conditional Density Analysis of The Hubble Deep Field**
Brittany L. Dames[1], P. H. Coleman[1]
[1]University of Hawai'i, Institute for Astronomy.

172: The Milky Way
AAS Poster, 9:20am-6:30pm, Exhibit Hall 4

172.01 **A Wide Area Map of The Galactic Center at 1.1 mm**
Elisabeth A. Mills[1], J. E. Aguirre[2], J. Bally[3], J. Glenn[3], M. L. Enoch[4], N. J. Evans, II[5], J. Walawender[6]
[1]Indiana Univ., [2]NRAO Jansky Fellow, CASA-University of Colorado, [3]CASA-University of Colorado, [4]Caltech, [5]University of Texas, [6]IfA-University of Hawaii.

172.02 **Modeling the Galactic Center Magnetic Field Using Synchrotron Flux Density Maps**
Benjamin J. Cowin[1], M. Morris[2]
[1]University of Washington, [2]UC, Los Angeles.

172.03 **New Hot Stars in the Galactic Center**
Jon Mauerhan[1], M. Muno[2], M. Morris[1]
[1]UCLA, [2]Space Radiation Lab, Caltech.

172.04 **Is the Vertical Velocity Distruibution of the Milky Way's Thick Disk Isothermal?**
Constance M. Rockosi[1]
[1]UCO/Lick Observatory.

172.05 **Studying the Intergalactic Medium via OVI absorption in the spectra of SDSS Quasars**
Stephan Frank[1], S. Mathur[1]
[1]The Ohio State University, Department of Astronomy.

172.06 **A High Precision Radial Velocity Survey of the Galactic Bulge**
Christian D. Howard[1], D. B. Reitzel[1], R. M. Rich[1]
[1]UC, Los Angeles.

172.07 **43 GHz SiO Masers for Phase Calibration with VERA in the Galactic Center**
Robert M. Edmonds[1], L. Sjouwerman[2], Y. Pihlstrom[1]
[1]University of New Mexico, [2]NRAO.

172.08 **Sagittarius Debris, the Virgo Stellar Stream, and the new stream near the Galactic Plane**
Heidi J. Newberg[1], B. Yanny[2], N. Cole[1], T. Beers[3]
[1]Rensselaer Polytechnic Inst., [2]Fermilab, [3]Michigan State University.

172.10 **Contour Map for the Gravitational Potential of the Milky Way**
David F. Bartlett[1]
[1]Univ. of Colorado.

172.11 **Abundacne Patterns in High-Velocity RAVE Stars**
Jon P. Fulbright[1], G. Ruchti[1], R. Wyse[1], RAVE Collaboration
[1]Johns Hopkins Univ..

172.12 **Gravitational Lensing and the Distance to the Galactic Center**
Erin L. Gutbrod[1], S. Levine[2]
[1]University of Notre Dame, [2]US Naval Observatory.

172.13 **Smith's Cloud (HVC) in 21 cm HI emission**
A. J. Heroux[1]
[1]University of Wisconsin Whitewater.

172.14 **Exploring the Local Milky Way: M Dwarfs as Tracers of Galactic Populations**
John J. Bochanski[1], S. L. Hawley[1], J. A. Munn[2], K. R. Covey[3], A. A. West[4], L. M. Walkowicz[1]
[1]Univ. of Washington, [2]US Naval Observatory, [3]Harvard-Smithsonian Center for Astrophysics, [4]Univ. of California.

172.15 **Galactic Structure Across the Sky with AAOmega**
Rosemary F. Wyse[1], G. Gilmore[2], J. E. Norris[3]
[1]Johns Hopkins Univ., [2]Institute of Astronomy, Univ. of Cambridge, United Kingdom, [3]RSAA, ANU, Australia.

172.16 **A High-resolution Polarimetric Survey of the Central 200 pc of the Galaxy**
Thomas M. Freismuth[1], C. C. Lang[1], T. J. Lazio[2], K. Golap[3]
[1]Univ. of Iowa, [2]NRL, [3]NRAO.

172.17 **The Line of Sight Velocity Distribution of the Galactic Bulge**
David B. Reitzel[1], C. Howard[1], R. M. Rich[1], H. Zhao[2], Y. Wang[3]
[1]UCLA, [2]University of St. Andrews, United Kingdom, [3]National Astronomical Observatory, China.

172.18 **Deep Astrometry of the Galactic Bulge with the HST ACS-WFC**
Will Clarkson[1], K. Sahu[1], E. Smith[1], S. Casertano[1]
[1]STSCI.

172.19 **An Arecibo HI 21-cm Absorption Survey of X-ray Rich Clusters**
Hector Hernandez[1], T. Ghosh[1], C. J. Salter[1], E. Momjian[1]
[1]Arecibo Observatory.

172.20 **A New Distance Calibration for Blue Stars in the Direction of Galactic High-Velocity Clouds**
Ronald J. Wilhelm[1], J. Barentine[2], T. C. Beers[3], B. P. Wakker[4], D. G. York[5]
[1]Texas Tech Univ., [2]University of Texas, [3]Michigan State University, [4]University of Wisconsin, [5]University of Chicago.

172.21 **Elemental Abundances of Metal-Poor Thick Disk Stars from the RAVE Survey**
Gregory R. Ruchti[1], J. Fulbright[1], R. F. Wyse[1], RAVE Collaboration
[1]Johns Hopkins Univ..

172.22 **The Identification of the Microlens in Event MACHO-LMC-20**
Michael W. Werner[1], N. Kallivayalil[2], B. M. Patten[2], M. Marengo[2], C. Alcock[2], G. Fazio[2]
[1]JPL/Caltech, [2]CfA.

172.23 **GPIPS: Season One**
Dan P. Clemens[1], A. Pinnick[1], M. Pavel[1], B. Taylor[1], K. Jameson[1]
[1]Institute for Astrophysical Research, Boston Univ..

172.24 **An HI Absorption Survey of the Central 250 pc of the Galactic Center: Distance Constraints & Understanding the Complex ISM**
Kelsey I. Clubb[1], C. C. Lang[1], W. M. Goss[2]
[1]University of Iowa, [2]National Radio Astronomy Observatory.

172.25 **Spectroscopic Observations of the Galactic Center with OSIRIS**
Tuan Do[1], A. Ghez[1], J. Lu[1], K. Matthews[2], M. Morris[1], A. Stolte[1], E. Becklin[1], J. Larkin[1], S. Wright[1]
[1]UC, Los Angeles, [2]Caltech.

172.26 **A Comparison of Spitzer, WIYN 0.9m, and Chandra Point Source Populations in the Inner Galaxy**
Luis C. Vargas[1], R. A. Benjamin[2]
[1]University of Kansas, [2]University of Wisconsin-Whitewater.

172.28 **Probing the Interstellar Medium using the Vela Pulsar**
Shauna Sallmen[1], D. C. Backer[2], L. Marschke[3]
[1]Univ. of Wisconsin, La Crosse, [2]Univ. of California at Berkeley, [3]Univ. of Northern Colorado.

172.29 **VERITAS Observations of LSI +61 303**
Andrew W. Smith[1]
[1]Harvard-Smithsonian CfA.

173: Instrumentation and Community Analysis
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

173.01 **Evaluation of a Novel Design for an Electrostatic Quadrupole Triplet Ion Beam Lens**
L. R. Burns[1], J. D. Bouas[1], S. Matteson[1], D. L. Weathers[1]
[1]Ion Beam Modification and Analysis Laboratory (IBMAL) — University of North Texas.

173.02 **Finding Astronomical Communities Through Co-readership Analysis**
Edwin A. Henneken[1], M. J. Kurtz[1], G. Eichhorn[1], A. Accomazzi[1], C. Grant[1], D. Thompson[1], E. Bohlen[1], S. S. Murray[1]
[1]Smithsonian Astrophysical Obs..

173.03 **Single Baseline Phases in Optical Interferometry**
Anders M. Jorgensen[1], D. Mozurkewich[2], H. Schmitt[3], C. Tycner[4], R. Hindsley[3], T. A. Pauls[3], J. T. Armstrong[3], D. Peterson[5]
[1]NMT and LANL, [2]Seabrook Engineering, [3]Naval Research Laboratory, [4]US Naval Observatory, [5]Stony Brook University.

Job Center
Attendee Services, 9:20am-5:00pm, Exhibit Hall 4

Gadgets and Gizmos
Attendee Services, 9:20am-5:00pm, South Lobby

See Sunday's listing for details.
Chair
Susana E. Deustua[1]
[1]*American Astronomical Society.*

Experience Digital Physics Curriculum II
Commercial Workshop, 9:30-11:00am, 302

View and experiment with a new digital physics textbook and virtual physics labs. Learn how a fully integrated digital physics curriculum can aid your instruction. Application of multi-learning styles and inquiry-based learning in a self-paced package provide students with the opportunity to experiment and explore.
Chair
Mark Bretl[1]
[1]*Kinetic Books.*

And You Thought It Was About Homework (The way you imagined teaching could be)
Commercial Workshop, 9:30-11:00am, 305

Find out how to deliver with WebAssign. WebAssign, the premier online homework, quizzing, and testing system, continues to have all of the features you want. We listen! Access Questions from all major physics and astronomy textbooks, or write your own. Check out our latest offerings with assignable simulations, assignable examples with basic and specific feedback. Give partial credit with conditional weighting. Assign practice questions or pick questions from a pool. Give group assignments. Streamline your work flow with WebAssign. It is easy to use, reliable, and helps you stay connected, your way. Quickly access student responses, communicate with class forums, Ask Your Teacher, and announcements, give students access to all of their course grades with complete class statistics, propagate common assignments to many sections, give secure quizzes and tests. Find out how to integrate WebAssign with Blackboard and WebCT. Over 190, 000 students are using WebAssign. Find out why. Visit us at http://webassign.net.
Chair
John S. Risley[1]
[1]*WebAssign.*

174: Impact of Intelligent Design and Responses to It
AAS Special, 10:00-11:30am, 204

174.01 **Overview of the Nature of Intelligent Design as a Pseudoscience**
Matthew Bobrowsky[1]
[1]*STScI.*

174.02 **The AAS Resolution on Teaching Evolution**
George D. Nelson[1]
[1]*Western Washington University.*

174.03
Francis Slakey[1]
[1]*American Physical Society.*

174.04 **Science and Faith: Discussing Astronomy Research with Religious Audiences**
Anton M. Koekemoer[1]
[1]STScI.

175: Observations and Models of Extragalactic LMXBs
AAS Special, 10:00-11:30am, 201

Chair
Stephen E. Zepf[1]
[1]Michigan State Univ..

175.01 **Deep Chandra Studies of LMXB Populations in Elliptical Galaxies**
Giuseppina Fabbiano[1]
[1]Harvard-Smithsonian Center for Astrophysics.

175.02 **The Low Mass X-Ray Binary Globular Cluster Connection and its Implications**
Arunav Kundu[1]
[1]Michigan State University.

175.03 **Theoretical Models of LMXBs in Elliptical Galaxies**
Vicky Kalogera[1]
[1]Northwestern University.

176: GLAST Science and Opportunities at All Wavelengths
HEAD Special, 10:00-11:30am, 611-12

176.01 **GLAST Science Across Wavelengths**
R. D. Blandford[1]
[1]SLAC.

176.02 **Enhancing GLAST Science Through Complementary Radio Observations**
James S. Ulvestad[1]
[1]NRAO.

176.03 **Galaxy Formation, Cold Dark Matter Substructure, and GLAST**
Piero Madau[1]
[1]UC, Santa Cruz.

176.04 **GLAST Mission Overview and Science Opportunities**
Julie E. McEnery[1]
[1]NASA's GSFC.

177: Andromeda All the Time
AAS Oral, 10:00-11:30am, 6B

177.01 **The Surface Brightness Profile of the Bulge and Halo of the Andromeda Spiral Galaxy (M31) from R = 10 to 165 kiloparsecs**
Puragra Guhathakurta[1], K. Gilbert[1], J. Kalirai[1], J. Ostheimer[2], S. Majewski[2], R. Patterson[2], M. Geha[3], M. Cooper[4], D. Reitzel[5], R. Rich[5]
[1]UC, Santa Cruz, [2]U Virginia, [3]DAO/HIA, NRC, Canada, [4]UC, Berkeley, [5]UCLA.

177.02 **New Substructure in the Spheroid of the Andromeda Spiral Galaxy**
Karoline Gilbert[1], J. Isler[2], J. Kalirai[1], M. Fardal[3], P. Guhathakurta[1], R. M. Rich[4], D. Reitzel[4], S. Majewski[5], M. Cooper[6], M. Geha[7], J. Ostheimer[5], R. Patterson[5]
[1]UCO/Lick Obs, [2]Vanderbilt/UCSC, [3]UMass, [4]UCLA, [5]U Virginia, [6]UC, Berkeley, [7]DAO/HIA/NRC, Canada.

177.03 **Unraveling NGC 205's Interaction with Andromeda (M31)**
Kirsten Howley[1], M. Geha[2], P. Guhathakurta[1], R. Montgomery[1], G. Laughlin[1]
[1]UCO/Lick Observatory, University of California Santa Cruz, [2]The Observatories of the Carnegie Institution of Washington.

177.04 **Reconstructing a Recent Collision in Andromeda**
Mark Fardal[1], P. Guhathakurta[2], A. Babul[3], A. McConnachie[3], C. Dodge[4]
[1]UMass, [2]UCO/Lick, [3]UVic, Canada, [4]Smith.

177.05 **Constraints on the Chemical Evolution of the M31 Spheroid**
Henry C. Ferguson[1], O. Certik[1], T. Brown[1], E. Smith[1], M. Rich[2], R. Guhathakurta[3], J. Kalirai[3], A. Renzini[4], A. Sweigart[5]
[1]STScI, [2]UCLA, [3]UC Santa Cruz, [4]Univ. Padova, Italy, [5]GSFC.

177.07 **Characterizing the Metallicity Distribution of the Extended Bulge of the Andromeda Spiral Galaxy (M31).**
Jedidah C. Isler[1], J. Kalirai[2], K. Gilbert[2], P. Guhathakurta[2], M. Geha[3], S. Majewski[4], J. Ostheimer[4], R. Patterson[4], D. Reitzel[5], R. Rich[5]
[1]Fisk U, Vanderbilt U, UC, Santa Cruz (Visiting Student), [2]UCO/Lick Obs., [3]DAO/HIA/NRC, Canada, [4]U Virginia, [5]UCLA.

177.08 **Keck/Deimos Spectroscopy of Distant M31 fields with Deep HST Imaging**
Robert M. Rich[1], T. M. Brown[2], D. B. Reitzel[1], H. Ferguson[2], A. Koch[1], E. Smith[2], P. Guhathakurta[3], J. Kalirai[4], A. Renzini[5], R. Kimble[6], A. Sweigart[6], K. Gilbert[4], M. Chiba[7], M. Iye[7], Y. Komiyama[7], M. Tanaka[7]
[1]UCLA, [2]STScI, [3]Lick Observatory/UCSC, [4]UCSC, [5]INAF-Padova, Italy, [6]GSFC, [7]NAOJ, Japan.

178: Dwarf Galaxies: Don't Let Their Size Fool You
AAS Oral, 10:00-11:30am, 3B

178.01 **Environment and the Gas Content of Dwarf Galaxies**
Marla C. Geha[1], M. Blanton[2], A. A. West[3]
[1]Herzberg Institute of Astrophysics, Canada, [2]New York University, [3]UC Berkeley.

178.02 **Spitzer Mid-Infrared Observations of Blue Compact Dwarf Galaxies**
Yanling Wu[1], V. Charmandaris[2], L. Hao[1], J. Bernard-Salas[1], L. Hunt[3], J. R. Houck[1]
[1]Cornell Univ., [2]University of Crete, Greece, [3]INAF-IRA, Italy.

178.03 **Mass and Substructure in Dwarf Spheroidal Galaxies**
Matthew G. Walker[1]
[1]Univ. of Michigan.

178.04 **Compact Elliptical Galaxies and Ultracompact Dwarfs in the Sloan Digital Sky Survey**
Ronald O. Marzke[1], P. Pellegrini[2], L. da Costa[2], M. Maia[2], D. Burstein[3]
[1]San Francisco State University, [2]ON/CNPq, Brazil, [3]Arizona State University.

178.05 **A New Population of Ultra-faint Local Group Galaxies**
Daniel B. Zucker[1], V. Belokurov[1], N. W. Evans[1], G. Gilmore[1], M. I. Wilkinson[1]
[1]University Of Cambridge, United Kingdom.

178.06 **The Dwarf Galaxy Leo A: A Survivor From the Epoch of Reionization**
Andrew A. Cole[1], E. D. Skillman[1], A. E. Dolphin[2], J. S. Gallagher, III[3], E. Tolstoy[4], C. Gallart[5], D. Weisz[1], S. L. Hidalgo[1], A. Saha[6], P. B. Stetson[7], A. Aparicio[5]
[1]U. Minnesota, [2]U. Arizona, [3]U. Wisconsin, [4]Kapteyn Inst., The Netherlands, [5]IAC, Spain, [6]NOAO, [7]DAO, Canada.

178.07 **Spitzer Observations of the Far-Infrared Radio Continuum Correlation in the Small Magellanic Cloud**
Karin M. Sandstrom[1], A. Bolatto[1], A. Leroy[2], S. Stanimirovic[3], J. D. Simon[4], L. Staveley-Smith[5], J. R. Dickel[6], R. Shah[7], P. F. Winkler[8], R. C. Smith[9], N. Mizuno[10]
[1]University of California, Berkeley, [2]Max Planck Institute for Astronomy, Germany, [3]University of Wisconsin, Madison, [4]California Institute of Technology, [5]Australia Telescope National Facility, CSIRO, Australia, [6]University of New Mexico, [7]Institute for Astrophysical Research, Boston University, [8]Middlebury College, [9]NOAO, [10]Department of Astrophysics, Nagoya University, Japan.

179: Extrasolar Planets I
AAS Oral, 10:00-11:30am, 605-07

179.01 **The Migration of Giant Planets**
Richard G. Edgar[1]
[1]University of Rochester.

179.02 **Behavior of Apsidal Orientations in Planetary Systems**
Rory Barnes[1], R. Greenberg[1]
[1]Univ. Of Arizona.

179.03 **Turbulent Torques on Protoplanets in a Dead Zone**
Jeffrey S. Oishi[1], M. Mac Low[2], K. Menou[3]
[1]AMNH/UVa, [2]AMNH, [3]Columbia University.

179.04 **Stellar Magnetic Activity and the Detection of Exoplanets**
Jason Wright[1]
[1]UC, Berkeley.

179.05 **A Survey of Close, Young Stars with SDI at the VLT and MMT**
Beth A. Biller[1], L. Close[1], E. Masciadri[2], R. Lenzen[3], W. Brandner[3], D. McCarthy[1], T. Henning[3], E. Nielsen[1], M. Hartung[4]
[1]Univ. Of Arizona, [2]Observatorio Astrofisico di Arcetri, Italy, [3]MPIA-Heidelberg, Germany, [4]European Southern Observatory, Chile.

179.06 **Planets Formed in Habitable Zones of M Dwarf Stars Probably Lack Volatiles**
Jack J. Lissauer[1], E. V. Quintana[1]
[1]NASA/Ames Research Center.

180: Galaxy Clusters III
AAS Oral, 10:00-11:30am, 613-14

180.01 **Projected 3pt Correlation Function in the Sloan Digital Sky Survey**
Cameron McBride[1], R. Scranton[1], A. Connolly[1], J. Gardner[2]
[1]University of Pittsburgh, [2]Pittsburgh Supercomputing Center.

180.02 **High-Redshift Clusters in the SpARCS Survey**
Adam Muzzin[1], H. Yee[1], G. Wilson[2], SpARCS Collaboration
[1]Univ. of Toronto, Canada, [2]Spitzer Science Center.

180.03 **AGN Heating and the Growth of Black Holes and Bulges in Cluster Cores**
David A. Rafferty[1], B. R. McNamara[2], P. E. Nulsen[3], M. W. Wise[4]
[1]Ohio University, [2]University of Waterloo, Canada, [3]CfA, [4]University of Amsterdam, The Netherlands.

180.04 **Simulating the Universe: Large Area Synthetic Galaxy Cluster Surveys**
Eric J. Hallman[1], B. O'Shea[2], M. Norman[3], R. Wagner[3], J. Burns[1]
[1]University of Colorado, [2]Los Alamos National Laboratory, [3]University of California-San Diego.

180.05 **Galaxy Populations in Clusters and the Estimation of Cluster Optical Richness in Wide-Field Surveys**
Ben Koester[1]
[1]University of Michigan.

180.06 **Probing Structure Formation Physics with the Evolution of Galaxy Cluster Properties**
Douglas J. Burke[1], M. Arnaud[2], H. Boehringer[3], S. Borgani[4], C. Collins[5], C. Mullis[6], R. Nichol[7], E. Pointecouteau[8], G. Pratt[3], K. Romer[9], S. Sabirli[10], P. Viana[11], A. Vikhlihnin[1], M. Voit[12]
[1]SAO, [2]CEA Service d'Astrophysique, France, [3]MPE, Germany, [4]Osservatorio Astronomico di Trieste, Italy, [5]Liverpool John Moores University, United Kingdom, [6]University of Michigan, [7]University of Portsmouth, United Kingdom, [8]Centre d'Etude Spatiale des Rayonnements, France, [9]University of Sussex, United Kingdom, [10]Carnegie Mellon University, [11]Universidade do Porto, Portugal, [12]MSU.

181: Galaxy Evolution with DEEP2
AAS Oral, 10:00-11:30am, 608-10

181.01 **The DEEP2 Galaxy Redshift Survey: the Formation of the Red Sequence**
Michael C. Cooper[1]
[1]University of California at Berkeley.

181.02 **Are Massive Galaxies Formed by z~1?**
Christopher Conselice[1], AEGIS Team
[1]Univ. of Nottingham, United Kingdom.

181.03 **The Evolution of the Blue Galaxy Fraction in DEEP2 Groups and Isolated Galaxies**
Brian Gerke[1]
[1]UC-Berkeley.

181.04 **Redshift Identification of Single-Line Emission Galaxies in the DEEP2 Survey**
Evan Kirby[1], P. Guhathakurta[1], S. M. Faber[1], B. J. Weiner[2]
[1]UC Santa Cruz, [2]University of Maryland.

181.05 **Galaxies in Transition: AGN Activity and Environments of Post-starburst Galaxies**
Renbin Yan[1], DEEP2 Team
[1]UC, Berkeley.

181.06 **The Stellar Mass Tully-Fisher Relation to z=1.2**
Susan A. Kassin[1], B. Weiner[2], S. Faber[1], D. Koo[1], J. Lotz[2], DEEP2 Team
[1]UC Santa Cruz, [2]Steward Observatory.

182: Novae/Cataclysmic Variables
AAS Oral, 10:00-11:30am, 6A

182.01 **Radio Imaging of the Recurrent Nova RS Ophiuchus**
Michael P. Rupen[1], A. J. Mioduszewski[1], J. L. Sokoloski[2], C. R. Kaiser[3], C. Brocksopp[4]
[1]NRAO, [2]Columbia University, [3]University of Southampton, United Kingdom, [4]Mullard Space Science Laboratory, Univ. College London, United Kingdom.

182.02 **Hubble Space Telescope Observations of the 2006 Outburst of RS Ophiuchi**
Michael F. Bode[1], D. Harman[1], T. J. O'Brien[2], H. E. Bond[3], S. Starrfield[4], M. Shara[5], S. Eyres[6], A. Evans[7]
[1]Liverpool John Moores University, United Kingdom, [2]Jodrell Bank Observatory, United Kingdom, [3]STScI, [4]Arizona State University, [5]American Museum of Natural History, [6]University of Central Lancashire, United Kingdom, [7]Keele University, United Kingdom.

182.03 **The Metallicity and Lithium Abundances in the Repeating Novae, RS Oph and T CrB**
George Wallerstein[1], T. Harrison[1], U. Munari[2]
[1]Univ. of Washington, [2]Osservatorio Asiago, Italy.

182.04 **Mass Transfer and Evolution of Compact Binaries**
Vayujeet Gokhale[1]
[1]Louisiana State Univ..

182.05 **Hubble Space Telescope Observations of Thirteen Novae Candidates in the Core of M87**
Juan P. Madrid[1], W. B. Sparks[1], H. Ferguson[1], M. Livio[1], D. Macchetto[2]
[1]STScI, [2]STScI/ESA.

182.06 **X-ray Ne/O Ratio in Cataclysmic Variables**
Eric M. Schlegel[1], V. Rana[2], K. Singh[2], V. Girish[2], P. Barrett[3]
[1]Univ. of Texas, San Antonio, [2]Tata Inst. of Fundamental Research, India, [3]US Naval Observatory.

182.07 **Accreting Pulsating White Dwarfs: Hotter than Single DAVs**
Paula Szkody[1], A. Mukadam[1], B. T. Gaensicke[2], P. A. Woudt[3], J. Solheim[4], E. M. Sion[5], A. Nitta[6], B. Warner[3], D. K. Sahu[7], T. Prabhu[7], A. Henden[8]
[1]Univ. of Washington, [2]Univ. of Warwick, United Kingdom, [3]Univ. of Cape Town, South Africa, [4]Institute of Theoretical Astrophysics, Norway, [5]Villanova University, [6]Gemini Observatory, [7]Indian Institute of Theoretical Astrophysics, India, [8]AAVSO.

183: SDSS and GALEX
AAS Oral, 10:00-11:30am, 3A

183.01 **The Intrinsic Properties of SDSS Galaxies: Taking off the Rose Tinted Glasses**
Ariyed Maller[1], A. Berlind[2], M. Blanton[2], D. Hogg[2]
[1]New York City College of Technology, [2]CCPP, NYU.

183.02 **Dependence of Merger Rates and Ram Pressure Stripping on Environment and Galaxy Mass**
Janice Hester[1]
[1]Princeton Univ..

183.03 **Reflections of Cluster Assembly in the Stellar Populations and Dynamics of Member Galaxies**
Sean Moran[1], R. S. Ellis[1], T. Treu[2], G. P. Smith[3], N. Miller[4]
[1]Caltech, [2]University of California, [3]University of Birmingham, United Kingdom, [4]Caltech/UC Santa Cruz.

183.04 **The Star Formation and Extinction Evolution of UV-Selected Galaxies over 0<z<1.25**
Christopher D. Martin[1], GALEX Science Team, Spitzer-MIPS Science Team
[1]Caltech.

183.05 **How Special are Brightest Cluster Galaxies?**
Anja Von Der Linden[1], P. N. Best[2], G. Kauffmann[1], S. D. White[1]
[1]Max-Planck-Institut fuer Astrophysik, Germany, [2]Institute for Astronomy, Royal Observatory Edinburgh, United Kingdom.

183.06 **Star Formation and Attenuation in SDSS Galaxies from GALEX and Spitzer: Exploring the Links**
Benjamin D. Johnson[1], D. Schiminovich[1], GALEX Science Team
[1]Columbia University.

184: Helping Faculty/Teachers Become More Adept at Working with Under-represented Groups
AAPT Panel, 10:00-11:30am, 615

Chair
Juan R. Burciaga[1]
[1]Whitman College.

184.01 **Stalking the Anti-Racist Atom: Engaging Educational Equity and Diversity in Physics Teaching**
Apriel K. Hodari[1]
[1]The CNA Corporation.

184.02 **Practical Ways to Improve Physics Education**
Daryao S. Khatri[1]
[1]University of the District of Columbia.

184.03 **Labels Matter: Changing the Conversation From "-isms" to Privilege**
Melissa H. Dancy[1]
[1]UNC-Charlotte.

184.04 **Designing a Workshop for Change in the Community of Physics**
Juan R. Burciaga[1]
[1]Whitman College.

185: NAEP Science 2009: Why Should Physics Teachers Care?
AAPT Panel, 10:00-11:30am, 310

Panelists: Arthur Eisenkraft, Univ. of Massachusetts-Boston; Jack Hehn, American Institute of Physics; Jim Minstrell, FACET Innovatioins National Assessment of Educational Progress (NAEP) is commonly called "The Nation's Report Card." Beginning in 2009 there will be a new science test that is based on a framework developed over the last two years. The panelists, who were members of the steering and planning committees, will describe the need for this new instrument, outline the development process, compare the old and new frameworks and explain why this new exam is important and will represent a new trend-line to measure student achievement in science.

Chair
Paul Hickman[1]
[1]Science Education Consultant.

186: 1957: the Legacy of Sputnik
AAPT Special, 10:00-11:30am, 303

Chair
Richard Jacob[1]
[1]Arizona State U..

186.01 **Eisenhower, Scientists, and Sputnik**
John S. Rigden[1]
[1]Washington University.

186.02 **The Influence of Sputnik on U.S. Science Education and Research**
Leon M. Lederman[1]
[1]Illinois Institute of Technology and Illinois Mathematics and Science Academy.

187: Virtual Observatories
AAPT Special, 10:00-11:30am, 618

Chair
Jordan Raddick[1]
[1]Johns Hopkins University.

187.01 **The Science and Technology of the National Virtual Observatory**
Alex Szalay[1]
[1]Johns Hopkins University.

187.02 **Education Potential of the National Virtual Observatory**
Carol Christian[1]
[1]STScI.

187.03 **The Challenges of Using Virtual Observatories in the Classroom**
Robert T. Sparks[1]
[1]National Optical Astronomy Observatory.

187.04 **Discover an Asteroid Using SDSS**
Elizabeth A. Ramseyer[1]
[1]Niles West High School.

188: PER: Student Understanding and Student Reasoning
AAPT Oral, 10:00-11:30am, 307-08

Chair
Marina M. Milner-Bolotin[1]
[1]University of British Columbia, Canada.

188.01 **Techniques and Tools for Teaching the Photoelectric Effect**
S. B. McKagan[1], W. Handley[1], K. K. Perkins[1], C. E. Wieman[1]
[1]University of Colorado.

188.02 **Examining Student Understanding of Quantum Wavefunctions**
Homeyra R. Sadaghiani[1], P. S. Shaffer[1], L. C. McDermott[1]
[1]University of Washington.

188.03 **Pedagogical Landscape in Upper-Level Thermal Physics** *
David E. Meltzer[1], W. M. Christensen[2]
[1]University of Washington, [2]Iowa State University.

188.04 **"Is Entropy Conserved?" Student Understanding of Entropy in Introductory Physics**
Warren M. Christensen[1], D. E. Meltzer[2]
[1]Iowa State University, [2]University of Washington.

188.05 **Longitudinal Standing Waves in a Tutorial Environment**
Jack Dostal[1]
[1]Montana State University.

188.06 **Investigating Student Understanding of Wave Behavior at Boundaries***
Mila Kryjevskaia[1], M. R. Stetzer[1], P. R. Heron[1], L. C. McDermott[1]
[1]University of Washington.

188.07 **Investigating Student Understanding of Control of Variables**
Andrew Boudreaux[1], P. R. Heron[2], P. S. Shaffer[2]
[1]Western Washington University, [2]University of Washington.

188.08 **Modeling Student Thinking about Motion in Tutorial**
Brian W. Frank[1], R. E. Scherr[1]
[1]University of Maryland.

188.09 **Sensemaking: Conceptualizing and Coding for "Good" Student Reasoning**
Andrew Elby[1], R. Scherr[1], T. Bing[1]
[1]*University of Maryland.*

189: Techniques in Introductory Physics Teaching
AAPT Oral, 10:00-11:30am, 616

Chair
Frieda Stahl[1]
[1]*California State Univ., Los Angeles.*

189.01 **Aesthetic Physics Education: A Symmetry Based, Physics and Fine Arts Curriculum**
Jatila van der Veen[1], P. M. Lubin[2], J. Cook-Gumperz[3], J. D. Raley[3], E. Mazur[4]
[1]*Gevirtz Graduate School of Education and Physics Dept., University of California, Santa Barbara,* [2]*Physics Dept. UCSB,* [3]*Gevirtz Graduate School of Education, UCSB,* [4]*Physics Dept, Harvard University.*

189.02 **Science One: An Interdisciplinary First-year Science Program**
Domingo J. Louis-Martinez[1], N. Dryden[1], M. Maclean[1]
[1]*University of British Columbia, Canada.*

189.03 **Curbing "Math Anxiety" with Galileo While Teaching Physicists, too**
Brian P. Schwartz[1]
[1]*Carthage College.*

189.04 **Using Whole Vector Force Representations for "Friction Problems″**
Daniel H. Phelps[1]
[1]*Columbia College (Retired), Canada.*

189.05 **Teaching Physics for Conceptual Understanding Exemplified for Einstein's Special Relativity**
Lucian M. Undreiu[1]
[1]*UVA's College at Wise.*

189.06 **Student Reported Learning Gains From Pre-Class Questions**
David T. Kagan[1]
[1]*California State University, Chico.*

189.07 **High School Physics Experience and Learning Outcomes in Introductory Physics Courses**
Tetyana Antimirova[1]
[1]*Ryerson University, Canada.*

189.08 **The Impact of Teaching Technologies in the Introductory Physics Classroom**
William W. McNairy[1]
[1]*Duke University.*

189.09 **Examples from Research on the Learning and Teaching of Quantum Mechanics**
Andrew D. Crouse[1], P. S. Shaffer[1], L. C. McDermott[1]
[1]*Univ. of Washington.*

190: Heineman Prize Lecture
Plenary, 11:40am-12:30pm, Ballroom 6

190.01 **The DEEP2 Redshift Survey: From Galaxies to Large-Scale Structure**
Marc Davis[1]
[1]*UC, Berkeley.*

Begin With Special Relativity
Commercial Workshop, 12:30-2:00pm, 302

For nearly a century we have lived with an introductory physics curriculum that divides physics into classical and modern parts, and teachers only the classical part to the majority of students. The Physics2000 workshop demonstrates how to easily overcome this divide by starting with special relativity in the first week, and fitting in 20th century topics as you go along. As examples we will discuss introducing magnetism from Coulomb's Law and the Lorentz contradiction teach the time-energy form of the uncertainty principle and introduce Fourier Optics using the pulse Fourier Transformation capability of MacScopeII.
Chair
Elisha Huggins[1]
[1]*Physics2000.com.*

Decadal Survey Town Hall
AAS Town Hall Meeting, 12:45-1:45pm, 613

In our field, the National Academy of Sciences - National Research Council (NRC) is best known as the organization that convenes the Astronomy and Astrophysics Decadal Surveys (AADSs). The series of AADS reports has provided priorities for the federal investment that has, in turn, enabled the remarkable success of the field. The January 2007 AAS meeting will provide a good opportunity to take stock of the progress that has been made since the 2001 AADS and to begin to turn our attention forward to planning the next one. The AADS process is organized by the NRC's Board on Physics and Astronomy, in cooperation with the Space Studies Board and with the active involvement of their joint subcommittee, the Committee on Astronomy and Astrophysics. With this session, the BPA/SSB/CAA will begin a dialogue with the community about the next AADS. The Boards are considering whether, in light of the current circumstances in the field, to recommend some adjustments in the decadal survey process. AAS members are encouraged to take the opportunity presented by this Town Hall to comment on this issue.
Chair
Anneila I. Sargent[1]
[1]*(Caltech), Chair, Board on Physics and Astronomy NRC.*
Chair
Lennard A. Fisk[1]
[1]*(U. Michigan), Chair, Space Studies Board.*
Chair
C. M. Urry[1]
[1]*(Yale Univ.), Cochair, Committee on Astronomy and Astrophysics.*

HEAD Business Meeting
AAS Splinter Meeting, 12:45-1:45pm, 609
Chair
Mitchell C. Begelman[1]
[1]*Univ. of Colorado.*

Astronomy Education Research Town Hall
AAPT Crackerbarrel, 1:00-2:00pm, 617
Chair
Edward Prather[1]
[1]*Univ. of Arizona.*

Physics and Society Education
AAPT Crackerbarrel, 1:00-2:00pm, 619

Are you looking for ways to incorporate societal issues into a physics course? Join your colleagues to share questions and ideas in an informal discussion about how to accomplish this. A small number of people will make brief presentations on their successful activities, then the session will open for all to share and discuss. Information about presenters will be posted through the PHYSOC listserv prior to the meeting.

Chair
Jane Flood[1]
[1]Muhlenberg College.

High Performance Computing for Undergraduate Physics and Astronomy Education - Let's talk about it
AAPT Crackerbarrel, 1:00-2:00pm, 618

For year supercomputers have been the domain of the relatively few researchers whose extreme computational performance demands could justify the costs - both time and equipment - of this extreme technology. Now anyone can afford mega-mega flops, even on their laptops, and software with which they can create numerical simulations without expensive support staff. So why are we inviting you to talk about high performance computing? Come; find out why; and join in this discussion. Discussion Leader: Scott Lathrop (lathrop@mcs.anl.gov), TeraGrid Director of Education, Outreach and Training, SC07 Education Program Chair. Session sponsor: "Computing in Science and Engineer", the AIP/IEEE-CS technical magazine for computational science.

Chair
Norman Chonacky[1]
[1]Yale U.

AAPT Town Hall Meeting
AAPT Event, 1:00-2:00pm, 617

191: Next Generation Radial Velocity Planet Surveys
AAS Special, 2:00-3:30pm, 3B

191.01 **N2K and Beyond**
Greg Laughlin[1]
[1]UC Santa Cruz.

191.02 **Status of the All Sky Extrasolar Planet Survey and Early Results**
Jian Ge[1]
[1]University of Florida.

191.03 **Spectroscopic Follow-Up Observations of Transiting Planet Candidates Identified by the Kepler Mission**
David Latham[1], D. D. Sasselov[1], A. H. Szentgyorgyi[1]
[1]Harvard-Smithsonian Center for Astrophysics.

191.04 **An Infrared Precision Radial Velocity Spectrograph for Gemini**
John Rayner[1]
[1]University of Hawaii Institute for Astronomy.

191.05 **Big Questions About Planet Formation That Can Be Addressed By Next-Generation Radial Velocity Planet Searches**
Eric B. Ford[1], E. Agol[2]
[1]Harvard-Smithsonian Center for Astrophysics, [2]U. Washington.

192: SAGE: Surveying the Agents of a Galaxy's Evolution
AAS Special, 2:00-3:30pm, 201

Chair
Alexander G. Tielens[1]
[1]NASA Ames Research Center.

192.01 **The Large Magellanic Cloud as a Galaxy**
John (Jay) Gallagher[1], M. Meixner[2], J. Bernard[3], R. Blum[4], K. Gordon[5], R. Indebetouw[6], W. Reach[7], B. Whitney[8], B. Babler[1], M. Block[5], E. Churchwell[1], C. Engelbracht[5], B. For[9], J. Hora[10], C. Leitherer[2], M. Meade[1], K. Misselt[5], A. Tielens[11], U. Vijh[2], SAGE Team
[1]University of Wisconsin-Madison, [2]Space Telescope Science Institute, [3]CESR, France, [4]NOAO, [5]University of Arizona, [6]University of Virginia, [7]Caltech, [8]Space Science Institute, [9]University of Texas, [10]Harvard/CfA, [11]NASA/Ames.

192.02 **Spitzer SAGE Survey of the Large Magellanic Cloud: Project Overview**
Margaret Meixner[1], B. Babler[2], J. Bernard[3], M. Block[4], R. Blum[5], C. Engelbracht[4], B. For[6], K. Gordon[4], J. Hora[7], R. Indebetouw[8], C. Leitherer[1], M. Meade[2], K. Misselt[4], W. Reach[9], A. G. Tielens[10], U. Vijh[1], B. Whitney[11], S. Team[1]
[1]STScI, [2]University of Wisconsin, [3]CESR, France, [4]University of Arizona, [5]NOAO, [6]University of Texas, [7]Harvard/CfA, [8]University of Virginia, [9]SSC/Caltech, [10]NASA/Ames, [11]Space Science Institute.

192.03 **The Spitzer/SAGE View of Star Formation in the LMC**
Remy Indebetouw[1], B. Whitney[2], M. Sewilo[3], T. Robitaille[4], M. Meade[3], B. Babler[3], J. Hora[5], K. Gordon[6], C. Engelbracht[6], B. For[7], M. Block[6], K. Misselt[6], M. Meixner[8], U. Vijh[8], K. Leitherer[8], SAGE Team
[1]Univ. of Virginia, [2]Space Science Institute, [3]Univ. of Wisconsin, [4]Univ. of St-Andrews, United Kingdom, [5]Harvard-Smithsonian/CfA, [6]Univ. of Arizona, [7]Univ. of Texas, [8]STScI.

192.04 **Dust and gas in the Interstellar Medium of the LMC**
William T. Reach[1], J. Bernard[2], D. Paradis[2], M. Meixner[3], A. Kawamura[4], Y. Fukui[5], SAGE Legacy Team
[1]Caltech, [2]CESR, France, [3]STScI, [4]Nagoya Univ., Japan, [5]Nagoya U., Japan.

192.05 **Mass Loss from Evolved Stars in the LMC: A Spitzer SAGE View**
Robert D. Blum[1], K. Volk[2], S. Srinivasan[3], F. Markwick-Kemper[4], M. Meixner[5], S. Points[6], K. Olsen[6], K. Gordon[7], C. Engelbracht[7], B. For[8], M. Block[7], K. Misselt[7], B. Whitney[9], M. Meade[10], B. Babler[10], R. Indebetouw[11], J. Hora[12], U. Vijh[5], C. Leitherer[5], J. Mould[1], SAGE Team
[1]NOAO, [2]Gemini Observatory, [3]Johns Hopkins University, [4]University of Manchester, United Kingdom, [5]STScI, [6]CTIO, Chile, [7]Steward Observatory, [8]University of Texas, [9]Space Science Institute, [10]University of Wisconsin, [11]University of Virginia, [12]Harvard-Smithsonian/CfA.

192.06 **Spitzer Spectroscopy of Evolved Stars in the LMC**
Joel H. Kastner[1]
[1]RIT Center for Imaging Science.

193: Science from the NDWFS Bootes Field
AAS Special, 2:00-3:30pm, 3A

Chair
Daniel Stern[1]
[1]JPL/ Caltech.

193.01 **The NOAO Deep Wide-Field Survey An Introduction**
Buell Jannuzi[1]
[1]NOAO.

193.02 **The Flamingos Extragalactic Survey**
S A. Stanford[1], A. Gonzalez[2], P. Eisenhardt[3], M. Brodwin[3], D. Stern[3], E. McKenzie[2], R. Elston[2]
[1]UC, Davis, [2]UF, [3]JPL.

193.03 **The IRAC Shallow Survey**
Peter R. Eisenhardt[1]
[1]JPL/Caltech.

193.04 **A Spitzer Far-infrared Look at the NOAO-Deep Wide Field Survey**
Emeric LeFloc'h[1]
[1]Institute for Astronomy, University of Hawaii.

193.05 **XBootes Chandra Shallow Survey of the Bootes Region**
Stephen S. Murray[1], XBootes Team
[1]SAO.

193.06 **AGES: The AGN and Galaxy Evolution Survey**
Richard J. Cool[1]
[1]Univ. of Arizona.

194: Short Gamma-Ray Bursts
HEAD Special, 2:00-3:30pm, 205

Chair
Neil Gehrels[1]
[1]NASA's GSFC.

194.01 **On the Prompt Gamma-ray Emission Properties of Short GRBs**
Chryssa Kouveliotou[1]
[1]MSFC.

194.02 **X-ray Afterglows of Short Gamma-Ray Bursts**
David N. Burrows[1]
[1]Penn State Univ..

194.03 **The Host Galaxies and Host Clusters of Short Gamma Ray Bursts: Constraints on the Progenitor Age Distribution**
Edo Berger[1]
[1]Carnegie Observatories.

194.04 **Theoretical Interpretation of Short GRB Observations**
Ehud Nakar[1]
[1]Caltech.

195: AGN, Starbursts and Sub-mm Galaxies
AAS Oral, 2:00-3:30pm, 6C

195.01 **Millimeter Detection of Spitzer-selected High Redshift Hyperluminus Starburst Galaxies**
Carol J. Lonsdale[1], A. Omont[2], M. del Carmen Polletta[3], R. Zylka[4], D. Shupe[1], H. E. Smith, Jr[3], S. Berta[5], N. Bavouzet[6], G. Lagache[6], D. Farrah[7], F. Bertoldi[8], P. Cox[4], C. de Breuck[9], H. Dole[6], D. Lutz[10], L. Tacconi[10], I. Perez-Fournon[11], H. Aussel[12], H. McCracken[13], D. Clements[14], M. Rowan-Robinson[14], A. Franceschini[5], D. Frayer[1], J. Surace[1], B. Siana[1]
[1]IPAC, Caltech, [2]Institut d'Astrophysique de Paris, France, [3]UCSD, [4]IRAM, France, [5]University of Padova, Italy, [6]IAS, France, [7]Cornell, [8]University of Bonn, Germany, [9]ESO, France, [10]MPIE, Germany, [11]Instituto Astrofisica, Spain, [12]Service d'Astrpphysique, CEA, France, [13]Service d'Astrophysique, CEA, France, [14]Imperial College, United Kingdom.

195.02 **The Masses and Luminosities of Submillimeter-Selected Galaxies**
Laura J. Hainline[1]
[1]*Caltech.*

195.03 **Mid-Infrared Spectral Diagnostics of Submillimetre Galaxies**
Alexandra Pope[1], R. Chary[2], M. Dickinson[3], D. Scott[1]
[1]*Univ. of Bristish Columbia, Canada,* [2]*Spitzer Science Center,* [3]*National Optical Astronomy Observatory.*

195.04 **The Redshift Distribution of 24 micron sources in the NDWFS Bootes Field**
Vandana Desai[1]
[1]*Caltech.*

195.05 **History and Modes of Star Formation since z~1 in Field Galaxies: A New Picture from the AEGIS Collaboration**
Kai Noeske[1], AEGIS collaboration
[1]*UC, Santa Cruz.*

195.06 **The Molecular ISM of Quasar Host Galaxies in the Early Universe**
Dominik A. Riechers[1]
[1]*Max-Planck Institut fuer Astronomie, Germany.*

195.07 **The Hard X-ray 20-40 keV AGN Luminosity Function**
Volker Beckmann[1], S. Soldi[2], C. R. Shrader[1], N. Gehrels[1], N. Produit[2]
[1]*NASA's GSFC,* [2]*INTEGRAL Science Data Centre, Switzerland.*

196: Extrasolar Planets III
AAS Oral, 2:00-3:30pm, 605-07

196.01 **MIPS Lightcurves for Extrasolar Planets**
Bradley M. Hansen[1], J. Harrington[2], S. Luszcz[3], D. Deming[4], S. Seager[5], K. Menou[6], J. Cho[7], J. Richardson[4]
[1]*UC, Los Angeles,* [2]*U. Central Florida,* [3]*UC, Berkeley,* [4]*GSFC,* [5]*OCIW,* [6]*Columbia,* [7]*QMUL, United Kingdom.*

196.02 **Infrared Spectrocopy of the Transiting Extrasolar Planet HD209458b**
Lee J. Richardson[1], D. Deming[1], K. Horning[2], S. Seager[3], J. Harrington[4]
[1]*NASA's GSFC,* [2]*Florida Institute of Technology,* [3]*Carnegie Institution of Washington,* [4]*University of Central Florida.*

196.03 **The Thermal Flux of the Extrasolar Planet HD 209458b at 7-14 Microns**
Drake Deming[1], S. Seager[2], L. J. Richardson[1], K. Horning[3], J. Harrington[4]
[1]*NASA's GSFC,* [2]*CIW/MIT,* [3]*FIT,* [4]*UCF.*

196.04 **High Precision Differential Photometry of the Transit and Secondary Eclipse of HD209458b**
Daniel E. Potter[1]
[1]*Univ. of Arizona.*

196.05 **First High-Contrast Science with an IFU: The Sub-Stellar Companion to GQ Lup**
Stanimir A. Metchev[1], M. McElwain[1], J. Larkin[1]
[1]*UCLA.*

196.06 **Search for Planetary Transits of the Debris Disk Star AU Mic**
Larry D. Petro[1], L. Hebb[2], H. Ford[3], D. Golimowski[3], J. Rogers[3], P. Sackett[4], K. Lewis[4], M. Clampin[5], J. Wisniewski[5], D. Minniti[6], I. Toledo[6], P. Espinoza[6], D. Ardila[7]
[1]*STScI,* [2]*University of St. Andrews, United Kingdom,* [3]*Johns Hopkins University,* [4]*Australian National University, Australia,* [5]*NASA's Goddard Space Flight Center,* [6]*Pontificia Universidad Catolica de Chile, Chile,* [7]*CalTech/Spitzer Science Center.*

196.07 **Forming Earth-like Planets With Migrating Giants: Modeling and Observations**
Avi Mandell[1], S. Sigurdsson[2], S. Raymond[3], M. Mumma[4], G. Blake[5]
[1]Penn State University / NASA GSFC, [2]Penn State University, [3]Univ. of Colorado / VPL, [4]NASA GSFC, [5]Cal Tech.

196.08 **Correlations Between Stellar Metallicity and the Frequency of Planetary and Stellar Companions**
Charles Lineweaver[1], D. Grether[2]
[1]Australian National University, Australia, [2]University of New South Wales, Australia.

197: Galaxy Clusters IV
AAS Oral, 2:00-3:30pm, 608-10

197.01 **Radio and X-ray Properties of Cavities in the Hot Atmospheres of Ellipticals, Groups, and Clusters**
Laura Birzan[1], B. R. McNamara[2], C. L. Carilli[3], P. E. Nulsen[4], M. Wise[5]
[1]Ohio University, [2]University of Waterloo, Canada, [3]NRAO, [4]CfA, [5]University of Amsterdam, The Netherlands.

197.02 **The X-Ray Luminosity-Mass Relation for Local Clusters of Galaxies**
Rebecca Stanek[1], A. Evrard[1], H. Boehringer[2], P. Schuecker[2], B. Nord[1]
[1]Univ. of Michigan, [2]Max-Planck-Institut fur extraterrestrische Physik, Germany.

197.03 **Cosmological Constraints from the maxBCG Cluster Sample**
Eduardo Rozo[1]
[1]Ohio State Univeristy.

197.04 **The Age Dependence of Galaxy Clustering**
Darren S. Reed[1], F. Governato[2], T. Quinn[2], J. Stadel[3], G. Lake[3]
[1]Los Alamos National Laboratory, Theoretical Astrophysics (T-6), [2]Univ. of Washington, [3]Univ. of Zurich, Switzerland.

197.05 **Tracing Galaxy Evolution in Clusters and Groups at z>1**
Simona Mei[1], A. Stanford[2], J. Blakeslee[3], R. Demarco[4], P. Eisenhardt[5], H. Ford[4], B. Holden[6], N. Homeier[4], M. J. Jee[4], T. Kodama[7], F. Nakata[8], M. Postman[9], P. Rosati[10], R. White[9]
[1]Johns Hopkins Univ., UC Berkeley, Obervatoire de Paris, [2]IGPP/LLNL, [3]Washington State University, [4]Johns Hopkins Univ., [5]JPL, [6]University of California Santa Cruz, [7]National Astronomical Observatory of Japan (NAOJ), Japan, [8]University of Tokyo, Institute of Astronomy, Japan, [9]Space Telescope Science Institute, [10]European Southern Observatory, Germany.

197.06 **Evidence of Hierarchical Galaxy Formation from Strong MgII Absorbers**
Andrew Mshar[1], J. C. Charlton[1], C. W. Churchill[2], T. Kim[3]
[1]Penn State, [2]New Mexico State University, [3]Institute of Astronomy, United Kingdom.

198: ISM/Star Formation
AAS Oral, 2:00-3:30pm, 611-12

198.01 **Using Cloudshine to Constrain Turbulent Star Formation**
Jonathan B. Foster[1], A. A. Goodman[1], J. Pineda[1], P. Caselli[2]
[1]Harvard Univ., [2]Osservatorio Astrofisico di Arcetri, Italy.

198.02 **The Scale of Turbulence in Molecular Clouds**
Naomi A. Ridge[1], A. A. Goodman[1], N. Whitehorn[1]
[1]Harvard-Smithsonian, CfA.

198.03 **What is the True Core Mass Function?**
Di Li[1], X. Guan[2], Y. Dai[2]
[1]Jet Propulsion Laboratory / Caltech, [2]Peking University, China.

198.04 **Updated Interstellar Abundance Studies with FUSE and STIS**
Adam G. Jensen[1]
[1]Univ. Of Colorado.

198.05 **Study of Diffuse Interstellar Bands in 7 Intermediate Redshift Galaxies**
Brandon L. Lawton[1], C. W. Churchill[1], B. A. York[2], S. L. Ellison[2], T. P. Snow[3], R. A. Johnson[4], S. G. Ryan[5]
[1]New Mexico State Univ., [2]University of Victoria, Canada, [3]University of Colorado, [4]Oxford University, United Kingdom, [5]University of Hertfordshire, United Kingdom.

198.06 **The Discovery of Extragalactic Magnetic Fields in OH Megamasers**
Timothy Robishaw[1]
[1]UC Berkeley.

198.07 **The Effect of Star Formation Activity on the Far-Infrared--Radio Correlation within Spiral Galaxies**
Eric J. Murphy[1], G. Helou[2], R. Braun[3], J. D. Kenney[1], L. Armus[2], the SINGS team
[1]Yale Univ., [2]Caltech, [3]ASTRON, The Netherlands.

198.08 **Disentangling Density and Heating Effects in the Infrared Emission of SINGS Galaxies**
Caroline Bot[1], SINGS team
[1]Caltech.

199: Kinematics of Galaxies Internal and External
AAS Oral, 2:00-3:30pm, 204

199.01 **The Kinematics of the Disk-Halo Interaction in Spiral Galaxies**
George H. Heald[1], R. J. Rand[2], R. A. Benjamin[3]
[1]ASTRON, The Netherlands, [2]U. New Mexico, [3]U. Wisconsin.

199.02 **Thick Disks in External Galaxies: Structure, Kinematics, and Abundances**
Peter Yoachim[1]
[1]Univ. of Washington.

199.03 **Dwarf Satellites of Distant Galaxies**
Michael R. Blanton[1]
[1]New York Univ..

199.04 **The Motions of the Magellanic Clouds About the Milky Way**
Nitya Kallivayalil[1], R. van der Marel[2], C. Alcock[1]
[1]Harvard-Smithsonian Center for Astrophysics, [2]Space Telescope Science Institute.

199.05 **Spectral Indices of Early Type Galaxies in Rich Clusters of Galaxies**
Robert C. Berrington[1], M. Pierce[1], A. Monson[1]
[1]Univ. of Wyoming.

199.06 **Gas Dynamics and Star Formation in the Barred Galaxy NGC 4303**
Jin Koda[1]
[1]Caltech.

200: Supernovae Ia, Ib, Ic & II
AAS Oral, 2:00-3:30pm, 613-14

200.01 **Type Ia Supernova Spectral Line Ratios as Luminosity Indicators: "From Phenomenology to Radiative Transfer and Back Again"**
Sebastien Bongard[1], E. Baron[2], G. Smadja[3], D. Branch[2], P. Hauschildt[4]
[1]Lawrence Berkeley Lab., [2]University of Oklahoma City, [3]Institut de Physique Nucleaire de Lyon, France, [4]Hamburger Sternwarte, Germany.

200.02 **Type Ia Supernova Model Light Curves And The Width-Luminosity Relation**
Daniel Kasen[1]
[1]Johns Hopkins Univ..

200.03 **Numerical Simulations of Carbon Ignition in Type Ia Supernovae**
Haitao Ma[1], S. Woosley[1], M. Kuhlen[2], M. Evonuk[1], G. Glatzmaier[1]
[1]UC, Santa Cruz, [2]Institute for Advanced Study.

200.04 **Varied Deaths of Massive Stars: Optical and NIR Properties of Type Ib/c Supernovae**
Maryam Modjaz[1]
[1]Harvard Univ..

200.05 **VLT-FORS1 Spectropolarimetry of Core-Collapse Supernovae**
Justyn R. Maund[1], L. Wang[2], F. Patat[3], P. Hoeflich[4], D. Baade[3], C. Wheeler[1]
[1]Univ. of Texas, Austin, [2]Texas A&M, [3]ESO, Germany, [4]Dept. of Physics, Florida State.

200.06 **Lost and Found: Another Missed Type IIn SN, CG X-2**
Franz E. Bauer[1], S. Smartt[2], W. N. Brandt[3], S. Immler[4]
[1]Columbia Univ., [2]Queen's University Belfast, Ireland, [3]Pennsylvania State University, [4]GSFC.

201: Effective Mentoring of Women and Minority Students in Physics and Astronomy
AAPT Invited, 2:00-3:30pm, 615

Chair
Timothy F. Slater[1]
[1]Univ. of Arizona.

201.01 **Building Bridges to Diversity in Graduate Physics & Astronomy: The Fisk-Vanderbilt Masters-to-PhD Bridge Program**
Keivan G. Stassun[1]
[1]Vanderbilt University and Fisk University.

201.02 **A Novel Approach to Improving Diversity in Science: A Post-Baccalurate Research Year**
Kartik Sheth[1]
[1]Caltech / Spitzer Science Center / IPAC.

201.03 **Increasing Underrepresented Student Participation in Science Majors: The Pre-Major in Astronomy Program**
Daryl Haggard[1]
[1]University of Washington.

202: Visualizing and Simulating the Cosmos with Computers
AAPT Invited, 2:00-3:30pm, 616

Chair
Wolfgang Christian[1]
[1]Davidson College.

202.01 **Discovering the Complexity of Supernovae through Three-Dimensional Simulations**
John M. Blondin[1]
[1]North Carolina State University.

202.02 **Scientific Computation and Astrophysical Gas Dynamics**
James M. Stone[1]
[1]Princeton University.

202.03 **Computational Astrophysics reaches its Third Age: From Star Formation to the Death of the Sun**.
Adam Frank[1]
[1]University of Rochester.

203: Panel on Choosing a Keypad System
AAPT Panel, 2:00-3:30pm, 303

The panelists will present different perspectives concerning the choice and effective use of wireless keypads. These viewpoints describe the wide range of applications for keypads, from their use in small high school classes to large university lectures. Panelists: C. Fred Moore, Univ. of Texas, Austin, TX; Tim Stelzer, Univ. of Illinoois, Urbana, IL; and Paul Williams, Austin Comm. College, Austin, TX
Chair
Ray Burnstein[1]
[1]Illinois Institute of Technology.
Chair
Leon M. Lederman[1]
[1]Illinois Institute of Technology.

204: University Supervisors and Cooperating Teachers: Their Critical Roles for Student Teaching
AAPT Special, 2:00-3:40pm, 310
Chair
Stamatis Vokos[1]
[1]Seattle Pacific University.

204.01 **Field Experiences for Prospective Physics Teachers***
Ingrid Novodvorsky[1]
[1]University of Arizona.

204.02 **Essential Support Systems for Emerging Physics Teachers**
Sally Luttrell-Montes[1]
[1]University of Washington.

204.03 **Teachers in Residence: University Supervisors, Cooperating Teachers, and In-Service Mentors**
Michael D. Wolter, Mr.[1]
[1]Muncie Central HS.

204.04 **A Student Teacher Effectiveness Review System**
Carl J. Wenning[1]
[1]Illinois State University.

205: Implementing Reform Instruction
AAPT Oral, 2:00-3:30pm, 307-08
Chair
Ann Brandon[1]
[1]Joliet West HS.

205.01 **Promoting Instructional Change: Beyond an Emphasis Curriculum**
Charles Henderson[1], M. H. Dancy[2], A. Beach[1]
[1]Western Michigan University, [2]University of North Carolina at Charlotte.

205.02 **Replicating Reforms in a Large-scale Lecture Environment**
Noah Finkelstein[1], S. Pollock[1]
[1]University of Colorado at Boulder.

205.03 **Implementation and Results of a Learning Assistant Program**
Thomas B. Bogue[1], L. Seeley[1], S. Vokos[1]
[1]Seattle Pacific University.

205.04 **Understanding Graduate Teaching Assistants as Tutorial Instructors**
Rachel E. Scherr[1], A. Elby[1]
[1]University of Maryland.

205.05 **Graduate TAs as Tutorial Instructors: A Case Study**
Renee Michelle Goertzen[1], R. E. Scherr[1], A. Elby[1]
[1]University of Maryland.

205.06 **Teaching AP Physics with the Activity Based Physics CD**
Maxine C. Willis[1]
[1]Dickinson College.

205.07 **Adventures in Studio Physics**
Sarah D. Johnson[1], N. Alberding[1]
[1]Simon Fraser University, Canada.

205.08 **Tracking and Analyzing Student Writing in Physics by Inquiry**
Dedra Demaree[1], G. Aubrecht[2], L. Bao[2], W. Zhao[2]
[1]College of the Holy Cross, [2]The Ohio State University.

205.09 **Student Evaluation Differences between Diffrent Physics by Inquiry Courses**
Gordon J. Aubrecht, II[1]
[1]Ohio State University at Marion.

206: Stardust Mission
Plenary, 3:40-4:30pm, Ballroom 6

206.01 **The Return of Stardust**
Andrew J. Westphal[1]
[1]UC, Berkeley.

207: Richtmyer Memorial Lecture
Plenary, 4:40-5:30pm, Ballroom 6

Chair
Richard Peterson[1]
[1]Bethel Univ..

207.01 **Evidence from Type Ia Supernovae for an Accelerating Universe and Dark Energy**
Alexei V. Filippenko[1]
[1]University of California, Berkeley.

Herschel: The Coming of Observing Opportunities
AAS Splinter Meeting, 7:00-9:30pm, 605-07

The NASA Herschel Science Center is hosting this session to provide up to date information on the capabilities and status of Herschel, the 4th Cornerstone Mission of the European Space Agency, with NASA participation. The first announcement of opportunity for Herschel

observing proposals -- Key Programs -- will be issued soon. This opportunity will be discussed, as will the role of the NASA Herschel Science Center for US-based investigators, including data analysis funding for successful proposals.
Chair
William B. Latter[1]
[1]IPAC/Caltech.

WEDNESDAY

Speaker Ready Room
Attendee Services, Wednesday, 7:30am-4:00pm, 603-04

See Saturday's listing for AV instructions.
Chair
Rick Matthews[1]
[1]American Audio Video.

Registration
Attendee Services, 8:00am-2:00pm, South Lobby

Cyber Café
Attendee Services, 8:00am-3:30pm, South Lobby

See Sunday's listing for details.

208: Rossi Prize Lecture
Plenary, 8:30-9:20am, Ballroom 6

208.01 **Spin and Magnetic Evolution of Millisecond Pulsars in X-Ray Binaries**
Deepto Chakrabarty[1]
[1]MIT.

208.02 **Burst Oscillations: A New Spin on Neutron Stars**
Tod E. Strohmayer[1]
[1]NASA's GSFC.

208.03 **Accreting Millisecond Pulsars An Overview of Recent Developments**
Rudy Wijnands[1]
[1]University of Amsterdam, The Netherlands.

209: Poster Session IV
AAPT Poster, 9:20am-4:00pm, Exhibit Hall 4

209.01 **Reasoning Ability and Epistemological Attitudes as Predictors of Success**
Elizabeth B. Etters[1], O. Tfeily[1], M. Dancy[1]
[1]UNC-Charlotte.

209.02 **Optical Limiting in Solid-Core Holey Fibers**
Stacey R. Sueoka, Ms.[1], J. Butler[1], S. Montgomery[2], J. Shirk[3], S. Flom[3], R. Pong[3], B. Wright[3], T. Tauney[3], A. Rosenberg[3], C. Menyuk[4], J. Hu[4]
[1]Pacific University, [2]United States Naval Academy, [3]Naval Research Lab, [4]University of Maryland.

209.03 **Is Fresnel Diffraction a Unified Diffraction Model‘**
Mark P. Neyer[1], H. Schmitzer[1]
[1]Xavier University.

209.04 **Repeatability and Precision of Laser Diffraction Measurements of Small Objects**
Scott C. Dudley[1], R. Mudry[1]
[1]USAF Academy.

209.05 **Applying Archimedes' Law to Ice Melting in Sea Water**
Peter D. Noerdlinger[1], K. R. Brower[2]
[1]St Mary's University, Halifax, NS Canada, [2]New Mexico Institute of Technology.

209.06 **Spherical Rare Earth Magnets And The Dipole-Dipole Interaction**
Al J. Adams[1]
[1]University Arkansas Little Rock.

209.07 **The Effects of Magnetic Fields on Cooling Fans**
Raphael G. Cherney[1]
[1]Brownell-Talbot School.

209.08 **Using SAT scores to identify students at risk in introductory physics**
Vincent P. Coletta[1], J. Phillips[1]
[1]Loyola Marymount University.

209.09 **A Methodology for Developing Diagnostic Concept Inventories**
Rebecca Lindell[1]
[1]Southern Illinois University Edwardsville.

209.10 **A Classification Scheme for Categorizing Different Concept Inventories**
Rebecca Lindell[1], T. Foster[1]
[1]Southern Illinois University Edwardsville.

209.11 **Student Perceptions of Science Ability, Experiences, Expectations, and Career Choices**
Michael Cherney[1], I. Cherney[1]
[1]Creighton University.

209.12 **"Is Entropy conserved?" Student Understanding of Entropy in Introductory Physics**
Warren M. Christensen[1], D. E. Meltzer[2]
[1]Iowa State University, [2]University of Washington.

209.13 **Sensemaking: Conceptualizing and Coding for "Good" Student Reasoning**
Andrew Elby[1], R. Scherr[1], T. Bing[1]
[1]University of Maryland.

209.14 **Modeling Student Thinking about Motion in Tutorial**
Brian W. Frank[1], R. E. Scherr[1]
[1]University of Maryland.

209.15 **Keeping a Good Things Going: What does sustaining reforms in physics mean?**
Noah D. Finkelstein[1], S. Pollock[1]
[1]University of Colorado at Boulder.

209.16 **Graduate TAs as Tutorial Instructors: A Case Study**
Renee Michelle Goertzen[1], R. E. Scherr[1], A. Elby[1]
[1]*University of Maryland.*

209.17 **The Epistemological Development of Physics Majors**
Elizabeth Gire[1], E. Price[2], B. Jones[1]
[1]*University of California, San Diego,* [2]*California State University, San Marcos.*

209.18 **Concepts Retention and Its Dependence on the Type of Instruction**
Hugo Alarcon[1], J. J. Velarde-Magana[2], G. Zavala[1]
[1]*Tecnológico de Monterrey, Mexico,* [2]*Tecnologico de Monterrey, Mexico.*

209.19 **Group Problem Solving as a Zone of Proximal Development activity**
Eric Brewe[1]
[1]*Hawaii Pacific University.*

209.20 **Student Estimates of Probability and Uncertainty in Statistical Physics**
Donald B. Mountcastle[1], B. R. Bucy[1], J. R. Thompson[1]
[1]*University of Maine.*

209.21 **Swoosing: Why and When does it Occur in a Physics Class?**
Valerie K. Otero[1], S. Jalovec[1], I. Her Many Horses[1], D. Harlow[1]
[1]*University of Colorado, Boulder.*

209.22 **Proportional Reasoning: A Valid Instrument to Survey Understanding**
Cheryl P. Schaefer[1]
[1]*Missouri State University.*

209.23 **Stabilization: A Descriptive Framework for Problem Solving**
Sherry L. Savrda[1]
[1]*Seminole Community College.*

209.24 **The Background of PER People: A Survey**
Laura McCullough[1]
[1]*University of Wisconsin-Stout.*

209.25 **What Gets Swept Under the Rug in Teaching Quantum Tunneling**
S. B. McKagan[1], K. K. Perkins[1], C. E. Wieman[1]
[1]*University of Colorado.*

210: Space-Based Instrumentation II
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

210.01 **Status of the James Webb Space Telescope (JWST)**
Mark Clampin[1], C. Bowers[1], L. Feinberg[1], JWST Project
[1]*NASA's GSFC.*

210.02 **JWST Mirror Building Paradigms at Tinsley, Part 3**
Anthony B. Hull[1], J. Kincade[1], G. Cole[1], R. Garfield[1], R. Bernier[1], C. Kiikka[1], J. Daniel[1], R. Brown[2], B. Gallagher[2], D. Chaney[2], A. McKay[3], D. Neal[4], L. Cohen[5]
[1]*L-3 Communications, Tinsley,* [2]*BATC,* [3]*NGST,* [4]*WFSI,* [5]*SAO.*

210.03 **Status of Wavefront Sensing and Control of the James Webb Space Telescope**
Charles W. Bowers[1], S. Acton[2], A. Contos[2], B. Dean[1], L. Feinberg[1], B. Hayden[1], D. Shields[2]
[1]*NASA's GSFC,* [2]*BATC.*

210.04 **Progress on NIRCam, the Near-Infrared Camera for JWST**
Marcia J. Rieke[1], S. Horner[2], D. Kelly[1], J. Stansberry[1], E. Young[1], D. Eisenstein[1], D. McCarthy[1], M. Meyer[1], G. Rieke[1], S. Baum[3], C. Beichman[4], R. Doyon[5], A. Dressler[6], L. Ferrarese[7], T. Greene[8], D. Hall[9], K. Hodapp[9], D. Johnstone[7], S. Lilly[10], P. Martin[11], T. Roellig[8], J. Stauffer[12], J. Trauger[4]
[1]Univ. of Arizona, [2]Lockheed Martin Advanced Technology Center, [3]Rochester Institute of Techonolgy, [4]JPL, [5]Universite de Montreal, Canada, [6]Carnegie Observatories, [7]HIA/DAO, Canada, [8]NASA/ARC, [9]Univ. of Hawaii, [10]ETH, Switzerland, [11]Univ. of Toronto, Canada, [12]Spitzer Science Center.

210.05 **Detectors for the James Webb Space Telescope Near Infrared Spectrograph: Test Performance and Calibration Studies**
Bernard J. Rauscher[1]
[1]NASA Goddard Space Flight Center.

210.06 **Building the Mid-Infrared Instrument for JWST**
George Rieke[1], G. S. Wright[2], MIRI Science Team
[1]Univ. of Arizona, [2]Royal Observatory, United Kingdom.

210.07 **How can the James Webb Space Telescope measure First Light, Reionization, and Galaxy Assembly?**
Rogier A. Windhorst[1], R. A. Jansen[1], S. H. Cohen[1], M. Mechtley[1], H. Yan[2], C. Conselice[3]
[1]Arizona State Univ., [2]Carnegie Observatories, [3]University of Nottingham, United Kingdom.

210.08 **Optimization of the Kepler Field of View**
Natalie M. Batalha[1], W. Borucki[2], D. A. Caldwell[3], H. Chandrasekaran[3], T. N. Gautier[4], J. Jenkins[3], D. G. Koch[2]
[1]San Jose State University, [2]NASA Ames Research Center, [3]SETI Institute, [4]Jet Propulsion Laboratory.

210.09 **Photometric Analysis for the Kepler Mission: Optimal Aperture Photometry and Difference Image Analysis**
Jon M. Jenkins[1], R. L. Gilliland[2], H. Chandrasekaran[1], S. T. Bryson[3], D. A. Caldwell[1], W. J. Borucki[3]
[1]SETI Institute, [2]Space Telescope Science Institute, [3]NASA Ames Research Center.

210.10 **Simulating Kepler Data: the End-To-End Model of the Kepler Photometer**
Stephen T. Bryson[1], J. M. Jenkins[2], D. J. Peters[3], W. J. Borucki[1]
[1]NASA Ames Research Center, [2]SETI Institute, [3]Ball Aerospace.

210.11 **First Photometric Performance Results of the Kepler Single String Focal Plane**
David G. Koch[1], W. Borucki[1], E. Dunham[2], J. Geary[3], J. Jenkins[4], V. Argabright[5], R. Bauer[5], C. Dumont[5], S. McArthur[5], D. Peters[5], R. Philbrick[5], A. Rudeen[5], J. VanCleve[5], F. Witteborn[6]
[1]NASA/Ames Research Center, [2]Lowell Observatory, [3]Smithsonian Astrophysical Observatory, [4]SETI Institute, [5]Ball Aerospace, [6]Orbital Sciences Corp.

210.12 **Quick Look Software for the Kepler Photometer**
Kenneth Topka[1], J. Jenkins[1], D. Caldwell[1], W. J. Borucki[2]
[1]SETI Institute, [2]NASA Ames Research Center.

210.13 **Validation of Kepler Planet Candidates**
Douglas A. Caldwell[1], N. M. Batalha[2], W. J. Borucki[3], D. G. Koch[3], H. Chandrasekaran[1], J. M. Jenkins[1], K. P. Topka[1], T. N. Gautier[4], R. L. Gilliland[5]
[1]SETI Institute, [2]San Jose State University, [3]NASA Ames Research Center, [4]JPL, [5]Space Telescope Science Institute.

210.15 **Carbon Star Science with SIM**
Guy Worthey[1]
[1]Washington State University.

211: Studying Galaxy Evolution with Nearby Galaxies
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

211.01 **Numerical Simulations of Major Barred Galaxies**
Chien-Chang Yen[1], L. Lin[2], C. Yuan[1]
[1]Inst. of Astronomy & Astrophysics, Taiwan, [2]Dept. of Physics, National Taiwan University, Taiwan.

211.02 **The Carnegie-Irvine Nearby Galaxies Survey (CINGS): Surface Brightness Profiles, Color Profiles and 1-D Decompositions**
Marc Seigar[1], L. C. Ho[2], A. J. Barth[1], C. Y. Peng[3]
[1]UC, Irvine, [2]OCIW, [3]STScI.

211.03 **The Angular Momentum of Disk Galaxies: A Multi-Wavelength Study Using the Virtual Observatory**
Luca Cortese[1], B. Catinella[2], C. M. Springob[3]
[1]Cardiff University, United Kingdom, [2]NAIC-Arecibo Observatory, [3]US Naval Research Laboratory.

211.04 **Tests of the Modified Tremaine-Weinberg Method**
Sharon Meidt[1], R. J. Rand[1], M. R. Merrifield[2], V. P. Debattista[3], J. Shen[4]
[1]Univ. of New Mexico, [2]Univ. of Nottingham, United Kingdom, [3]Univ. of Washington, [4]Univ. of Texas.

211.05 **A New Method for Detecting Stellar Streams in the Halos of Galaxies**
Jonathan Sick[1], R. S. de Jong[2]
[1]Rice University, [2]Space Telescope Science Institute.

211.06 **Characterizing Disk Truncations with N-Body Simulations**
Rok Roskar[1], V. P. Debattista[1], G. S. Stinson[1], T. R. Quinn[1], T. Kaufmann[2], J. Wadsley[3]
[1]Univ. of Washington, [2]University of California, Irvine, [3]McMaster University, Canada.

211.07 **A Detailed Look at 13 of the Nearest E+A Galaxies**
James E. Turner[1], M. P. Bergmann[1], W. J. Couch[2], C. Blake[2], K. Gebhardt[3], K. Bekki[4], B. W. Miller[1]
[1]Gemini Observatory, Chile, [2]Swinburne University of Technology, Australia, [3]University of Texas at Austin, [4]University of New South Wales, Australia.

211.08 **Modes of Star Formation in an Early Universe Laboratory: HST/ACS Imaging of Hickson Compact Group 31**
Joshua Tobolewski[1], S. C. Gallagher[2], R. Chandar[3], C. Gronwall[1], J. English[4], K. E. Johnson[5], P. R. Durrell[6], J. E. Hibbard[7], C. Mendes de Oliveira[8], B. C. Whitmore[9], J. C. Charlton[1]
[1]Penn State Univ., [2]UCLA, [3]OCIW, [4]U. Manitoba, Canada, [5]Univ. of Virginia, [6]Youngstown State Univ., [7]NRAO, [8]Univ. of Sao Paulo, Brazil, [9]STScI.

211.09 **Analysis of Star Formation in Closely Interacting Galaxy Pairs**
Jacob Arnold[1], E. J. Barton[1]
[1]University of California, Irvine.

211.10 **Modes of Star Formation in an Early Universe Laboratory: HST/ACS Imaging of Hickson Compact Group 7**
Patrick Durrell[1], S. C. Gallagher[2], C. Gronwall[3], J. English[4], R. Chandar[5], K. E. Johnson[6], J. E. Hibbard[7], A. L. Heiderman[8], B. C. Whitmore[9], J. C. Charlton[3]
[1]Youngstown State Univ., [2]UCLA, [3]Penn State Univ., [4]Univ. of Manitoba, Canada, [5]OCIW, [6]Univ. of Virginia, [7]NRAO, [8]Univ. of Texas, [9]STScI.

211.11 **Where in the Virgo Cluster are Galaxies Stripped?**
Hugh H. Crowl[1], J. D. Kenney[1], J. H. vanGorkom[2], A. Chung[3], J. A. Rose[4]
[1]Yale University, [2]Columbia University, [3]University of Massachusetts, [4]University of North Carolina.

211.12 **Deep X-ray (and Multiwavelength) Survey of the Coma Cluster of Galaxies**
Ann E. Hornschemeier[1], B. Mobasher[2], L. P. Jenkins[1], N. A. Miller[3], C. A. Kilbourne[1], M. W. Bautz[4], D. M. Hammer[3]
[1]NASA GSFC, [2]STScI, [3]Johns Hopkins University, [4]MIT.

211.13 **Grism Selected Emission Line Galaxies in the Field Of Abell 1689**
Gerhardt R. Meurer[1], N. Benítez[2], D. Coe[1], J. M. Vilchez[2], B. L. Frye[3], H. C. Ford[1], G. D. Illingworth[4], C. Gronwall[5], ACS ScienceTeam
[1]Johns Hopkins Univ., [2]Instituto de Astrofísica de Andalucía, Spain, [3]Dublin City University, Ireland, [4]University of California Santa Cruz, [5]Pennsylvania State University.

211.14 **A UV-NIR Photometric Comparison of Simulated and Observed Cluster Galaxies**
Cameron B. Hummels[1], D. Schiminovich[1], G. Bryan[1], GALEX Science Team
[1]Columbia Univ.

212: Gamma-Ray Bursts
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

212.01 **Multi-wavelength Study of Prompt Optical Counterparts of Swift GRBs Detected by ROTSE-III**
Eli S. Rykoff[1], F. Aharonian[2], C. Akerlof[1], M. C. Ashley[3], S. Barthelmy[4], N. Gehrels[4], E. Gogus[5], T. Guver[6], D. Horns[2], U. Kiziloglu[7], H. Krimm[4], T. A. McKay[1], M. Ozel[8], A. Phillips[3], R. Quimby[9], G. Rowell[10], W. Rujokaparn[11], B. Schaefer[12], D. A. Smith[13], H. Swan[1], W. T. Vestrand[14], J. C. Wheeler[9], J. Wren[14], S. A. Yost[1], F. Yuan[1]
[1]Univ. of Michigan, [2]MPIK, Germany, [3]UNSW, Australia, [4]GSFC, [5]Sabanci U., Turkey, [6]Univ. of Istanbul, Turkey, [7]METU, Turkey, [8]COMU, Turkey, [9]Univ. of Texas, [10]Univ. of Adelaide, Australia, [11]Univ. of Arizona, [12]LSU, [13]Guilford College, [14]LANL.

212.02 **The Diverse eV Emission from Gamma-ray Bursts**
Sarah Yost[1], F. Aharonian[2], C. Akerlof[1], M. Ashley[3], S. Barthelmy[4], N. Gehrels[4], E. Gogus[5], T. Guver[6], D. Horns[2], U. Kiziloglu[7], H. Krimm[4], T. McKay[1], M. Ozel[8], A. Phillips[3], R. Quimby[9], G. Rowell[2], W. Rujopakarn[1], E. Rykoff[1], B. Schaefer[10], D. Smith[11], H. Swan[1], W. Vestrand[12], C. Wheeler[9], J. Wren[12], F. Yuan[1]
[1]Univ. of Michigan, [2]Max-Planck-Institut fur Kernphysik, Germany, [3]Univ. of New South Wales, Australia, [4]Goddard, [5]Sabanci University, Turkey, [6]Univ. of Istanbul, Turkey, [7]METU, Turkey, [8]Canakkale University, Turkey, [9]Univ. of Texas, [10]Louisiana State University, [11]Guilford College, [12]LANL.

212.03 **Temporal and Angular Properties of GRB Jets Emerging from Massive Stars**
Brian J. Morsony[1], D. Lazzati[1], M. C. Begelman[1]
[1]University of Colorado, Boulder.

212.04 **An Estimation Of The Gamma-Ray Burst Afterglow Apparent Optical Luminosity Distribution Function**
Carl W. Akerlof[1], H. F. Swan[1]
[1]Univ. of Michigan.

212.05 **A Search for Short Timescale Structure in GRB041223**
Stephanie L. Fiorenza[1], E. E. Fenimore[2], M. Galassi[2], B. Norman[2]
[1]Pennsylvania State University, [2]Los Alamos National Lab.

212.06 **Probing the Early Universe with GRBs**
Adria C. Updike[1], D. H. Hartmann[1], J. R. King[1], S. D. Brittain[1]
[1]Clemson University.

212.07 **GRB Photometric Redshifts and Spectral Slopes From the Swift UVOT**
Daniel Vanden Berk[1], Swift UVOT Team
[1]Pennsylvania State Univ..

212.08 **New Catalog of Astrometry Corrected Swift XRT GRB X-ray Afterglow Positions**
Judith L. Racusin[1], D. N. Burrows[1], Swift XRT team
[1]Penn State University.

212.09 **Using Interplanetary Network Data to Search for Hypernova/GRB Coincidences**
Kevin C. Hurley[1], E. Pian[2]
[1]UC, Berkeley, [2]INAF, Italy.

213: How To ... Resources for Scientist Educators
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

213.02 **SABER: The Searchable Annotated Bibliography of Education Research in Astronomy**
David H. Bruning[1], J. M. Bailey[2], G. Brissenden[3]
[1]Univ. of Wisconsin-Parkside, [2]Univ. of Nevada, Las Vegas, [3]Univ. of Arizona.

213.03 **Edplum: A Wikipedia-Style Resource for Educators**
David M. Rothstein[1]
[1]Cornell Univ..

213.04 **Best Practices for Modifying Astronomy Curriculum for Special Needs Students**
Julia K. Olsen[1], T. F. Slater[1]
[1]University of Arizona.

213.05 **Resources and Issues to Consider for Astronomers Who Wish to Work with Out-of-School Time Organizations and Programs**
Julie H. Lutz[1], D. Powell[2], J. Frieling[3]
[1]Univ. of Washington, [2]University of Washington, [3]School's Out Washington.

213.06 **Adapting Formal Education Materials for Out-of-School Settings**
Denise A. Smith[1], H. Gibbons[2]
[1]STScI, [2]Pacific Science Center.

214: It's All About Clear Skies
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

214.01 **Controlling Light Pollution in Chile A Status Report.**
Malcolm G. Smith[1], P. Sanhueza[2], H. E. Schwarz[1], A. R. Walker[1]
[1]Cerro Tololo Inter-Amer. Obs., Chile, [2]OPCC, Chile.

214.02 **Willingness to Pay for a Clear Night Sky: Use of the Contingent Valuation Method**
Stephanie Simpson[1], J. Winebrake[1], J. Noel-Storr[1]
[1]Rochester Inst. of Technology.

215: Optical Cluster Finding
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

215.01 **Scatter in the Richness-Velocity Dispersion Relation for SDSS Galaxy Clusters**
Matthew R. Becker[1]
[1]University of Michigan.

215.02 **Optical Galaxy Cluster Detection in SDSS DR5**
Wayne Barkhouse[1], T. Hacker[2], J. Song[1], J. J. Mohr[1]
[1]Univ. of Illinois, [2]USAF Academy.

215.03 **Improving Galaxy Cluster Photometric Redshifts**
Huan Lin[1], M. Lima[2], H. Oyaizu[2], C. Cunha[2], J. Frieman[3], J. Annis[1], B. Koester[4], J. Hao[4], T. McKay[4], E. Sheldon[5]
[1]Fermilab, [2]University of Chicago, [3]Fermilab/U. Chicago, [4]University of Michigan, [5]NYU.

215.04 **Selection Effects in Galaxy Cluster Surveys: What Do We Learn from Observed Scaling Relations?**
Brian D. Nord[1], A. E. Evrard[1]
[1]University of Michigan.

215.05 **Luminosity and Color Distributions of Galaxies in Clusters and Groups in the SDSS**
Sarah M. Hansen[1], E. S. Sheldon[2], R. H. Wechsler[3], M. Masjedi[2]
[1]Univ. of Chicago, [2]New York University, [3]Stanford.

215.06 **Galaxy Cluster Correlation Function in the Dark Energy Survey**
Juan Estrada[1], A. Plazas[2], Fermilab Galaxy Cluster Group
[1]Fermilab, [2]Universidad de Los Andes, Colombia.

215.07 **A Systematic Search for High Surface Brightness Giant Arcs in a Sloan Digital Sky Survey Cluster Sample**
Victor Scarpine[1], S. Allam[1], J. Annis[1], T. Diehl[1], J. Estrada[1], P. Hall[2], T. Las[1], H. Lin[1], M. Makler[3], W. Merritt[1], D. Tucker[1], D. McGinnis[1], J. Kubo[1], D. Kubik[4]
[1]Fermi National Accelerator Laboratory, [2]York University, Canada, [3]Centro Brasileiro de Pesquisas Fisicas, Brazil, [4]Northern Illinois University.

215.08 **Red Sequence Cluster Finding in the Millennium Simulation**
August E. Evrard[1], D. Croton[2], M. White[2], J. Cohn[2], E. Ellingson[3]
[1]Univ. of Michigan, [2]Univ. of California, Berkeley, [3]Univ. of Colorado.

215.09 **The SDSS Southern Survey Coadd Data**
James T. Annis[1], H. Lin[1], G. Miknaitis[1], R. Lupton[2], M. Strauss[2], J. Gunn[2], L. Jiang[3], X. Fan[3], A. Becker[4]
[1]Fermi National Accelerator Lab., [2]Princeton University, [3]University of Arizona, [4]University of Washington.

216: Modelling Variable and Binary Stars
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

216.01 **Light Curves and Spot Modelling for V471 Tauri**
Valmin J. Miranda[1], T. Vaccaro[1]
[1]Florida Institute of Technology.

216.02 **Polaris' Pulsational Mass**
Siobahn Morgan[1]
[1]Univ. of Northern Iowa.

216.03 **Modeling the Stellar Evolution of V725 Sgr**
Holly M. Kagy[1], S. M. Morgan[1]
[1]University of Northern Iowa.

216.04 **Angular Momentum Transport in Double White Dwarf Binaries**
Patrick M. Motl[1], J. E. Tohline[1], J. Frank[1]
[1]Louisiana State University.

216.05 **A Pulsational Study of V823 Cas**
Jennifer N. Wahl[1], S. M. Morgan[1]
[1]University of Northern Iowa.

216.06 **How Do Starspots Affect Light Curves of Contact Binary Stars?**
Robert L. Hill[1]
[1]Ball State University.

216.07 **Extending the Model of KH 15D**
Devin W. Silvia[1], E. Agol[1]
[1]University of Washington.

217: Starbursts & Interacting Galaxies
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

217.01 **The Extended Environments of ULIRGS and LIRGS: Clusters in Formation**
Edward A. Laag[1]
[1]UC, Riverside.

217.02 **The Nature of the Densest Gas in Nearby Starbursts**
David S. Meier[1], J. L. Turner[2]
[1]Jansky Fellow; National Radio Astronomy Observatory, [2]Dept. of Physics & Astronomy, UCLA.

217.03 **The Radio Continuum, Far-infrared Emission, and Dense Molecular Gas in Star-forming Galaxies**
Fan Liu[1], Y. Gao[1]
[1]Purple Mountain Observatory, China.

217.04 **IRS Spectroscopy of Collisional Ring Galaxies**
Philip N. Appleton[1], P. Beirao[2], L. Armus[3], B. Brandl[2], V. Charmandaris[4], T. Jarrett[3], S. Lord[1], B. Madore[5], J. Mazzarella[6], W. T. Reach[6], M. Seibert[5], B. J. Smith[7], C. Struck[8]
[1]NHSC-Caltech, [2]Leiden University, Netherlands Antilles, [3]SSC-Caltech, [4]Crete University, Greece, [5]OCIW, [6]IPAC-Caltech, [7]ETSU, [8]ISU.

217.05 **A Radio Spectral Line Study of the 2-Jy IRAS-NVSS Sample**
Maria Ximena Fernandez[1], E. Momjian[2], T. Ghosh[2], C. J. Salter[2]
[1]Vassar College, [2]NAIC.

217.06 **An Optical Datacube of Seyfert/Starburst Composite Galaxy NGC1365**
Katie M. Chynoweth[1], R. A. Knop, Jr.[1], R. A. Gibbons[1]
[1]Vanderbilt Univ..

218: The 3Ts: Telescopes, Technologies and Techniques for Astronomy Education
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

218.01 **A Labview-controlled Small Radio Telescope**
Robert L. Mutel[1], T. Jaeger[1], V. Poole[2]
[1]Univ. of Iowa, [2]Truman State University.

218.02 **GNAT Educational Opportunities**
Roger B. Culver[1], E. R. Craine[2]
[1]Colorado State Univ./GNAT, [2]Western Research Company/GNAT.

218.03 **Las Cumbres Observatory Global Telescope Network: Keeping Education in the Dark**
Rachel J. Ross[1], W. Geibink[1], W. E. Rosing[1], T. M. Brown[1]
[1]Las Cumbres Observatory.

218.04 **The Little Thompson Observatory Receives the Retired Mt. Wilson 24-inch Telescope**
Andrea E. Schweitzer[1]
[1]Little Thompson Obs..

218.05 **NIRo Telescope: Research and Education**
Adam W. Rengstorf[1], S. Slavin[1]
[1]Purdue University Calumet.

218.06 **Improved Undergraduate Astronomy Laboratories with A Modern Telescope Control System**
Anthony J. Milano[1], D. Broder[2], R. Finn[2], H. Newberg[1], A. Weatherwax[2], D. Whittet[1]
[1]Rensselaer Polytechnic Institute, [2]Siena College.

218.07 **The MTSU Uranidrome: A Naked-Eye Observatory for Teaching Astronomy and Geometry**
Eric W. Klumpe[1]
[1]Middle Tennessee State University.

218.08 **New Searching Capability and OpenURL Linking in the ADS**
Guenther Eichhorn[1], A. Accomazzi[1], C. S. Grant[1], E. Henneken[1], M. J. Kurtz[1], D. M. Thompson[1], S. S. Murray[1]
[1]SAO.

218.09 **The New Physics and Astronomy Education Portal of the Smithsonian/NASA Astrophysics Data System**
Michael J. Kurtz[1], G. Eichhorn[1], A. Accomazzi[1], C. Grant[1], E. Henneken[1], D. Thompson[1], E. Bohlen[1], S. S. Murray[1]
[1]Harvard-Smithsonian, CfA.

218.10 **Sharing Images Intelligently: The Astronomical Visualization Metadata Standard**
Robert L. Hurt[1], L. Christensen[2], A. Gauthier[3]
[1]Spitzer Science Center/Caltech, [2]ESA/Hubble, Germany, [3]University of Arizona.

218.11 **Ensuring Quality of Digital Library Learning Objects for Computational Physics and Astronomy Education**
David A. Joiner[1]
[1]Kean Univ..

218.12 **Appreciating Hubble at Hyper-speed: A Web-tool for Students and Teachers**
Lisa M. Will[1], M. Mechtley[2], S. Cohen[2], R. A. Windhorst[2], S. Malhotra[2], J. Rhoads[2], N. Pirzkal[3], F. Summers[3]
[1]Mesa Community College, [2]Arizona State University, [3]Space Telecope Science Institute.

218.13 **Use Authentic Digital Sky Data to Investigate Earth's Motions**
Rick Kang[1]
[1]Friends of Pine Mountain Obs..

218.14 **Hera: Using NASA Astronomy Data in the Classroom**
James C. Lochner[1], S. Mitchell[2], W. D. Pence[3]
[1]USRA & NASA/GSFC, [2]SP Systems & NASA/GSFC, [3]NASA/GSFC.

218.15 **Spitzer Space Telescope Research Program for Teachers and Students: Using Spitzer data in *your* classroom with (relatively) simple software**
Theresa E. Roelofsen Moody[1], J. J. Feldmeier[2], V. Gorjian[3], B. Sepulveda[4], E. Sharma[4], T. Spuck[5], C. Weehler[6]
[1]New Jersey Astronomy Center for Education, [2]YSU, [3]JPL/Spitzer Science Center, [4]Lincoln High School, [5]Oil City Area Senior High School, [6]Luther Burbank High School.

218.16 **MPS Internships in Public Science Education: Sensing the Radio Sky**
Melvin Blake[1], M. W. Castelaz[1], D. Moffett[2], L. Walsh[3], M. LaFratta[3]
[1]Pisgah Astronomical Research Institute., [2]Furman University, [3]University of North Carolina-Asheville.

219: YSO / Star Formation III
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

219.01 **Young Spectroscopic Binary M Stars in Ophiuchus**
Lisa A. Prato[1]
[1]Lowell Observatory.

219.02 **Keck HiRES Spectroscopy of Candidate Post T Tauri Stars**
Eric J. Bubar[1], J. King[1], D. Soderblom[2], C. Deliyannis[3], R. Boone[1]
[1]Clemson Univ., [2]Space Telescope Science Institute, [3]Indiana University.

219.03 **Spitzer IR Sudy of Sar Formation in an Embedded Young Cluster NGC2316**
William Langer[1], T. Velusamy[1], T. Thompson[1]
[1]JPL/Caltech.

219.04 **SiO Masers in the Orion BN-KL Outflow**
Christopher Beaumont[1], S. S. Doeleman[2]
[1]Calvin College, [2]MIT Haystack Observatory.

219.05 **Infrared and Optical Spectroscopy of Protostars in the Elephant Trunk Nebula**
Dohy Faied[1], W. T. Reach[1], A. Tappe[1], J. Rho[1]
[1]Caltech.

219.06 **Statistical Analysis of the Relationship Between Rotation, Disks, and X-rays Among Low-Mass Pre-Main-Sequence Stars**
Keivan Stassun[1], D. Ardila[2], S. Matt[3], E. Feigelson[4]
[1]Vanderbilt Univ., [2]Spitzer Science Center, [3]University of Virginia, [4]Penn State Univ..

219.07 **Pure Rotational H2 Emission from GSS 30 IRS 1**
Matthew Richter[1], M. A. Bitner[2], J. H. Lacy[2], D. T. Jaffe[2], T. K. Greathouse[3], G. A. Blake[4], A. C. Boogert[5], J. S. Carr[6], T. Currie[7], U. Gorti[8], G. J. Herczeg[4], D. Hollenbach[9], S. J. Kenyon[7], C. Knez[10], F. Lahuis[11], J. Najita[12], S. Redfield[2]
[1]UC, Davis, [2]Univ of Texas, [3]Lunar and Planetary Institute, [4]California Institute of Technology, [5]NOAO Gemini Science Center, Chile, [6]Naval Research Lab, [7]Harvard-Smithsonian Center for Astrophysics, [8]Univ of California, [9]NASA-Ames, [10]Univ of Maryland, [11]SRON-Groningen, The Netherlands, [12]NOAO.

219.08 **Young Vega and Altair Analogs: Rotationally-Enhanced Activity in HD 169142 and HD 135344**
C. A. Grady[1], G. Schneider[2], K. Hamaguchi[3], M. Sitko[4], W. Carpenter[5], K. Collins[6], G. Williger[6], B. Woodgate[7], R. Petre[7], J. Nuth, III[7], D. Hines[8], T. Henning[9], A. Quirrenbach[9], F. Menard[10], D. Wilner[11]
[1]Eureka Scientific and GSFC, [2]U. of Arizona, [3]USRA and GSFC, [4]Space Sciences Institute and U. Cincinnati, [5]U. Cincinnati, [6]U. Louisville, [7]NASA's GSFC, [8]Space Sciences Institute, [9]MPIA, Germany, [10]Laboratoire d'Astrophysique de Grenoble, France, [11]CfA.

219.09 **The Spin of Accreting Stars and Accretion-Powered Stellar Winds**
Sean Matt[1], R. E. Pudritz[2]
[1]University of Virginia, [2]McMaster University, Canada.

219.10 **The Gould's Belt Spitzer Legacy Project**
Lori Allen[1], Gould's Belt Team
[1]Harvard-Smithsonian Center for Astrophysics.

219.11 **The Cores to Disks (c2d) Spitzer Legacy Program: Summary of Resultson Evolution in Five Large Clouds**
Neal J. Evans, II[1], c2d Team
[1]*Univ. of Texas.*

219.12 **Near-Infrared Spectroscopy of Young Binaries**
Mary A. Barsony[1], T. P. Greene[2], K. E. Haisch, Jr.[3]
[1]*San Francisco State Univ. & Space Science Institute,* [2]*NASA's Ames Research Center,* [3]*Utah Valley State College.*

219.13 **A Non-Magnetocentrifugal Jet Model for Young Stellar Objects**
Peter T. Williams[1]
[1]*M.O.I.O..*

219.14 **An Archive of Chandra Observations of Regions of Star Formation (ANCHORS)**
Bradley D. Spitzbart[1], S. J. Wolk[1]
[1]*Smithsonian Astrophysical Obs..*

219.15 **Star Formation in the Gum Nebula: Cometary Globules CG4/6/SA101**
Jinyoung S. Kim[1], F. M. Walter[2], S. J. Wolk[3], W. H. Sherry[4], M. Foster[1]
[1]*Univ. of Arizona,* [2]*Stony Brook University,* [3]*CfA,* [4]*NSO/NOAO.*

219.16 **Clustering around Herbig Ae/Be Stars**
Nicole S. Van Der Bliek[1], B. Rodgers[2], S. Thomas[3], G. Doppmann[2]
[1]*CTIO, Chile,* [2]*Gemini Observatory, Chile,* [3]*Lick Observatory.*

219.17 **MOMIE: MIKE Observations of Mid-Infrared Excesses**
Brian R. Uzpen[1], H. A. Kobulnicky[1], C. Thom[2], M. E. Putman[3]
[1]*Univ. of Wyoming,* [2]*University of Chicago,* [3]*Univ. Of Michigan.*

219.18 **Visible Spectra of the Central Stars of Proplyds in Orion**
Michael W. Castelaz[1], B. McCollum[2], F. W. Bruhweiler[3], M. W. Niedner[4], A. B. Schultz[4], C. Mickey[4], D. J. MacConnell[5]
[1]*Pisgah Astronomical Research Inst.,* [2]*Spitzer Science Center / IPAC / Caltech,* [3]*Catholic University of America,* [4]*NASA/GSFC,* [5]*CSC/STScI.*

219.19 **An X-ray Survey of FU Orionis Stars andUnusual X-ray Emission from Embedded YoungStars in NGC 2071**
Steve L. Skinner[1], A. E. Simmons[1], M. Audard[2], K. R. Briggs[3], M. Guedel[3], M. R. Meyer[4]
[1]*Univ. of Colorado,* [2]*Univ. of Geneva, Switzerland,* [3]*Paul Scherrer Inst., Switzerland,* [4]*Univ. of Arizona.*

219.20 **The Eagle Nebula: Pillars of Creation, EGGs, and PMS Stars in NGC 6611**
Jeffrey Linsky[1], M. Gagne[2], A. Mytyk[2], M. McCaughrean[3], M. Andersen[4]
[1]*JILA/Univ. of Colorado and NIST,* [2]*West Chester University,* [3]*University of Exeter, United Kingdom,* [4]*University of Arizona.*

219.21 **Outflows in the Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE)**
Douglas F. Watson[1], B. A. Whitney[2], M. Gomez[3], P. M. Denzmore[4], R. Indebetouw[5], M. Meade[1], B. Babler[1], E. Churchwell[1], GLIMPSE Team
[1]*University of Wisconsin-Madison, Dept. of Astronomy,* [2]*Space Science Institute,* [3]*Observatorio Astronomico, Universidad Nacional de Cordoba, Observatorio, Argentina,* [4]*Rice University, Physics and Astronomy Department,* [5]*University of Viriginia, Astronomy Dept..*

220: Fortune and Fame: Fellowships, Textbooks, Cartoons
AAS Poster, 9:20am-4:00pm, Exhibit Hall 4

220.01 **The Lowell Observatory Predoctoral Program**
Lisa A. Prato[1], W. M. Grundy[1]
[1]Lowell Observatory.

220.02 **The Textbook of the Future: What Will It Look Like?**
Harry L. Shipman[1], N. Finkelstein[2], D. McCray[3], M. Mac Low[4], D. Zollman[5]
[1]Univ. of Delaware, [2]University of Colorado, [3]Univ. of Colorado, [4]American Museum of Natural History, [5]Kansas State University.

220.03 **Eustace Tilley Views our Profession: The Astronomer as Portrayed in the Cartoons of** *The New Yorker* **Magazine**
Kenneth S. Rumstay[1]
[1]Valdosta State Univ..

Gadgets and Gizmos
Attendee Services, 9:20am-1:00pm, South Lobby

See Sunday's listing for details.
Chair
Susana E. Deustua[1]
[1]American Astronomical Society.

Job Center
Attendee Services, 9:20am-12:00pm, Exhibit Hall 4

221: Biology of Astrobiology I Extremes of Earth Life
AAS Special, 10:00-11:30am, 611-12

Chair
Sanjoy Som[1]
[1]University of Washington.
Chair
Woodruff T. Sullivan[1]
[1]Univ. of Washington.

221.01 **The Dark, Hot Biosphere on Earth and Elsewhere**
John Baross[1]
[1]UW School of Oceanography.

221.02 **Of Ice and Microbes**
Jody Deming[1]
[1]School of Oceanography.

222: Optical Cluster Finding: SDSS, RCS, DEEP
AAS Special, 10:00-11:30am, 613-14

Chair
Timothy A. McKay[1]
[1]University of Michigan.

222.01 **Photometrically Identified Clusters from the RCS**
Michael Gladders[1], RCS Collaboration
[1]University of Chicago.

222.02 **Optical Clusters from SDSS Imaging: The MaxBCG Cluster Catalog**
Ben Koester[1]
[1]*University of Michigan.*

222.03 **Groups and Clusters in DEEP2: The Evolution of Massive Halos and their Contents over 10 Gyr**
Brian Gerke[1]
[1]*UC-Berkeley.*

222.04 **Cluster Mass Profiles and Mass-to-light Ratios from Weak Lensing in the SDSS**
Erin Sheldon[1]
[1]*New York University.*

222.05 **Simulating Galaxy Populations in Clusters**
Risa H. Wechsler[1]
[1]*Stanford University.*

223: AGN General Properties and Relativistic Jet Acceleration.
AAS Oral, 10:00-11:30am, 6A

223.01 **Probing the Black Hole-Galaxy Connection with AGN Host Galaxy Morphologies**
Brooke Simmons[1], C. M. Urry[1], COSMOS Team
[1]*Yale Univ..*

223.02 **Refining the Radius-Luminosity Relationship for AGNs**
Misty C. Bentz[1], B. M. Peterson[1], R. W. Pogge[1]
[1]*Ohio State Univ..*

223.03 **Models of the Molecular Interstellar Medium in Starbursts and AGN from z=0-6**
Desika T. Narayanan[1], T. Cox[2], S. Chakrabarti[2], R. Dave[1], T. Di Matteo[3], B. Kelly[1], L. Hernquist[2], P. Hopkins[2], C. Kulesa[1], Y. Li[2], B. Robertson[4], C. Walker[1]
[1]*Univ. of Arizona,* [2]*CfA,* [3]*CMU,* [4]*KICP, University of Chicago.*

223.04 **The Black Hole Mass and Eddington Ratio Distributions of the 2QZ**
Christopher A. Onken[1], J. A. Kollmeier[2]
[1]*Herzberg Inst. of Astrophys., Canada,* [2]*OCIW & Princeton.*

223.05 **Radiation from Relativistic Poynting Jets and Collisionless Shocks**
Edison P. Liang[1], K. Noguchi[1], S. Sugiyama[2]
[1]*Rice Univ.,* [2]*Osaka University, Japan.*

223.06 **Local Electron Acceleration in GRB Shocks**
Mikhail Medvedev[1]
[1]*Univ. of Kansas.*

224: CMB Theory and 21 cm Cosmology
AAS Oral, 10:00-11:30am, 6B

224.01 **Probing the First Sources with the Redshifted 21 cm Line**
Jonathan R. Pritchard[1], S. R. Furlanetto[2], M. Kamionkowski[1]
[1]*Caltech,* [2]*Yale.*

224.02 **Revealing the Epoch of Reionization with Redshifted 21 cm Measurements**
Judd D. Bowman[1]
[1]*MIT.*

224.03 **Integrated Sachs-Wolfe Effect Tomography**
Shirley Ho[1], C. Hirata[2], N. Padmanabhan[3], U. Seljak[4]
[1]Princeton Univ., [2]Institute of Advanced Studies, [3]Lawrence Berkeley Lab/ UC Berkeley, [4]International Center for Theoretical Physics, Italy.

224.04 **Measurement of Gigaparsec-Scale Perturbation Modes with Remote Quadrupole Observations**
Emory F. Bunn[1]
[1]Univ. of Richmond.

224.05 **Sunyaev-Zeldovich effect from Active Galactic Nuclei**
Suchetana Chatterjee[1], A. Kosowsky[1]
[1]Univ. Of Pittsburgh.

224.06 **Improving the Cosmological Recombination Calculation**
Wan Yan Wong[1], D. Scott[1]
[1]Univ. Of British Columbia, Canada.

225: COSMOS and Other Surveys
AAS Oral, 10:00-11:30am, 605-07

225.01 **First Results from S-COSMOS: the Spitzer Legacy Survey of the HST-ACS 2sq.deg. Field**
David B. Sanders[1], M. Salvato[2], O. Ilbert[1], H. Aussel[3], J. Kartaltepe[1], J. Surace[4], D. Frayer[4], K. Sheth[4], N. Scoville[2], B. Bhattacharya[4], T. Brooke[2], G. Helou[2], L. Yan[4]
[1]Univ. of Hawaii, [2]Caltech, [3]CEA/Saclay, France, [4]SSC/Caltech.

225.02 **Large Structures and Galaxy Evolution in the COSMOS Survey**
Nicholas Scoville[1]
[1]Caltech.

225.03 **The Evolution of Bulges in COSMOS Spirals**
Kartik Sheth[1], L. Spalsbury[1], N. Scoville[1], COSMOS Collaboration
[1]Caltech.

225.04 **Morphology of z~0.7 Star-forming Galaxies from Deep GALEX Imaging of the COSMOS Field**
Michel A. Zamojski[1], D. Schiminovich[1], M. Rich[2], B. Mobasher[3], A. M. Koekemoer[3], P. Capak[4], GALEX Team, COSMOS Team
[1]Columbia Univ., [2]UCLA, [3]Space Telescope Science Institute, [4]Caltech.

225.05 **The X-ray Evolution of Early-Type Galaxies in the Extended Chandra Deep Field-South**
Bret Lehmer[1]
[1]Pennsylvania State University.

225.06 **Revealing the Star-formation History of the Universe up to z=2.5 from Deep Radio Surveys**
Nick Seymour[1], I. McHardy[2], M. Page[3], D. Moss[2], T. Dwelly[2]
[1]SSC/Caltech, [2]University of Southampton, United Kingdom, [3]UCL/MSSL, United Kingdom.

225.07 **The Nature of Lyman Alpha Emitters at z=3.1 in the MUSYC Survey**
Eric J. Gawiser[1], C. Gronwall[2], R. Ciardullo[2], H. Francke[3], P. G. van Dokkum[1], J. Feldmeier[4], C. M. Urry[1], MUSYC Collaboration
[1]Yale Univ., [2]Penn State, [3]U. de Chile, Chile, [4]Youngstown St..

225.08 **Cosmic Shear and its Redshift Evolution from the Deep Lens Survey**
Vera E. Margoniner[1], D. M. Wittman[1], D. Rusin[1], T. Tyson[1], I. P. Dell'Antonio[2]
[1]UC, Davis, [2]Brown University.

226: Extrasolar Planets II
AAS Oral, 10:00-11:30am, 608-10

226.01 **Results From the KELT Transit Survey**
Joshua Pepper[1]
[1]*The Ohio State University.*

226.02 **Detection and Exploration of Planets from the Trans-atlantic Exoplanet Survey**
Francis T. O'Donovan[1], D. Charbonneau[2], L. Hillenbrand[1]
[1]*California Institute of Technology,* [2]*Harvard-Smithsonian Center for Astrophysics.*

226.03 **An L' and M-band AO Imaging Survey for Extrasolar Giant Planets: Progress and Preliminary Results**
Aren Heinze[1], P. Hinz[1], S. Sivanandam[1], M. Meyer[1]
[1]*Univ. of Arizona.*

226.04 **Astrometric Discovery of M-Dwarf Planets**
Steven H. Pravdo[1], S. B. Shaklan[1], M. J. Ireland[2], P. G. Tuthill[3]
[1]*JPL, Caltech,* [2]*Caltech,* [3]*U. of Syndney, Australia.*

226.05 **A KECK HIRES Doppler Search for Planets Orbiting Metal-Poor Dwarfs. II. On the Frequency of Short-Period Giant Planets in the Low-Metallicity Regime**
Alessandro Sozzetti[1], D. W. Latham[1], G. Torres[1], B. W. Carney[2], A. P. Boss[3], J. B. Laird[4], R. P. Stefanik[1]
[1]*Harvard-Smithsonian, CfA,* [2]*University of North Carolina,* [3]*Carnegie Institution of Washington,* [4]*Bowling Green State University.*

226.06 **The All Sky Extrasolar Planet Survey Using New Generation Multi-object Keck Exoplanet Tracker Instruments at the SDSS 2.5m telescope**
Jian Ge[1], J. C. van Eyken, M[1], S. Mahadevan[1], X. Wan[1], B. Zhao[1], A. Hariharan[1], C. DeWitt[1], P. Guo[1], R. Cohen[1], S. W. Fleming[1], J. Crepp[1], C. Warner[1], S. Kane[1], F. Leger[2], K. Pan[3], S. Snedden[3], S. Shaklan[4], E. Ford[5], D. P. Schneider[6], S. Seager[7], E. Agol[8], H. Ford[9]
[1]*Univ. of Florida,* [2]*Fermilab,* [3]*Apache Point Observatory,* [4]*JPL,* [5]*CFA, Harvard University,* [6]*Penn State,* [7]*Carnegie Institution of Washington,* [8]*Univ. of Washington,* [9]*John Hopkins University.*

227: Gamma-Ray Bursts
AAS Oral, 10:00-11:30am, 3B

227.01 **GRB 060607A: A Bright Early Optical Afterglow with Minimal Prompt Emission**
Stephen Holland[1], Swift Science Team
[1]*NASA's GSFC & USRA.*

227.02 **A Multi-wavelength Perspective on the GRB-SN Connection**
Alicia M. Soderberg[1]
[1]*Caltech.*

227.03 **Pulse-Width Evolution of Late Time X-ray flares in GRBs**
Daniel Kocevski[1], N. Butler[1], J. Bloom[1]
[1]*UC Berkeley.*

227.04 **X-ray Flares in GRB Afterglows: Spectral and Temporal Characteristics**
David Morris[1]
[1]*PSU.*

227.05 **Observations of Unusual Gamma-ray Burst Afterglows with the Robotic Palomar 60-inch Telescope**
Stephen B. Cenko[1]
[1]Caltech.

227.06 **Afterglow and Environment of the High-redshift GRB 050904**
Lijun Gou[1], D. Fox[1], P. Meszaros[1]
[1]Penn State Univ..

227.07 **GRB 060614 Opens a New Window on Short and Long Burst Categorization**
Neil Gehrels[1], Swift Team
[1]NASA's GSFC.

228: Star Clusters I
AAS Oral, 10:00-11:30am, 204

228.01 **The Convergence Age of the Globular Cluster NGC 6397**
Harvey B. Richer[1], B. M. Hansen[2], S. Davis[1], J. Anderson[3], G. G. Fahlman[4], J. S. Kalirai[5], I. R. King[6], M. Rich[2], M. M. Shara[7], P. B. Stetson[4]
[1]Univ. of British Columbia, Canada, [2]UCLA, [3]Rice University, [4]Herzberg Institute of Astrophysics, Canada, [5]UCSC, [6]Univ. of Washington, [7]AMNH.

228.02 **Globular Clusters in a Globular Cluster**
Jason S. Kalirai[1], H. Richer[2], J. Anderson[3], J. Strader[1], K. Forde[1]
[1]UC, Santa Cruz, [2]University of British Columbia, Canada, [3]Rice University.

228.03 Are white dwarfs born with a ′KICK'?
Saul Davis[1], H. B. Richer[1], J. Coffey[1], J. Anderson[2], J. Brewer[1], G. G. Fahlman[3], B. M. Hansen[4], J. Hurley[5], J. S. Kalirai[6], I. R. King[7], D. Reitzel[4], R. M. Rich[1], M. R. Rich[4], M. M. Shara[8]
[1]Univ. of Bristish Columbia, Canada, [2]Rice University, [3]Herzberg Institute of Astrophysics, Canada, [4]Univ. of California at Los Angeles, [5]Monash University, Australia, [6]Univ. of California at Santa Cruz, [7]Univ. of Washington, [8]American Museum of Natural History.

228.04 **Chemical Composition of Globulars of the Sagittarius System**
Marta Mottini[1], G. Wallerstein[1], A. McWilliam[2]
[1]University of Washington, [2]Observatories of the Carnegie Institution of Washington.

228.05 **NGC 346: Mass Function at Low Metallicity**
Elena Sabbi[1], M. Sabbi[2], A. Nota[2], M. Tosi[3], J. Gallagher, III[4], M. Meixner[1], S. Oey[5]
[1]STScI, [2]STScI/ESA, Space Telescope Operation Division, [3]INAF-Osservatorio Astronomico di Bologna, Italy, [4]University of Wisconsin, [5]UNIVERSITY of Michigan.

228.06 **The B and Be Star Population of NGC 3766**
M. V. McSwain[1]
[1]Yale Univ..

229: The Supernova Legacy Survey and other SN Ia Surveys
AAS Oral, 10:00-11:30am, 3A

229.01 **Galaxy Clustering in Environments of Type Ia Supernovae from the CFHT Supernova Legacy Survey (SNLS).**
Melissa L. Graham[1], C. J. Pritchet[1], Supernova Legacy Survey
[1]University of Victoria, Canada.

229.02 **Dark Energy Constraints from the Supernova Legacy Survey**
Mark Sullivan[1], Supernova Legacy Survey
[1]University of Toronto, Canada.

229.03 **Analysis Techniques and Systematics in the Supernova Legacy Survey**
Alexander J. Conley[1], Supernova Legacy Survey
[1]*Univ. of Toronto, Canada.*

229.04 **Predicted Evolution in the Mean Properties of SNe Ia from SNLS Data**
Dale A. Howell[1], Supernova Legacy Survey
[1]*Univ. of Toronto, Canada.*

229.05 **The Texas Supernova Search**
Robert Quimby[1]
[1]*Univ. of Texas.*

229.06 **Spectropolarimetry of Type Ia Supernovae**
Ryan Chornock[1]
[1]*UC Berkeley.*

229.07 **Nearby Supernova Factory Spectroscopy of the Type Ia Supernova 2006D**
Rollin Thomas[1], G. Aldering[1], S. Bailey[1], S. Bongard[1], S. Loken[1], P. Nugent[1], S. Perlmutter[1], R. Scalzo[1], L. Wang[1], B. Weaver[1], P. Antilogus[2], S. Gilles[2], R. Pain[2], R. Pereira[2], C. Buton[3], Y. Copin[3], E. Gangler[3], G. Smadja[3], E. Pecontal[4], G. Rigaudier[4], R. Kessler[5], E. Baron[6], J. Parrent[6], C. Baltay[7], D. Rabinowitz[7]
[1]*LBNL,* [2]*LPNHE, France,* [3]*IPNL, France,* [4]*CRAL, France,* [5]*KICP,* [6]*University of Oklahoma,* [7]*Yale University.*

230: Variable and Binary Stars
AAS Oral, 10:00-11:30am, 201

230.01 **Interacting Binaries with Eccentric Orbits**
Jeremy F. Sepinsky[1], B. Willems[1], V. Kalogera[1]
[1]*Northwestern Univ..*

230.02 **StarSpotz: A Sensitive Probe of the Differential Rotation Profile of Stars using MOST Photometry**
Bryce Croll[1], G. A. Walker[2], R. Kuschnig[2], J. M. Matthews[2], J. F. Rowe[2], A. Walker[3], S. M. Rucinski[1], A. P. Hatzes[4], W. D. Cochran[5], R. M. Robb[6], D. B. Guenther[7], A. F. Moffat[8], D. Sasselov[9], W. W. Weiss[10]
[1]*University of Toronto, Canada,* [2]*University of British Columbia, Canada,* [3]*Sumus Technology Limited, Canada,* [4]*Thuringer Landessternwarte Tautenburg, Germany,* [5]*McDonald Observatory,* [6]*University of Victoria, Canada,* [7]*St. Mary's University, Canada,* [8]*Universite de Montreal, Canada,* [9]*Harvard-Smithsonian Center for Astrophysics,* [10]*Universitat Wien Turkenschanzstrasse, Austria.*

230.03 **Mean Pulsation Period of Cool White Dwarf Variables Gauges Stellar Temperature**
Anjum S. Mukadam[1], M. H. Montgomery[2], A. Kim[2], D. E. Winget[2], S. O. Kepler[3], J. C. Clemens[4]
[1]*Univ. of Washington,* [2]*Univ. of Texas at Austin,* [3]*Universidade Federal do Rio Grande do Sul, Brazil,* [4]*Univ. of North Carolina.*

230.04 **Measurement of the Surface Gravity of η Boo**
Gerard van Belle[1], D. R. Ciardi[1], A. F. Boden[1]
[1]*Michelson Science Center.*

230.05 **An X-ray View of the Interacting Binary Beta Lyrae with Suzaku**
Richard Ignace[1], L. Oskinova[2], W. Waldron[3], J. Hoffman[3], W. Hamann[2]
[1]*East Tennessee State Univ.,* [2]*University of Potsdam, Germany,* [3]*Eureka Scientific.*

230.06 **Late-Type Near-Contact Binary [HH97] FS Aur-79**
Scott J. Austin[1]
[1]*Univ. Of Central Arkansas.*

230.07 **A Search for Variable Stars in Selected Fields of the Open Cluster NGC 752**
Eugene F. Milone[1], M. D. Williams[1], L. Kim[1], T. Lenhardt[1], S. J. Schiller[1]
[1]University of Calgary, Canada.

230.08 **Mid-IR Keck Segment-Tilting Observations of the Disk Around Mira B**
Michael J. Ireland[1], J. D. Monnier[2], P. G. Tuthill[3], R. Cohen[4]
[1]Caltech, [2]University of Michigan, [3]University of Sydney, Australia, [4]W.M. Keck Observatory.

231: Physics in Art and Art in Physics

AAPT Invited, 10:00-11:30am, 211

Chair
Stanley Micklavzina[1]
[1]University of Oregon.

231.01 **Did the great masters "cheat" using optics? Image analysis of Renaissance masterpieces sheds light on a bold theory**
David Stork[1]
[1]Ricoh Innovations.

231.02 **Science Circus**
Rhys D. Thomas[1]
[1]Up For Grabs, Inc..

232: Demonstrations for Teaching Astronomy

AAPT Special, 10:00-11:30am, 617

Chair
Stephen M. Pompea[1]
[1]NOAO.

232.01 **Astronomy LITE Demonstrations**
Kenneth Brecher[1]
[1]Boston University.

232.02 **A Status Report on the ALIVE Project**
James B. Dove[1]
[1]Metropolitan State College of Denver.

232.03 **Using Planetarium Software as a Virtual Observatory**
Richard Ditteon[1]
[1]Rose-Hulman Institute.

232.04 **Affordable Laser Communication in the Classroom**
Constance E. Walker[1], R. Sparks[1], S. Pompea[1]
[1]National Optical Astronomy Observatory.

233: Bringing Physics by Inquiry to K-12 Classrooms, Part II

AAPT Oral, 10:00-11:30am, 303

Chair
Paula Heron[1]
[1]Univ. of Washington.

233.01 **Teaching Physical Science by Inqiry in the K-12 Classroom**
Brian E. Meza[1], D. L. Messina[2], L. C. McDermott[2]
[1]Seattle Preparatory School, [2]Univ. of Washington.

233.02 **Effects of a Research-based Curriculum on the Learning of Physics by K-12 Teachers and Students***
Donna L. Messina[1], M. R. Stetzer[1], L. C. McDermott[1]
[1]*Univ. of Washington.*

234: Introductory Physics Curriculum and Delivery
AAPT Oral, 10:00-11:30am, 616

Chair
Charles F. Niederriter[1]
[1]*Gustavus Adolphus College.*

234.01 **A Mechanics Curriculum as a Prelude to Electricity and Magnetism**
Poovan Murugesan[1]
[1]*San Diego City College.*

234.02 **Scientific Reasoning Outcomes and the General Education Physics Course**
Stephen P. Phipps[1], D. B. Morris[1], M. E. Dearborn[1], G. M. Novak[1]
[1]*United States Air Force Academy.*

234.03 **Teaching to Promote Deep Understanding and Instigate Conceptual Change**
Esther Zirbel[1]
[1]*Tufts University.*

234.04 **Implementing Interactive Lecture Experiments in Large Introductory Physics Courses (Part I)**
Rachel Moll[1], M. M. Milner-Bolotin[1], K. McPhee[1], S. Zhdanovich[1], A. Kotlicki[1], G. Rieger[1], F. Bates[1]
[1]*University of British Columbia, Canada.*

234.05 **The Impact of Interactive Lecture Experiments on Student Academic Achievement, Motivation and Attitudes towards Science (Part II)**
Marina M. Milner-Bolotin[1], R. Moll[1], A. Kotlicki[1], F. Bates[1], G. Rieger[1], S. Nashon[1]
[1]*University of British Columbia, Canada.*

234.06 **GRIPs (Group Investigation Problems) for Introductory Physics**
Thomas A. Moore[1]
[1]*Pomona College.*

234.07 **New Insights into Student Understanding of Complete Circuits***
MacKenzie R. Stetzer[1], P. van Kampen[2], P. S. Shaffer[1], L. C. McDermott[1]
[1]*Univ. of Washington,* [2]*Dublin City University, Ireland.*

234.08 **Andes: An Intelligent Homework System for Introductory Physics**
Brett van de Sande[1], K. VanLehn[1], R. Hausmann[1], D. Treacy[2], R. Shelby[2]
[1]*University of Pittsburgh,* [2]*US Naval Academy.*

234.09 **Helping Student Relate Work and Changes in Energy***
Beth A. Lindsey[1], P. R. Heron[1], P. S. Shaffer[1], L. C. McDermott[1]
[1]*Univ. of Washington.*

235: Teacher Learning
AAPT Oral, 10:00-11:30am, 310

Chair
Harold Stokes[1]
[1]*Brigham Young Univ..*

235.01 **What Did We Learn from the Teachers' Journals?**
Kastro M. Hamed[1]
[1]*University of Texas at El Paso.*

235.02 **Support for New Physics Teachers**
Brian W. Adrian[1], D. Zollman[1], S. Stevens[2]
[1]Kansas State Univ, [2]Carnegie Mellon University.

235.03 **Using Facet Clusters to Map Learner Modes of Reasoning**
Stamatis Vokos[1], L. S. DeWater[1], L. Seeley[1], P. Kraus[2]
[1]Seattle Pacific University, [2]Facet Innovations, LLC.

235.04 **Using Facet Clusters to Guide Teacher Professional Development**
Lane Seeley[1], L. S. DeWater[1], S. Vokos[1], P. Kraus[2]
[1]Seattle Pacific University, [2]Facet Innovations, LLC.

235.05 **Teaching about 21st Century Energy Sources to Pre-college Students and Teachers**
Andrew P. Zwicker[1], J. Morgan[1], C. Ritter[1], J. DeLooper[1], N. Guilbert[2]
[1]Princeton Plasma Physics Laboratory, [2]The Peddie School.

235.06 **Conceptual Dynamics: Comparing Inquiry and Direct Instructional Designs**
Adriana Undreiu[1], B. Adams[1], D. Schuster[1]
[1]Western Michigan University.

235.07 **Pre-Service Elementary Teachers' Ideas about the Nature of Science**
Rhett Allain[1]
[1]Southeastern Louisiana University.

235.08 **Integrals for Pre-service Elementary Teachers: Approximating Seasonal Solar Radiation Differences**
Paul G. Ashcraft[1]
[1]Penn State Erie, The Behrend College.

236: Cannon Award in Astronomy
Plenary, 11:40am-12:30pm, Ballroom 6

236.01 **The Star Formation and Metallicity History of Star Forming Galaxies**
Lisa J. Kewley[1]
[1]University of Hawaii.

Revealing the Hidden Nature of Space and Time (EPP2010)
AAS Town Hall Meeting, 12:45-1:45pm, 609

The United States has been at the forefront of elementary particle physics for more than half a century. Physicists working in the United States developed many of the theoretical ideas that describe and explain how elementary particles interact and why they have the properties that they do. And the federal government has supported the experimental facilities -- including large particle accelerators -- that have produced profound scientific discoveries and a steady stream of new technologies. Yet as elementary particle physics is poised to address some of the most basic questions in science, our leadership position is now in jeopardy. Many of the major particle physics facilities in the United States are being closed or converted to other uses. Funding for particle physics in the United States has stagnated for more than a decade. Within a few years, the majority of U.S. experimental particle physicists will be working on experiments that are being conducted in other countries The National Academies convened a committee with membership drawn both from inside and outside the field of elementary-particle physics that was charged to construct a plan for U.S. participation in this effort through an in-depth assessment to identify, articulate and prioritize the scientific questions and opportunities that define elementary-particle physics and provide a 15-year plan for the future of the field.

D.B. Lang, National Research Council, will introduce members of the National Academies committee that prepared the "Revealing the Hidden Nature of Space and Time" report. The speakers, Edward Witten (Institute for Advanced Study), Helen Quinn (Stanford Linear Accelerator Center), and Neal Lane (Rice University) will present prepared remarks for 30-40 minutes and then open the floor for discussion and questions.

Chair
David Lang[1]
[1]The National Academies.

237: Biology of Astrobiology II History of Earth's Life
AAS Special, 2:00-3:30pm, 611-12

Chair
Mark Claire[1]
[1]Univ. of Washington.
Chair
Woodruff T. Sullivan[1]
[1]Univ. of Washington.

237.01 **From the Earliest Evidence of Life to Complex Single-cell Organisms: The First 3 Gyr on Earth**
Roger Buick[1]
[1]UW Dept. of Earth & Space Sciences.

237.02 **A New History of Animal Life on Earth**
Peter Ward[1]
[1]UW Dept. of Biology.

238: Ground-Based Mid-IR Astronomy in the Spitzer Era
AAS Special, 2:00-3:30pm, 613-14

Chair
Jay A. Frogel[1]
[1]AURA, Inc.

238.01 **Synergy between Mid-IR Astronomy from 8-meter Class Ground Based Telescopes and Spitzer**
Tom Soifer[1]
[1]Caltech.

238.02 **Mid-IR Capabilities of the Gemini Telescopes**
Scott Fisher[1]
[1]Gemini Observatory.

238.03 **Mid-IR Observations of the Outer Planets**
Heidi B. Hammel[1]
[1]Space Science Institute.

238.04 **Evaporating Disks, Outflows, and their Embedded Sources in Orion**
Nathan Smith[1]
[1]University of California.

238.05 **Protostars and Disks**
Doug Johnstone[1]
[1]NRC Canada:HIA (and UVic), Canada.

238.06 **High Resolution Mid-infrared Spectroscopy of Star Formation Regions**
John Lacy[1]
[1]University of Texas.

238.07 **Mid-IR Observations of Herbig Ae and Be Stars**
Marshall D. Perrin[1], J. R. Graham[1]
[1]UC Berkeley.

238.08 **MIR-Imaging brown dwarfs in binary systems with ESO/VLT and Gemini**
Michael Sterzic[1]
[1]ESO/VLT, Chile.

238.09 **High Spatial Resolution Observations of AGN at Mid-IR Wavelengths**
Chris Packham[1], A. Alonso-Herrero[2], L. Colina[2], T. Diaz-Santos[2], J. Radomski[3], R. Mason[4], P. Roche[5], E. Perlman[6], N. Levenson[7], M. Elitzur[7], S. Young[8], C. Telesco[1]
[1]University of Florida, [2]CSIC, Spain, [3]Gemini Observatory, Chile, [4]Gemini Observatory, [5]University of Oxford, United Kingdom, [6]Florida Institute of Technology, [7]University of Kentucky, [8]University of Hertfordshire, United Kingdom.

239: AGN Jets
AAS Oral, 2:00-3:30pm, 3B

239.01 **New Multiwavelength Variability and Optical Microvariability Investigations of X-ray and Radio Selected Blazars**
Margaret A. Osterman[1]
[1]Georgia State Univ..

239.02 **Beaming and the Intrinsic Properties of Extragalactic Radio Jets**
Marshall H. Cohen[1]
[1]CalTech.

239.03 **Constraining Electron Spectra in the Hotspots of Cygnus A with Spitzer**
D. E. Harris[1], L. Stawarz[2], C. C. Cheung[3], M. Ostrowski[4]
[1]HEACenter for Astrophysics, [2]Kipac, Stanford U., [3]NRAO and Kipac, Stanford U., [4]Astronomical Observatory UJ, Poland.

239.04 **The Kiloparsec Scale Jet of the Quasar 1317+520**
Svetlana G. Jorstad[1], A. P. Marscher[1], J. M. Gelbord[2], H. L. Marshall[2], D. A. Schwartz[3], D. M. Worrall[4], M. Birkinshaw[4], E. S. Perlman[5]
[1]IAR BU, [2]MIT, [3]CfA, [4]Univ. of Bristol, United Kingdom, [5]UMBC.

239.05 **Limit to the Positron Content of the Jet in 3C 120 from INTEGRAL and mm-Wave VLBI Observations**
Alan P. Marscher[1], S. G. Jorstad[1], J. L. Gomez[2], I. M. McHardy[3], T. P. Krichbaum[4], I. Agudo[4]
[1]Boston Univ., [2]IAA, Spain, [3]Univ. Southampton, United Kingdom, [4]MPIfR, Germany.

239.06 **Multiple Circular Polarization Outbursts in the QSO 3C 279 at Centimeter Wavelengths**
Hugh D. Aller[1], M. F. Aller[1], P. A. Hughes[1]
[1]Univ. of Michigan.

239.07 **Relativistic Ejections Associated with High-energy Outbursts in the M87 Jet**
Chi C. Cheung[1], D. E. Harris[2], L. Stawarz[3]
[1]NRAO & Stanford, [2]Harvard-Smithsonian Center for Astrophysics, [3]KIPAC/Stanford.

239.08 **Synthetic Maps of Relativistic Jets The Origin of Bright Features**
Carrie Swift[1], P. Hughes[2]
[1]Univ. of Michigan Dearborn, [2]Univ. of Michigan.

240: CMB-Experiments
AAS Oral, 2:00-3:30pm, 6A

240.01 **Prospects for the ACBAR Experiment**
Christian L. Reichardt[1]
[1]Caltech.

240.02 **Preliminary Results from ARCADE II**
Dale J. Fixsen[1], A. Kogut[1], M. Limon[1], E. Wollack[1], P. Mirel[1], J. Singal[2], P. Lubin[2], S. Levin[3], M. Seiffert[3]
[1]NASA's GSFC, [2]UCSB, [3]JPL.

240.03 **The Atacama Cosmology Telescope**
Joseph W. Fowler[1], ACT Collaboration
[1]Princeton University.

240.04 **Status of EBEX, a Balloon Borne CMB Polarization Experiment**
Johannes Hubmayr[1], EBEX collaboration
[1]University of Minnesota.

240.05 **The Millimeter-Wave Bolometric Interferometer**
Andrei Korotkov[1], P. A. Ade[2], S. Ali[3], E. Bierman[4], E. F. Bunn[5], C. Calderon[2], A. C. Gault[6], P. O. Hyland[6], B. G. Keating[4], J. Kim[1], S. S. Malu[6], P. D. Mauskopf[2], J. A. Murphy[7], C. O'Sullivan[7], L. Piccirillo[8], P. T. Timbie[6], G. S. Tucker[1], B. D. Wandelt[9]
[1]Brown University, [2]Cardiff University, United Kingdom, [3]LLNL, [4]University of California San Diego, [5]University of Richmond, [6]University of Wisconsin Madison, [7]National University of Ireland, Ireland, [8]University of Manchester, United Kingdom, [9]University of Illinois Urbana-Champaign.

240.06 **Point Source Power in 3-year Wilkinson Microwave Anisotropy Probe Data**
Kevin M. Huffenberger[1], H. K. Eriksen[2], F. K. Hansen[2]
[1]Caltech/Jet Propulsion Lab, [2]University of Oslo, Norway.

241: Extrasolar Planets IV
AAS Oral, 2:00-3:30pm, 605-07

241.01 **Detecting Neptune-mass Planets Around 2,000 Nearby Stars with SIM**
Nicholas M. Law[1], A. Tanner[2], S. Kulkarni[1], M. Shao[3], C. Gelino[4]
[1]Caltech, [2]JPL/IPAC, [3]JPL, [4]IPAC.

241.02 **Finding Terrestrial Planets in the HZ of Nearby Stars with SIM PlanetQuest**
Angelle M. Tanner[1], J. Catanzarite[2], M. Shao[2], S. Unwin[2]
[1]JPL/IPAC, [2]JPL.

241.03 **Spectral Evolution of an Earth-like Planet**
Lisa Kaltenegger[1], W. A. Traub[2], K. W. Jucks[1]
[1]Harvard-Smithsonian, CfA, [2]Harvard-Smithsonian CfA & JPL.

241.04 **PHASES: A Search for Planets in Binary Systems**
Benjamin Lane[1], M. Muterpspaugh[2], M. Konacki[3], S. Kulkarni[4], M. Shao[5], M. Colavita[5], B. Burke[1]
[1]MIT, [2]Berkeley Space Science Lab, [3]Nicolaus Copernicus Astronomical Center, Poland, [4]Caltech, [5]JPL.

241.05 **M Dwarf Planetary Systems**
Peter Plavchan[1], M. Jura[2], R. Cutri[1], J. D. Kirkpatrick[1], S. C. Gallagher[2], S. J. Lipscy[3]
[1]IPAC/Caltech, [2]UCLA, [3]Ball Aerospace.

241.06 **Evidence From Spitzer for a Low-Mass Companion and a Circumbinary Disk Around a Pre-Cataclysmic Variable**
Carolyn Brinkworth[1], D. W. Hoard[1], T. R. Marsh[2]
[1]Spitzer Science Center, [2]University of Warwick, United Kingdom.

241.07 **New Very Low Mass Binaries in the Taurus Star-Forming Region**
Quinn M. Konopacky[1], A. M. Ghez[1], E. L. Rice[1]
[1]UCLA.

242: Milky Way Topics
AAS Oral, 2:00-3:30pm, 3A

242.01 **Probing the Milky Way at Mid-Infrared Wavelengths using GLIMPSE**
Emily P. Mercer[1]
[1]Boston Univ..

242.02 **The Frequency of Warm Carbon-Enhanced Metal-Poor Stars in SDSS-I DR-5**
Brian E. Marsteller[1], T. C. Beers[1], T. Sivarani[1], S. Rossi[2], J. Knapp[3], B. Plez[4], J. Johnson[5], T. Masseron[5]
[1]Michigan State Univ. & JINA, [2]IAG, Univ. of Sao Paulo, Brazil, [3]Princeton Univ., [4]Univ. of Montpellier, France, [5]Ohio State Univ..

242.03 **A Search for Obscured Dwarf Novae in the Galactic Bulge**
Silas Laycock[1], J. E. Grindlay[1], M. van den Berg[1], J. Hong[1], P. Zhao[1]
[1]Harvard-Smithsonian, CfA.

242.04 **Observations of the Unidentified TeV Gamma-ray Source in the Cygnus Region with the Whipple Observatory 10 m Telescope**
Alexander Konopelko[1], VERITAS collaboration
[1]Purdue University.

242.05 **The Sagittarius Spiral Arm of the Galaxy: Now You See It, Now You Don't**
Robert A. Benjamin[1], E. Churchwell[2], M. Haffner[2], GLIMPSE team
[1]Univ. of Wisconsin,Whitewater, [2]Univ. of Wisconsin-Madison.

243: SNR, Cosmic Rays and Neutron Stars
AAS Oral, 2:00-3:30pm, 201

243.01 **A Plausible X-ray Counterpart of the Unidentified TeV Gamma-ray Source HESS J1804-216**
Wei Cui[1], A. Konopelko[1]
[1]Purdue Univ..

243.02 **Thermal and Non-thermal Emission from Cosmic Ray Modified Shocks**
Daniel Patnaude[1], D. Ellison[2], P. Slane[1]
[1]Harvard-Smithsonian, CfA, [2]North Carolina State Univ..

243.03 **SUBARU HDS Observation of Balmer-Dominated Shock in Tycho**
Jae-Joon Lee[1], B. Koo[1], J. Raymond[2], P. Ghavamian[3], T. Pyo[4], A. Tajitsu[4], M. Hayashi[4]
[1]Seoul National Univ., Republic of Korea, [2]Harvard-Smithsonian Center for Astrophysics, [3]Johns Hopkins University, [4]Subaru Telescope, NAOJ.

243.05 **Suzaku Observations of Supernova Remnant G93.3+6.9 (DA 530)**
Michael Stage[1], D. Q. Wang[1]
[1]Univ. of Massachusetts.

243.06 **Probing Ejecta Properties in Supernova and GRB Remnants: The example of W49B**
Laura A. Lopez[1], E. Ramirez-Ruiz[1], D. Pooley[2], S. K. Patel[3], D. Chelouche[4]
[1]UC, Santa Cruz, [2]UC, Berkeley, [3]NASA Marshall Space Flight Center, [4]Institute for Advanced Study.

243.07 **Initial Results From CHAZSS: the Chandra HETGS Atoll/Z Spectroscopic Survey**
Edward Cackett[1], J. Miller[1], CHAZSS team
[1]Univ. Of Michigan.

243.08 **X-ray Binaries in Nearby Galaxies: Identifying Black Hole and Neutron Star Candidates**
Sergey P. Trudolyubov[1], W. C. Priedhorsky[2], F. A. Cordova[3]
[1]IGPP/UCR, [2]LANL, [3]UCR.

243.09 **Evidence that (some) Ultra High Energy Cosmic Rays Come From a Bursting Source**
Glennys R. Farrar[1]
[1]New York Univ..

244: Star Clusters II
AAS Oral, 2:00-3:30pm, 204

244.01 **High Resolution Analysis of Globular Clusters in M87**
Christopher Z. Waters[1]
[1]Michigan State Univ..

244.02 **Probing the M87 Globular Cluster System with Deep NICMOS Imaging**
Arunav Kundu[1], S. E. Zepf[1], M. Hempel[2]
[1]Michigan State Univ., [2]Univ. of Florida.

244.03 **Extragalactic Star Clusters: the Resolved Star Approach**
Anne Pellerin[1], M. J. Meyer[1], H. Jason[2], D. Calzetti[1]
[1]STScI, [2]Steward Observatory.

244.04 **Tidal Tales of Minor Mergers II: Star Formation in the Tidal Debris of Minor Mergers**
Karen A. Knierman[1], P. Knezek[2], E. Wehner[3]
[1]Univ. of Arizona, [2]WIYN, [3]McMaster University, Canada.

244.05 **Restarting Galaxy Formation in Arp 82: An UV, Optical and Mid-IR Study of Star Formation in NGC 2535/6**
Mark Hancock[1], B. J. Smith[1], C. Struck[2], M. L. Giroux[1], P. N. Appleton[3], V. Charmandaris[4], W. T. Reach[3]
[1]East Tennessee State University, [2]Iowa State University, [3]Spitzer Science Center, [4]University of Crete, Greece.

245: Instructional Technology in Physics and Astronomy Courses
AAPT Oral, 2:00-3:30pm, 303

Chair
Jeffrey Williams[1]
[1]Bridgewater State College.

245.02 **Web-based Classroom Interaction System and Impact on Student Learning**
Joseph Beuckman[1], N. Rebello[2]
[1]Southern Illinois University-Edwardsville, [2]Kansas State University.

245.03 **Grid-based e-Labs for Pre-College Research in Physics and Astronomy**
Thomas J. Loughran[1]
[1]University of Notre Dame Department of Physics/Fermi National Accelerator Lab.

245.04 **Preparation Strategies for Video-based Introductory Physics**
David M. DeMuth, Jr.[1], M. Schwalm[2]
[1]Un. of Minnesota, Crookston, [2]Un. of North Dakota.

245.05 **PowerPoint Nuggets for Pre-lab Content Review**
Michael R. Meyer[1]
[1]Michigan Tech University.

245.06 **Optical Analogies for Teaching Physics of X-rays and CAT Scans***
Spartak Kalita[1], D. A. Zollman[1]
[1]*Kansas State University.*

245.07 **How Converging Lens Simulation Designs Affect Understanding of Image Formation**
Joel A. Bryan[1]
[1]*Texas A&M University.*

246: Physics and Society Education

AAPT Oral, 2:00-3:30pm, 617

Chair
Gordon McIntosh[1]
[1]*University of Minnesota, Morris.*

246.01 **The Fusion Energy Problem Has Been Solved**
John W. White[1]
[1]*LLNL & Modesto J C.*

246.02 **Energy Storage Systems as a Compliment to Wind Power**
Jared D. Sieling[1], C. F. Niederriter[1], D. A. Berg[1]
[1]*Gustavus Adolphus College.*

246.03 **Quantoons: Physics, Art, and Literature**
Larry D. Kirkpatrick[1], A. Eisenkraft[2]
[1]*Montana State University,* [2]*University of Massachusetts Boston.*

246.05 **Michael Faraday vs. the Spiritualists**
Alan Hirshfeld[1]
[1]*UMass Dartmouth.*

246.06 **Maupertuis, Leibniz, Least Action and Design**
James K. Simmons[1]
[1]*Waynesburg College.*

246.07 **Spotting Junk Science A Classroom Exercise**
Brian Houser[1]
[1]*Eastern Washington University.*

246.08 **Service Learning in Physics Courses in the United States**
Lynn Aldrich[1]
[1]*College Misericordia.*

246.09 **Never Before Seen Mnemonic Technique**
Shannon Schunicht[1]
[1]*Texas A&M University.*

247: Teacher Professional Development Programs and Assesments

AAPT Oral, 2:00-3:30pm, 310

Chair
Todd Leif[1]
[1]*Cloud County Comm. College.*

247.02 **Expanding Science Teacher Preparation: the Role of External Funding**
John M. Lindberg[1], S. Vokos[1], L. Seeley[1], E. Close[1]
[1]*Seattle Pacific University.*

247.03 **Courses and Programs to Motivate and Train Future Science Teachers**
Suzanne Amador Kane[1], A. Lesnick[2], J. Cantley[3]
[1]Haverford College, [2]Haverford College & Bryn Mawr College, [3]Ohio State University.

247.04 **Instruments for Assessment of Instructional Practices in Standards-Based Teaching**
Camille L. Wainwright[1]
[1]Pacific University.

247.05 **Future Elementary Teachers' Epistemological Beliefs and Views of Science**
N. Sanjay Rebello[1]
[1]Kansas State University.

247.06 **Exploring Relationships: Teacher Characteristics and Student Learning in Physical Science**
Eleanor Close[1], S. Vokos[1], L. Seeley[1]
[1]Seattle Pacific University.

248: Theoretical and Diagnostic Issues
AAPT Oral, 2:00-3:30pm, 307-08

Chair
Mary Mogge[1]
[1]California State Polytechnic Univ..

248.01 **Diagnostic Tests for Entering and Departing Undergraduate Students**
Chris Waltham[1], A. Kotlicki[1]
[1]Department of Physics & Astronomy, University of BC, Canada.

248.02 **Student Preparation, Aptitude, and Performance in a First-Semester Algebra-Based Physics Course**
Robert L. Hill[1], D. Grosnick[1], D. Ober[1]
[1]Ball State University.

248.03 **Comparing Item Responses on the FMCE and FCI**
Karen Cummings[1], J. Marx[2], R. Thornton[3], D. Kuhl[4]
[1]Southern Connecticut State Univ, [2]McDaniel College, [3]Tufts Univ, [4]Marietta College.

248.04 **Exploration of Epistemological Beliefs in a Summer Science Program for High Achieving Students(1)**
Sebastien Cormier[1], F. Raia[1], R. Steinberg[1]
[1]City College New York.

248.05 **Rate of Learning Models, Mental Models, and Item Response Theory**
David E. Pritchard[1], Y. Lee[1], L. Bao[2]
[1]Massachusetts Institute of Technology, [2]Ohio State University.

248.06 **Transfer of Learning: From Physical Models to Understanding Complex Phenomena***
Bijaya Aryal[1], D. A. Zollman[1]
[1]Kansas State University.

248.07 **A Transformed Introductory Mechanics Lab Focused on Developing Reasoning**
Vincent P. Coletta[1], J. Evans[1], J. Phillips[1]
[1]Loyola Marymount University.

248.08 **Content-Independent Problem Categorization to Cultivate Real Problem Solving Skills**
Kathleen A. Harper[1], R. J. Freuler[1], J. T. Demel[1]
[1]The Ohio State University.

248.09 **Discussion of the** *Correlation Coefficient and R^2-Value Survey*
Jeffrey Marx[1]
[1]*McDaniel College.*

249: Oersted Medal Lecture
Plenary, 3:40-4:30pm, Ballroom 6

Chair
Richard Peterson[1]
[1]*Bethel Univ..*

249.01 **Interactive Simulations for Teaching Physics; What Works, What Doesn't, and Why**
Carl E. Wieman[1]
[1]*Univ. of British Columbia and Univ. of Colorado, Canada.*

250: New Planets
Plenary, 4:40-5:30pm, Ballroom 6

250.01 **The Dwarf Planets of the Outer Solar System**
Michael E. Brown[1]
[1]*Caltech.*

209TH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY
5–10 January 2007
Seattle, WA

001: Opening Remarks
Plenary, Sunday, 8:15-8:30am, Ballroom 6

002: Space Flight: A Human Perspective
Plenary, Sunday, 8:30-9:20am, Ballroom 6

Chair

Janelle M. Bailey[1]
[1]*Univ. Nevada, Las Vegas.*

002.01

Space Flight: A Human Perspective

Kathryn C. Thornton[1]
[1]*University of Virginia.*

In this ″Space Age″ we are just beginning to explore the solar system, and human space flights into Earth orbit are our first baby steps off our home planet. Why do we go to space? What do we do there? What will we learn in this environment that will benefit future explorers? A four-time space flight veteran will describe experiences in space and opportunities for future explorers.

003: Poster Session I
AAPT Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

003.01

PhysicsFirst: Building Connections with a Concurrent Mathematics Course

Boris M. Korsunsky[1]
[1]*Weston High School.*

I will present the results of the continuing effort at my school to make sure that physics/math experience of the freshmen taking Honors Physics is as seamless and meaningful as possible. Regular communications between physics and math teachers help ensure that the two curricula reinforce and build upon each other in terms of both content and skill-building. We also make sure that the expectations and the terminology are consistent and the difficulties that a student may have in one course are communicated to the teacher of the other. We feel that it helps us improve the rigor and the overall quality of both courses.

This initiative has been generously supported by Weston Public Schools by providing in-service workshop time during the summer; in addition, regular meetings (formal and informal) between the physics and the math teachers have been held during the year.

003.02

Building Problem-Solving Skills in PhysicsFirst Classroom

Boris M. Korsunsky[1]
[1]*Weston High School.*

One of the common objections to teaching PhysicsFirst is that the limited mathematics background of high-school freshmen does not allow for rigorous problem-solving. I argue that problem solving can, in fact, be a central part of a freshman physics course and that the lack of cognitive maturity and certain skills, rather than that of mathematics knowledge, is the main limiting issue. I will present several teaching techniques that I have found useful as well as examples of fairly challenging problems that have been solved (or NOT solved despite all the effort) in my Honors Physics freshman classes.

003.03

Putting the “Spark” into Physical Science and Algebra

Andre Dagenais[1], B. Pill[1]
[1]*Sanford School.*

The presenters will describe a number of laboratory activities developed in collaboration with the Department of Electrical Engineering at the University of Delaware as part of their outreach program to help make math and science more authentic on the pre-college level. Lessons relating to electrical topics are often abstract and appropriate only for advanced students in math and science. We have devised lessons that rely on simple equipment. They promote skills that are included in National and State Standards. They emphasize the connections between math and science; they are appropriate for an algebra course, a physical science course, a PhysicsFirst course or a traditional physics course. Students benefit from seeing that what they learn in math and science courses can lead to cutting-edge work in areas such as passive wave imaging, photonics, wireless communication and high performance computing. The collaboration has been meaningful because it has motivated us to tailor our lessons to reflect what is happening in the research lab of our local university. Written materials for use in teacher training workshops will also be available.

Funded by NSF Research Experience for Teachers(RET #0322633) program under the direction of Dr. Dennis Prather, University of Delaware Electrical Engineering

003.04

Teaching Lower Socio-Economic Students About The Electromagnetic Spectrum Uses

Sharon R. Blauvelt[1]
[1]*Missouri State University.*

Educating students from lower socio-economic backgrounds can be both challenging and rewarding. In this study, I attempted to present information on the electromagnetic spectrum in several creative ways to make it both interesting and concrete for my students. Students from lower socio-economic backgrounds must have a connection with the subject matter and the electromagnetic spectrum presents the challenge of thinking abstractly about light and its properties. In the state of Missouri students are exposed to the concept of light and how humans perceive light in the 6^{th} grade. Students at this age and especially in economically depressed areas have a harder time thinking abstractly and therefore the concept of light and sight can be confusing and misconceptions formed. The goal of my research is to gain insight to students' prior knowledge, dispel misconceptions with concrete evidence and ideas while creating engaging lessons about electromagnetic spectrum. The understanding of the electromagnetic spectrum is fundamental for students to understand other concepts such as the Doppler Effect in stars, stellar magnitudes, distances to stars and other physics and astronomical concepts.

003.05

Impulse In, Impulse Out Understanding Elastic Collisions Before Energy

Richard G. Piccioni[1]
[1]*James A. Garfield High School.*

Many fine textbooks and teachers of introductory physics postpone discussion of elastic collisions until after the concept of energy conservation has been developed. Even then, the explanations of readily-observed features of one-dimensional elastic collisions, including the signature "velocity swapping" by objects of equal mass, remain buried in some rather daunting algebra. An alternative approach is to focus on impulse, comparing in particular the impulse imparted to each object before the instant of closest approach to that imparted after. For an interaction in which the repulsive force between the objects is a single-valued function of their center-to-center separation, it can easily be proved and/or demonstrated, e.g. by integrating a force-time graph of two carts fitted with force sensors, that these two quantities are equal. Under such circumstances, the standard equations relating final and initial velocities fall out as simple consequences of momentum conservation. Furthermore, a straightforward regrouping of terms shows that $\Sigma(mv^2)$ remains unchanged by the collision, foreshadowing a later discussion of kinetic energy.

003.06

Characterizing Student Experiences in Physics Competitions: The Power of Emotions

Rachel F. Moll[1], S. Nashon[1], D. Anderson[1]
[1]*University of British Columbia, Canada.*

Low enrolment and motivation are key issues in physics education and recently the affective dimension of learning is being studied for evidence of its influence on student attitudes towards physics. Physics Olympics competitions are a novel context for stimulating intense emotional experiences. In this study, one team of students and their teacher were interviewed and observed prior to and during the event to characterize their emotions and determine the connections between their experiences and learning and attitudes/motivation towards physics. Results showed that certain types of events stimulated strong emotions of frustration and ownership, and that students' attitudes were that physics is fun, diverse and relevant. Analysis of these themes indicated that the nature of emotions generated was connected to their attitudes towards physics. This finding points to the potential and value of informal and novel contexts in creating strong positive emotions, which have a strong influence on student attitudes towards physics.

003.07

Introduction to Physics of the Universe in AP Physics Classrooms

Stephanie L. Allen[1]
[1]*Hope College.*

Often students have difficulty understanding the connections that must be made between old and new concepts. This curriculum is designed to lead AP Physics students through this process with gamma ray bursts. Students will participate in various discussions, demonstrations, exercises and activities that lead them through universe basics, life cycles of stars, black holes, the electromagnetic spectrum, and they will learn about various NASA observatories. Ultimately, this will result in a better understanding of how astrophysicists have come to understand the gamma ray burst. This series of lessons was created for the three to four weeks after the AP Physics exam. The curriculum was developed through gathering resources from various scientific organizations, developing new ideas and speaking with scientists at NASA Goddard Space Flight Center. The result is a manual of lesson plans, activities and answer keys for teachers to use in their own classrooms.

003.08

Modification of Multiple-Choice Assessment Items Based on Student Feedback

Thomas J. Regan[1]
[1]*AAAS/Project 2061.*

Project 2061 is creating assessment items targeting the learning goals recommended by AAAS?s Benchmarks for Science Literacy (1993) and the NRC?s National Science Education Standards (1996).). One of our topics is force and motion at the middle grades level. Our item development process includes pilot testing and student interviews. We will describe how this feedback is used to modify the items. Examples will include modifications to vocabulary, context, and distractors. In addition we will describe the use of this feedback to modify item design tools.

003.09

Producing a Brighter Future by Changing a Trend

Elaine Gwinn[1]
[1]*Ball State University.*

As production of physics teachers declines across the nation, efforts are being employed at Ball Statue University to change that trend. BSU has been a PhysTEC coalition member since the Fall of 2001 and continues to be a Principal Project Institution for the project. This presentation will show various methods that have shown success toward the goal of the recruitment of more and better prepared science teachers. This will be an overview of the entire project, showing the current methods being utilized as well as the successful techniques used in the past.

003.10

The Illinois Pipeline Project

Carl J. Wenning[1]
[1]*Illinois State University.*

The Pipeline Project of the Illinois Section of the AAPT (ISAAPT) has been a work in progress since 2004. During that time there have been a number of workshops and cracker barrel sessions focusing on recruiting the next generation of high school physics teachers for Illinois. The ISAAPT has subsequently produced and published guidelines and a recruitment brochure. The Section is now working diligently with other Illinois associations to recruit science teachers of the major disciplines for all levels of school instruction.

003.11

Efforts to Recruit Secondary STEM Teachers at Columbus State University

Zodiac T. Webster[1], MaSST Preparation Council
[1]*Columbus State University.*

Physics as a discipline is not alone in having difficulty finding qualified teachers. Under-qualified teachers are present in high school Mathematics, Chemistry, Biology, and Earth-science classrooms as well. Columbus State University (CSU) has formed the Mathematics and Science Secondary Teachers (MaSST) Preparation Council to recruit more majors into our existing secondary teaching programs: Mathematics, Biology, Chemistry, and Geology. College of Education and College of Science faculty are working together to create a higher profile for these majors at our institution within the state of Georgia. In addition, we are planning an aggressive campaign to recruit from within by implementing a peer-tutoring program using outstanding students who have completed introductory math and science courses. Our group's organization and initiatives can serve as a model for other institutions concerned about recruiting more high-school teachers.

003.12

Mentoring Beginning and Crossover Teachers

Dale Freeland[1]
[1]*Portage Central High School.*

This poster focuses on mentoring efforts with the Physics Teacher Education Coalition Project (PhysTEC) and comments from some mentees. This poster will focus on mentor-mentee interactions during the last three years. Types of interactions, time spent on those different interaction types, and summary comments from mentees will be available. (The PhysTEC project goals include increasing the number of physics teachers produced, improving undergraduate physics teacher education preparation, better equipping prospective teachers through their undergraduate education, and providing some mentoring support during their first years of teaching. The author served as a high school Teacher in Residence at Western Michigan University during 2002-2003 and has continued his involvement with the PhysTEC project through mentoring beginning and crossover teachers.)

003.13

Is Special Training Needed to Teach ″Physics For Elementary Teachers″?

Paul W. Zitzewitz[1], J. F. Devlin[1], R. M. Savage[1], C. M. Swift[1]
[1]*University of Michigan-Dearborn.*

A group of 16 physics teachers spent five days in San Diego in the summer of 2004 learning about the newly developed Physics for Elementary Teachers (PET) curriculum. A large fraction of the time was spent honing skills in teaching this inquiry-based curriculum. How necessary is specialized training such as this week-long session to successfully teaching the PET curriculum? At the University of Michigan-Dearborn the PET curriculum is taught to five sections of 24 students each. Two sections are taught in the fall and winter terms, one section in the summer term. Between January 2005 and December 2006 ten sections were taught, five by PWZ who received the training, the remainder by the other authors of this poster. JFD had previously taught inquiry-based physics courses based on Powerful Ideas in Physical Science, CMS had previously taught inquiry-based courses in space/earth science. RMS is a high school teacher. All instructors made use of the text, video, and web-based resources supplied by the PET development team. There was also communication between instructors teaching different sections in the same term about daily progress and problems. There was, however, no program of class visitations or other means of coordinating teaching techniques. Comparisons of scores on diagnostic exams and student evaluations show that student learning and satisfaction with the course was not significantly different among the various instructors. We conclude that specialized training is not needed for a successful implementation of the PET curriculum.

003.14

Training Future Physics Teachers at BYU: Successes in Teacher Training

Duane B. Merrell[1], R. Beck Clark[1]
[1]*Brigham Young University.*

Science disciplines at BYU graduate their fair share of teachers. In the school year 2005-2006 the physical science teaching program will graduate 22 teachers. The break down of those 22 teachers comes out Physics (10) Physical Science Composite (6) Earth Space Science (2) and Chemistry (4). With 32 physics students specializing in physics teaching, BYU is striving to encourage students to become science educators. All physical science teaching majors have very strong content programs. Physics students who chose the teaching option degrees only differs by approximately 3 classes from that of a physic major. With strong collaboration with the BYU McKay School of Education the College of Physical Science and Mathematics has created an advising program that focuses on getting the students who want to become teachers into the schools early. This introduction into the school is continuous from the beginning of the student's junior year thru graduation. Students take introduction to science teaching to enter the teacher preparation program. In the introduction class students have a minimum of 48 hours in the public schools supervised by both the college and public school teachers and partnerships that have been established.

003.15

A Proposal for a Research-based Constructivist Physics-and-Pedagogy Course

Esther Zirbel[1]
[1]*Tufts University.*

This poster proposes a research-based science-and-pedagogy course that will combine the learning of fundamental physics concepts with methods of how to teach these concepts. Entitled "Understanding the Cosmos: From Antiquity to the Modern Day," the course will explore how people learn science concepts through the ages, and from childhood through adulthood. This course will use the historical-constructivist approach to illustrate how our understanding of scientific phenomena advanced as we progressed from simple 2-dimensional thinking (starting with the flat Earth concept) to 3-D thinking (learning about the structure of the solar system) to 4-D thinking (understanding space-time and theories about the Big Bang). While transitioning from Impetus to Aristotelian to Newtonian to Einsteinian thinking, students will learn the essence of scientific thinking and inquiry. The overall goal of this course is to excite students in the process of scientific discovery, help them develop scientific reasoning skills, and provide them with fulfilling experiences of truly understanding science concepts. This will be done by employing active engagement techniques (e.g., peer tutoring, Socratic dialogue, and think/pair/share methods) and by challenging students to articulate their thoughts clearly and persuasively. This course could be of value for anybody wanting to enter the teaching profession or simply for anybody who would like to deepen their science understanding.

003.16

PET as a Model for Other Introductory Content Courses

George D. Nelson[1]
[1]*Western Washington University.*

Western Washington University is the lead institution of the North Cascades and Olympic Science Partnership (NCOSP), a 5-year NSF Math-Science Partnership program designed to improve science teaching K-16. The broad scope of the project entails revising science methods courses, developing new science content courses, and providing professional development opportunities to practicing teachers in the region. In collaboration with science faculty from four partner two-year schools, we have developed and implemented a yearlong science content course sequence that uses the Physics for Elementary Teachers (PET) as the curriculum for the first quarter. The second and third quarter courses, developed in-house, cover topics in geology and biology with the common theme of the flow of matter and energy. The philosophy and format of those courses closely mimics PET. Independent assessments of student learning verify the effectiveness of the approach.

003.17

Teacher Leaders as Intern Supervisors: Lessons from an MSP Project

Jacob Clark Blickenstaff[1]
[1]*Western Washington University.*

Western Washington University is the lead institution of the North Cascades and Olympic Science Partnership (NCOSP), a 5-year NSF Math-Science Partnership program designed to improve science teaching K-16. The broad scope of the project entails revising science methods courses, developing new science content courses, and providing professional development opportunities to practicing teachers in the region. Approximately 150 practicing teachers have become Teacher Leaders through many hours of focused professional development as NCOSP participants. Over the past three years, the combination of a two-week Summer Academy and monthly Learning Community Forums has provided Teacher Leaders with strong content and pedagogy professional development. NCOSP is now working to take advantage of this expertise by placing WWU student teaching interns in

Teacher Leaders' classrooms. Since this part of NCOSP is very new, the poster will focus on the development and initial implementation of this intern placement project.

003.18

The Need and Effectiveness of Professional Development for K-12 Teachers

Robert J. Endorf[1], K. M. Koenig[2]
[1]University of Cincinnati, [2]Wright State University.

K-12 teachers are often encouraged to use more inquiry activities and lessons in their science classes. However, many teachers are not prepared to successfully implement science inquiry in their classrooms because they lack a sufficient understanding of the basic science concepts or of scientific reasoning skills. An effective professional development program is essential to help these teachers utilize inquiry-based science teaching. At the University of Cincinnati, we have conducted numerous physical science professional development programs and workshops of various lengths and topics for K-12 teachers. These workshops have primarily used the *Physics by Inquiry*[1] modules by Lillian McDermott and the Physics Education Group at the University of Washington. We will present pretest and posttest data taken from these workshops to assess the need and effectiveness of the professional development programs. The results show much greater gains for the more extensive inquiry-based professional development programs.

* Partially Supported by The Improving Teacher Quality Development Program administered by the Ohio Board of Regents.

1. L.C. McDermott and the Physics Education Group at the University of Washington, *Physics by Inquiry,* (Wiley, 1996).

003.19

Orange Peel The Orange's Life Vest

Milijana Suskavcevic[1], E. Hagedorn[1]
[1]University of Texas at El Paso.

We developed a lesson unit using an orange as a main ingredient to illustrate the concept of density of the system. The orange may be treated as a system comprised of two major components: pulp and peel. Teachers involved in the study tested whether they can average the densities of these components to find the value for the density of the system. The unit is flexible enough to be introduced in inquiry based classrooms at several grade bands and at different levels of sophistication: from basic qualitative description of the behavior of the orange in different liquids to quantitative calculations of the buoyant force which selected liquids exert on the orange. The activity has been implemented among several populations of pre and in service teachers through physical science courses and workshops. The impact of this activity on teachers' and their K-12 students' understanding of the density of the system will be discussed in this presentation.

003.20

Never Fear; Scaffolding is Here: Solar Research in the Classroom

Constance E. Walker[1], N. DeMuth[2], D. Isbell[1], S. M. Pompea[1], K. Garmany[1]
[1]National Optical Astronomy Observatory, [2]El Camino College.

Astronomy Research Based Science Education (A-RBSE) has been a multi-year teacher professional development program sponsored by NSF and administered through the National Optical Astronomy Observatory (NOAO). Previously TLRBSE, the program reaches the formal education community through a national audience of well-trained and supported middleand high-school teachers. Every year, a new cohort of teachers prepare for research through an on-line course in the spring. In the summer they conduct astronomy research at NOAO, working with astronomer-mentors to gather and analyze their data. They then return to their classrooms and engage their students in inquiry-based astronomy research using the data.

A-RBSE has much to offer teachers both inside and outside the program who wish to initiate research in the classroom. However, the activation energy to conduct authentic research is high. To address the needs of a wider audience of teachers and students, steps have been taken to supply web-based resources for the solar research program. Teachers can use this solar scaffolding to support the implementation of authentic solar research in the classroom. The scaffolding files will serve as a template for other A-RBSE research strands, as well as enable non-A-RBSE middle and high school teachers to download and use A-RBSE data in their own classrooms. These scaffolding resources and future directions will be described in this session.

NOAO is operated by the Association of Universities for Research in Astronomy (AURA), Inc. under cooperative agreement with the National Science Foundation. For further information, visit http://www.noao.edu/outreach/tlrbse/.

003.21

Using Case Studies to Assess the Impact of Modeling Workshops

Jeff Saul[1], G. O'Brien[1], L. Kramer[1]
[1]Florida International University.

The Center for High Energy Physics Research, Education, and Outreach (CHEPREO) has been running Hestenes-style Physics Modeling workshops for High School math and science teachers for the past four summers. Workshop assessment and evaluation found participants substantially improve teacher content knowledge as measured in both pre/post and post only nationally-normed tests such as FCI, TUG-K, and MBT. This year we are extending our assessment to see how teachers are using what they learn in the workshop(s) in their classrooms. This study uses both standard pre/post assessments and classroom observations. The classroom observations use a protocol similar to RTOP. In this paper, we will report on preliminary results from case studies of three physics teachers who attended their first modeling workshop in Summer 2006. Each of these three teachers will be observed during multiple site visits.

003.22

Contrasting Inquiry and Direct Physics Instructional Designs: Examples from Dynamics

Betty Adams[1], A. Undreiu[1], D. Schuster[1]
[1]Western Michigan University.

We present and compare 'inquiry' and 'direct' instructional designs for teaching physics topics. A scientific inquiry process approach develops physics concepts and laws as 'science-in-the-making', rather than presenting them directly as 'already-made-science'. The contrasting designs reflect different views of' 'what is science' and 'what shall we teach'. We also distinguish the guided scientific inquiry approach from 'discovery learning' and from some inquiry approaches which 'elicit conclusions' upfront. We have produced a set of parallel lesson units, in inquiry and direct modes, for teaching introductory conceptual dynamics. Each mode is reflected in an appropriate learning cycle, including application and assessment. We are using the units in a physics course for prospective teachers, and in a research study comparing the effects of the two approaches, with respect to both content and process. Examples from dynamics will be presented, and a demonstration if possible.

003.23

Report on the IX Inter-American Conference on Physics Education

Gordon J. Aubrecht, II[1], J. F. Sullivan[2]
[1]Ohio State University at Marion, [2]College of Applied Science/University of Cincinnati.

Every three years, the Inter-American Council on Physics Education runs a hemisphere-wide meeting of physicists interested in physics education. We report on experiences and outcomes from the the Inter-American Conference meeting in July, 2006 in San José, Costa Rica.

003.24

Latin America's Presentation of ″World Year of Physics 2005″

Margarete B. Allen[1]
[1]Los Angeles Pierce College.

I attended the Inter-American Physics Educators Conference in Costa Rica in July 2006. Several Latin countries gave presentations on how they celebrated the 2005 Worl Year of Physics. They were very inventive in involving the general public. I believe that raising the general publics interest and understanding of physics is cruicial, so I was very impressed with their efforts. I would like to share the creative method's used by these countries at the AAPT meeting.

003.25

A Masterclass in Particle Physics for High School Students

Kenneth Cecire[1], T. Entwistle[2]
[1]Hampton University, [2]Ward Melville High School.

The European Particle Physics Outreach Group (EPPOG) developed the Masterclass in 2004 to bring particle physics to high school classrooms in Europe. They put real data on a website (http://wyp.teilchenphysik.org/mc.htm) from the Large Electron-Positron (LEP) collider at CERN. Students analyze this data and draw conclusions at their schools. They then compare their results with those found at other schools in Masterclass live video conferences hosted by CERN over the internet.

In March 2004, six students at Ward Melville High School on Long Island were sponsored by QuarkNet and Brookhaven National Laboratory to become the first U.S. team to participate in the EPPOG Masterclass. The Ward Melville group was positive about the experience and their results tracked well with those of their colleagues in the video conference from high schools in Greece, Slovakia, and Poland.

003.26

Physics Education in Nigeria

Jefferson L. Collier[1]
[1]ABTI-American University of Nigeria, Nigeria.

For the last year and half I have been teaching at ABTI-American University of Nigeria (AAUN) in Yola, Nigeria (a small rural town in eastern Nigeria). One of the primary goals of AAUN is to offer American-style higher education in West Africa. Before coming to AAUN, I taught beginning physics using lecture/discussion and Real-Time Physics laboratories in the USA for ten years. I will discuss the differences and difficulties I have found in trying to use these teaching methods with West African students.

003.27

Physics Education in Russia and in the United States

Irina Struganova[1]
[1]Barry University.

Being a graduate of one of Russia's high schools and then of the Department of Physics at Moscow State University and teaching General College Physics in the United States for ten years, I would like to share my opinion about some aspects of physics education in these two countries. Both systems have their positive and negative features and the best combination could be achieved by exercising different methods and pedagogies taken from the two traditional systems of education.

003.28

The Comparison Between Russian High School And American College Curricula

Valentin Voroshilov[1]
[1]Boston University.

For nine years before moving in the U.S.A. I had been teaching Physics to high school and college students. Now I teach Physics (and Mathematics as well) at a two year college. The comparison between Russian high school Physics curriculum and American college curriculum shows that Russian high school graduates are suppose to demonstrate the similar amount of knowledge as American two year college students when finishing Physics class.

003.29

Representations of Force and Motion Concepts at the Middle Level

Thomas J. Regan[1], B. Sweeney[1], T. Willard[1], G. DeBoer[1]
[1]AAAS/Project 2061.

Project 2061 is creating assessment items targeting the learning goals recommended by AAAS*s Benchmarks for Science Literacy (1993) and the NRC*s National Science Education Standards (1996). One of our topics is force and motion at the middle grades level. To reduce the dependence of student performance on verbal ability, we employ graphical representations of concepts and situations. We will describe representations of (1) position versus time (Oil Drop), (2) force, speed, and change of speed (block and line arrows), (3) speed versus time (speed table). We will present sample assessment items and preliminary results from pilot testing and student interviews on comprehensibility, grade-level suitability, and effectiveness relative to purely verbal representations.

SUNDAY

004: A Potpourri of Internal Properties of Galaxies AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

004.01

A Deep HST Survey of the Prototypical Spiral Galaxy M81

Andreas Zezas[1], J. S. Gallagher, III[2], P. Mucciarelli[3]
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We present a deep HST survey of the nearby spiral galaxy M81 with the HST Advanced Camera for Surveys. The survey consists of ″B″ and ″V″ observations of 29 ACS fields, totalling to 38 orbits. These observations, together with archival ″I-band″ ACS data, will provide complete, deep coverage of the D25 area of the galaxy in all three filters. The observations are designed to reach a detection limit of 26-27 mag in B and V bands, which probe the bulk of early-type (O,B) stars and the population of star-clusters. The goals of this survey are: (a) to characterize the X-ray source population of M81; (b) to study the stellar populations and star-formation history across the galaxy; and (c) link the X-ray source populations with their parent stellar populations. In this contribution we describe the observations, summarize the data analysis procedures, discuss in detail the goals of the survey and present some results from a pilot study of one field.

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004.02

Panchromatic Tully-Fisher Relations

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We present panchromatic Tully-Fisher relations from the Spitzer Infrared Nearby Galaxies Survey (SINGS) and its ancillary data archive. These data span a wide range of optical and infrared wavelengths including B, V, R, I, J, H, K, 3.6 and 4.5 microns. We explore trends in the slope and scatter of the observed relations, and discuss the implications of these on the properties of rotationally supported galaxies. Importantly, we extend the study of the Tully-Fisher relation to the 3.6 and 4.5 micron Spitzer wavebands, placing novel constraints on the stellar populations and dust content of these galaxies.

004.03

Mapping Tidal Interactions in the M51 System

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We present deep R-band imaging of the NGC 5194/94 (M51) galaxy pair obtained with the WIYN 0.9-m telescope. Dithered R-band images are mosaicked to provide a wider field of view covering the main body of the interacting system. We estimate stellar densities in the outer features from surface photometry and look for small structures to locate possible outer sites of recent star formation. We interpret our data in the context of simulations of the interactions in the M51 system. The northern region in particular contains several unusual features around NGC 5195, such as sharp stellar density gradients, multiple debris streams, stellar shell candidates, and radial dust streamers which are not reproduced by models. We also note differences between the northern and southern tidal streams in terms of gas content, star formation and which galaxy appears to be the source of the stars.

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004.04

Ultraviolet Observations of M51 with Swift/UVOT

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We present a study of star-forming regions in M51 using observations from the Swift UV/Optical telescope (UVOT). We have obtained deep UV images in three filters in the near UV (UVW2, UVM2, UVW1) ranging from 1600 Angstroms to 3500 Angstroms. Compared to GALEX, our data provide improved color resolution, as well as improved spatial resolution (FWHM ~ 2 arcsec). We use these data in combination with existing optical observations to place constraints on the ages, masses, and reddening of the star-forming regions in M51, and study the star formation history of the galaxy.

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004.05

Spitzer IRS Spectral Maps of Spatially Resolved Molecular Hydrogen in NGC 5194

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NGC 5194 is a nearby face-on spiral galaxy whose inclination and morphology make it an optimal target for studies of the ISM (interstellar medium) across the disk of a galaxy. Using the Spitzer Space Telescope IRS (Infrared Spectrograph), we have spectrally mapped a radial strip across NGC 5194. The strip covers a range of dynamically distinct regions allowing us to probe the conditions of the warm molecular gas throughout NGC 5194. We present spectral maps of the molecular hydrogen emission features and use them to measure the mass and temperature of the warm molecular gas. The warm molecular gas distribution is compared to the cold molecular gas distribution that is traced by CO (J = 1-0) emission.

This research was supported by the Spitzer Science Center Visiting Graduate Student Fellowship Program.

004.06

Excess 4.5 Micron Emission from SINGS Galaxies

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In the SINGS images of nearby galaxies the two short wavelength IRAC channels on Spitzer (3.6 microns and 4.5 microns) primarily observe stellar photospheric emission while the two longer wavelength channels also observe significant emission from polycyclic aromatic hydrocarbons (PAHs).

In this poster we will present maps of the ratio of 4.5 to 3.6 micron emission for galaxies in SINGS sample. These ratio maps show a strong correlation between high ratios of 4.5 to 3.6 micron emission and PAH emission. In these high ratio regions the ratio is up to a factor of two higher than what is seen from stellar emission alone. We show that the high ratio is due to an excess of 4.5 micron emission and discuss possible reasons for this excess.

004.07

Evolution and Instability of Galactic Gas Disks inresponse to A Spiral Density-wave Potential

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We revisit the classic problem of the response of the gas in a galactic disk to an imposed spiral density-wave potential of stellar origin. The results show the distinct difference between waves generated by resonance excitation and forced oscillation. To avoid the confusion of mixing these two types of waves, we systematically reduce the strength of the spiral potential or the force near the primary Lindblad resonances. So we can study the original problem of shock formation and star formation problem formulated by Roberts (1969). For the cases without self-gravitation of the gas disk, in addition to the primary doubly periodic shocks, the presence of the branch-like structures which correspond to the ultra-harmonic resonances is pronounced. On the other hand, once the self-gravitation is included, unlike the work of Chakrabarti et al. (2003), the sub-structures associated with the ultra-harmonics are not necessarily enhanced by the self-gravity. Their growth may be deteriorated by the growth of the primary shocks. Sub-structures other than those identified with the ultra-harmonics may result from shear instability of Rayleigh's kind or gravitational instability of Toomre's kind. They are responsible for the branches, feathers or chaotic sub-structures observed in nearby galaxies in far infra-red. The work is in parts supported by a grant from National Science Council, Taiwan NSC95-2752-M-001-009-PAE.

004.08

Hydrodynamical Simulations of the Barred Spiral Galaxy NGC 6782

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NGC 6782 is a type (R_1R_2')SB(r)a galaxy with multiple ring patterns. It has a nearly circular bright nuclear ring connected with a pair of almost straight dust lanes, the other ends of which attach to a diamond-shaped (or pointy oval) inner ring. Two faint arms in turn extend from the two tips of the inner ring to the outermost parts of the galaxy, forming a faint double outer ring-pseudoring morphology. In this study we use numerical simulations to show that such striking features can be reproduced by imposing a strong bar to a gaseous disk system. Since strong bar potentials may, through instabilities, lead to chaotic sub-structures, they present challenging problems to the numerical simulations. Our simulations are performed with our own Antares code, which employs Cartesian coordinates and the higher-order Godunov scheme with unsplit flux calculated from the exact Riemann solver. Calculations are carried out with and without self-gravitation, which produce similar results. In both cases, the bar is able to drive spiral density waves simultaneously at both the outer Lindblad resonance (OLR) and the inner Lindblad resonance (ILR). When the bar potential is strong enough, these two waves excited at the two resonances interact with each other,

giving rise to the diamond-shaped structure. All the essential features are in excellent agreement with observations. Our work is in part supported by National Science Council, Taiwan, NSC95-2752-M-001-009-PAE, and by NSF grant AST050-7140.

004.09

Star formation and figure rotation in the early-type galaxy NGC2974

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We present Galaxy Evolution Explorer (GALEX) far and near ultraviolet imaging of the nearby early-type galaxy NGC2974, along with complementary optical imaging. In the ultraviolet, the galaxy reveals a central spheroid-like component and a newly discovered complete outer ring of radius 6.2 kpc, with suggestions of another partial ring at an even larger radius. Blue FUV-NUV and UV-optical colors are observed in the center of the galaxy and from the outer ring outward, suggesting young stellar populations (<1Gyr) and recent star formation. This is supported by a simple stellar population model which assumes two bursts of star formation, allowing us to constrain the age, mass fraction of the young component pixel by pixel. Overall, the mass fraction of the young component appears to be just under 1 percent. The additional presence of a nuclear and an inner ring (radii 1.4 and 2.9 kpc, respectively), as traced by [OIII] emission, suggests ring formation through resonances. All three rings are consistent with a single pattern speed of 78 ± 6 km s^{-1} kpc^{-1}, typical of S0 galaxies and only marginally slower than expected for a fast bar if traced by a small observed surface brightness plateau. This thus suggests that star formation and morphological evolution in NGC2974 are primarily driven by a rotating asymmetry (probably a large-scale bar), despite the standard classification of NGC2974 as an E4 elliptical.

004.10

A Multi-Waveband Study of the Southern Compact Group, SCG 0018-4854

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I will present the results of a multi-waveband (u', g', r', and i'), Gemini South study of SCG 0018-4854. Compact groups of galaxies have extremely low velocity dispersions between group members and are expected to be environments conducive to multiple collisions and mergers. There is also evidence to suggest that in some groups, the individual member galaxies will eventually coalesce into a single field galaxy. This compact group, SCG 0018-4854, consists of four galaxies that are interacting and exhibit signs of intense star formation. I present deep, high-resolution Gemini South data of this system and a detailed examination of its morphology and colour structure. I will also present the my preliminary findings on the star clusters in the individual member galaxies.

004.11

Mapping a Low Surface Brightness Galaxy

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The purpose of this project is to study the low surface brightness (LSB) galaxy UGC 6614. The project involves examining the optical data taken by the HST WFPC2 instrument and combining it with HI data taken by the Very Large Array. The goal is to create optical and HI maps of this galaxy and combine them with a CO map of the galaxy obtained by Das, et al. (2006) and analyze the star forming regions of the galaxy. From the WFPC2 images, we can clearly see that UGC 6614 has distinct spiral arms, with the CO detection lying in a region of the galaxy disk. Additionally, we have detected 28 background galaxies and analyzed them with surface brightness and color profiles.

All of the data presented in this paper were obtained from the Multimission Archive at the Space Telescope Science Institute (MAST). STScI is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS5-26555.

004.12

In Search of the Highest Velocity Dispersion Galaxies in the Universe

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We present Hobby-Eberly Telescope (HET) observations for galaxies at $z < 0.3$ from the Sloan Digital Sky Survey (SDSS) showing large velocity dispersions while appearing to be single galaxies in HST images. The high signal-to-noise HET spectra provide more definitive velocity dispersions and tests of binarity. The results are compared with the large velocity dispersions expected from the large black hole masses found in some QSOs. Galaxies with the largest confirmed velocity dispersions will provide targets to search for the largest black holes.

004.13

The Connection In Bulge Properties And The Bimodailty Of Galaxy Properties

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The global colors and structural properties of galaxies have recently been shown to follow bimodal distributions. Also, recent work has established that there are two types of bulges: "classical bulges'' that are dynamically hot systems resembling ellipticals, and "pseudobulges'', dynamically cold, flattened, disk-like structures that could not have formed via violent relaxation. At intermediate Hubble types (Sa-Sc) does the galaxy dichotomy separates galaxies at a specific bulge-to-total ratio, B/T, or does it separate galaxies of different bulge type?

Detailed surface photometry reveals that: (1) The red -blue dichotomy is a function of bulge type: at the same B/T pseudobulges are in globally blue galaxies and classical bulges are in globally red galaxies. (2) Bulge type also predicts where the galaxy lies in other dichotomous global structural parameters: global Sersic index and central surface brightness. (3) Hence, the red -blue dichotomy is not due to decreasing bulge prominence alone, and the bulge type of a galaxy carries significance for the galaxy's evolutionary history. Classical bulges indicate that a galaxy has suffered a major merger (of smaller fragments) in its past. This is more likely to have happened early, in higher-density environments. Therefore, these galaxies are likely to be red today. Pseudobulges form via cold internal evolution; such a galaxy has not suffered a major merger since its disk formed. This is more likely at later epochs, when the merger rate is lower and in low-density environments. Therefore, these are likely to be younger, blue galaxies.

004.14

Revisiting the Low Metallicity Problem of the Hot ISM in X-ray Faint Early-type Galaxies

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The metallicity of the hot interstellar medium (ISM) of early-type galaxies has been vigorously debated over the years, but recent studies by XMM-Newton and Chandra seem to be converging on a metallicity value consistent with solar, at least for X-ray bright ellipticals and S0s. This is expected, since the source of much of the hot ISM is mass loss from stars with optically-measured metallicities of approximately solar. However, very low hot gas metallicities (<10% solar) have been reported in X-ray faint ellipticals and S0 galaxies. We investigate this discrepancy by analyzing the joint Chandra + XMM-Newton (174 ksec + 41 ksec) spectrum of the X-ray faint elliptical galaxy NGC4697. The long exposure time affords us enough counts to untie individual elements (O, Ne, Mg, Si, S, Ni) from Fe, some-

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thing that was not possible in previous studies because of low X-ray count rates. We find that although the extremely low metallicities (<10% solar) reported previously are ruled out, O, Ne, Mg, and Fe are still substantially sub-solar (~25% solar). We discuss possible mechanisms by which the metal content of the hot gas has been diluted.

004.15

Chandra Observations of Maffei 1

Christopher S. Reynolds[1], C. Miller[1]
[1]*Univ. Of Maryland.*

We present Chandra observations of Maffei 1, the nearest giant elliptical galaxy (D=3,Mpc) and the dominant member of the Maffei group of galaxies. Although we discover weak nuclear activity, Maffei 1 is shown to have the quietest nucleus of any elliptical galaxy observed by Chandra to date. We also characterize the luminosity function (LF) of the low mass X-ray binaries (LMXBs) in the core regions of this galaxy. Given the proximity of this galaxy, we can study X-ray binaries down to a 0.5-10keV X-ray luminosity of 10^{37},erg/s or less; we find that the faint-end LF is rather flat. Above 10^{37} erg/s, the LF breaks to become rather steeper than typically found in LMXB populations. We discuss implications for the nature of LMXBs in normal elliptical galaxies.

004.16

PNLF Distances to Six Face-On Spiral Galaxies

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As the first step in our program to determine disk mass-to-light ratios in spiral galaxies, we have performed narrow-band imaging surveys in six face-on systems. In order from most to least massive, they are: M74, M83, M94, IC 342, NGC 6946, and NGC 5068. We have identified between 25 and 250 planetary nebulae (PNe) in each galaxy. The photometry of these PN populations enables us to determine a reliable distance to each spiral, which we compare to other distances in the literature. For the larger PN samples, we also split the data in half (inner vs. outer) to examine the luminosity functions derived from both regions to test for consistency and possible differences due to stellar populations and/or local extinction. In addition, we explore the luminosity-specific PN number density, N_{PN}/L_{gal}, as a function of radial distance in the galactic disks to establish how well PNe trace the general disk stellar population.

This work is supported by NSF grant AST 06-07416 and a Pennsylvania Space Grant Fellowship.

004.17

The Star Formation History in Andromeda's Diffuse Stellar Halo

Thomas M. Brown[1], E. Smith[1], H. Ferguson[1], P. Guhathakurta[2], R. Rich[3], J. Kalirai[2], A. Renzini[4], A. Sweigart[5]
[1]*STScI,* [2]*UCSC,* [3]*UCLA,* [4]*INAF, Italy,* [5]*NASA/GSFC.*

We present a color-magnitude diagram from deep Hubble Space Telescope observations of a minor-axis field 21 kpc away from the center of Andromeda. In both star counts and chemical abundances, this field represents a transition point between the highly-disturbed inner spheroid that dominates within 15 kpc and the diffuse population that dominates beyond 30 kpc. Our observations reach well below the oldest main sequence turnoff in the population, allowing a complete reconstruction of the star formation history in this field. We compare the current observations to our previous observations in the inner spheroid, outer disk, and tidal stream, and consider implications for the formation history of these structural components.

005: AGN, Starbursts, and Sub-mm Galaxies
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

005.01

SPIRE Multi-Color Fluctuation *P(D)* Analysis Below the Confusion Limit.

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The *SPIRE* instrument on the *Herschel* telescope will obtain sensitive spectral and photometric observations in wavebands centered at 250, 350, and 520 microns. As these wavelengths trace the thermal emission from interstellar gas and dust that comprise the cosmic integrated background radiation (CIB), *SPIRE* will provide unique information on the history of energy injection through star formation and active galactic nuclei in the universe. Even with *Herschel*,

much of the background radiation will be unresolved, especially at the longest wavelengths, which probe the largest redshifts. Analysis of the fluctuations in the background generally referred to as a *P(D)* analysis provides unique information on the sources of the cosmic infrared background at redshifts where they are too faint to be detected individually. We present results of a

fluctuation analysis of simulated observations with *SPIRE* on the *Herschel* satellite. We show that such an analysis provides much more stringent constraints on the source number counts than those derived using the point sources identified in the *Herschel* survey. We show that with observations of approximately one square degree it will be possible to place tight constraints

on the source population that produces a large fraction of the cosmic infrared background.

005.02

A Comparison of Effective Volumes for X-ray Surveys

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In comparing X-ray survyes 'Cone diagrams' are often used to show how wide-angle/shallow surveys complement pencil-beam/deep surveys.While this is illustrative, it lacks quantitative rigor.

We consider instead the effective volumes covered by a number of X-ray surveys of different depths and areas. The volume clearly depends on the luminosity of the source being probed, so we choose several fiducial values, based on the L* luminosities of the AGN luminosity functions.

The high redshift limit used is simply given by the sensitivity of the survey. The low redshift limit is more complicated; the survey does not begin until we expect at least one (and preferably 10) objects within the survey volume. Hence the low z limit is set by the space density of the AGN population, which is itself a function of redshift. We use the well measured X-ray luminosity function of AGN to illustrate how the effective volumes of the major surveys compare with one another.

005.03

Colour Bimodality in Powerful AGN Host Galaxies

David Floyd[1]
[1]*STScI.*

Using host galaxy morphological modelling of powerful radio-loud and radio-quiet AGN from z=0.1-2 we show that the two populations exhibit diverging evolutionary tracks. Locally, matched samples of RG, RLQ and RQQ occupy similarly massive host galaxies, but whereas the radio-loud quasar hosts exhibit near-passive evolution out to z=2, the radio-quiet host galaxies become increasingly blue as we move outward. This suggests that radio-loud objects are found in older systems and/or are able to truncate the star-formation in their host galaxies.

We explore the cluster and host and merger environments of the sources. In a survey of ~100 z<0.3 powerful (3CR) radio galaxies, there is evidence for minor mergers in >50%. This suggests that minor mergers are capable of triggering or re-triggering a radio-loud phase in an elliptical galaxy if the merged object is sufficiently gas rich. Ramifications and future directions for AGN and unification models are briefly discussed.

005.04

Cosmological History of Massive Black Hole Interactions in Triples

Frederic A. Rasio[1], J. Fregeau[1], S. Umbreit[1], M. Volonteri[1]
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We investigate triple interactions between massive black holes (MBHs) formed through galaxy mergers in a Lambda cold dark matter universe. We follow the assembly and growth of MBHs from primordial seeds, remnants of the first generation of stars, to the present day, by considering the merger history of dark matter haloes and their associated black holes in Monte Carlo realizations of the merger hierarchy. As a result of such a merger, the MBHs that were initially embedded in the galactic nuclei of the colliding galaxies form a binary system in the center of the merger remnant due to dynamical friction. If the coalescence timescale of such a MBH binary can be long

enough for a third MBH to fall in and interact with the central binary, the triple interaction leads typically to the final ejection of one of the three bodies and recoil of the remaining binary. In our study we simulate a large number of such triple interactions, with initial conditions constrained by the detailed merger history. Our results have implications for the abundance and properties of ejected single and binary MBHs, for observations of MBH mergers with LISA as a function of redshift, and for the M-sigma relation.

005.05

Local Benchmarks for the Evolution of Major-Merger Galaxies (I)--Spitzer Observations of a K-Band Selected Sample

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We have obtained Spitzer IRAC and MIPS maps for a sample of close major-merger pairs of galaxies selected from the joint 2MASS/SDSS-DR3 database. This is to provide a highly accurate and unbiased local benchmark for studies of evolution of major-merger galaxies. The parent sample (46 pairs) is complete, consisting of all physical pairs (in 3000 deg^2) with the primary brighter than K=12.5, projected separations of 5<r<20/h kpc and stellar mass ratios < 2.5 ('major-mergers'). Other samples of local interacting galaxies selected from photographic plates are severely biased. With the Spitzer observations, we aim to obtain for the first time unbiased statistics on the star formation rate (SFR) and star formation (SF) strength (SFR per unit stellar mass) of close major mergers at z=0. The Spitzer sample (27 pairs, 54 galaxies) includes all S+S and E+S pairs in the parent sample which have measured redshifts for both components (i.e. spectroscopically confirmed pairs). The Spitzer data show very diversified SF properties among galaxy pairs in the sample. In particular, majority of these NIR selected close major-merger galaxies have rather moderate SFR. This is very different from FIR selected interacting galaxy samples.

005.06

Local Benchmarks for the Evolution of Major-Merger Galaxies (II) --Palomar H_alpha/H_beta Observations of a K-Band Selected Sample

Yi-Wen Cheng[1], C. K. Xu[1], N. Lu[1], R. Cutri[1], D. Domingue[2], Y. Gao[3], J. Huang[4], J. Mazzarella[1], J. Surace[1], W. Sun[5]
[1]*IPAC/Caltech,* [2]*GCSU,* [3]*Purple Mountain, China,* [4]*CfA,* [5]*National Central Univ., Taiwan.*

As part of a multi-wavelength study of a sample of K-Band selected major-merger galaxy pairs at z=0, narrow band H_alpha and H_beta imaging observations have been carried out using Palomar 200″ telescope. The H_alpha emission, once corrected for the dust extinction, is one of the best measurements of the star formation rate (SFR). As demonstrated in the literature, the combined H_alpha and H_beta imaging can result in a reliable extinction map. Complementary to the Spitzer observations of the same sample (see Xu et al., this volume), we aim to obtain an unbiased statistics of the SFR and its spatial distribution in these interacting galaxy systems. Furthermore, fitting the multiband (ugrizJHK) images and optical spectrographs in the SDSS-DR3 and 2MASS database with the stellar synthesis model (Bruzual & Charlot 2003) and dust extinction model (Calzetti 1994) provides additional constraints to the star formation history of these major-merger pairs.

005.07

Evidence for Evolution in the FIR Luminosity Function of Luminous Infrared Galaxies from Spitzer and ISO Observations of the Lockman Hole

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We use a complete sample of 70μm and 160μm selected sources from Spitzer observations of a 1 square-degree region in the Lockman Hole, supplemented by ISOPHOT data at 90μm and 170μm, to determine the evolution of the far-infrared luminosity function (LF) of luminous infrared galaxies (LIGs) out to redshift z ~ 1. Keck spectroscopy is available for the majority of these sources and for the remainder we use photometric redshifts obtained from a combination of multi-wavelength ground-based optical/NIR photometry and Spitzer-IRAC data. We present evidence for strong evolution in the LF for LIGs in the luminosity range $\log(L_{ir}/L_{sun}) = 11\ 12.5$.

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006: Astrobiology and Lab Results
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

006.01

Investigation of Anomalous Sputtering Behavior of a Ga-In Target

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Nonstoichiometric sputtering has been studied for decades, in part because of its potential role in modifying the composition of materials in the inner Solar System. Sputtering of multi-component materials typically results in lighter atoms/isotopes sputtering at average angles closer to the target normal than heavier atoms/isotopes in the absence of chemical influences, but Ga-In may not adhere to this. There is a hint of experimental evidence that the isotopes of Ga sputtered from this target exhibit the opposite behavior. We present computer simulation results that also suggest this anomalous behavior, and discuss a new experiment we are conducting to probe this behavior in more detail. In the experiment, material sputtered by Ar+ is collected on carbon foil, which is analyzed after collection to determine the angular distribution of sputtered material. Analysis of the collector foils utilizes two techniques, SIMS (Secondary Ion Mass Spectrometry) and RBS (Rutherford Backscattering Spectrometry).

006.02

Laboratory Infrared Optical Constants and Reflectance Spectra of Silicon Carbide

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The observed SiC features in astronomical IR spectra of carbon stars (C-stars) correlate with thin-film IR absorption spectra of β-SiC, the polytype most commonly found as presolar grains in meteorites. Comparison between spectra of astronomical sources and laboratory compounds alone is also not sufficient to assess the relative contributions of different minerals to a given observed spectrum: radiative transfer modeling must be performed (cf. Thompson et al. 2006, ApJ, 652, in press). For C-star spectra, radiative transfer modeling is impeded by the lack of trustworthy SiC optical constants for both β and α polytypes. To address the need for improved dust composition parameters, we measured midand far-infrared room temperature reflectance spectra for several polytypes and orientations (E perpendicular to c, E parallel to c) of commercially manufactured SiC: semiconductor grade purity 3C (β-)SiC, several colors of 6H (α-SiC), and synthetic moissanite (α-SiC). The extremely high reflectivity was connected with discrepancies existing among previous absorption laboratory spectra from thin films, crystallites, and powders. We extracted the real and imaginary parts of the complex refractive index ($m(\lambda) = n(\lambda) + ik(\lambda)$) from these data using classical dispersion analyses [Spitzer et al. 1962] and supplied these results to 1-D radiative transfer models (DUSTY; Ivezic & Elitzur 1995; Nenkova et al. 2000) to determine how the emerging spectrum should change in response to our $n(\lambda)$ and $k(\lambda)$ and other dust shell parameters (effective stellar temperature, inner dust shell temperature, optical depth). The results of this work have direct application to carbon-rich AGB stellar outflows, novae, supernovae, and potentially proto-planetary nebulae and may further our understanding of the contribution of SiC to carbon star spectra and the lack of SiC features in the ISM.

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006.03

Modeling Atmospheric Effects of the September 1859 Solar Flare

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We have modeled atmospheric effects, especially depletion of ozone, due to a solar proton event which probably accompanied the extreme magnetic storm of 1-2 September 1859. We use an inferred proton flux for this event as determined from nitrate levels in Greenland ice cores. We present results showing production of odd nitrogen compounds and their impact on ozone. We also compute rainout of nitrate in our model and compare to values from ice core data.

006.04

Living with a dM Star: Evolution over Time of Dynamo Generated X-ray UV Emissions and Effects on Hosted Planets

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We report on a multi-frequency study of dM stars with ages from <30 Myr to ~13 Gyr. The goals are to understand the magnetic activity, coronal physics, and XUV spectral irradiances of dM stars with widely different rotations, ages, and widely different levels of XUV emissions. Because of the large number of dM stars ($>70\%$ of all stars), and their very long lifetimes, there should be numerous dM stars hosting planets. Thus dM stars are attractive targets of extrasolar planet search missions such as COROT, Kepler, SIM, and Darwin/TPF. The habitable zones (HZs) around dM stars are close to the host star (HZ ~ 0.05-0.40 AU) making the hypothetical HZ planet strongly influenced by stellar flares, winds, and plasma ejection events that are frequent in dM stars. Also, with the long-lifetimes of dM-stars of $>$ 20-Gyr, it might be possible for life on a HZ-planet to be much more evolved than ourselves. Of particular interest is the determination of XUV emission flux evolution with time. This is because of the critical roles that XUV coronal and chromospheric emissions play in the photoionization and photochemical evolution (and possible erosion) of planetary atmospheres and ionospheres. We have used ROSAT, ASCA, XMM and Chandra X-ray observations and combined these with EUV, and FUV-UV data (from EUVE, FUSE and IUE or HST) to form XUV spectral irradiance tables of dM stars covering a wide range of ages and XUV fluxes. These results are critical to the studies of XUV radiation of dM-stars and its effects on the environments of possible hosted extrasolar planets and on the possible origin and evolution of extraterrestrial life on such planets. The initial results of this study will be presented and discussed.

This research is supported by grants from NASA/FUSE and NSF which we gratefully acknowledge.

006.05

Evolutionary Competition Between Primitive Photosynthetic Systems: Existence of an early purple Earth?

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The onset of photosynthesis in primitive cyanobacteria is thought to have profoundly altered the Earth's atmosphere by producing an oxygen-rich atmosphere some 2 billion years ago. However, the pigments used by chlorophyll-based photosynthesis absorb at a variety of wavelengths, curiously except those centered around the peak of the Solar spectrum, ~550nm. By contrast, simpler retinal-based light harvesting systems such as the haloarchaeal purple membrane bacteriorhodopsin and halorhodopsin show a strong well-defined peak of absorbance centered at ~550nm. The spectroscopic complementarity for retinal pigments with chlorophyll-based pigments suggests an intriguing possibility of their co-evolution. This hypothesis argues that simpler retinal-based phototrophic capability may have evolved earlier, in microorganisms that dominated during the anaerobic and purple phase of the planet. Later, the more complex chlorophyll-based photosystem pigments could have evolved to harvest light in regions of the spectrum not absorbed by preexisting species. This would have led to the greening and oxidation of our planet and displacement of most of the retinal-based microorganisms. Not surprisingly, evidence for retinal chromoproteins have recently turned up in a variety of planktonic microorganisms. Although speculative, such a scenario would indicate that retinal-based phototrophy may be one of the oldest metabolic capabilities on Earth. Moreover, if the chlorophyll absorption spectrum is simply a product of adaptation, then its utility as a potential biomarker is likely to be limited.

007: Black Holes
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

007.01

The Binary Nucleus in VCC 128: A Candidate Supermassive Black Hole in a Dwarf Elliptical Galaxy

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Searching through archival Hubble Space Telescope (HST) images of dwarf elliptical galaxies, we identified galaxies with compound nuclei. HST Wide Field Planetary Camera 2 (WFPC2) images of the Virgo Cluster dwarf elliptical galaxy VCC 128 reveal an apparently double nucleus. The two components, which are separated by 32 pc in projection, have the same magnitude and color. Spectra of this double nucleus are inconsistent with one or both components being emission-line background objects or foreground stars. The most likely interpretation is that, as suggested by Lauer et al. (1996) for the double nucleus in NGC 4486B, we are seeing a nuclear disk surrounding a supermassive black hole. This is only the second time an early-type dwarf (dE/dSph) galaxy has been suggested to host a SMBH.

VPD is supported by a Brooks Prize Fellowship at the University of Washington.

007.02

First Constraints on Black Hole Spin in Broad Iron Line AGN

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Black holes are arguably the simplest objects in nature, with an ability to be completely defined by two mathematical quantities: mass and spin. Spin, being a general relativistic effect, is the more difficult to discern of the two. One of the most promising and robust methods for constraining this quantity relies on modeling the relativistically altered shape of the iron-K line emitted from the accretion disk around the black hole. With this in mind, I have expanded upon previous emission line model codes to create a new relativistic emission line model, called kerrdisk, which allows the black hole spin to be fit as a free parameter. This allows us to robustly constrain the angular momentum of a black hole for the first time. Herein I present the results of spectral fitting of this model to several AGN with robustly observed broad iron lines in an effort to perform the very first statistically robust study of black hole spin distribution in these types of sources. This is a crucial first step toward taking a census of black hole spin in both AGN and GBHCs.

I gratefully acknowledge funding from NSF grant AST0205990, which has contributed to this research.

007.03

The Accretion Disk of GRS 1915+105: What Makes it Go Crazy?

David M. Rothstein[1]
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GRS 1915+105 is a black hole in the Milky Way galaxy accreting material from a companion star. It has been in an active state of outburst since its discovery in 1992, exhibiting large plasma ejections and rapid X-ray variability. Here, I present a study of some of the most extreme variability seen from this source and perform simple accretion disk simulations to try to reproduce it. I present evidence that the ejection of material into a jet and the associated destruction of a large-scale magnetic field may directly trigger instabilities in the accretion disk.

D. M. Rothstein is supported by an NSF Astronomy and Astrophysics Postdoctoral Fellowship under award AST-0602259.

007.04

Toward Understanding the Spectral Energy Distribution of Microquasars. I. Multiwavelength Properties of XTE J1550--564

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We report results from a systematic study of the spectral energy distribution (SED) of XTE J1550--564. The main objectives include: 1) assessing the roles of jets and accretion flows; 2) disentangling variabilities associated with the jets and accretion flows and quantifying the coupling between the two; and 3) re-examining the concepts of spectral states, state transitions, and spectral hysteresis. The jets of XTE J1550--564 have been directly imaged at X-ray energies. We began by applying a synchrotron model to the broadband SED of the western ′′blob′′ (in the jets), to constrain the SED of radiating electrons in the ′′blob′′. Assuming that the electron distribution is the same for all ′′blobs′′, we then applied the model to the overall radio spectrum of the source and extrapolated the best fits to higher frequencies. Dispite of significant degeneracy in the fits, it seems clear that the synchrotron radiation from the jet contributes little to the observed X-ray emission, when the source is relatively bright. Assuming that the X-ray emission originated mostly from the accretion flows, we took an empirical approach to model the X-ray spectrum and study its evolution. From the compilation of the SEDs of XTE J1550--564, we found it straightforward to define spectral states based on the shape of SEDs and visualize transitions between various states thus defined. There is evidence for spectral hysteresis associated with the rise and fall of the 2000 outburst. Comparing outbursts of varying magnitude, we can also see that a specific state transition may occur at different fluxes. We also examined the radio/X-ray correlation of the source. While a rough correlation seems to be present, it is a fairly loose one. The implication of the results is discussed.

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007.05

Active X-ray States of Black Hole Binaries: Current Overview

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We use the RXTE archive to define X-ray states for 30 black hole binaries and candidates. We examine the frequencies for occupying each state, the correlations between states and Eddington-scaled luminosity, and the distribution of measured spectral and timing parameters within each state. The results are used to argue forcefully that there are three different states of active accretion for black hole binaries. Two of these states (thermal and hard) are shared by accreting neutron stars, but the other (steep power law) is not.

007.06

High Resolution Ultraviolet Spectroscopy of the X-ray Binary Cygnus X-1

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High-resolution ultraviolet observations of the black hole X-ray binary Cygnus X-1 were obtained using the Space Telescope Imaging Spectrograph on the Hubble Space Telescope. Observations were taken at two epochs roughly a year apart; orbital phase ranges around $f_{orb} = 0$ and $f_{orb} = 0.5$ were covered at each epoch. We detected P Cygni line features from both high (N~V, C~IV, Si~IV) and low (Si~II, C~II, O~I, Al~II) ionization state material. We analyze the characteristics of a selection of P Cygni profiles and note, in particular, a strong dependence on orbital phase: the profiles show strong, broad emission when the X-ray source is behind the companion star and noticeably less absorption when the X-ray object is between us and the companion star. We discuss possible explanations for this effect, including the Hatchett-McCray effect, in which X-rays from the compact object photo-ionize the stellar wind from the companion star, reducing absorption, or a 'focusing' of the wind toward the compact object as has been suggested by several authors.

008: Blazars and AGN jets
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

008.01

Collimation and Stability Properties in AGN Jets

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Propagation of ″magnetic tower′′ jets in gravitationally stratified atmospheres in large scales (> tens of kpc) has been examined by performing three-dimensional magnetohydrodynamic (MHD) simulations. The MHD wave structures, the cylindrical radial force balance, and the stability properties of magnetic tower jets will be discussed based on the nonlinear solutions. During the dynamical evolution of magnetic towers, the narrow ″jet body′′ and the expanded ″lobe′′, both of which are magnetically dominated, are formed. In our results, a preceding hydrodynamic shock, which may be identified as an AGN-driven shock in X-ray observation, plays an important role in the dynamics of magnetic towers. A strong compression at the head of tower front and radial collimation to produce a slender-shaped jet are

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observed. The axial jet current and the external gas pressure can determine the width of radio lobes. The current-carrying, Poynting flux-dominated magnetic tower jet, which possesses a highly wound helical magnetic field, is subject to the current-driven instability (CDI). We find that the propagating magnetic tower jets develop the non-axisymmetric mode of the CDI. Both the internal elliptical (m=2) mode like the ″double helix'' and the external kink (m=1) mode to form the large scale wiggles grow in different parts of magnetic towers. The pressure-driven and shear-driven instabilities do not occur in the magnetic tower jets. This strongly suggests that the CDI is the primary reason to determine the large scale structure in AGN jets.

008.02

Correlated Multifrequency Variability in the Blazars 3C 279 and PKS 1510-089

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We have analyzed light curves of blazars 3C 279 and PKS 1510-089 in X-rays (RXTE-PCA, 2-10 keV), Optical (R band), and Radio (UMRAO) between 1996 and 2005. Power Spectral Densities (PSD) for both sources are power laws with slopes between -1.5 and -1.9 in all three bands with no significant ′break' within the observed frequency range. Cross-correlation between X-rays and optical and X-rays and radio gives a high coefficient for 3C 279 and more modest value for PKS 1510-089. In each case, correlation between simulated light-curves generated randomly with a similar power spectrum as the real data indicates that the correlation is significant. The time delay between variations at high and low frequency bands undergoes large variations during the 10 years of observation for both sources. A large shift in time delay for 3C 279 occurred near the time of a major multifrequency flare in 2001. This coincided with the onset of a swing toward a more southerly direction of the trajectories of new superluminal radio knots.

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008.03

Spitzer Observations of Cygnus A and Pictor A

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We present observations of the FRII radio galaxies Cygnus A and Pictor A obtained with the Multiband Imaging Photometer for Spitzer (MIPS) and the Infrared Spectrograph (IRS). The nuclei and radio hot spots in both galaxies are detected with MIPS at 24 microns, but the nuclei have thermal emission components indicative of dust heated by the central active nucleus. The IRS spectrum of Pictor A shows strong silicate emission, while Cygnus A shows strong silicate absorption. We discuss these results in the context of AGN unified schemes.

Support for this work was provided by NASA through contract 1255094 issued by JPL/ California Institute of Technology.

008.04

Multi-frequency VLBA Observations of Circular Polarization fromExtragalactic Radio Jets

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Circular polarization represents a tiny fraction of the synchrotron emission from extra-galactic radio jets; however, it has the potential to reveal important clues about their three-dimensional magnetic field structure and low energy particle population. We are currently obtaining multi-epoch circular polarization images of a large sample of active galactic jets with the MOJAVE VLBA program, and have started a follow-up program to obtain deep multi-frequency VLBA observations of the strongest detections. With this new program we are obtaining the first ever parsec-scale spectra of circular polarization at more than two frequencies. We present first results from recent six-frequency VLBA observations (from 8.0 to 24 GHz) of 18 Extra-galactic radio jets. Three well known radio jets: 3C84, 3C279, and 3C380 show different, interesting frequency dependent trends. 3C84 displays a clear change in sign of the circular polarization with frequency with a peak in the circular polarization at 15 GHz; however, 3C279 has a consistent sign for its circular polarization with a fractional level that appears to hold steady or perhaps increase with frequency. Finally, 3C380 displays an intriquing trend with strong negative circular polarization at low frequency (8-9 GHz), decreasing in strength at the intermediate frequencies (12-15 GHz), and potentially switching to positive circular polarization at high frequency (22 24 GHz). These changes in 3C380 are accompanied by a strong increase in core flux and linear polarization with frequency.

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008.05

Cm-band Circular Polarization Spectral Variability from Blazars: Recent Results from the UMRAO Program

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Circular polarization (CP; Stokes V) observations provide unique constraints on the magnetic field topology and degree of order in AGN jets, and a potential direct link between the central engine and the jet, but, because of low CP emission levels from AGNs (typically tens of mJy at most) its characteristic temporal evolution has not been widely exploited as a radio jet probe. To determine CP variability properties on time scales of weeks to years in a sample of radio-bright AGNs, in 2001 we resumed a program of CP measurements carried out from 1978-1983 using the Michigan 26-m paraboloid operating at 8.0 and 4.8 GHz; in late 2003 we commenced observations at 14.5 GHz. The program provides spectra in all 4 Stokes parameters at 3 frequencies with data spanning nearly 3 decades. We find examples of 1) changes in polarity on decade-long time scales; 2) multimonth, frequency-dependent, ordered changes in amplitude (and sometimes changes in polarity) which are largest in V/I at the two lowest frequencies where Faraday effects are expected to dominate; 3) frequency-dependent differences in both amplitude and polarity at a single epoch; and 4) temporal association between detectable CP levels and self-absorption in the emitting region. These properties are suggestive of the generation of CP by linear-to-circular mode conversion (Jones and O'Dell, 1977, ApJ, 215, 236) in a self-absorbed source with a turbulent magnetic field: radiative transfer calculations confirm that this mechanism can reproduce the observed levels of fractional linear and circular polarization and polarity changes with time. Published VLBI imaging data show that the emission is primarily from the radio core, and we speculate that the observed variability is associated with shifts in the tau=1 surface within the jet. This research was partially funded by NSF grants (AST-0307629, AST-0607523) and the U. Michigan Astronomy Department.

008.06

Observations of Blazar S5 0716+714 With Ground Based Telescopes and the Spitzer Infrared Space Telescope

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The Gamma-Ray Large Area Space Telescope (GLAST) to be launched in 2007 has a proposed observing list that includes AGNs and Polars bright enough to be observed optically by amateurs and students. This observing list is maintained by the Global Telescope Network (GTN). One of our targets, S5 0716+714, was observed with the Spitzer Space Telescope MIPS and IRAC instruments and also using ground based telescopes. Observations were made in seven infrared bands with Spitzer. Additional observations made from the ground by students, amateur astronomers, and college observatories in R,V, and I were nearly simultaneous with the Spitzer observations. This data were used to construct light curves over the course of the observation and the Spectral Energy Distribution (SED) of the target using all the sources. These data were compared to models of the dust emission from the torus, synchrotron emission from the radio core, and thermal emission from the accretion disk to determine the relative importance of the different emission mechanisms in this object as a function of wavelength. Results were compared to observations of 4C 29.45 made last year.

This research was supported by the Spitzer Science Center, the National Optical Astronomy Observatory, and the California Department of Education's Specialized Secondary Program.

008.07

Microvariabilty in Active Galactic Nuclei at 1420 MHz

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Active Galactic Nuclei (AGNs) are some of the most distant objects known in the universe. Quasars, blazers, and Seyfert galaxies are all categorized as AGNs. One of the interesting characteristics of AGNs is that they vary in brightness over a variety of time scales including long term (years or decades), intraday (days or weeks), and very short periods (hours or minutes). Using the Morehead State University 21m Space Tracking Antenna we can measure short term variations (microvariability) of the radio frequency radiation of these distant objects. By monitoring the microvariability in the atomic hydrogen line at 1420 MHz we may be able to determine if the variability is due the internal processes of these objects or due to the intervening medium, and to provide insight into the nature and process of the AGN central engines. Initial observations of a set of target AGNs have been undertaken. These data sets will be correlated with simultaneous optical (Bell observatory) and gamma ray (GLAST) observations to produce broad band, multiwavelength observations of a target set of AGNs. This project is supported by the Kentucky Space Grants Consortium.

008.08

Ejection Direction Variations in MOJAVE AGN Jets

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The MOJAVE program is currently studying relativistic jet phenomena in nearly two hundred of the brightest AGN in the northern sky. By obtaining regularly-spaced, milliarcsecond-resolution full polarization images with the VLBA, we are the first study to investigate the structural evolution of AGN jets on decade-long timescales. Our sample is complete with respect to compact radio flux density, and consists mainly of highly beamed blazars in which the jet is pointing nearly directly at us. In our sample we have found several sources in which successive bright jet features travel outwards at superluminal speed after emerging from the base of the jet, but along distinctly different position angles. In some cases the ejection direction oscillates with time, as might be expected for a precessing jet nozzle. We discuss how these variations can lead to apparently curved jet morphologies, and how these differ from other jets in which features appear to accelerate along curved trajectories.

The MOJAVE project is supported under National Science Foundation grant 0406923-AST and a grant from the Purdue Research Foundation.

008.09

Effects of Jet Opening Angle and Velocity Structure on Blazar Parameters

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In order to better understand the impact of the jet opening angle on certain key parameters inferred from VLBI radio observations of blazar nuclear jets we present analytical modeling of different types of conical relativistic jets. We had earlier shown that for a constant velocity jet, the discrepancy between low speeds indicated by VLBI knot motions and the high ones inferred from the emission of TeV photons could be reconciled if ultrarelativistic jets had modest opening angles. The key parameters we now evaluate are the the viewing angle of the jet and the apparent speed and Doppler factor of the radio knots on parsec scales. We make quantitative comparisons of the influence of the jet opening angle on these radio knot parameters, as would be estimated for two frequently considered types of relativistic nuclear jets: those having uniform bulk speed and those in which the bulk Lorentz factor of the flow decreases with distance from the jet axis (a ′spine--sheath' flow). Our analysis shows that for both types of jet velocity distributions the expectation value of the jet orientation angle at first falls dramatically with increases in the (central) jet Lorentz factor, but it levels off at a fraction of the opening angle for extremely relativistic jets. We also find that the effective values of the apparent speeds and Doppler factors of the knots always decline substantially with increasing jet opening angle, but that this effect is strongest for ultrarelativistic jets with uniform bulk speed. We suggest that the rarity of highly superluminal parsec-scale radio components in TeV blazars can be understood if their jets are both highly relativistic and intrinsically weaker, so probably less well collimated than the jets in other blazars. This work was supported in part by NSF grant 0507529.

008.10

Searching for TeV Blazar Candidates in the Sloan Digital Sky Survey

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Telescopes dedicated to discovering sources emitting TeV gamma-rays are now in operation in both northern and southern hemispheres. We expect that these telescopes will detect > 50 extragalactic TeV sources. Many of these will be blazars, and to date 11 blazars have been detected. The goal of our study is to assemble a list of highly-probable TeV emitting blazars drawn from objects previously observed by the Sloan Digital Sky Survey (SDSS) and archived in Data Release 5. Our search combines ideas described in a variety of published efforts to identify TeV blazars from measured radio-optical-xray fluxes, as well as efforts to clearly identify blazars and weak line active galactic nuclei among objects observed by SDSS showing nearly featureless spectra. Criteria for identification include 1) redshifts < 0.7; 2) large x-ray flux; 3) large radio flux; 4) large optical color-indices; 5) low proper motion; and 6) clear signs of large amplitude variability. In this paper, we present characteristics of this TeV-probable population.

We gratefully acknowledge support for this research from the Adler Planetarium, the Brinson Foundation, and the Kentucky Space Grant Consortium.

008.11

Rapid Multiwavelength Polarization Variability in the Quasar 0420-014

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In October and November 2005, we executed a ten-day multiwavelength study of a number of blazars using optical, near-infrared, and radio measurements of total and polarized flux density and VLBA polarimetric imaging at 7 mm. This study endeavors to find correlations of polarization and

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flux variability of the synchrotron emission across multiple parts of the spectrum. The VLBA images provide a map of the complex and variable resolved radio structure of a blazar's relativistic jet which, in concert with polarization variability correlation, can locate the unresolved high-frequency emission. Our results show strong correlations in the multiwavelength polarization characteristics of the blazar 0420-014, demonstrating a clear connection between the optical emission and the 43 GHz core region. We successfully describe the VLBA core and optical polarization in terms of root-N depolarization of intrinsically highly polarized emission from a collection of turbulent magnetic cells. This research was funded in part by the National Science Foundation through grant AST-0406865.

008.12

A Multi-Wavelength Study of Blazars with WIYN VERITAS IceCube

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We present the beginning of a multi-wavelength study of TeV blazars with the WIYN 0.9 meter telescope, the VERITAS/Whipple gamma-ray telescope, and the AMANDA/IceCube neutrino detectors. Corresponding optical and gamma-ray observations were taken of Mrk 421, Mrk 501, and 1ES 1959+650 in April and June of 2006. We aim to determine the flux variability of our sources and locate flaring moments to verify the timing dependence of neutrino occurrences and form a basis for a blinded neutrino analysis for AMANDA-II and IceCube. This work was supported by the National Science Foundation's REU program and the Department of Defense's ASSURE program through NSF Award AST-0453442

008.13

Deep Hubble Space Telescope Imaging of the M87 Jet

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Near-Ultraviolet imaging with HST offers the best possible spatial resolution currently available for optical/UV astronomical imaging. The giant elliptical galaxy M87 hosts one of the most spectacular, best studied and nearest (d=16 Mpc) galactic-scale relativistic jets. We have extracted from the HST archive all 220 nm images of the jet of M87, taken with the STIS MAMA camera and co-added them to provide the deepest image ever at this wavelength. The combination of highest spatial resolution and long integration time, 42,500 seconds, reveals a wealth of complex structure, knots, filaments and shocks. We compare this image with deep imaging data in other wavebands.

008.14

A Large Homogeneous Sample of BL Lacs from SDSS and FIRST

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The BL Lac phenomenon is often interpreted as arising from (FR I) radio jets viewed along the line of sight, resulting in multiwavelength emission, variability, polarization, and nearly featureless optical spectra. Historically, radio-selected BL Lac samples have tended to favor objects whose synchrotron emission peaks at low frequencies, while X-ray selected samples tended to favor high peak frequency objects. But recent large BL Lac samples are helping ameliorate some of these selection biases. We have thus searched the SDSS (DR5) data for objects with approximately featureless optical spectra that match to FIRST radio sources, and thereby identify/recover over 600 radio-emitting BL Lac candidates, one of the largest homogeneous samples to date; about 1/3 are also detected as X-ray sources in ROSAT. Half our objects have reasonably secure redshifts from weak host galaxy features which, along with proper motion information, confirm the extragalactic nature of the bulk of our candidates. Our large SDSS/FIRST sample supports suggestions of a smooth distribution of properties among various BL Lac sub-populations. This work is supported by NASA/ADP grant NNG05GC45G.

008.15

An Optical Survey of Potential Gamma-ray Sources

Lisa R. Carpenter[1]
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The EGRET instrument aboard the Compton Gamma-Ray Observatory detected 271 sources. Several objects were identified as "high-confidence" AGN, quasars, and low-confidence AGN. 170 sources remain unidentified (Hartman et al. 1999). Our project is to conduct an optical survey of unidentified sources, looking for evidence of blazar activity that may have been missed by the initial EGRET survey. The method of identifying sources used by the EGRET survey was to search for radio spectra peaking at 5 GHz. Such a spectrum is evidence of blazar-like activity. However, a study by Mattox et al. (1997); Mattox, Hartman & Reimer (2001) concluded that any gamma-ray source with a flux density less than 500 mJy at 5 GHz would be difficult to positively identify.

The method described above neglects the possibility that blazar-like sources may be dim at such low frequencies and peak instead at higher frequencies (at least 200 Ghz). It has been hypothesized that sources that behave in this way could very well be counterparts to gamma-ray blazars (Tornikoski et al. 2002; Bloom et al. 1997, 2000). Our goal is to determine the magnitudes of objects in the optical wavelengths and check for evidence of

blazar-like activity.

008.16

A Two-Fluid Plasma Shock Wave Model for the Strong Shock in Centaurus A

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Recent Chandra observations of the plasma shell around the southwest radio lobe of Centaurus A measure an electron temperature which is remarkably uniform throughout the shell. Using a model for a one-dimensional shock in a simple two-fluid plasma, we explore how the post-shock temperature depends on the pre-shock density and the timescale for the proton and electron temperatures to equilibrate. We describe the energy transfer from electron-proton collisions and adiabatic expansion downstream of the shock. The model successfully reproduces the constant electron temperature observed behind the shock. It also accounts for some reduction in the temperature variation around the shell that would otherwise be expected due to variation of the shock strength.

009: Cataclysmic / Eruptive Variables / Novae
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

009.01

Observations of SS Cyg Quiescence to Outburst

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We collected data at both the SARA 0.9 meter telescope at Kitt Peak National Observatory and at the Ball State University Observatory to investigate the behavior of the Cataclysmic Variable Binary System SS Cygni. The majority of our data covers the system's quiescent state, while the last two nights show the rise to outburst and the outburst. We investigated changes in the temperature and radius of the accretion disk over time.

The period search found a periodicity of ~2.5 hours when SS Cyg began its rise to outburst. This could be due to changes in the disk related to the onset of the outburst.

The color-color diagrams show the disk to be a good approximation to a blackbody at longer wavelengths. Surprisingly, this appears to be true even in quiescence. In the first hours of the outburst the color-temperature of the disk rose about 270 K while the disk radius increased by ~ 30%. Twenty four hours later the disk was about 15,000 K hotter, 2 magnitudes brighter but ~10% smaller than its size in quiescence. This behavior is different from U Gem where the disk size increases at outburst and slowly declines until quiescent brightness is reached (Warner 1995) and is not predicted by current models.

Further multi-color observations of outburst are needed to determine if the June 25, 2006 outburst of SS Cyg was unique in this manner.

This project was funded by a partnership between the National Science Foundation (NSF AST-0552798), Research Experiences for Undergraduates (REU), and the Department of Defense (DoD) ASSURE (Awards to Stimulate and Support Undergraduate Research Experiences) programs.

009.02

HD 109962 The Most Massive Dwarf Nova?

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We report photometric and spectroscopic observations of HD 109962, a peculiar F2V star. This star undergoes quasi-periodic outbursts about every 350 days. During the most recent outburst, in January 2006, He II 4686 was in emission above the F star continuum with an equivalent width of 2.5 Angstroms.

While no other emission was detected above the continuum, a difference spectrum revealed a typical accretion disk emission spectrum. SWIFT and CHANDRA observations about a month after the start of the outburst revealed a weak X-ray source. The previously-reported photometric light curve is that of an ellipsoidal variable with a 0.893 day period. The radial velocity of the F2V primary, however, suggests an eccentric orbit. We will present our observations of the decay of the outburst. We will discuss orbital fits to the light curve and the radial velocities. We suggest that this is a dwarf nova system with a 1.3 solar mass primary and an approximately 1 solar mass white dwarf, perhaps the most massive dwarf nova system currently known.

009.03

Phase-Resloved Infrared Cyclotron Spectroscopy of Polars

Ryan Campbell[1]
[1]New Mexico State Univ..

We present phase-resloved(~0.1 phase intervals) cyclotron spectrocopy of four polars(AN UMa, EF Eri, VV Pup, and EQ Cet) obtained with SPEX on the IRTF. SPEX covers the I, J, H, and K bands simultaneously allowing for great wavelength coverage of all the observed systems. For each object, ConstantLambda models were run to compute model cyclotron spectra which were fit to the data observed by altering four parameters: B, the magnetic field strength, T, the global temperature of the plasma in the accretion region, Lambda, the "size parameter" of the accretion column, and Theta, the viewing angle. In general, we find the fits to be satisfactory, although the high temperatures in EQ Cet(14.5 Kev) and EF Eri(~20 Kev) are a concern. To allow for more physical setup in the accretion regions in question, we will soon transition to a structured-shock code based on Fischer and Beuermann (2001), which allows the effects of variable mass accretion and magnetic fields to be included.

009.04

Near Infrared Quantitative Abundance Analysis of The Secondary Stars in a Sample of CVs

Joseph W. Wellhouse[1], T. E. Harrison[1]
[1]New Mexico State University.

Recent work has suggested that the accepted evolutionary track for cataclysmic variables, CVs, may be in error. Measurements of carbon abundances have suggested that the secondary stars in these systems may have undergone far more changes during the formation of the CV than previously thought. Also magnetic and non-magnetic CVs appear to follow different evolutionary tracks. A principal probe of this evolution are metal abundance in the secondary star. To expand our understanding in this area we have obtained near infrared spectra of a sample of CVs with SPEX on the NASA Infrared Telescope Facility. These data permit quantitative measurements of carbon and other metal abundances in the secondary stars with the aid of a stellar atmosphere model. We have used the program SPECTRUM to generate these models. We find that both AE Aqr and GK Per show extreme carbon 12 deficits. In the future we plan to extend these models to include Na, Mg, and Fe.

009.05

The 0.5 13 μm Spectrum of V4332 Sagittarii in 2006

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V4334 Sgr is one of three strange stars that suddenly brightened and cooled dramatically (V838 Mon and M31 RV are the others). The outburst mechanism(s) are not understood but judging from the enormous energy release (more than a nova and less than a supernova), it must involve a new mechanism or be an extremely rare (or brief) stage in stellar evolution.

During spring and summer 2006, we observed V4332 Sgr using VNIRIS on the Lick 3 meter telescope, SpeX on the IRTF and BASS on the IRTF. Owing to the star's slow changes, we view the combined spectrum as a common-epoch observation, i.e. essentially simultaneous.

At short wacelengths, the spectrum is dominated by emission lines of aluminum oxide (AlO). Also present are the anomalously bright KI resonance lines at 0.7667 and 0.7701 μm, and the deep ice absorption feature at 3.05 μm reported earlier by Banerjee et al. (2003 ApJL 598, L31 and 2004 ApJL 615 L53). At longer wavelengths the spectrum and spectral energy distribution are consistent with a 900 K black body with a strong absorption between 8 and 13 μm. This feature cannot be fit by absorption by gaseous silicon monoxide (SiO) or water ice absorption. It can be reasonably fit by a profile derived from the interstellar amorphous silicate feature. Whether this absorption is interstellar or circumstellar is still under investigation.

009.06

Spitzer Space Telescope and Visible/IR Spectrophotometry of V574 Pupis (Nova Pupis 2004)

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V574 Pup was a nova whose observational properties were intermediate between those typical of explosions on a carbon/oxygen (CO) or a oxygen/magnesium/neon (OMgNe) white dwarf. A strong Fe II emitter shortly after outburst, V574 Pup's light curve had a slow decline rate (t2 ~ 20 days) and emission lines of moderate width (~1800 km/sec) characteristic of a high mass ejection from a CO white dwarf. However, V574 Pup did not form dust and its spectrum developed the strong nitrogen and helium lines and the fairly high excitation coronal lines (e.g., [S IX], [Si X]) more representative of the energetic outburst from an OMgNe white dwarf.

Data will be presented from two epochs_0.43-2.5 micron spectroscopy from two months after outburst, and Spitzer observations from 5-20 microns together with simultaneous visible and near-infrared measurements one year past outburst. Spitzer makes possible the study of nova spectra to unprecedented faintness levels and in V574 Pup reveals the strong coronal lines of Mg and Ne ions (but no [Ne II] at 12.8 microns), behavior that is again suggestive of an explosion on the surface of a OMgNe white dwarf.

Support for this work was provided by NASA and by the The Aerospace Corporation's Independent Research and Development progam.

009.07

A New, Bright, Short-period, Emission Line Binary in Ophiuchus

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The 11th magnitude star LS IV -08d 3 has been classified as an OB star in the Luminous Stars survey, or alternatively as a hot subdwarf. The star may be the counterpart of a weak ROSAT X-ray source. We initially observed it as part of a program on composite-spectrum hot subdwarf stars, owing to its red observed optical and near-IR colors. We found emission in the cores of H and He I absorption lines. Emission is also present from He II 468.6 nm and near 465 nm (C III or N III). Diffuse interstellar bands indicate considerable reddening. Time-series spectroscopy collected from June 2004 to March 2006 shows coherent, periodic radial velocity variations of the H-alpha line, which we interpret as orbital motion with a 0.2d period. There is less coherent, low-amplitude photometric variability on a similar timescale. We will present our findings, including spectra, the spectroscopic orbital elements, and time series photometry, from observations made at the KPNO 2.1m, Steward 2.3m, HET 9.2m, MDM 1.3m and 2.4m, and MSU 0.6m telescopes. Many aspects of this star are consistent with those of a novalike cataclysmic variable, although other interpretations may be possible. Partially supported by NASA and NSF.

009.08

Low-State Photometry of AM Her during 2005-06

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We report on observations of the magnetic polar cataclysmic variable AM Her during its low-state. Photometry during 2005-06 reveal events that might be related to activity on the secondary star.

009.09

Steady-State Modeling and Possible Detection of HCl in Eta Carinae's -513 km/s Ejecta

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A component of Eta Carinae's ejecta with a radial velocity of -513 km/s has recently been found to be conducive to the formation of molecules; CH and OH have most likely been identified there. In order to explain the abundances of the already observed species in this component and also predict possible new detections, we undertook statistical equilibrium modeling with the most recent version of the steady-state chemistry code CLOUDY. One of the many features of this new version was the inclusion of more Cl-bearing species. We found that, under a wide range of physical parameters, relatively high abundances of HCl were consistently predicted by our models. Using the public domain data obtained with the STIS spectrograph aboard the Hubble Space Telescope, we searched for new molecular signatures in the spectrum of the -513 km/s component that were favored by our models. We report a probable detection of the $C^1\Pi$-$X^1\Sigma^+$ electronic band of HCl and a tentative detection of a few rotational components of the $A^1\Pi$-$X^1\Sigma^+$ band. From the observed relative equivalent widths of several rotational components of the $C^1\Pi$-$X^1\Sigma^+$ band, we estimated the rotational temperature of HCl to be $T_r \approx 500\pm140$ K and the total column density to be $N \approx 10^{15}$ cm^{-2}. This project was supported by the NSF/REU grant AST-0354056 and the Nantucket Maria Mitchell Association.

009.10

Population Synthesis Studies of Close Binary Systems Using a Variable Alpha: Dependence Upon the Evolutionary State of the Giant

Michael Politano[1]
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Common envelope (CE) evolution is believed to occur in a significant fraction of close binary stars. During this phase, sizeable amounts of mass and angular momentum may be shed from the binary as the secondary spirals toward the core of the primary and transfers orbital energy into the CE. The efficiency of this transfer is very uncertain and is parameterized by a quantity, α_{CE}, known as the CE efficiency parameter. The majority of population synthesis calculations of close binary systems have assumed that α_{CE} is a global constant for the entire population of binaries. In previous work, we calculated model populations of present-day, zero-age post-CE binaries (PCEBs) and cataclysmic variables (CVs) using an α_{CE} that depended upon the mass of the secondary star. In this poster, we again calculate model populations of present-day, zero-age PCEBs and CVs, but this time using an α_{CE} that is a function of the total mass, M_p, and/or core mass, M_c, of the primary at the onset of the CE phase.

This work was funded in part by grants from the Wisconsin Space Grant Consortium and the National Science Foundation (AST-0328484) to Marquette University.

009.11

Understanding the White Dwarfs in Intermediate Polars

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The temperature of a white dwarf (WD) in a cataclysmic variable (CV) can tell you much about the accretion history of the binary system, and hence the evolution of the system. Best seen in the ultraviolet, a white dwarf's temperature is typically measured through modeling of a UV spectrum. This approach has been taken for numerous CVs modeling the spectrum as a combination of accretion disk and WD photosphere and also for polars, the strongly magnetic (B ~ 10-80 MG) subset of CVs that contain magnetically controlled accretion streams rather than a disk. The task of extracting information about the WD in an intermediate polar (IP, magnetic CVs with B <~ 5 MG) is a bit trickier as they contain both magnetically controlled accretion streams and a truncated accretion disk. The fact that there are only five IPs for which WD temperatures have been estimated is a testament to the difficulty of modeling these systems. Here we present initial results from our project of determining the temperatures of WDs in IPs. We show that traditional methods of obtaining an inner accretion disk radius via optical emission line wings is likely inaccurate for most IPs, and that in some cases, the truncation radius is so large that the accretion disk does not contribute UV flux. Finally, we show that IPs follow the general trend of magnetic CVs containing cooler WDs than non-magnetic CVs.

This work is supported in part by NSF grant AST0507514 and by NASA grant NNG04GE78G.

009.12

The Hard X-ray Bright Magnetic Catclysmic Variable IGR J14536-5522=Swift J1453.4-5524

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Cataclysmic variables (CVs) are an important class of X-ray emitting objects, including the hard (>10 keV) X-ray regime that INTEGRAL and Swift/BAT have begun to explore. Many CVs detected above 10 keV so far are well known objects, but some are little known or previously unnoticed objects. Here we present our preliminary analysis of one example of the latter, IGR J14536-5522=Swift J1453.4-5514. using a pointed Swift observation as well as optical spectroscopy with SALT and optical photometry with SAAO 1.9m telescope, we show that this is likely to be a rare type of magnetic CV.

009.13

Galactic Wolf-Rayet Infrared Imaging Survey

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Wolf-Rayet (WR) stars are very massive, luminous stars, likely descended from O stars with initial masses greater than 30 solar masses. The byproducts of nuclear burning have been brought to the surface of these He-rich stars and a high rate of mass loss is evident through strong emission lines of He, C, N and O. The unique emission line spectra of WR stars make them readily identifiable. Despite the importance of WR stars both in the evolutionary paths of massive stars and as tracers of active star formation, only ~250 of these stars have been identified in the Galaxy due to absorption. To detect Galactic WR stars, a narrowband infrared imaging survey has been completed in seven filters. The survey covers the Galactic plane +/-1 degree and was taken in J, narrowband filters centered on HeI, HeII, CIV, Bracket Gamma and in continuum filters both redward and blueward of the narrowband filters. WR candidates are being selected by their excess emission in the narrowband filters; we present initial CMDs and new WR candidates from select fields. This survey is expected to yield several thousand WR candidates in the Galactic plane. Spectra of the candidates will be necessary to confirm each object as a WR star.

009.14

Wind-Clumping does not Depend on Ambient Metallicity: Wolf-Rayet Stars in the SMC

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The mass-loss rates of hot, massive, luminous stars are considered a decisive parameter in shaping their evolutionary tracks and influencing the interstellar medium on galactic scales. The small-scale structures (clumps) omnipresent in such winds may reduce empirical estimates of mass-loss rates by an evolutionarily significant factor of >=3. So far, there has been no direct observational evidence that the wind-clumping may persist at the same level in environments with a low ambient metallicity, where the wind-driving opacity is reduced. Here we report an unambiguous detection of small-scale inhomogeneities in the winds of three Population I Wolf-Rayet stars in the Small Magellanic Clouds, where metallicity is ~1/5 Z_{solar}. The general properties of the detected clumps, such as their velocity dispersions, emissivities and average accelerations, closely match the corresponding characteristics of small-scale inhomogeneities in the winds of Galactic Wolf-Rayet stars.

009.15

Revised Ephemerides for V1776 Cygni and QU Vulpeculae

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Time-resolved CCD observations of two eclipsing cataclysmic variables: the novalike variable V1776 Cyg (Lanning 90), and the classical nova, QU Vul (Nova Vulpeculae 1984#2) are presented. Eclipse timings (a total of four for V1776 Cyg and five for QU Vul) have been measured in order to update the orbital ephemerides of these systems. After including eclipse timings from the literature, the following updated ephemerides have been determined. For V1776 Cyg: T_min = HJD 2,446,716.6795(3) + 0.16473866(1) E, and for QU Vul: T_min = HJD 2,449,514.8780(2) + 0.111764743(7) E. QU Vul is a particularly interesting system, being the archetypal ″neon nova″ (Gehrz et al. 1985 ApJL, 298, L47) with a period near the middle of the 2-3 hr ″gap″ in the orbital period distribution for cataclysmic variables. Our most recent observations show that QU Vul is continuing to fade following its outburst in 1984. Specifically, we found QU Vul at V=19.4 on 02-Sep-2005 UT, which is ~1.5 mag fainter than the value of V=17.9 measured by Shafter et al. (1995 ApJL, 448, L33) roughly a decade earlier. This work has been supported in part through an REU grant (AST-0453609) to SDSU.

009.16

A 2006 Spectroscopic Study of ST LMi

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Orbit-resolved spectroscopic and photometric observations of the magnetic cataclysmic variable ST LMi were obtained at several epochs during the high state and during its recent low state. In the low state the H-alpha line is triple-peaked. The satellite components are attributed to gas motions near the secondary star, likely due to extreme chromospheric activity. We compare these activity signatures with similar structures in AM Her. In the high state the H-alpha profile is complex, having two main components plus an extended blue wing at some orbital phases, similar to previously-reported high-state behavior in this system.

009.17

Magnetic Activity on the Degenerate Secondary Star in EF Eri

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We present a spectroscopic and photometric study of the magnetic cataclysmic variable EF Eri during its current low state. We discuss the origin of its emission lines including a multi-component H-alpha line. The emission clearly originates on the secondary star and advocates the presence of stellar activity on the 55 Jupiter mass secondary star. We present an initial model of magnetic flux tubes connecting to the two stars inCVs such as EF

Eri. Our model is based on the growing sample of active secondary stars in magnetic CVs.

009.18

VLT Spectroscopy of Four Short Period Cataclysmic Variables

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VLT UVES spectroscopy of four short period, non-magnetic cataclysmic variable stars is presented. The stars observed were GW Lib, BW Scl, VY Aqr, and Z Cha. The 0.1A resolution spectra were uses to measure line strengths and velocity information. Using these measured values, physical parameters, such as the stellar masses, the binary inclination, and the nature of the accretion disk were determined. Mass constraints in the stars BW Scl and GW Lib strongly suggest that the mass donors are likely to be degenerate stars with masses less than 0.06 M-sun. Skinner's research was supported by the NOAO/KPNO Research Experiences for Undergraduates (REU) Program which is funded by the National Science Foundation through Scientific Program Order No. 3 (AST-0243875) of the Cooperative Agreement No. AST-0132798 between the Association of Universities for Research in Astronomy (AURA) and the NSF.

009.19

XMM-Newton Observations of Three Interesting Cataclysmic Variables

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We have used the high sensitivity and large energy coverage of XMM_Newton to study 3 interesting cataclysmic variables: the pulsating accreting white dwarf in GW Lib and two confirmed polars from SDSS. Our analysis includes X-ray and optical light curves to determine periodicities and geometry of the X-ray emitting areas and X-ray spectra to obtain temperatures, column density and X-ray luminosity. The X-ray flux observed from GW Lib does not show the non-radial pulsations that are evident in the optical at 648, 376 and 236s, implying that the pulsation is not propagated into the boundary layer in accreting white dwarfs. A 21 min, high amplitude, periodic X-ray modulation is observed in SDSSJ2333+15, confirming this system as an intermediate polar with a 21 min spin period for the white dwarf. An upper limit to the X-ray luminosity of the extremely low accretion rate polar SDSSJ0837+38 confirms the lack of a hard X-ray shock and associates the accretion with the bombardment regime in this system.

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009.20

HET Spectroscopy of Extragalactic Novae

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We are currently involved in a multifaceted campaign to study extragalactic novae in the optical and IR using a variety of instruments: The Mount Laguna 1m, the Steward 2.3m, and the Liverpool 2m telescopes for optical imaging, the Hobbey-Eberly Telescope (HET) for optical spectroscopy, and the Spitzer Space Telescope for IR photometry and spectroscopy. Here, we report the initial results from our program of spectroscopic observations obtained with the LRS on the HET. Thus far, we have obtained spectra of three novae: Nova M31-2006#9 (ATEL 887), Nova M32-2006#1 (CBET 591), and Nova M33-2006#1 (CBET 655), which were taken on 24-Sep-2006 UT, 30-Sep-2006 UT, and 02-Oct-2006 UT, approximately 6, 65, and 4 days post discovery, for the three novae respectively. The spectra of Nova M31-2006#9 and Nova M33-2006#1 revealed prominent Balmer (FWHM ~ 1600 km/s) and Fe II emission lines typical of the "Fe II" class in the classification system of Williams (1992 AJ, 104, 725). The spectrum of Nova M32-2006#1, which was obtained much longer after eruption, showed strong H-alpha (FWHM ~1300 km/s), along with weaker H-beta, Fe II, and [N II] 5755, indicating that this nova is also a member of the Fe II class, and that it had entered the nebular phase at the time of our observations. In addition to these three novae, we also attempted to obtain a spectrum of Nova M31-2006#7 (CBET 615) on 23-Sep-2006 UT, approximately three weeks after discovery. However, by the time of our observations, the nova had faded to invisibility. An 1800s integration at the reported position reveled no trace of the nova. It is likely that this optical transient was an unusually fast nova, possibly of the "He/N" class. This work is being supported in part by NSF grant AST-0607682.

009.21

The Distance to V838 Monocerotis

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The peculiar variable star V838 Mon underwent an extremely unusual outburst in early 2002. Unlike a classical nova, V838 Mon has remained very cool throughout its outburst. It is illuminating the most spectacular light echo in astronomical history, which is being imaged regularly with the *Hubble Space Telescope* (*HST*) as well as from the ground.

In 2002 and again in 2005, we obtained polarimetric imagery of the light echo, using the Advanced Camera for Surveys onboard *HST*. These images allow us to determine a purely geometric distance to the star, based upon a method developed by Sparks (1994, ApJ 433, 29). This technique employs the fact that the locus of maximum linear polarization in the light echo should form a ring around the star with a linear radius of $c\Delta t$, where Δt is the time since the outburst.

We have also serendipitously discovered that V838 Mon belongs to a sparse young open cluster, whose main sequence extends up to spectral type B3 V. Based on photometric and spectroscopic main-sequence fitting, we have determined a distance to the cluster that is completely independent of the polarimetric method.

Both the polarimetric and cluster methods yield essentially the same distances, 6.1 and 6.2 kpc. At this large distance, V838 Mon at maximum light was temporarily one of the most luminous stars in the entire Local Group. Its peak luminosity was very similar to that of M31 RV, an event that occurred in the Andromeda Galaxy in 1988. Unlike V838 Mon, however, M31 RV arose from a very old population in the bulge of M31. We will discuss constraints on the outburst mechanisms for these objects based on our findings.

Partially supported by STScI grant GO-10618 and by the STScI Director's Discretionary Research Fund.

009.22

Modeling Eclipses of the Novalike Variable TT Triangulum

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Multicolor (BVRI) light curves of the eclipsing novalike variable TT Tri are presented and fit with a parameter-fitting eclipse model. The mass ratio of TT Tri is poorly constrained in our models, but must lie roughly in the range 0.3 <= q <= 0.9 (where q = M2/M1). Models characterized by mass ratios of q = 0.3 (i = 76.1 deg), q = 0.6 (i = 72.6 deg), and q = 0.9 (i = 70.4 deg) were all capable of providing acceptable fits to the data, although the best fits were achieved for mass ratios near the upper end of the permitted range (q = 0.6 and 0.9). The accretion disk was found to extend to approximately 50 to 60 percent of the distance to the inner Lagrangian point in all models, but came closer to reaching the tidal limit (as expected for steady-state accretion) in the higher mass ratio models. The same behavior was found for the radial temperature profile of the disk, which increased with mass ratio, becoming more consistent with that expected for steady-state accretion in the q = 0.6 and q = 0.9 models. A total of 22 eclipse timings were measured for the system, which yielded an ephemeris for the times of mideclipse given by HJD = 2,453,618.953(3) + 0.1396369(4)E. A comparison of the observed brightness and color at mideclipse with the photometric properties of the best-fitting model suggests that TT Tri lies at a distance of ~400-500 pc.

010: Circumstellar Disk Observations
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

010.01

The Formation and Evolution of Solar Systems: Penultimate Status Report on Results from a Spitzer Legacy Science Program

Lynne Hillenbrand[1], FEPS Spitzer Legacy Science Team
[1]Caltech.

We provide a summary of results from the Spitzer Legacy Program ″Formation and Evolution of Planetary Systems″ (FEPS). This program, summarized in Meyer et al. (2006, PASP), exploits the sensitivity of Spitzer to carry out mid-infrared spectrophotometric observations of solar-type stars.

With a sample of ~328 stars ranging in age from ~3 Myr to ~3 Gyr, we trace the evolution of circumstellar gas and dust from primordial planet-building stages in young circumstellar disks through to older collisionally generated debris disks. Recent results from late 2006 and early 2007 include the following:

a) Bouwman et al. (2007) analyze dust size and composition in the optically--thick accretion disks in the FEPS sample using IRS high resolution observations;

b) Pascucci et al. (2006) report that gas-rich disks capable of forming Jupiter-mass planets dissipate in less than 10 Myr based in part on IRS high resolution spectra while Pascucci et al. (2007) discuss several gas line detections;

c) Meyer et al. (2007) report on the evolution of mid-IR excess emission around sun-like stars during the epoch of terrestrial planet formation 10-100 Myr;

d) Hillenbrand et al. (2007) report on the structure of cool debris disks tracing material at large radii;

e) Moro-Martin et al. (2007ab) report on a study of the possible connection between radial velocity planets and debris disks while

f) Najita et al. (2007) do the same for metallicity and debris disks. Results on debris disk evolution as traced by 3-70 um FEPS observations will be presented by Carpenter et al. (2007).

010.02

A Detection of OH in the Planet Formation Regions of Circumstellar Disks

Steinn Sigurdsson[1], A. M. Mandell[1], M. Mumma[2], G. Blake[3]
[1]Pennsylvania State Univ., [2]GSFC, [3]Caltech.

Detecting new molecular species in young circumstellar disks will allow us to constrain the abundances and thermodynamics of the gas chemistry critical to understanding the origins of planetary systems. NIR observations are just beginning to probe the detailed chemistry of the warm gas in circumstellar disks around young stars, detecting CO ro-vibrational emission, hot H_2O, organics and warm H_2 emission. Modeling of these disks suggests that additional molecular species such as OH may be abundant and detectable. We acquired spectroscopic observations of several nearly face-on Herbig Ae/Be stars and T Tauri stars in the 3.0 3.7 μm wavelength range (L-band) using the NIRSPEC instrument on Keck II. This region samples lowand high-J transitions of OH and water hot-bands, as well as transitions of methane and ethane. Preliminary reductions reveal tentative detections of emission lines from a low-J OH doublet in the Herbig Ae stars AB Aurigae and MWC 758. Line shapes match those of low-J CO, suggesting the emission originates in the outer regions of the disk. If confirmed, analysis of these transitions can provide new constraints on the water vapor abundance, distribution and temperature in these young protoplanetary disks.

010.03

Updated Observations of V1647 Orionis: Measuring Hα and Brγ in the Optical and Near-Infrared

Matthew Troutman[1], S. Brittain[1], E. Gibb[2], T. Rettig[3], T. Simon[4], B. Donehew[1]
[1]Clemson University, [2]University of Missouri, [3]University of Notre Dame, [4]University of Hawaii.

We present the current state of V1647 Ori, the star whose outburst illuminated McNeil's nebula. Recent optical and near-infrared measurements of H-alpha and Brackett Gamma are compared with previous observations in order to determine the degree to which the system has relaxed and the current accretion rate. During the outburst, the stellar luminosity increased by a factor of three, and the accretion rate reached ~10^{-5} $M_{\&\#8857;}$ yr^{-1}. The latest photometry of this nebula indicates that the star has nearly returned to its pre-outburst brightness, and the accretion rate has decreased by more than two orders of magnitude. During the outburst, H-alpha exhibited a P Cygni line profile, due possibly to a warm outflow, which has since cooled. H-alpha is also compared to previous observations as the system returns to quiescence.

010.04

Characterizing the Disk Around the Brown Dwarf Planetary System 2MASSW J1207334-393254

Basmah Riaz[1], J. E. Gizis[1]
[1]Univ. of Delaware.

The brown dwarf planetary system 2MASSW J1207334-393254 (2M1207) consists of a 30 M_{JUP} primary and a 5 M_{JUP} extrasolar planet. The primary is known to be undergoing active accretion, and harbors a circum-substellar disk of gas and dust, detected by excess emission in the IR. Previous measurements of IR excess emission were too few in number to correctly model the disk spectral energy distribution. Existing results suggest a high inclination angle (≥ 60º) with an inner hole that can be fit by both a large grain size, large inclination angle flared disk and a small grain size flat disk. Using our *SPITZER* observations from 3.6 to 24 micron, we have used disk models described in Walker et al. (2004) to correctly characterize the disk around 2M1207, and determine important disk parameters, such as, the inclination angle, the disk midplane temperature and scale height at different radii, the disk mass, accretion rate and the inner and outer radii. We believe our 24 micron data point is valuable in determining the surface geometry of the disk, as it probes more distant regions (~1-5 AU) from the central object. An estimate of the outer disk radius is important to show if the planetary companion has any effect on the disk emission. We have also investigated the effects on disk geometry by varying the grain sizes in different disk regions, which is important in understanding if gas and dust are well mixed in this brown dwarf disk.

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010.05

Sub-millimeter Interferometric Study of Circumstellar Disks Surrounding Optically Visible, Young High Mass Stars

Manoj Puravankara[1], P. T. Ho[2], N. Ohashi[1], Q. Zhang[3]
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Observational evidence for circumstellar disks surrounding high mass (M > 8 M_sun) stars are currently limited to the deeply embedded, protostellar phase, where it is not clear if the central object is a single protostar, a multiple system or an unresolved star cluster. One of the ways to overcome the ambiguity about the central source is to search for the presence of disk around massive young stars at a less embedded, more evolved phase. We are carrying out an interferometric study of circumstellar disks surrounding optically visible, young high mass (M = 8 18 M_sun) stars, which exhibit strong evidence for the presence of accreting disks associated with them. Here we present Sub-Millimeter Array (SMA) observations at 230 GHz of the circumstellar environment of a B1.5 star MWC 297, which, at a distance of 250 pc, is one of the closest massive (M=12 M_sun) star associated with a star forming cloud. Investigation of the structure and properties of circumstellar disks in these relatively 'evolved' systems has implications for the studies of disk evolution in massive young stars.

010.06

Silica in Protoplanetary Disks

Benjamin A. Sargent[1], W. J. Forrest[1], D. M. Watson[1], M. K. McClure[1], C. J. Bohac[1], E. Furlan[2], K. H. Kim[1], J. D. Green[1], G. C. Sloan[3]
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Mid-infrared spectra of a handful of Class II Young Stellar Objects taken using the Infrared Spectrograph (IRS) on board the Spitzer Space Telescope show very prominent narrow emission features indicating silica (crystalline silicon dioxide). Silica is not believed to be a major constituent of the interstellar medium; therefore, any silica present in the circumstellar disks of Class II YSOs must be largely the result of processing of primitive dust

material in the protoplanetary disks surrouding these stars. We model the silica features in our spectra using the opacities of various polymorphs of silica and amorphous versions thereof computed from earth-based laboratory measurements. This modeling suggests that the polymorphs of silica that form at high temperatures and low pressures are the dominant forms of silica in some Class II YSO disks. In turn, this constrains the locations within the disk and the physical processes involved in the thermal processing of dust grains. This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under NASA contract 1407. Support for this work was provided by NASA through contract number 1257184 issued by JPL/Caltech, JPL contract 960803 to Cornell University, and Cornell subcontracts 31419-5714 to the University of Rochester.

010.07

Coronographic Observations of Circumstellar Disks with Subaru

Jennifer Karr[1], M. Puravankara[1], M. Tamura[2], T. Kudo[2], N. Ohashi[1]
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The direct imaging of circumstellar disks in the optical and near infrared is challenging, due to both the small angular size and the brightness of the central star. The combination of a large telescope, adaptive optics and coronography now makes direct study possible.

I will present results from a NIR coronographic study of circumstellar disks and low mass stellar companions with the Subaru telescope.

010.08

The TEXES/Gemini Survey for Protoplanetary Disk Gas

Martin Bitner[1], M. J. Richter[2], J. H. Lacy[1], T. K. Greathouse[3], D. T. Jaffe[1], G. J. Herczeg[4], J. Najita[5], J. S. Carr[6], R. Y. Shuping[7], G. A. Blake[8], S. J. Kenyon[9], T. Currie[9], U. Gorti[7], D. Hollenbach[7]
[1]Department of Astronomy, University of Texas, Austin, [2]Department of Physics, University of California, Davis, [3]Lunar and Planetary Institute, [4]Department of Astronomy, Caltech, [5]National Optical Astronomy Observatory, [6]Naval Research Laboratory, [7]NASA Ames Research Center, [8]Division of Geological and Planetary Sciences, Caltech, [9]Harvard Smithsonian Center for Astrophysics.

In November 2006 we have 85 hours of observing time in order to conduct a survey for mid-infrared rotational H_2 emission in disk sources using TEXES, the Texas Echelon-cross-Echelle Spectrograph (Lacy et al. 2002) on Gemini-North. TEXES is a high spectral resolution, mid-infrared spectrograph available to the astronomical community on both the NASA IRTF and Gemini-North telescopes. We will observe each target at both the J=3-1 (17.035 microns) and J=4-2 (12.279 microns) settings. Sources with a detection at either setting will be followed up with observations at the J=6-4 (8.026 microns) setting to constrain the gas temperature. Flux ratios of the three lines are sensitive to gas temperatures between 200 and 800 K. Even non-detections will provide limits on the amount of warm gas in regions where the dust is optically thin. The high spectral resolution available with TEXES coupled with knowledge of the disk inclination by other means allows us to determine the radial location of the emitting gas.

Observations with TEXES are supported by NSF grant AST-0607312.

010.09

Warm HCN, C_2H_2, and CO in the Circumstellar Disk of GV Tau

Erika Gibb[1], K. Van Brunt[1], S. D. Brittain[2], T. W. Rettig[3]
[1]Univ. of Missouri St. Louis, [2]Clemson University, [3]Univ. of Notre Dame.

We present high-resolution, ground-based observations of HCN and C_2H_2 toward the T Tauri binary star system GV Tau. We detected strong absorption due to HCN ν_3 and weak C_2H_2 (ν_3 and $\nu_2+(\nu_4+\nu_5)$) absorption toward the primary (GV Tau S) but not the infrared companion. We also report CO column densities and rotational temperatures, and present abundances relative to CO of HCN/CO ~ 0.6% and C_2H_2/CO ~ 1.2% and an upper limit for CH_4/CO <0.37% toward GV Tau S. Neither HCN nor \acetylene\ were detected toward the infrared companion, arguing that the gas is located in the circumstellar disk of GV Tau S. Results suggest that HCN may be about a factor of four less abundant toward the infrared companion relative to CO.

010.10

Observing Grain Growth in Protoplanetary Disks

Sarah T. Maddison[1], D. Lommen[2], C. Wright[3], T. Bourke[4], J. Jorgensen[4], E. van Dishoeck[2], M. Burton[5], A. Hughes[1], D. Wilner[4]
[1]Swinburne University, Australia, [2]Leiden Observatory, The Netherlands, [3]UNSW@ADFA, Australia, [4]CfA, [5]UNSW, Australia.

In order to understand planet formation, we need to probe the physical conditions of protoplanetary disks to see when and where grains begin to grow in size. Over the past four years we have been conducting a 3mm continuum survey with the Australia Telescope Compact Array of disks around young stars (both T Tauri and Herbig Ae/B stars) in southern molecular clouds to investigate the evolution of protoplanetary disks and grain growth within these disks. The goals of our project are to obtain fluxes and hence determine the millimetre spectral energy indices, which provides information about the grain size distribution. We present results from our successful 2005 millimetre season, in which we observed 15 southern T Tauri sources (10 in Chamaeleon and 5 in Lupus). The opacity indices suggest the presence of mm-sized dust aggregates and hence substantial grain growth in the majority of these disks. We also present preliminary results from our follow-up 2006 observations of three sources (HD100546, WW Cha and RU Lup) are centimetre wavelengths and discuss the possibility of detecting pebble-sized ″grains″ in these disks.

011: Cosmic Microwave Background
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

011.01

CBI2: Current Status

Jonathan L. Sievers[1], CBI Collaboration
[1]CITA, Canada.

The Cosmic Background Imager is a sensitive 13-element radio interferometer operating at 5070m in the Chilean Andes (the future ALMA site). We have upgraded the CBI's 0.9m dishes with 1.4m dishes, effectively doubling the sensitivity. CBI2's primary science goal is a better measurement of the CMB power spectrum in the ell~2000-3000 range, where previous CBI measurements found an excess of power at 30 GHz over what was expected. We will also observe galaxy clusters and diffuse emission in the Milky Way with CBI2. We present the current status of CBI2, the errors on the CMB spectrum we expect to achieve, and hopefully early results. The CBI is a collaboration between Caltech, CITA, NRAO, MPI-Radioastronomie, Oxford, Manchester, Universidad de Chile, and Universidad de Concepcion.

011.02

The Q/U Imaging Experiment (QUIET)

Michael D. Seiffert[1], QUIET Collaboration
[1]JPL.

The goal of the Q/U Imaging ExperimenT (QUIET) is to measure the Cosmic Microwave Background (CMB) polarization with unprecedented sensitivity and an angular resolution that is well matched to the scale at which the signature of inflationary gravity waves (or "B-modes") is expected to peak. The initial version of QUIET will consist of two frequency channels, 44 and 90 GHz, with 19 and 91 elements respectively, to provide an order of magnitude sensitivity improvement over WMAP. The QUIET approach is completely scalable, and we can achieve even greater sensitivity with order one thousand elements. We describe the science goals, the polarimeter modules, the observing strategy, and other instrumental aspects of the experiment.

QUIET has recently received funding from the National Science Foundation and is a collaboration among scientists at the following institutions: California Institute of Technology, Columbia University, Jet Propulsion Laboratory, Kavli Institute for Cosmological Physics at the University of Chicago, Kavli Institute for Particle Astrophysics and Cosmology at Stanford University, University of Miami, MPI Bonn, University of Oxford, and Princeton University.

011.03

PAPPA: A New Generation of CMB Polarimetry

Alan J. Kogut[1], D. T. Chuss[1], M. Devlin[2], S. Dicker[2], D. Fixsen[3], G. F. Hinshaw[1], K. Irwin[4], M. Limon[3], D. Marsden[2], S. H. Moseley[1], N. G. Phillips[3], C. Semisch[2], T. Stevenson[1], E. J. Wollack[1]
[1]NASA's GSFC, [2]University of Pennsylvania, [3]SSAI/GSFC, [4]NIST.

The Primordial Anisotropy Polarization Pathfinder Array (PAPPA) is a balloon-based instrument to measure the polarization of the cosmic microwave background and search for the signal from gravity waves excited during an inflationary epoch in the early universe. PAPPA will survey a 20 x 20 degree patch at the North Celestial Pole using 32 pixels in 3 passbands centered at 89, 212, and 302 GHz. Each pixel uses MEMS switches in a superconducting microstrip transmission line to combine the phase modulation techniques used in radio astronomy with the sensitivity of transition-edge superconducting bolometers. Each switched circuit modulates the incident polarization on a single detector, allowing nearly instantaneous characterization of the Stokes I, Q, and U parameters. We describe the instrument design and status.

011.04

Spider: Searching for the Echos of Inflation

William C. Jones[1], Observational Cosmology Group
[1]Caltech.

Spider is a balloon-borne scientific and technical pathfinder for CMBpol. Spider will map over half the sky with degree angular resolution, characterizing the linear polarization in five bands between 70 and 300 GHz, to a depth greater than Planck. The Spider data will complement the WMAP data (<100 GHz) in frequency coverage, and the data from Planck in polarimetric fidelity, significantly enhancing the scientific value of each of these orbital missions. The Spider flight will test receiver technology, optics, and an observing strategy that are directly applicable to CMBpol.

011.05

BICEP2 and SPUD: Searching for Inflation with Degree-Scale Polarimetry from the South Pole

John Kovac[1], BICEP/SPUD collaboration
[1]California Institute of Technology.

Inflation predicts a cosmic gravitational-wave background (CGB), the amplitude of which measures the Inflationary energy scale. The CGB in turn produces a faint but unique signature in the 'B-mode' polarization of the CMB at angular scales between 4 and 2 degrees. The simplest models of Inflation predict the CGB at levels r ~ 0.01 to 0.1. At these levels, the Inflationary B-mode signal should be within experimental reach, leading the 2005 Task Force on CMB Research to identify this search as the number one priority for the field.

BICEP, the first CMB polarimeter specifically designed for this search, began operating at South Pole Station in early 2006. BICEP is mapping 2% of the sky that is uniquely free of Galactic confusion with angular resolution of 0.9 deg (100 GHz) and 0.6 deg (150 GHz), and should reach sensitivity to $r < 0.1$ during 2008.

A coordinated series of upgrades will retain the compact, cryogenic optical design which has been key to BICEP's success and efficiency, while providing the increased sensitivity and more exacting control of instrumental effects and confusion from Galactic foregrounds necessary to search more deeply. A powerful new 150 GHz receiver, BICEP2, is planned to replace BICEP1 in 2009, exploiting newly available antenna-coupled TES detector arrays to achieve ~ 9 times higher mapping speed. In 2010, the first of a series of compact, mechanically-cooled receivers, SPUD1, will be ready for deployment on the DASI mount, providing similar speed at 100 GHz in parallel with BICEP2. In two seasons of operation, these receivers provide the sensitivity to detect $r > 0.02$ with 95% confidence, characterize the Galactic foregrounds in the cleanest field on the sky, and prepare for a yet more sensitive search for the CGB from South Pole with 6 SPUD-like telescopes deployed simultaneously on the DASI mount.

011.06

Search for Extragalactic Point Sources using WMAP Q-, Vand W-band Data

Xi Chen[1], E. L. Wright[1]
[1]UC, Los Angeles.

The CMB signal in the WMAP sky maps is primarily contaminated by microwave emission from extragalactic point sources on small angular scales. Driven by the goal to provide a clean CMB map for cosmological analysis, we performed a series of extragalactic point source searches in the WMAP Q-, Vand W-band maps, using a method that cancels the CMB anisotropy signal. These bands are chosen because they have relatively higher resolution and less foreground contamination among the WMAP bands. We reported our result for the search using WMAP first-year Vand W-band sky maps in the 207th AAS meeting; 30 point sources were detected, of which 27 were identified with catalogued objects ($1\sigma = 2.2'$). With the release of WMAP three-year data this year, we repeated this 2-band search and found 63 point sources (53 identified, $1\sigma = 1.3'$). We further did a 3-band search using Q-, Vand W-band sky maps. 254 point sources (99 identified, $1\sigma = 1.7'$) and 470 point sources (204 identified, $1\sigma = 1.5'$) were found in the WMAP first-year and three-year data respectively. A major advantage of this method is that it has no CMB signal dependency; the noise comes primarily from the detector noise that can be reduced as $1/\sqrt{t}$ by integrating longer. As the three-year WMAP data is nearly $\sqrt{3}$ times less noisy than the first year data, we did find more than $\sqrt{3}$ times as many sources in the three-year search. VLA and ATCA observations were proposed and approved for all the sources without solid identification in the 2-band search. Observations on currently unidentified sources in the 3-band search will be proposed in the near future.

We acknowledge the use of the Legacy Archive for Microwave Background Data Analysis (LAMBDA). Support for LAMBDA is provided by the NASA Office of Space Science.

011.07

Primordial non-Gaussianity using CMB Temperature and Polarization Anisotropies.

Amit P. Yadav[1], E. Komatsu[2], B. D. Wandelt[1]
[1]Univ. Of Illinois, Urban-Champaign, [2]University of Texas at Austin.

We derive an efficient way for measuring the primordial non-Gaussianity using our new tomographic technique. This technique allows us to reconstruct the primordial perturbations using CMB temperature and polarization data. We have demonstrated that the primordial adiabatic perturbations can be reconstructed using CMB temperature and E polarization information. For measuring the primordial non-Gaussianity, we construct a cubic statistic using the reconstructed maps of primordial perturbations, and use that to define our estimator. We also show that our fast estimator is nearly optimal. Our estimator takes only $N^{3/2}$ *operations in comparison to the full bispectrum calculation which takes* $N^{5/2}$ *operations. Here N refers to the total number of pixels. For Planck* $N \sim 10^8$*, we obtain 100 simulations in only 10 hours using our fast estimator, while it would take approximately* 10^4 *years to compute the full estimator. Hence our analysis is feasible, but the full bispectrum analysis is not. Another advantage of our formalism is that it allows us to be more sensitive to the primordial perturbations, which is*

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important because most current probes of non-Gaussianity do not specifically select for the primordial perturbations

012: Dark Matter
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

012.01

Comparing the Cosmological Critical Density of Neutralinos and Cold Dark Matter

Sarah McMurray[1], K. Andrew[1], D. Barnaby[1], B. Bolen[1], L. Strolger[1]
[1]*Western Kentucky University.*

Cosmological surveys conducted in the last decade have placed substantial constraints upon the cold dark matter (CDM) component of the universe. These surveys include NASA's Wilkinson Microwave Anisotropy Probe and the Sloan Digital Sky Survey, which is exhaustively mapping the positions of clusters of galaxies out to >4 billion light years. These results place the CDM cosmological density in the range of $0.087 < \Omega_{CDM}\, h^2 < 0.138$ at the 99% confidence level. An ideal candidate for the CDM is the lowest mass, weakly interacting, neutral, long lived, suspersymmetric particle known as the neutralino, χ. As long as the neutralino conserves R parity exactly it will be stable. Here we examine the sensitivity of the neutralino cross section in a range of minimal supersymmetric models using the DarkSUSY algorithm. We do this under the constraint that the cosmological WIMP CDM contribution to the mass-energy density scales as $\Omega_\chi h^2 \approx 1/\langle\sigma v\rangle$, where the cross section, σ, is a calculable parameter in the DarkSUSY code, v is the relative velocity of the neutralino and the cross section target and $\langle\ \rangle$ indicates thermal averaging. We compare these neutralino densities to the observed CDM density to constrain the model parameter space. We gratefully acknowledge the Kentucky Space Grant Consortium and NASA for supporting this research.

012.02

Constraining the Angular Distribution of Satellite Galaxies Surrounding Disk-like Host Galaxies

Jason H. Steffen[1]
[1]*Fermilab.*

Recent studies of galaxies from the Sloan Digital Sky Survey (SDSS) show that small satellite galaxies are not distributed isotropically about their hosts. The standard practice of measuring the angular distribution of the satellites is limited by projection effects. I present a method that can overcome the effects of projection and can therefore identify the actual angular distribution of satellite galaxies. I apply this method to disk galaxies selected from the SDSS catalog and constrain the allowed angular distribution of satellite galaxies orbiting disk-like hosts. These results may be used to constrain the shapes of galactic dark matter halos if the distribution of satellite galaxies is correlated with the distribution of the dark matter.

013: Debris Disks
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

013.01

Debris-Disk Candidates in the Open Cluster NGC 2362: An Examination of 24 Micron Stellar Excesses

Alexander J. Shvonski[1], T. Monroe[1], C. A. Pilachowski[1]
[1]*Indiana University.*

We present 24 micron photometry obtained with the Multiband Imaging Photometer for Spitzer on the Spitzer Space Telescope of the young open cluster NGC 2362. Preliminary results show eight A and B stars have moderate to large mid-IR excesses in the range of $(K-[24])_0=0.85-2.24$. These excesses may indicate the presence of unresolved dusty circumstellar disks, produced by the collision of large planetesimals that may be perturbed by large Jovian-like bodies. Long-term goals include investigation of the occurrence of debris disks around A stars with age and stellar metallicity.

This work has been supported by the National Science Foundation under grant AST-04-52975 (the REU program at Indiana University).

013.02

Secular Planetary Perturbations in Circumstellar Debris Disks

Joseph M. Hahn[1], C. Capobianco,[2], P. Kalas[3], K. A. Marsh[4], C. Telesco[5]
[1]*Space Science Institute,* [2]*Queen's University, Canada,* [3]*UC Berkeley,* [4]*NASA/JPL,* [5]*University of Florida.*

Circumstellar debris disks are likely the by-product of collisions among unseen planetesimals. Planetesimals are also the seeds of planets, so it is reasonable to expect that some debris disks might also harbor planets. In fact several such disks, like those orbiting beta Pictoris, Fomalhaut, etc., do appear to be perturbed by unseen planets orbiting within. The signatures of planetary perturbations include: central gaps, warps, and radial offsets in the disk's surface brightness. By modeling the disturbances observed in a circumstellar dust disk, one can then measure or constrain the masses and orbits of the planets that may be lurking within.

Of particular interest here are the warps and radial offsets seen in such disks, since these features can be due to secular planetary perturbations (Mouillet et al 1997, Wyatt et al 1999). Secular perturbations are the slowly varying gravitational perturbations that can excite orbital eccentricities and inclinations in a disk, and can also drive a slow orbital precession. Note that a dust grain's motion is completely analytic when suffering secular perturbations (Murray & Dermott 1999), which allows us to rapidly generate a synthetic image of a simulated disk as would be seen in scattered starlight or via thermal emission. And because this model is quite fast, our model can rapidly scan a rather large parameter space in order to determine the planetary configuration that may be responsible for the disk's perturbed appearance.

We have applied this dust-disk model to Hubble observations of the β Pictoris dust-disk (from Heap et al 2000), and will report on the planets that may be responsible for the warp seen in this edge-on disk. We will also apply the model to optical and IR observations of debris disks at Fomalhaut, AU Microscopii, and others, with additional results to be reported at conference time.

013.03

The Signature of Primordial Grain Growth in the Polarized Light of the AU Mic Debris Disk

James R. Graham[1], P. Kalas[1], B. Matthews[2]
[1]*UC, Berkeley,* [2]*NRC-HIA, Canada.*

We have used the Hubble Space Telescope/ACS coronagraph to make polarization maps of the AU Mic debris disk. The fractional linear polarization rises monotonically from about 0.05 to 0.4 between 20 and 80 AU. The polarization is perpendicular to the disk, indicating that the scattered light originates from micron sized grains in an optically thin disk. Disk models, which simultaneously fit the surface brightness and polarization, show that the inner disk (< 40-50 AU) is depleted of micron-sized dust by a factor of more than 300, which means that the disk is collision dominated. The grains have high maximum linear polarization and strong forward scattering. Spherical grains composed of conventional materials cannot reproduce these optical properties. A Mie/Maxwell-Garnett analysis implicates highly porous (91-94%) particles. In the inner Solar System, porous particles form in cometary dust, where the sublimation of ices leaves a ″bird's nest″ of refractory organic and silicate material. In AU Mic, the grain porosity may be primordial, because the dust ″birth ring″ lies beyond the ice sublimation point. The observed porosities span the range of values implied by laboratory studies of particle coagulation by ballistic cluster-cluster aggregation. To avoid com-

pactification, the upper size limit for the parent bodies is in the decimeter range, in agreement with theoretical predictions based on collisional lifetime arguments. Consequently, AU Mic may exhibit the signature of the primordial agglomeration process whereby interstellar grains first assembled to form macroscopic objects.

013.04

A Search for Debris Disks around Stars with Planets

David R. Ardila[1], A. Kospal[2]
[1]Caltech, [2]Konkoly Observatory/Caltech, Hungary.

We present a Spitzer archival project to search for infrared excess due to debris disks around 67 main-sequence stars for which planets have been found using radial velocity methods. We used MIPS 24 and 70 micron measurements, since the contrast between the emission of the stellar photosphere and the cold dust is highest in the far infrared. Our sample includes all planet-bearing stars for which MIPS measurements are available in the Spitzer archive to date, and thus uses a considerably larger sample than in previously published studies. We compare the results with a sample of 77 field stars without any known planets (published by Beichman et al. 2006). We analyse whether the frequency and magnitude of infrared excess is different for planet-bearing stars and field stars and whether the metallicity distribution of stars with planets and excess is different from that of field stars with excess. In our study we also take advantage of the non-detections by using statistical methods especially developed for datasets with upper limits.

013.05

Spitzer's Dirty Dozen: MIPS and IRACImaging of Nearby Debris Disks

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Bright, nearby stars with infrared excess offer the best prospects for detailed studies of debris disk structure and dust grain properties. The ″Fabulous Four″ debris disks (Vega, Fomalhaut, β Pic, and ε Eri) were resolved by IRAS and have already been intensively studied with the Spitzer Space Telescope. In this contribution, we report on Spitzer imaging of a dozen other nearby, IRAS-selected debris disks with the potential to be spatially resolved in the MIPS 70 µm fine scale channel. The sample consists of nine A type stars (α CrB, β Leo, β UMa, δ Vel, ηTel, γ Oph, γ Tri, τ3 Eri, and ζ Lep) and three solar-type stars (τ Ceti, σ Boo, and 61 Cyg). The dataset includes MIPS imaging photometry at 24, 70, and 160 µm; 55-90 µm MIPS SED mode measurements for most of the targets; and IRAC imaging of 2/3 of the sample to search for cool companions that might dynamically affect the disks. Only the disk of γ Oph is marginally resolved at 70 µm, with outer radius of 500 AU. Weak IRAS excesses for 61 Cyg and τ3 Eri are not confirmed. Results for the companion search, which has the sensitivity to detect objects as small as 5 Jupiter masses in wide orbits, will be reported.

Support for this work was provided by NASA to the Jet Propulsion Laboratory, California Institute of Technology.

013.06

Dual Imaging Polarimetry of young stars in Rho Ophiuchus

Catarina Ubach[1], D. Potter[1]
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We report the results of a high resolution, high contrast polarimetric H-band imaging survey of optically bright (V<15) young stars in the Rho Ophiuchus star forming region taken with the Hokupa′a 36 element AO system used on the Gemini North 8 m telescope. A total of 11 stars were observed, 8 previously classified as Classical T-Tauri stars (CTTS) and 3 as Weak-lined T-Tauri stars (WTTS). Out of the 8 CTTS stars observed, 5 revealed a centrosymmetric scattering signature (SR24 N/S, ROXR1 23, ROXR1 51a, ROXR1 3). Out of the 3 WTTS observed, one of them (Roxj1626.0-2421) was found to have a centrosymmetric scattering signature. Polarized intensity H-Band images of the objects with positive detections are presented.

014: Differential Rotation & Activity of Cool Dwarfs AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

014.01

The Differential Rotation Profile of kappa1 Ceti from MOST Photometry

Gordon A. Walker[1], B. Croll[1], R. Kuschnig[1], J. Matthews[1], A. Walker[1], S. Rucinski[2], D. Guenther[3], A. Moffat[4], D. Sassalov[5], W. Weiss[6]
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The nearby G5 V star, kappa1 Ceti, has a differential rotation profile closely ressembling that for the Sun, despite rotating nearly three time faster. This conclusion is based on the different rotation periods of star spots detected over a wide range of latitudes in MOST satellite light curves from 2003, 2004 and 2005.

SUNDAY

014.02

Differential Rotation in Solar-type Stars

David H. Bruning[1]
[1]Univ. of Wisconsin-Parkside.

Stellar dynamos require differential rotation. Recent observations by Reiners (A&A 446, 267, 2006) showed the presence of differential rotation in 28 of 147 stars of spectral type F and hotter. Yet, the observational signature of differential rotation in solar-type stars remains elusive, largely because of the smaller magnitude of differential rotation in cooler stars. This paper looks at the effect of surface convection on the Fourier signal of differential rotation and seeks the known signature of differential rotation in the solar flux spectrum.

This research has been supported in part by the Wisconsin Space Grant Consortium.

014.03

Tracers of Chromospheric Structure: Observations of CaII K and Hα in M Dwarfs

Lucianne M. Walkowicz[1], S. L. Hawley[1]
[1]University of Washington.

We report on our observing program to capture simultaneous high resolution spectra of Ca II and Balmer lines in a sample of nearby M3 dwarfs. Our goal is to investigate the chromospheric heating required to produce both of these lines at the observed levels. We present the results of our observing program so far, and discuss the application of these results as empirical constraints on models of quiescent M dwarf atmospheres. We also present initial model calculations and place them in the context of the data.

014.04

Solar Physics at Evergreen: Solar Dynamo and Chromospheric MHD

E. J. Zita[1], J. Maxwell[1], N. Song[1], M. Dikpati[2]
[1]Evergreen State College, [2]High Altitude Observatory National Center for Atmospheric Research.

We describe our five year old solar physics research program at The Evergreen State College. Famed for its cloudy skies, the Pacific Northwest is an ideal location for theoretical and remote solar physics research activities. Why does the Sun's magnetic field flip polarity every 11 years or so? How does this contribute to the magnetic storms Earth experiences when the Sun's field reverses? Why is the temperature in the Sun's upper atmosphere millions of degrees higher than the Sun's surface temperature? How do magnetic waves transport energy in the Sun's chromosphere and the Earth's atmosphere? How does solar variability affect climate change?

Faculty and undergraduates investigate questions such as these in collaboration with the High Altitude Observatory (HAO) at the National Center for Atmospheric Research (NCAR) in Boulder. We will describe successful student research projects, logistics of remote computing, and our current physics investigations into (1) the solar dynamo and (2) chromospheric magnetohydrodynamics.

015: Extragalactic ISM
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

015.01

Spitzer View of Four Low Surface Brightness Giant Galaxies: Malin 1, UGC 6614, UGC 6879, UGC 9024

M. N. Rahman[1], J. Howell[2], B. Buckalew[2], G. Helou[2]
[1]*Caltech,* [2]*IPAC/Caltech.*

We present $Spitzer$ IRAC and MIPS imaging of four low surface brightness (LSB) galaxies: Malin 1, UGC 6614, UGC 6879, UGC 9024. Our study shows that the gigantic disks such as Malin 1 and UGC 9024 appear just like a point source in the IRAC and MIPS images. Their morphological features suggest that IR emission is concentrated in central few kpc in these disks. For Malin 1, however, far-IR emission from the rest of the disk is too faint to be detected by the IRAC and MIPS implying presence of cold cirrus components in this galaxy emitting mostly in the ≥ 200 micron. UGC 6614 and UGC 6894, on the other hand have, substantial amount of dust with various radiation intensity: hot, warm and cool. The most striking outcome of our study is that these LSB galaxies show enhance PAH emission. The existence of diffuse PAH emission indicates that the ISM in LSB disks have significant amount of carbon enrichment over time and that radiation field intensity must have been significantly weak to be able to reduce the strength of diffuse emission. We have constructed IR spectral energy distribution (SED) for these LSB galaxies. Though we still lack information beyond $\sim$200 micron the trend seen in our preliminary study suggests that cirrus emission heated by the interstellar radiation field must play a significant role at least in Malin type disks. However, at present using SST alone we are unable to probe the cold dust components.

015.02

PDR-Produced HI in Star-Forming Regions of M33

Jonathan S. Heiner[1], R. J. Allen[1], P. C. van der Kruit[2]
[1]*STScI,* [2]*Kapteyn Astronomical Institute, The Netherlands.*

We report our latest findings on the volume densities of molecular hydrogen in Giant Molecular Clouds (GMCs) associated with photodissociation regions (PDRs) in the nearby galaxy M33, using HI continuum, FUVand metallicity data.

The morphology of the atomic hydrogen distribution is similar to what is expected for PDRs, since the HI is seen surrounding bright FUV sources. Potential PDRs that we detect, in which dissociating photons dominate the radiation field, have sizes in the order of 100 parsec. Complexes of young, hot stars are responsible for these PDRs. They create a 'blanket' of photodissociated HI.

The balance equation governing the photodissociation process needs the ultraviolet luminosity incident on the surface of the GMC and the local dust-to-gas ratio together with the HI column density in order to calculate the volume density of molecular hydrogen.

Verification of the PDR scheme that we are testing depends ciritically on the spatial resolution of the M33 data. At a resolution in the order of 20-30pc we expect to see a PDR morphology. Earlier results for M81 and M83 had the right resolution to apply our method, but lacked the spatial resolution to truly discern any structure.

We used M33 radio data kindly provided by David Thilker and Robert Braun and publicly available Galex UV data.

This work is funded by STScI's Director's Discretionary Research Fund.

015.03

The Relationship of Atomic Gas and Aromatic Emission in SINGS Spiral Galaxies

Esther Chapman[1], M. D. Thornley[2], The SINGS team
[1]*Cornell College,* [2]*Bucknell University.*

We present a comparison of emission from atomic gas and stochastically heated dust in two nearby, relatively face-on spirals, M51 and M74, using HI emission maps from THINGS and 8 micron dust emission from the SINGS Legacy project. This poster will describe initial results from an exploration of the extent to which Spitzer IRAC 8 micron emission traces the distribution of the interstellar medium and the star formation process in nearby spiral galaxies.

015.04

Spitzer Observations of Extraplanar PAH Emission from Several Edge-On Galaxies

Nicolas Lehner[1], C. Howk[1]
[1]*University of Notre Dame.*

We present Spitzer/IRAC observations of polycylic aromatic hydrocarbon (PAH) emission from interstellar material in the thick disks of several edge-on spiral galaxies. Our Spitzer 8 micron images reveal many dust structures with various morphologies far above the planes of these galaxies. There are round and irregular clouds, smoother clouds, vertical clouds and loop-like structures. Emission from PAHs can be seen to at least 2-4 kpc above the midplanes of the galaxies in our sample. PAHs appear to be a common constituent of extraplanar material in spiral galaxies, and the processes that circulate material from the thin interstellar disks of galaxies do not destroy these very small grains.

015.05

WFPC2 Imaging of the Multiphase Halos of Two Spiral Galaxies: Dust and Ionized Gas

Katherine Rueff[1], M. Pitterle[1], A. Hirschauer[1], N. Lehner[1], C. Howk[1]
[1]*Univ. of Notre Dame.*

We present high-resolution optical images of the interstellar medium (ISM) in the thick disks of the spiral galaxies NGC 4013 and NGC 4302. Our broadband (BVI) images acquired with the Hubble Space Telescopeâ€™s WFPC2 show extensive extraplanar dust clouds seen in absorption against the background stellar light, while our narrow-band H-alpha images taken with the WIYN 3.5-m telescope show the diffuse ionized gas (DIG) in these galaxies. The dusty, thick disk clouds visible in our WFPC2 images, which can be found to heights approaching 2 kpc from the midplanes of these galaxies, trace a phase of the ISM that shows significant structure on quite small scales. In general this material is seen to be highly filamentary. By contrast, the thick disk DIG in these galaxies has significantly smoother distribution. We note several unresolved knots of H-alpha emission which may represent thick disk H II regions. We discuss the relationship of the dust-bearing clouds and the DIG in these galaxies.

015.06

Multiwavelength Observations of Tidally Induced Star Formation in the M81 Group

Abigail S. Hedden[1], K. Knierman[1], T. Roelofsen[2], C. Kulesa[1], J. Feldmeier[3], V. Gorjian[4], P. Durrell[3], B. Sepulveda[5], T. Spuck[6], C. Wheeler[7]
[1]University of Arizona, Steward Observatory, [2]New Jersey Astronomy Center for Education, [3]Youngstown State University, [4]JPL, [5]Lincoln High School, [6]Oil City Area Senior High School, [7]Luther Burbank High School.

We combine optical, infrared, and millimeter/submillimeter-wave observations to study a small clump of recently formed stars and the interstellar environment between the galaxies of M81 and NGC 3077. This clump is coincident with an HI emission knot in the Southern Tidal Arm of the M81 system, and is known to have formed stars as recently as 30-70 Myr ago; long after the interactions that created the HI arm. This object is about 1 kpc in extent, and is considered a tidal dwarf (TD) candidate. To better characterize its star forming environment, we place limits on the molecular gas and dust content of this potential TD object, and compare its properties to well-studied star forming regions. The infrared observations were obtained as part of the Spitzer Space Telescope Research Program for Teachers and Students, so these data are also being used for educational purposes by teachers and students across the US.

015.07

Evidence for Outflows and a Galactic Wind in the Large Magellanic Cloud?

J. C. Howk[1], N. Lehner[1]
[1]Univ. of Notre Dame.

We present observations of the high ions C IV, Si IV, N V, O VI toward four hot stars in the Large Magellanic Cloud (LMC). High-quality FUSE and HST/STIS spectra of these stars, located toward superbubbles and HII regions, show absorption from the high ions and strong low-ionization lines over the velocity range [-50,+350] km/s. In the LMC (v>+175 km/s), we find narrow and broad C IV and Si IV absorption, but only very broad O VI absorption. The breadth of the narrow LMC components of C IV and Si IV implies very cool temperatures of a few times 10,000 K or less. The properties of these narrow components can be explained if they arise within the interstellar environments associated with the stars. The breadths of the broad LMC components imply hot, collisionally ionized gas at temperatures of a few times 100,000 K. We find a striking similarity in the O VI/C IV ratios for the broad LMC and HVC components; this suggests much of the material at v>+100 km/s is associated with the LMC. While there are differences in the high-ion ratios of the broad LMC and HVC components between the four sight lines, implying different processes or varying conditions are present, the stellar environments do not appear to dictate the production of the high ions in these components. Conductive interface models can reproduce the high-ion ratios of the broad LMC and HVC components; such models are also favored by the apparent kinematically coupling between the high and the weak ions. Our analysis is consistent with the existence of a hot LMC halo fed by energetic outflows from the LMC disk and even possibly with a galactic wind, since the velocity of the HVC relative to the LMC disk is actually large enough to escape altogether the LMC.

015.08

Spitzer IRS Observations of the Gaseous Halo of NGC 891

Richard J. Rand[1], R. A. Benjamin[2], K. Wood[3]
[1]Univ. of New Mexico, [2]Univ. of Wisconsin-Whitewater, [3]Univ. of St. Andrews, United Kingdom.

The source(s) of ionization and heating of the diffuse ionized gas in spiral galaxy disks and halos remains unclear. The usual optical diagnostic line ratios suffer from dependence on a confusing number of variables: not only the ionization state but also the temperature and abundance of the gas, as well as extinction, which is significant in some galaxies up to heights of 2 kpc above the plane. The Spitzer Space Telescope provides the opportunity to study the [Ne III]/[Ne II] mid-IR diagnostic, for which temperature, gas-phase abundance and extinction effects are unimportant. Here we report the first detection of these lines in an external spiral galaxy halo, and find that the ratio is enhanced relative to the disk a result which, as we also show, is problematic for pure photo-ionization models. We also report on the first spectroscopic detections of PAH features in an external galaxy halo. Their emission suggests rough scale-heights of 300-500 pc.

015.09

Models of the Effect of Gaseous Drag on the Accretion of Intergalactic Clouds

Travis C. Fischer[1], R. Benjamin[1]
[1]University of Wisconsin-Whitewater.

Neutral gas clouds are observed outside the disks of ordinary spiral galaxies like the Milky Way. The high velocity clouds of our own Galaxy, assumed to be within ~200 kpc, show evidence of interaction with the gaseous halo. We present models of the orbital decay of such clouds over time for a realistic model of the density and velocity structure of the interstellar Galactic disk and halo. We examine the effects of impact parameter, initial velocity, column density and prograde/retrograde trajectories on when such clouds are accreted. We demonstrate that clouds with higher column density, clouds that are retrograde, and clouds with smaller impact parameters will settle deeper into the center of the gaseous galactic disk. This research was supported by NSF REU Site grant to UW-Madison, AST-0453442.

015.10

A PAH Deficit in Extremely Low Luminosity Galaxies

Rongying Wu[1], D. W. Hogg[1]
[1]New York University.

We present a study of 29 extremely low luminosity galaxies randomly selected from the footprint of the Sloan Digital Sky Survey (SDSS). The galaxies comprise a statistically complete sample of galaxies with Mr > -15 and recession velocity v < 2000 km s^-1 as measured in SDSS Data Release 2 (DR2). We also observe these sample galaxies in all four channels with the Spitzer Infrared Array Camera (IRAC). The photometry in SDSS shows that these galaxies appear to be visually blue (g-r < 0.6), and the IRAC color analysis shows that they are blue in IRAC infrared color [3.6]-[8]. The IRAC [3.6] magnitude measures the starlight, and the [8] measures PAH emissions. We find that these star-forming galaxies show very low PAH to star ratios. This result agrees with earlier observations on other dwarf galaxies including SBS0335-052 and small samples from ISO and the overlap of the SDSS with the Spitzer First Look Survey, but it is worth emphasizing that this sample has a lower mean luminosity than those samples. The PAH deficiency of these galaxies is discussed in the context of their metallicity and dust properties.

015.11

Low Frequency Turnovers of Compact Radio Sources in NGC 247

Sara K. Schultz[1], C. K. Lacey[1]
[1]Univ. of South Carolina.

We present high angular resolution VLA images of NGC 247 at 20 and 6 cm. Multiple compact radio sources have been identified in this galaxy and the spectral index for each source was calculated. Two compact sources near the nucleus of the galaxy show spectral turnovers occurring at 20 cm and these sources have been identified as candidate ultracompact HII regions. Ultracompact HII regions are of interest because they have high enough densities to cause internal absorption and are sites of current star formation. We discuss the properties of the candidate ultracompact HII regions and compare these sources with other ultracompact HII regions in nearby galaxies.

015.12

SCONES: Determining the Warm Gas Properties of Nearby Galaxies

Glen R. Petitpas[1], C. D. Wilson[2], A. J. Baker[3], D. Iono[4], A. B. Peck[1], K. Sakamoto[4], M. Krips[1], P. T. Ho[5], S. Matsushita[5]
[1]*Harvard-Smithsonian Center for Astrophysics,* [2]*McMaster University, Canada,* [3]*Rutgers,* [4]*NAOJ, Japan,* [5]*ASIAA, Taiwan.*

We present preliminary results from our SMA CO Nearby Extragalactic Survey (SCONES) which will determine the warm gas properties of a sample of nearby galaxies at high angular resolution. Thus far we have mapped seven galaxies in ^{12}CO J=2-1, ^{13}CO J=2-1, C^{18}O J=2-1 and ^{12}CO J=3-2. Using these SMA data combined with archival data we will answer the following questions: 1) Do the temperature and density of molecular gas correlate with the CO morphology? 2) Do the morphologies and dynamics of the warm gas match those of the cool gas? 3) How does the CO-to-H_2 conversion factor vary with galaxy type?

015.13

Understanding the Interplay Between Star Clusters and Their Interstellar Medium Using SINGS H II Regions

Brent A. Buckalew[1], SINGS Team
[1]*Caltech/IPAC.*

Many issues in a galaxy's evolution and properties of its interstellar medium (ISM) are driven by massive stars in young (0-10 Myr) star clusters. At these ages, star clusters produce metals from supernovae explosions, generate ionizing photons that determine the phase of the ISM, and provide mechanical energy to rearrange the ISM. Here, we analyze the IRS spectra of 62 HII regions to determine the importance of the star cluster's ionization hardness (measured via [Ne III]/[Ne II]) on the polycyclic aromatic hydrocarbon (PAH) equivalent widths (e.g., PAH 6.2 EW), the amount of warm molecular hydrogen emission relative to the CO emission (i.e., H_2 S(2)/CO), and the mass and temperature of the dust. We also analyze these properties relative to metallicity (i.e., oxygen abundance). Our SINGS data contribute a larger wavelength range and sensitivity than past work and can contribute a larger metallicity range (12+log(O/H) between 7.7 and 8.7) with a more significant sample. We find a relation between the metallicity, ionization hardness, and PAH EW. As the ionization hardness increases by a factor of 10 for metallicities lower than 8.41, the PAH EWs for the major features decrease by a factor of 100. Ionization hardnesses for H II regions with larger metallicities do not affect the PAH emission at all. The warm molecular hydrogen relative to the cold emission also increases as the ionization hardness. We find no relation between the star cluster's ionization hardness and the dust masses and temperatures. This work is based in part on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

016: The Sun
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

016.01

Broadband Spectroscopy of the Corona during the Total Solar Eclipse of March 29, 2006

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[1]*Institute for Astronomy, Univ. of Hawaii,* [2]*Dept. of Physics, Univ. of Illinois at Urbana-Champaign.*

We present coronal observations from the total solar eclipse of 29 March 2006 taken near Waw al Namus, Libya. During the 4 minutes and 6 seconds of totality, observations were made with a tracking collecting mirror and fiber-fed spectrograph. The spectrograph used is a high quantum efficiency commercial Ocean Optics QE65000 Spectrometer with a wavelength range of 350 to 1100 nm, and spectral resolution of about 0.75 nm. High quantum efficiency allowed for many short exposures of the inner (100 msec) and outer (10,000 msec) corona during the eclipse. Important spectral features, and the difference in color between the inner and outer corona are identified. Atmospheric contributions are discussed. Likely candidates for the nature of dust grains contributing to the F-corona measurements are also presented. These are compared with laboratory spectra of silicon nanoparticles.

016.02

Changes in Sunspot Umbral Intensity Over Time

Rachel MacDonald[1]
[1]*University of Washington.*

This project investigated archival data from the Kitt Peak Vacuum Telescope, to see if there were any time-varying trends in the minimum umbral intensity of sunspots. Using spectroheliograms taken at 8688 Å a sample of over 3000 sunspot observations was gathered, covering the time period from November, 1992 to September 2003. Analysis of this data revealed that there is a pattern to the umbral intensity variation, and that it is tied to the solar cycle. The minimum umbral intensity of sunspots increased from solar maximum to minimum, and decreased from solar minimum to maximum. These results agree with a study of infrared spectra of sunspot umbra, and with a study using data from the Michelson Doppler Imager (MDI) on the SOHO satellite.

This work was carried out through the National Solar Observatory Research Experiences for Undergraduate (REU) site program, which is cofunded by the Department of Defense in partnership with the National Science Foundation REU Program.

016.03

Relationship Between the Radio Bursts from the Sun and Ionospheric Propagation

Mary Lou West[1], N. Frissell[1], M. Papalos[1]
[1]*Montclair State Univ..*

We are monitoring the sun's radio activity at 20.1 MHz with a Radio Jove rig, and have begun to monitor the Earth's ionosphere for HF radio propagation using the worldwide network of beacons set up by the Northern California DX Foundation. These 18 beacons transmit at 14.1, 18.11, 21.15, 24.93, and 28.2 MHz on a 3 minute cadence and allow ham radio operators to judge the radio propagation characteristics to distant lands easily.

Although the solar activity cycle is now near its bottom, there are occasional outbursts, some spectacular. August 29, 2006, was such a day, prompting the Radio Jove community to post ten times the usual number of reports to the archive at Goddard Space Flight Center. The next day the Earth's ionosphere suddenly blossomed with HF openings without any X-ray flares reported. The delay time of 26 hours from the most energetic radio event indicated a velocity of 1600 km/s, normal for a coronal mass ejection. Several other events have also shown delays of about 24 hours from the radio sun to the ionosphere, and are especially noticeable at the higher frequency bands and on the events list of the Space Environment Center of NOAA.

The 20.1 MHz monitors may serve as a method to predict radio propagation properties of the ionosphere more quickly than previous methods.

016.04

Coronal Loop Recognition: A Diagnostic Tool for Magnetic Field Extrapolation Models

Julia Sandell[1], V. Kashyap[2], M. Weber[2], A. van Ballegooijen[3], E. Deluca[3], M. Bobra[3]
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Constraining the structure and extent of the coronal magnetic field is important for theories of coronal heating. This can be accomplished by matching the models of magnetic fields derived by extrapolating measurements of surface magnetic flux, with highly detailed structure present in EUV and X-ray images of the corona. Using high resolution TRACE images we detect loops in an automated manner, and aim to replace the currently used method of manually selecting pixels that might comprisea loop. We apply this method to a set of TRACE images and identify loops for further analysis. We fit force-free potential field models of the magnetic field to these loops and derive useful parameters that describe the geometric and physical parameters of the loop. We find that the loops are generally of length $>$ 1010 cm. If assumed to be in static equilibrium, the loop top temperatures are 3-5 MK. the field lines are characterized by strength ranging from 0.4-27 G. After carrying out numerous Monte Carlo simulations, each time varying different parameters used in the program, we found this new automated process to be stable and robust. We thank the Harvard-Smithsonian Summer REU program for making this summer project possible as well as a grant from NASA (NASA grant NNG05GM44G), and the NSF for funding the REU program.

017: Galactic ISM I
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

017.01

Imaging of Diffuse FUV Emission from the Gum Nebula with SPEAR

Kaori Nishikida[1], R. Sankrit[1], M. Sirk[1], B. Welsh[1], K. Min[2], K. Ryu[2], J. Shinn[2], W. Han[3], D. Lee[3]
[1]Space Sciences Laboratory, UC Berkeley, [2]Korea Advanced Institute of Science and Technology, Republic of Korea, [3]Korea Astronomy and Space Science Institute, Republic of Korea.

We present imaging observation of diffuse FUV emission lines emanating from the Gum Nebula, a large ionized region ~18 degrees in radius centered around (l,b)=(258, -2). Observations covering about 50% of the Gum Nebula have been obtained with the SPEAR (*FIMS*) instrument, flown aboard the STSAT-1 satellite. Our understanding of this nebula and its origins is incomplete; however, past observations have shown that it has characteristics of an H II region, of a wind-blown bubble, and of an old supernova remnant. We report detection ($>$ 2-sigma) of C IV (1550 Å) and Si II (1533 Å) emission from the Gum Nebula. Emission is detected on angular scales of ~4 degrees and is localized, rather than being uniform across the Nebula. The C IV emission directly traces high ionization, intermediate temperature gas, while Si II traces lower ionization gas. By comparing the observations with photoionization and shock model predictions, we determine which of these processes dominates at different locations. SPEAR (*FIMS*) is supported by NASA grant NAG5-5355 and flies on the STSAT-1 Mission, supported by the Korea Ministry of Science and Technology.

017.02

Properties of the Hot Diffuse Gas in our Galaxy observed with SPEAR

Julia M. Kregenow[1], M. Sirk[2], R. Sankrit[2], C. Heiles[1], J. Edelstein[2], K. Min[3], K. Ryu[3], J. Shinn[3], W. Han[4], D. Lee[4]
[1]UC, Berkeley, [2]UC Berkeley, Space Sciences Lab, [3]KAIST, Republic of Korea, [4]KASI, Republic of Korea.

We have observed 2/3 of the FUV sky (between 900 and 1700 Angstroms) with the SPEAR imaging spectrometer. From these data, we have extracted maps of CIV (1550 Å) and OVI (1032 Å) emission. These emission lines are likely to be the dominant cooling mechanism for 1×10^5 and 3×10^5 K gas respectively, in transition from the hot to the warm phase of the Galactic ISM. SPEAR's unprecedented spectral and spatial coverage of FUV-emitting gas allows us to study this gas over the sky, giving us a new look at the large-scale distribution of this transition-temperature gas in the Galaxy. We present comparisons of our emission intensities with published absorption columns measured by Copernicus, HST, IUE, HUT, and FUSE. Such comparisons can provide constraints on the electron density and other physical properties of the gas that can lead to a determination of the filling factor of this elusive medium.

The SPEAR (or FIMS) instrument is supported by NASA grant NAG5-5355 and flies on the STSAT-1 Mission, supported by the Korea Ministry of Science and Technology.

017.03

Emission from Low Ionization Gas in the Galaxy observed with SPEAR

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[1]UC, Berkeley, [2]KAIST, Republic of Korea, [3]KASI, Republic of Korea.

We present sky maps of the Si II λλ1526,1533 and Al II λ1670 emission obtained with the SPEAR (FIMS) instrument. These emission lines trace low ionization gas, which exists mainly in the cool phases of the diffuse interstellar medium. Since these emission lines are photoexcited, their fluxes are sensitive to the radiation field. We examine the relationship of the low ionization gas in the interstellar medium with the dust , the molecular gas and the hot component by comparing these maps with SPEAR maps of the continuum, H_2, and C IV λ1550, respectively. The map can be compared with absorption line measurements to derive the physical conditions in the emitting regions.

SPEAR (FIMS) is supported by NASA grant NAG5-5355, and flies on the the STSAT-1 Mission, supported by the Korea Ministry of Science and Technology.

017.04

Molecular Hydrogen Fluorescence in our Galaxy Observed with SPEAR

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We present a map of molecular hydrogen in the Galaxy observed from its far-ultraviolet fluorescent emission. The map was obtained using observations over most of the sky using the SPEAR (FIMS) instrument, aboard the STSAT-1 satellite. Fluorescence emission is one of the few available direct tracers of molecular hydrogen. While the molecular hydrogen is concentrated toward the galactic plane, it is not strictly limited to low galactic latitudes. The coverage and quality of our data should allow us to place constraints on the column and destruction rate of Galactic interstellar molecular hydrogen and to compare its distribution with interstellar atomic hydrogen and dust over a variety of environments.

The SPEAR (*FIMS*) is supported by NASA grant NAG5-5355 and flies on the STSAT-1 Mission, supported of the Korea Ministry of Science and Technology.

017.05

Maps of Emission from Hot Diffuse Gas in our Galaxy with SPEAR

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We present maps of CIII λ 977, CIV λλ 1550, and OVI λλ 1032,1038 emission. These maps were obtained using observations over most of the sky using the SPEAR (FIMS) instrument, aboard the STSAT-1 satellite. These lines represent the dominant radiative cooling mechanisms for thin interstellar plasma of T=$8x10^4$, $1x10^5$, and $3x10^5$ K, respectively. We discuss the relationships between the intensities of these species and the implications of these relationships on our understanding of the Warm/Hot ISM and its distribution in the galaxy.

The SPEAR/FIMS is supported by NASA grant NAG5-5355 and flies on the STSAT-1 Mission, supported of the Korea Ministry of Science and Technology.

017.06

Mapping of FUV Emission Lines for the North Galactic Pole with SPEAR

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We present far ultraviolet (FUV:1350 1750Ang) spectral imaging observations recorded with the SPEAR satellite originating in a 60° x 30° rectangular region close to the North Galactic Pole. We have obtained maps of interstellar emission line intensity including the lines of CIV (1550Ang), SiIV (1394Ang) and SiII* (1533Ang), binned to a spatial resolution of 4 sq. deg. on the sky. These data represent the first spectral maps of the of the highly ionized medium (HIM) and the warm ionized medium (WIM) recorded at high galactic latitudes. The data are presented as line intensity ratio maps, e.g. CIV/SiIV and CIV/SiII*, such that the observed spatial variations in these ratios can be associated with the varying physical conditions of interstellar gas at high galactic latitude.

The SPEAR (or "FIMS") is supported by NASA grant NAG5-5355 and flies on the STSAT-1 Mission, supported of the Korea Ministry of Science and Technology.

017.07

Observation of Cosmic Far-ultraviolet Background Radiation with SPEAR

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We present a map of the cosmic far-ultraviolet (FUV; 1360-1710A) continuum background over the most of the sky. The map was obtained with the "Spectroscopy of Plasma Evolution from Astrophysical Radiation" instrument (SPEAR/FIMS), flown aboard the STSAT-1 satellite mission. The cosmic FUV flux distribution is consistent with what is generally believed to be its dominant component, light from early-type stars scattered by interstellar dust. We are developing a dust-scattering radiative transfer model to fit the FUV continuum data. The coverage and quality of our data should allow us to place simultaneous constraints on the dust properties and illumination parameters. We investigate the total FUV interstellar radiation field and comparisons of the diffuse FUV continuum map with maps of reddening, N(HI), and H_α. The SPEAR (FIMS) is supported by NASA grant NAG5-5355 and flies on the STSAT-1 Mission, supported of the Korea Ministry of Science and Technology.

017.08

Intermittency of the Velocity Field Structure in Compressible MHD Turbulence

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Intermittency of MHD turbulence can play important role for inhomogeneous heating of the interstellar gas. Strong intermittency can also affect the propagation and acceleration of cosmic rays. We report our recent studies on the intermittency of velocity field in the numerical simulations of 3D compressible MHD turbulence. We perform two types of velocity field separation: the first into incompressible and compressible parts performing the Helmholtz-Hodge decomposition and the second into Alfven, slow and fast modes using the Cho & Lazarian (2003) technique. For each resulting component we calculate two-point statistics which include longitudinal, transverse and total structure functions. We find that the turbulence intermittency is very different for different modes. They also depend on the system of reference in which the intermittency is studied. While the Alfven mode intermittency changes marginally with the Mach number, the intermittency of the fast mode is affected by the change of Mach number substantially larger. We show that observational studies of intermittencies may be an important tool for ISM turbulence studies.

017.09

Turbulence and Cosmic Ray Acceleration

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Both turbulence and cosmic rays exhibit power laws that spread over many decades. We analyze the problems that current theories of turbulence face in accounting for the interaction of turbulence and cosmic rays. We identify compressible motions as the major agent that enables efficient coupling of turbulence and cosmic rays. We consider both strong and weak turbulence, as well as super-Alfvenic turbulence, revisit the mechanisms of turbulent acceleration of cosmic rays. We establish conditions when the particular mechanisms dominate. In addition, we analyze a new technique termed Velocity Coordinate Spectrum (VCS) that enables observational studies of turbulence using Doppler-broadened spectroscopic lines. We discuss the feasibility of separating the compressible and incompressible components of turbulence and thus checking our theoretical constructions.

017.10

[O I] and [C II] Emission Towards NGC 6334 A

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This work attempts to explain [O I] and [C II] emission towards NGC 6334 A, an obscured ultra-compact H^+ region located 1.7 kpc away. Towards NGC 6334 A, the [O I] 63/146 micron ratio is surprisingly low (~2.4). We find a closed geometry, where the H^+ region and associated PDR is embedded in the molecular cloud is required to explain the observed emission. Using such a geometry, constant density PDR calculations were constructed to predict line intensities as a function of A_V (or N(H)), hydrogen density (n_H), and incident UV radiation field (G_0). We find that a single component model with A_V ~650 mag, $n_H = 5 \times 10^5$ cm^{-3}, and $G_0 = 7 \times 10^4$ reproduces the observed [O I] and [C II] intensities, and that the low [O I] ratio is due to thermalization of the 63μm line as it propagates through a large column density of atomic/molecular gas. We find that the effects of a density-law increase our derived A_V, while the effects of an asymmetric geometry decrease A_V, with the two effects largely canceling. Overall, the theoretical calculations presented in this work have utility for any PDR embedded in a molecular cloud.

017.11

The Galactic Center: High-resolution Imaging and Temperature Determination of Dense Molecular Clouds

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The Galactic Center region is obviously the most nearby core of a galaxy and is subject to extreme physical conditions, e.g., it contains the most nearby massive black hole Sgr A* and the very prominent star forming region Sgr B2. We present results of a high-resolution, wide-field, multi-line ammonia survey of the Galactic Center region obtained with he Australia Telescope Compact Array. The survey encompasses Sgr A* and Sgr B2 within its 1 degree x 0.2 degree field of view. At a resolution of ~1pc, this is the most detailed map of molecular gas across the Galactic Center region to date. The inversion transitions of ammonia are an excellent thermometer of molecular gas and we derive mean kinetic temperatures of ~50K with higher temperatures in some clouds near Sgr A* and in Sgr B2. A very prominent temperature gradient stretches across Sgr B2 (ranging from ~100 to ~30K),

with high temperatures away from the Galactic Center. A decomposition in individual molecular clouds reveals about 3000 individual complexes. The decomposition is used to derive the clump mass function which is flatter than in other Galactic star forming regions. The very high velocity dispersions and the relatively high temperatures also lead to considerable P/k overpressures of ~10^6-9 K cm-3.

017.12

High-Resolution Study of X-ray Absorption by the Interstellar Medium

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A proper understanding of the absorption of X-rays by the interstellar medium is important for the spectral modeling of X-ray sources. The XSPEC model tbabs takes into account improved abundances, new cross sections, and the influence of grains. We describe recent improvements to tbabs, including the addition of fine structure in the absorption edges of Fe-L, O, and Ne, which allow tbabs to be used with gratings instruments such as the Chandra HETGS and LETGS and the RGS on XMM-Newton.

017.13

Highly Excited Rovibrational Rate Coefficients for H_2 + He Collisions: Relevance to H_2 Spectra in the ISM

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Extensive quantum mechanical coupled-channel and quasi-classical trajectory scattering calculations have been performed to obtain inelastic scattering cross sections for rovibrational transitions in orthoand para-H_2 induced by He impact. Full rovibrational couplings and a reliable potential energy surface have been considered in the coupled-channel calculations. Cross sections for vibrational levels from $v = 0$ to 14 with rotational levels $j = 0$ to 30 were computed for kinetic energies between 10^{-4} and 3.5 eV, and the corresponding rate coefficients were calculated for the temperature range from 5 K to 10,000 K. The present rate coefficients are compared with recent results of Le Bourlot et al. (1999). Agreement is found to be less satisfactory for rovibrational transitions. A sample of astrophysical applications is also presented.

017.14

A Study of the Radio Continuum Far Infrared Correlation at Small Scales in the Galaxy

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We present a study of the behavior of the Radio Continuum (RC) Far Infrared (FIR) correlation on scales corresponding to the size of small molecular clouds. This was done by comparing the spatial distribution of RC emission and FIR emission from a sample of several regions, distributed within the range $79^\circ \leq l \leq 174^\circ$ in the Galaxy. We have examined the 408 and 1420 MHz mosaic images of the sample, from the Canadian Galactic Plane Survey (CGPS), which later were compared with images at 60 and 100 μm. Preliminary results suggest that the RC -FIR correlation still holds at small scales, since a good qualitative correlation between RC and FIR emission is found. The physical process involved that may cause such correlation will be discussed as well as the nature of the RC emission.

This research makes use of data from the Canadian Galactic Plane Survey.

017.15

Flows, Filaments & Fragmentation:Towards a Theory of Dynamical Star Formation

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The structural richness of molecular clouds and their observed linewidths indicate that they are highly dynamical. Observations suggest (a) that local star formation in such clouds is generally "rapid", i.e. it happens within a few (1-3) free-fall times, and (b) that the parent molecular clouds are short-lived. Numerical models have helped to identify turbulent fragmentation as one of the main agents for rapid star formation. However, turbulence often has been claimed to lend support to the parent molecular cloud, rendering star formation seemingly "slow". A solution to this conundrum requires understanding the initial conditions of star formation in a broader frame, i.e. a closer look at the details of molecular cloud formation. We conducted several numerical experiments, all centered on the scenario of molecular cloud formation in colliding flows (Balleteros-Paredes et al. 1999, ApJ, 527, 285; Hartmann et al. 2001, ApJ, 562, 852, Heitsch et al. 2006, ApJ 648, 1052) in the context of rapid star formation.

We find (1) that turbulence is a natural consequence of the formation process of the clouds, due to a combination of strong thermal and dynamical instabilities, and we give an analytical prediction for the relative importance of the instabilities in various regimes. (3) Initial conditions in the flows and the flow geometry play a crucial role for the structure of the resulting molecular cloud. (2) Stars begin locally to form immediately once sufficient cold dense gas is available. Thus, the local age spread of the stars is expected to be small. (3) Magnetic fields can play a dynamically important role, but generally do not prevent fragmentation, and are generally too weak to prevent gravitational collapse.

SUNDAY

017.16

A New View of the Light Echoes from SN 1987A

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Light echoes provide a valuable window into interesting stellar phenomena and serve as a sensitive probe of the structure and composition of the circumstellar and interstellar media. Using a new difference imaging technique, we have obtained deeper, more detailed images of the light echoes around SN 1987A than previously available. Difference imaging is normally necessary to separate light echoes from the sky background, due to their low surface brightnesses. This approach has traditionally relied on single light-echo free template image which is subtracted from each epoch. Generally, this template must be constructed. We have developed a new method, based on the NN2 algorithm of Barris et al. (2005), that produces images containing absolute light echo fluxes from individual epochs, without the need for an echo-free template (Newman & Rest 2006). Applications of this method to the light echoes around SN 1987A have yielded high-quality images that reveal new detail and faint structures. From these images we have measured new values for parameters of the rings, including a faint outer ring reflected from dust more than 1 kpc in the foreground of the supernova. Implications for the three-dimensional interstellar dust structure are considered.

017.17

ATCA Imaging of Dense Gas in Star-Forming Environments

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The HCN (J=1-0) line is the primary indicator of dense (10^5 cm^{-3}) molecular gas for extragalactic studies. However, the reliability of HCN as a tracer of dense gas mass has been questioned, given the possibility of abundance variations or mid-IR pumping. Alternatively, HCO^+ has been proposed as a superior tracer of dense gas, although it may be enhanced along with ionized carbon in the presence of strong radiation fields. To investigate the variation in the HCN/HCO^+ ratio across different environments, we have performed high-resolution simultaneous imaging in HCN and HCO^+ of a circumnuclear starburst lacking nuclear activity (NGC 7552) and an HII region within the Large Magellanic Cloud (N113) using the upgraded Australia Telescope Compact Array. Variations in the HCN/HCO^+ ratio as a function of spatial scale and IR emission brightness are discussed.

This research was supported by an ARC/CSIRO Linkage Grant and the U. of Illinois.

017.18

Diagnostics of Astrophysical Magnetic Fields based on AtomicAlignment and Hanle Effect

Huirong Yan[1], A. Lazarian[2]
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Atoms and ions with fine and hyperfine structure of levels can be aligned in their ground or metastable state by external radiation. The alignment here is understood in terms of projection of atomic angular momentum, if a classical picture is used. The atomic alignment induces the polarization of absorption lines and modification of the emission lines. As the species precess in magnetic field the field modifies the polarization. We show that the topology of fields weaker than one Gauss can be studied by polarimetry. In addition, depending on the distance from a pumping source and magnetic field strength, there could be different regimes that provide additional information on magnetic fields. For instance, magnetic splitting, when it is comparable to the line-width, changes the atomic occupations and coherence on their excited state, and thus changes the polarization pattern of resonant-scattered light. This is known as Hanle effect. We discuss how this effect is modified in the presence of atomic alignment.

We also report a ground state Hanle effect, which takes place when the precession rate becomes comparable with the pumping rate of the source. We provide predictions of the atomic line polarizations in various regimes and for a variety of atomic species and outline the exciting prospects of the technique for studies of magnetic fields within circumstellar regions, interplanetary medium, interstellar medium and AGNs.

017.19

Studying Magnetic Fields in Star Forming Regions with Aligned Atoms

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A new technique of studying interestellar and circumstellar magnetic fields was developed in Yan & Lazarian (2006). The technique is based on the ability of atoms with fine and hyperfine structure to be aligned in their ground or metastable state by anisotropic starlight radiation. The alignment induces polarization of both scattered and absorbed radiation. As the aligned atoms precess in magnetic field, the field modifies the observed polarization. For instance, absorption lines get polarized with the polarization direction that reveals the direction of magnetic field. We provide synthetic observations of several optical and UV lines originating from the vicinity of young stars and demonstrate that the technique allows to study very weak, e.g. microGauss magnetic fields. In fact, it can provide unique information about the 3D magnetic field topology that is not available with any other technique. The expected degree of polarization may exceed 30% for a favorable geometry of observations and therefore be easily detectable.

017.20

High-Mass Star Formation in Three Southern, Galactic Cores

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Using primarily data from 2MASS and GLIMPSE we examined three high-mass, southern, star-formation regions (central coordinates: G316.75-0.08, G321.05-0.50, G327.30-0.58; respective radii: 16', 27', 16'; respective distances: 2.9kpc, 4.1kpc, 2.9kpc). We incorporated the use of a 2-D radiation transfer model fitter, which enabled us to analyze our regions on a wide range of scales. We utilized the fitter's output data to map extinction levels; extract spectral energy distributions for protostellar candidates; put upper limits on YSO evolutionary stages; construct Initial Mass Functions, and measure preferred protostellar spacings. Within the fitting parameters we allowed for large variations in the possible distances and chi-squared values of the fitted models. With the exception of revisions on the most massive protostars in each region, and the removal of a detected binary star, we did no further corrections for poorly fitted sources; hoping that our pre-fitting criteria were sufficient, and that there was no bias in the distribution of such sources. We used CO emission data (Dame et al. 2001) and previous observations to determine the positions of masers, ultra-compact HII regions, and molecular clouds relative to areas of increased star formation. We conclude that both G316, and G327 are active star formation regions embedded in a large molecular complex, and that they both exhibit strong evidence for triggered star formation.

017.21

Interstellar Material towards the Nearby High Latitude Star eta UMa

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The rapidly rotating B3 V high latitude star eta UMa (31 pc) samples a typical sightline through the flow of ISM enveloping the Sun. We combine optical, HST GHRS, IMAPS, Copernicus and IUE data to synthesize a fairly complete portrait of the ISM in this direction. Together, these data provide data on HI, DI, CII, CII*, CIV, NI, NII, OI, PII, MgII, MgI, SiII, ArI, CaII, SII, FeII, and ZnII. Two interstellar components are seen. We use theoretical models of the eta UMa atmosphere to extract accurate information on the interstellar HI Lya line. A broad low column density redshifted HI Lya absorption feature is found at the velocity expected for charge exchange between the solar wind and interstellar HI inside of the solar system. This detection constitutes the discovery of a energetic neutral atom charge-exchange component (or 'neutral solar wind') formed by interstellar HI and the solar wind, and should provide an important constraint on models of heliospheric X-ray emission. A broad blue-shifted component appears to be due to mass loss from eta UMa. For a cloud temperature comparable to the temperature of the cloud surrounding the Sun (6400 K), we find that n(e)~0.1 /cc. For a nominal 50% ionization (NI~NII), N(HI) yields a cloud thickness of ~3 pc.

The authors thank NASA for supporting this research.

017.22

Mapping [O III] Emission in Diffuse Ionized Gas

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Doubly-ionized oxygen continues to be an intriguing tracer of physical conditions in diffuse ionized gas. Although [O III] emission is strong in many classical H II and PNe photoionized environments, [O III]/H-alpha has been consistently measured to be very low in the Warm Ionized Medium (WIM) of the Milky Way. Understanding how this ratio varies throughout the Galaxy is important for investigating changes in the dominant ionizing mechanism in a low-density medium. In some edge-on spiral galaxies, studies have found this line ratio to increase with height above the galactic

plane, which could be explained by an increase in temperature as well as a shift in the dominant ionization mechanism for doubly-ionized oxygen with height. The Wisconsin H-Alpha Mapper (WHAM) provides unprecedented spectral resolution and sensitivity for studying the diffuse interstellar environments of our Galaxy. We present three new WHAM maps of [O III] emission towards directions of known ionizing sources. These regions give us new insight into the physical conditions of low-density, photoionized gas and deliver unique measurements of the ionizing continuum from the sources. WHAM is supported by NSF grant AST 02-04973.

017.23

Density Distribution of the Warm Ionized Medium

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Observations of Hα emission measures and pulsar dispersion measures at high Galactic latitude (|b| $>$ 10°) provide information about the density and distribution of the diffuse warm ionized medium (WIM). We use data from the Wisconsin H-Alpha Mapper (WHAM) Northern Sky Survey. We have removed sightlines that intersect classical HII regions, leaving a sample of only the diffuse WIM. The diffuse WIM has a lognormal distribution of EM sin |b|, which is consistent with a density structure established by isothermal turbulence. A comparison of pulsar dispersion measures with emission measures shows that the H+ responsible for most of the emission along high-EM sightlines is clumped in high density ($>$ 0.2 cm^-3) regions that occupy only of order 10 parsecs along the line of sight and contribute little to the total H+ column density, while the H+ along low-EM sightlines occupies hundreds of parsecs with densities of 0.03 0.1 cm^-3. We find an approximate power law relationship between local density of the gas and occupation length.

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017.24

Hydrogen-Dating Molecular Clouds

Marko Krco[1], P. F. Goldsmith[2], D. Li[2]
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Using improved techniques for measuring the atomic hydrogen content of dark clouds utilizing HI Narrow Self-Absorption (HINSA) in conjunction with more traditional methods for determining the molecular hydrogen content we are able to estimate the HI/H2 ratio in an expanded sample of dark cloud cores. Using a simple evolutionary model we can estimate the ages of individual clouds or regions. We present the results of our survey of 36 dark cloud cores which exhibit HINSA absorption features. This dating procedure imposes constraints on the time scale for star formation in dense molecular regions.

017.25

Theoretical Studies of Wind Blown Nebulae around Massive Stars

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The combined action of winds and ionizing radiation from massive stars leads to the formation of large wind-blown nebulae surrounding the star. The properties of these nebulae depend on the initial mass of the star and the stellar and wind parameters, as well as the structure and density of the surrounding medium. Using analytic and semi-analytic calculations, supplemented by numerical simulations where necessary, we study the structure, evolution and properties of these nebulae for stars of different initial mass. These results are compared with observational data for stars in various evolutionary phases.

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018: Galactic Structures: Identification & Evolution AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

018.01

Development of a Fourier Technique for Automated Spiral Galaxy Morphology

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Morphological classification of galaxies is a crucial foundation for understanding the physics of each galaxy type. This classification has historically been a matter of visually inspecting galaxy images and organizing the galaxies in categorical bins according to their appearance. Recently, however, more efficient, continuous and quantitatively meaningful classification methods have been required for insight into galaxy formation and evolution that must be extracted from the ever-growing amount of data available to the astronomical community. Our goal was to develop an automated method of recognizing structures in spiral galaxies and to quantify their strength for classification purposes. We present a preliminary automated method of reconstructing select galaxy images from the Ohio State University Bright Spiral Galaxy Survey using two-dimensional Fourier models of galaxies. Particular harmonics in the Fourier series were analyzed to recognize and quantify bars and spiral arms. One barred spiral galaxy and one non-barred spiral galaxy were used to illustrate the technique and to come to some preliminary conclusions. This work was carried out over ten weeks at the McDonald Observatory REU program supported under NSF AST-0243745.

018.02

Self-Consistent Models for Time Varying Galaxy Potentials

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To understand the internal orbital structure and stability of asymmetric galaxies, it is helpful to be able to construct self-consistent models for these galaxies. We show how an extension to Schwarzschild's linear programming method for constructing self-consistent gravitational potentials can be extended to those that vary periodically over time. Using this, we look at the cases of a rotating galactic bar mis-aligned with respect to a surrounding disk or halo, and of a nuclear bar embedded in a larger galactic bar.

018.03

The Stellar Halos of Nearby Galaxies

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We present results from our ongoing HST/ACS survey of the outer disks and halos of 14 nearby galaxies. The stellar halos of galaxies are commonly thought to be created by interaction, however there is little agreement how these structures scale with mass. Observationally, only the galaxies in the local group have been well characterized. We analyze the surface brightness profiles and metallicity distributions of resolved RGB stars in the outer regions of numerous nearby galaxies. In NGC 4244, a low-mass (V_c=93 km/sec), edge-on galaxy, we place strong upper limits on the existence of a stellar halo. We also present initial results showing that the surface brightness in the inner halo of M81 drops off much more quickly than in the Milky Way.

018.04

A Search for Faint, Diffuse Halo Emission in Edge-On Galaxies with Spitzer/IRAC

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[1]Harvard-Smithsonian Center for Astrophysics, [2]NASA's Goddard Space

Flight Center, [3]University of Rochester, [4]Caltech/Spitzer Science Center.

We present deep infrared mosaics of the nearby edge-on spiral galaxies NGC 891, 4244, 4565, and 5907. These data were acquired at 3.6, 4.5, 5.8, and 8.0 microns using the Infrared Array Camera aboard Spitzer as part of GTO program number 3. This effort is designed to detect the putative faint, diffuse emission from halos and thick disks of spiral galaxies in the near-mid infrared under the thermally stable, low-background conditions of space. These conditions in combination with the advantageous viewing angles presented by these well-known edge-on spirals provide arguably the best opportunity to characterize the halo/thick disk components of such galaxies in the infrared. In this contribution we describe our observations, data reduction techniques, corrections for artifacts in the data, and the modeling approach we applied to analyze this unique dataset.

This work is based in part on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

018.05

Spitzer's View on Edge-On Spiral Disks

Benne W. Holwerda[1], R. S. de Jong[1], M. Regan[1], A. Seth[2], J. D. Dalcanton[3], E. Bell[4], S. Bianchi[5]
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Edge-on spiral galaxies offer a unique perspective on spiral galaxies; their vertical structure can be determined and their faint structure can be seen from line-of-sight integration.

We present the first result of our Spitzer/IRAC survey of 30 edge-on spiral disks. The 3.6 and 4.5 micron near-infrared channels allow a clear view of the stellar disk, almost unimpeded by dust extinction.

The 8 micron channel maps the emission of the smallest interstellar grains, the Polycyclic Aromatic Hydrocarbons (PAH). The observations of the PAH interstellar medium (ISM) and the old stellar disk

can be used to study the relative geometry of these components.

We fit two-dimensional models to the stellar and PAH light distributions to determine vertical and radial scales. We present our sample, and the results on the relative disk oblateness for the ISM and stellar disk and the implications on spiral disk stability.

018.06

A WIYN Study of Optical Asymmetry in Isolated Disk Galaxies

Alex C. Viana[1], E. M. Wilcots[1]
[1]University of Wisconsin Madison.

We present the results of an R-band study of the structure of a sample of isolated disk galaxies. Using mostly WIYN 3.5m observations we quantify the degree of optical asymmetry in 40 galaxies. The results have implications for the underlying gravitational potential and the origin of asymmetry in galaxies. This research was partially funded by the Wisconsin Space Grant Consortium.

018.07

The Structure of Polar Ring Galaxies UGC 7576, NGC 2685, and NGC 3718

Christopher Q. Trinh[1], L. S. Sparke[2], J. S. Gallagher[2]
[1]University of California, Berkeley, [2]University of Wisconsin, Madison.

We examine the inner structure of the polar ring galaxies UGC 7576, NGC 2685, and NGC 3718 in U, B, V, and R with images from the WIYN 3.5 meter telescope. Residual images reveal the presence of a luminous, warped disk-like structure in the central host of UGC 7576 and NGC 2685, which is consistent with an S0 morphology. Color maps indicate a B-R color difference in UGC 7576 and a U-B color difference in NGC 2685 between the central host and the polar ring. This provides an indication of a difference in age of stellar populations in the two components of these polar ring galaxies. Star formation can be traced across much of NGC 3718 from the presence of blue clumps and clusters of younger stars. We discuss the implications of these results and their role in shaping future studies of polar-ring galaxies using high resolution optical images from HST and infrared observations. This work was supported by the National Science Foundation's REU program and the Department of Defense's ASSURE program through NSF Award AST-0453442.

019: Galaxy Evolution over Cosmic History AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

019.01

Five Thousand Galaxy Redshifts from PEARS

Seth H. Cohen[1], R. E. Ryan, Jr.[1], S. Malhotra[1], J. E. Rhoads[1], N. P. Hathi[1], R. A. Windhorst[1], N. Pirzkal[2], C. Xu[2], PEARS Team
[1]Arizona State University, [2]Space Telescope Science Institute.

We present over 5,000 galaxy spectro-photo-z's (SPZ's) using grism spectra from the HST/ACS Probing Evolution and Reionization Spectroscopically (PEARS) grism survey. PEARS covers nine ACS pointings at multiple position angles in the two GOODS fields. For $i<27.0$ mag, redshifts are computed using a combination of the $R\approx100$ PEARS grism spectra and UV-optical-infrared broadband photometry. The addition of the grism spectra, which cover a wavelength range of 6000-9500 angstroms, provides improved redshift determination over traditional broadband-only photometric redshifts. In conjunction with our deeper pointing in the Hubble Ultra-Deep Field ($i<28$ mag), these SPZ's are used to construct the galaxy luminosity function at $z=1$,which goes 1.5-2 magnitudes fainter than can be done with ground-based spectroscopy.

PEARS is an HST Treasury Program and is supported by HST grant 10530.

019.02

The Size-Luminosity Relation of Disk Galaxies in EDisCS Clusters

Stephanie M. Gogarten[1], J. J. Dalcanton[1], L. Simard[2], G. Rudnick[3], V. Desai[4], EDisCS Collaboration
[1]Univ. of Washington, [2]Herzberg Institute of Astrophysics, NRC, Canada, [3]NOAO, [4]California Institute of Technology.

We present the size-luminosity relation (SLR) for disk galaxies observed in eight clusters from the ESO Distant Cluster Survey (EDisCS). These clusters, at redshifts $0.4 < z < 0.8$, were observed with the Hubble Space Telescope's Advanced Camera for Surveys. While we observe a change in the SLR with redshift, namely that there is an absence of low surface brightness galaxies at high redshift, we demonstrate that this could be a product of selection effects and thus is not a confirmation of evolution. We also compare the SLR for cluster and field galaxies in each redshift bin and see no significant effects of environment on the SLR.

019.03

Simulated Optical Images of High Redshift Galaxies using GALEX Ultraviolet Images of Nearby Galaxies

Bum-Suk Yeom[1], Y. Kim[1], S. Rey[1], J. Koo[1], S. Kim[1]
[1]Chungnam National University, Republic of Korea.

Galaxy morphology plays an important role in the assessment of the evolutionary state of galaxies. In this respect, the prediction of optical-band morphologies at high redshifts requires UV images of local galaxies with various morphologies. We present the simulated optical images of galaxies observed with the HST/ACS at high redshifts using Galaxy Evolution Explorer (GALEX) near-ultraviolet (NUV: ~2271 A) and far-ultraviolet (FUV:

~1528 A) images of nearby galaxies. We simulated optical images at cosmological distances using more diverse and high-quality nearby galaxies obtained through the GALEX UV observations.

019.04

Ages and Masses of Lyman Alpha Galaxies at z ~ 4.5

Steven L. Finkelstein[1], J. E. Rhoads[1], S. Malhotra[1], N. Pirzkal[2], J. Wang[3]
[1]Arizona State Univ., [2]Space Telescope Science Institute, [3]University of Science and Technology of China, China.

We examine the stellar populations of a sample of z ~ 4.5 Lyman alpha emitting galaxies using their broadband colors derived from deep photometry at the MMT. These galaxies were selected by narrowband excess from the Large Area Lyman Alpha survey. The typical strength of the Lyman alpha emission line in these galaxies is greater than would be expected for a normal stellar population. This strong emission likely indicates ongoing star formation in young, possibly primitive, galaxies. Our field includes 98 Lyman alpha galaxy candidates, among which 22 show continuum detections based in two or more of our MMT filters (g', r', i' and z'). By comparing broad and narrowband colors of these galaxies to synthetic colors from stellar population models, we find their ages and masses. The highest equivalent width objects had a very young age of 4 Myr, consistent with ongoing star formation. The lowest EW objects had the oldest age (40 200 Myr), consistent with the expectation that a larger number of older stars are causing low EWs. We found masses ranging from 2 x 10^7 $M_\odot$ for the youngest objects in the sample to 2 x 10^9 $M_\odot$ for the oldest. It is possible that dust effects could produce large equivalent widths even in older populations by allowing the Lyman alpha photons to escape, even while the continuum is extinguished, and we present models for this scenario also.

019.05

The Spitzer Interacting Galaxies Survey: IRAC Evaluations of Star Formation

Christopher R. Klein[1], M. L. Ashby[2], H. A. Smith[2], A. Zezas[2], J. L. Hora[2], M. A. Pahre[2], G. G. Fazio[2]
[1]Caltech, [2]Harvard-Smithsonian Center for Astrophysics.

With the Infrared Array Camera we have observed two well-defined and complementary samples of bright, nearby, interacting galaxies to seek evidence of any relationship between interaction strength and specific star formation rate (SFR). We used 8 μm non-stellar emission to measure SFRs in the Keel-complete (weakly interacting systems) and Keep-Arp (strong interaction) galaxy samples. With our complementary 3.6 μm observations we are able to measure stellar masses and thus derive specific star formation rates for all our sample galaxies. Although the data acquisition is still ongoing, on a statistical basis our analysis supports the conclusion that star formation rates are influenced by interaction strength. In particular, we conclude that galaxies involved in stronger interactions, defined by shorter separations and the presence of visually apparent morphological distortions, probably exhibit increased star formation rates.

019.06

Buildup of Massive Red Galaxies at redshift z=0.3

Morad Masjedi[1], D. W. Hogg[1], M. R. Blanton[1]
[1]New York Univ..

Recent work on the luminosity function and its evolution has found evidence for substantial growth of galaxies on the red sequence by merging. This process will show itself in the very small-scale clustering of galaxies around red-sequence galaxies. Here we independently measure the growth of galaxies by measuring and interpreting the cross-correlation of massive red galaxies with red and blue galaxies of various luminosities and interpreting that cross-correlation at very small scales as the result of a continuous merging process. We find that the accretion onto massive red galaxies is dominated by dry mergers of galaxies more massive than L*. In addition, we integrate the mass build-up due to all merger events and we find that these massive red galaxies are growing by about 2.5 percent per Gyr due to merger activity at redshift 0.3.

019.07

The Origin and Evolution of the Mass-Metallicity Relationship for Galaxies: Results from Cosmological N-Body Simulations

Alyson Brooks[1], F. Governato[1], C. M. Booth[2], B. Willman[3], J. P. Gardner[4], J. Wadsley[5], G. Stinson[1], T. Quinn[1]
[1]Univ. of Washington, [2]Univ. of Durham, United Kingdom, [3]Harvard-Smithsonian CfA, [4]Univ. of Pittsburgh, [5]McMaster Univ., Canada.

We examine the origin and evolution of the mass-metallicity relationship (M_*-Z) for galaxies using high resolution cosmological SPH + N-Body simulations that include a physically motivated description of the effects of supernovae feedback and subsequent metal enrichment. Our simulations allow us to distinguish between two possible sources that contribute to both the origin of the mass-metallicity relationship and to the low chemical yield observed at low galaxy masses: 1) metal and baryon loss due to gas outflow, or 2) inefficient star formation at the lowest galaxy masses. Our simulated galaxies reproduce the observed M_*-Z relationship in shape and normalization both at z=0 and z=2. We show that low star formation efficiencies, regulated by supernovae feedback, are primarily responsible for the lower metallicities of low mass galaxies and the overall M_*-Z trend. We find that the shape of the M_*-Z relation is relatively constant with redshift, but that its normalization increases with time. Simulations with no energy feedback from supernovae overproduce metals at low galaxy masses by rapidly transforming a large fraction of their gas into stars. We find that gas mass loss due to supernovae induced winds and the cosmic UV field becomes significant in our galaxies with $M_{baryon} < 10^8$ M_{solar}. Some gas loss due to supernovae feedback is necessary to reproduce the observed low effective yield observed in low mass galaxies. Despite the fact that our low mass galaxies have lost a majority of their baryons, they are still the most gas rich objects in our simulations due to their low star formation efficiencies.

019.08

Star-Forming Galaxies at z~2: Stellar, Gas and Dynamical Masses and the Mass-Metallicity Relation

Dawn Erb[1]
[1]Harvard-Smithsonian Center for Astrophysics.

Using Hα spectra and 0.3--8 μm photometry of over 100 star-forming galaxies at z~2, we compare dynamical masses inferred from the Hα line widths with stellar masses determined from SED modeling and gas masses estimated from the empirical correlation between star formation rate per unit area and gas density. These results suggest a mean gas fraction of ~50% and a strong decrease in gas fraction with increasing stellar mass. The combined gas and stellar masses are strongly correlated with the dynamical masses, and are in much better agreement with the dynamical masses than are the stellar masses alone. We also divide the sample into six bins by stellar mass and construct composite Hα and [N II] spectra for each bin. Using the [N II]/Hα ratio to estimate the oxygen abundance, we find a monotonic increase in metallicity with stellar mass. By combining this result with an estimate of the mean gas fraction of the galaxies in each bin, we show that the observed mass-metallicity relation is best described by a model in which galaxies of all masses lose gas to outflows at a rate ~4 times higher than their star formation rate.

SUNDAY

020: High Z Objects; IR, Optical Background
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

020.01

Search for High-Redshift Quasars in the Palomar-QUEST Survey

Anne Bauer[1], C. Baltay[1], N. Ellman[1], J. Jerke[1], D. Rabinowitz[1], A. Mahabal[2], E. Glickman[2], C. Donalek[2], S. G. Djorgovski[2]
[1]Yale University, [2]California Institute of Technology.

The Palomar-QUEST Survey is undertaking a search for very high-redshift quasars. The survey currently covers ~15,000 square degrees a minimum of two times in each of 2 filter sets: Johnson UBRI and Gunn rizz. A single scan reaches a depth of mag 20.8 in Johnson I and 19.6 in Gunn z. We have coadded data over our entire survey area in order to find quasars with Gunn z past mag 20. The coadd typically includes four passes in each filter set. We are searching for objects that are bright only in Johnson I and Gunn z, our reddest filters. This will yield quasars with redshift greater than roughly 5.8. Specifically, we target objects with Gunn i-z $>$ 2.2 and Johnson R-I $>$ 3.0. L and T dwarfs have similar optical colors to high-redshift quasars; to remove these we obtain follow-up data in the J band, where the dwarfs are very bright but the quasars are faint. Furthermore, we use an artificial neural network to separate point-like from extended objects.

Currently we are conducting a systematic quasar search over more than 10,000 square degrees of our survey area.

020.02

A Confirmation of the Optical EBL From HST Archival Data: First Results

Timothy Dolch[1], H. C. Ferguson[2], B. Mobasher[2], M. Stiavelli[2], S. Casertano[2], R. S. de Jong[2], M. Giavalisco[2], L. E. Bergeron[2]
[1]Johns Hopkins Univ., [2]Space Telescope Science Institute.

The optical extragalactic background light (EBL) currently exceeds the value from integrated galaxy counts. The unexplained component is, however, obtained from subtracting the zodiacal light (ZL) foreground from the raw background measurement. Many irregularities and free parameters remain in the ZL model, on which EBL determinations heavily depend. Here, we use archival ACS data to get a better handle on the periodic trends by looking at relatively empty areas of the sky imaged at different times throughout the year. Special attention is given to fluctuations of the background at periods other than a year, and to full-sky variability. We then discuss the implications of these results to the EBL uncertainties. Support for this work was provided by NASA through grant number AR-10950 from the Space Telescope Science Institute.

020.03

Probing the CIRB with Spitzer in 3 DIRBE Dark Spots

Louis R. Levenson[1], E. L. Wright[1]
[1]UCLA.

We have chosen three regions of the sky for which the CIRB has been determined at 3.5 microns using the ″DIRBE minus 2MASS″ method of Wright (2001). For each of these regions we have obtained 270 seconds of integration time with IRAC on Spitzer over the central square degree. We present galaxy counts in each of these 1 square degree IRAC surveys. And thus we are also able to compare the galactic content of each region with the ″DIRBE minus 2MASS″ determined L-Band CIRB.

This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

020.04

The First Stars in the Universe: Mass Function and Local Chemical Signatures

Jason Tumlinson[1]
[1]Yale University.

The first stars in the Universe initiated cosmic metal enrichment and the reionization of the IGM, so their detailed properties are of great interest to cosmology generally. Thanks to current and future surveys of metal-poor stars in the Local Group, we need not await JWST to test theories of star formation from primordial and very low-metallicity gas. Existing data indicates that the characteristic mass of the first stars was ~10 Msun, higher than in the solar neighborhood but smaller than the $>>$100 Msun predictions of recent numerical simulations. Recent discoveries of peculiar abundances in the lowest metallicity stars constitute evidence that the stellar mass function changes smoothly with metallicity and/or time. This contribution will survey the data now available and expected from future surveys and describe the theoretical framework being developed to turn these new data on metal-poor stars into detailed empirical knowledge of the first generations of stars in the Universe. This new theoretical technique calculates chemical evolution for the first time in the fully hierarchical and stochastic context of early galaxy formation. It thus provides a robust, flexible, and fast approach to testing models of primordial star formation against the only data presently available that can constrain them.

020.05

Photometric Redshift Survey Forecast for Luminous Red Galaxies at z~1.0

Xiaosheng Huang[1], D. J. Schlegel[1]
[1]Lawrence Berkeley National Laboratory.

We analyzed the data from the DEEP2 Redshift Survey to obtain the number densities for luminous red galaxies between z=0.4 and 1.2. Based on the DEEP photometric data in B, R and I bands and the spectroscopic redshift we synthesized spectrophotometry for the ~4000 DEEP galaxies in the extended groth strip (EGS) field, using templates from the Kinney-Calzetti catalog and Coleman, Wu and Weedman. We determined the number densities in the redshift ranges of $0.4<z<0.7$, $0.7<z<0.9$ and $0.9<z<1.2$. We estimated that for a PanSTARRS 3π luminous red galaxy survey, the sound horizon scale can be measured to an accuracy of 1.2-2% and w to 6-10%.

This work has been supported by the Office of Science, U.S. Department of Energy, through contract DE-AC02-05CH11231.

021: Gravitational Lensing
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

021.01

A Three-Dimensional View of the Environments of Three Strong Gravitational Lenses

Leonidas A. Moustakas[1], P. Marshall[2], AEGIS Collaboration
[1]JPL/Caltech, [2]UCSB.

Using the *HST*/ACS imaging of the Extended Groth Strip, we have found two new strong gravitational lenses, bringing the total known in that field up to three. We fit detailed lens models to these lenses. We also report on four additional as-yet unconfirmed gravitational lens candidates. This field, studied panchromatically by the AEGIS Collaboration, also has nearly complete spectroscopy to redshifts beyond 1 from the DEEP2 Survey. Using the three-dimensional view of the Universe towards these lenses, then, we study both the local environment, and the effect of the *all* galaxies along these lines of sight. We find that lenses live in a broad variety of environment, and that dark matter from large scale structure is required for consistency with the gravitational lens model results.

021.02

HST ACS Observations of the Gravitational Lens B1608+656

Sherry H. Suyu[1], R. D. Blandford[2], C. D. Fassnacht[3], L. V. Koopmans[4], P. J. Marshall[5], J. P. McKean[3], T. Treu[5]
[1]California Institute of Technology, [2]KIPAC, Stanford University, [3]University of California, Davis, [4]Kapteyn Institute, The Netherlands, [5]University of California, Santa Barbara.

By measuring the relative time delays between the multiple images of the lensed source and modeling the lens potential of a strong gravitational lens system, one can obtain a value of the Hubble constant. B1608+656 is a quadruply imaged gravitational lens system with an extended source intensity distribution and two interacting galaxy lenses. This system is unique in that the three relative time delays between the four images were measured accurately with errors of only a few percent, and thus provides an opportunity to measure the Hubble constant with high precision. With an extended source intensity distribution, simultaneous determination of the source intensity and the lens potential distributions is needed. This system permits mapping of the total matter (luminous and dark) distribution of interacting galaxies for the first time. We have deep and high-resolution HST ACS observations of the system showing a full Einstein ring of the extended source and a dust lane through the lens galaxies. A comprehensive analysis that takes into account the extended source intensity distribution, interacting galaxy lenses and the presence of dust is underway. Preliminary results will be presented.

021.03

LensPerfect: Exact Massmap Solutions for Gravitationally Lensed Multiple Images

Dan A. Coe[1], E. Fuselier[2], N. Benítez[3], T. Broadhurst[4], H. Ford[1], ACS Science Team
[1]Johns Hopkins Univ., [2]U.S. Military Academy, [3]Instituto de Astrofísica de Andalucía, Spain, [4]Tel Aviv Univ., Israel.

A new approach to massmap reconstruction is presented that delenses all multiple images of each lensed galaxy back to the exact same source position. Image sizes, shapes, and orientations may also be perfectly constrained. The massmap solution is obtained instantaneously without need for iterations. However, there is no unique solution given a set of multiple images, and other solutions may be obtained by adjusting the free parameters: the source positions and the basis function and its parameter(s). From these exact solutions, the user may choose that which best fits other observables: shears of singly-imaged galaxies, number count depletion, etc. No assumptions are made about the form of the massmap (although a basis function must be selected). And even though LensPerfect makes no assumptions about mass tracing light, we show that it is able to faithfully reproduce the significant features found in previous analyses of the lensing cluster Abell 1689. This new method is made possible by a recent advance in mathematics that allows for curl-free interpolation of a vector field (here, the image deflection) given at scattered data points (the image positions). LensPerfect is extremely straightforward and easy to use, and the software is made publicly available at http://www.iaa.es/~coe/LensPerfect/.

ACS was developed under NASA contract NAS 5-32865, and this research is supported by NASA grant NAG5-7697. We are grateful for an equipment grant from the Sun Microsystems, Inc. This work has also been supported by the European Commission Marie Curie International Reintegration Grant 017288-BPZ and the PNAYA grant AYA2005-09413-C02.

021.04

A Multi-Resolution Weak Lensing Reconstruction Method

Hossein Khiabanian[1], I. Dell'Antonio[1]
[1]Brown Univ..

We present a regularized maximum-likelihood method for reconstructing two dimensional mass maps using weak gravitational lensing data. To utilize all the shear information, we employ an iterative inverse method with a properly selected regularization coefficient which fits for the deflection potential at the position of each galaxy. The expectation value of the ellipticities of the sources is estimated as a function of the deflection potential via realistic simulations. By producing mass maps with multiple resolutions in the different parts of the observed field, we can achieve a uniform signal to noise level by increasing the resolution in regions of higher distortion or regions with an over-density of background galaxies. In addition, we are able to better study the sub-structure of massive clusters at a resolution which is not attainable in the rest of the observed field. We apply our technique to the simulated data and to a four square degree field obtained by the Deep Lens Survey ($R < 26$).

021.05

Application of Gravitational Lensing Models to the Brightest Strongly LensedLyman Break Galaxy the '8 o'clock arc'

Elizabeth J. Buckley-Geer[1], S. S. Allam[2], D. Tucker[1], H. Lin[1], H. T. Diehl[1], J. Annis[1], J. A. Frieman[3]
[1]Fermi National Accelerator Laboratory, [2]Fermi National Accelerator Laboratory/University of Wyoming, [3]Fermi National Accelerator Laboratory/University of Chicago.

SUNDAY

We report on modelling of the recently discovered brightest strongly lensed Lyman Break Galaxy (LBG), the so called ″8 o'clock arc″. This galaxy is at redshift 2.73 and is lensed by a luminous red galaxy (LRG, $z=0.38$) in the Sloan Digital Sky Survey (SDSS) DR4 imaging data. We observe four images, three in the arc plus a counterimage. The three lensed images in the arc subtend an angle of 160 degrees around the LRG and extend over more than 9.6 arcsec in length. For the modelling we are using information from all four images extracted from SPICAM images taken on the 3.5m telescope at APO. Using the GRAVLENS package with an SIE profile we obtain a velocity dispersion of 391 km/sec for the LRG and a total magnification of about 10. We will also report on results obtained using more sophisticated models.

021.06

Weak Lensing : Ground vs. Space in the Cosmos Field

Mansi M. Kasliwal[1], R. J. Massey[2], R. S. Ellis[2], J. Rhodes[3]
[1]Caltech (Hale Fellow of Moore Foundation), [2]Astronomy Department, Caltech, [3]Jet Propulsion Laboratory, Caltech.

Weak lensing statistics are best for large numbers wide surveys with greater number of galaxies and deep surveys with a higher number density of galaxies. Although space-based surveys are unparalleled in their depth, ground-based surveys are the more cost-effective way to survey wide regions of the sky. We assess the relative merits of the two observing platforms, by using premier, multi-band, ground-based Subaru SuprimeCam data and space-based Hubble ACS data, in the ~2 sq. degree COSMOS field in three ways. First, we compare shear measurements of individual galaxies and identify the relative calibration of the two datasets in terms of the largest subset in magnitude and size that is consistent. Second, we compare space- and ground-based mass maps to quantify the relative completeness and contamination of the resulting cluster catalogs. We find that more clusters with XMM catalog counterparts are detected from space than ground and some ground-based clusters are possibly spurious detections. Third, we perform a detailed comparison of the precision with which it is possible to reconstruct the mass and size of four clusters at various redshifts identified from both ground and space. We find that the noise is much lower from space in all three investigations, but find no evidence for systematic overestimation or underestimation of the individual cluster properties by either survey.

021.07

Time-Delays and Mass Models for the Quadruple Lens RXJ1131-1231

Nicholas D. Morgan[1], C. S. Kochanek[1], E. E. Falco[2], X. Dai[1]
[1]The Ohio State University, [2]Harvard Smithsonian Center for Astrophysics.

We have measured the three time delays for the quadruple gravitational lens RXJ1131 using three seasons of monitoring data. The short delays between cusp images are A-B = 11.65 +/0.46 days and A-C = 8.42 +/0.92 days, and the long A-D delay for the counter image is -85 +/2 days. The short delays are difficult to explain using standard isothermal halo models of the lensing potential, which instead prefer A-B and A-C delays of ~1 day for reasonable values of the Hubble constant. Matching the cusp delays is possible by adding a significant (~5x10^10 solar) amount of matter nearly coincident (~0.05″ South-East) with the A image. Adding such a satellite also helps improve the quasar and lens astrometry of the model, reduces the velocity dispersion of the main lens and shifts it closer to the Fundamental Plane. This is suggestive of a satellite galaxy to the primary lens, but its expected luminosity and proximity to both image A and the system's bright Einstein ring make visual identification impossible even with the existing HST data. We also find evidence for significant structure along the line of sight toward the lens. Archival Chandra observations show two nearby regions of extended X-ray emission, each with bolometric X-ray luminosities of 2-3x10^43 ergs/s. The brighter region is located approximately 153″ from the lens and centered on a z=0.1 foreground cD galaxy, and the fainter and presumably more distant region is 4-5 times closer (in angular separation) to the lens and likely corresponds to the weaker of two galaxy red sequences (which includes the lens galaxy) previously detected at optical wavelengths.

021.08

Mid Infrared Observations of Quasar Lenses

Eric Agol[1], C. Kochanek[2]
[1]Univ. of Washington, [2]Ohio State University.

We present mid-infrared observations with the Michelle camera on Gemini North of two gravitationally lensed quasars, MG 0414+0534 and H 1413+117. The mid-infrared is unaffected by extinction, microlensing, and electron scattering, making it the ideal wavelength to measure the flux ratios of the lensed images for constraining gravitational lens models. In addition, 8-meter class telescopes are diffraction-limited at 10 microns (without adaptive optics), allowing close pairs of lensed images to be resolved. We discuss the constraints on the mass models of these lenses imposed by our observations, in particular the non-smooth components of the lens potential, and compare with observations at other wavelengths and with mid-infrared observations of other lenses.

022: Ground-Based Instrumentation I
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

022.01

The Dark Energy Survey Instrument

Brenna Flaugher[1], Dark Energy Survey Collaboration
[1]Fermilab.

The Dark Energy Survey (DES) is designed to measure the dark energy equation of state parameter, w, to a statistical precision of ~5%, with four complementary techniques: galaxy cluster counts, weak lensing, angular power spectrum and type Ia supernovae. We present an overview of the DES instrument (DECam) which will be mounted at the prime focus of the Blanco 4m telescope at the Cerro-Tololo International Observatory (CTIO). DECam includes a focal plane of 62 2kx4k CCDs, a five element optical corrector, four filters (g,r,i,z), and the associated infrastructure for operation in a new prime focus cage. To reach redshifts of ~1, we plan to use the 250 micron thick fully-depleted CCDs that have been developed at the Lawrence Berkeley National Laboratory (LBNL). A CCD packaging and testing facility has been established at Fermilab to produce fully characterized four-side buttable modules. DECam also includes design features to enhance the image quality and the efficiency of operations. DECam will be devoted to the DES for 30% of the time over the five year survey and will otherwise be available to the community as an NOAO facility instrument. Status of the design and prototyping efforts will be described.

022.02

The Dark Energy Survey Camera Design

Herman P. Cease[1], DES Collaboration
[1]Fermilab.

The Dark Energy Survey is planning to use a 3 sq. deg. camera that houses an ~ 0.5m diameter focal plane of 62 2kx4k CCDs. The camera vessel including the optical window cell, focal plate, focal plate mounts, cooling system and thermal controls is described. As part of the development of the mechanical and cooling design, a full scale prototype camera vessel has been constructed and is being commissioned for multi-CCD readout tests. Results from this prototype camera are also described.

022.03

Front-End Electronics for the Dark Energy Survey Camera (DECam)

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The front-end electronics design for the Dark Energy Survey Camera (DECam) is based on the MONSOON Image Acquisition System that was developed by the National Optical Astronomy Observatory (NOAO). MONSOON systems are currently being used to test and characterize CCDs. The Dark Energy Survey group both in the U.S. and Spain will produce custom versions of these systems for use in the production readout that will better match the requirements of a large focal plane of 70+ CCDs and the tight space constraints of a prime focus instrument. The customization of the MONSOON boards and the electronics path will be presented.

022.04

Characterication and Testing of Dark Energy Survey CCDs

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The Dark Energy Survey focal plane will have 62 2k x 4k imaging CCDs. The CCDs are back-illuminated, fully-depleted 250 micron thick devices developed at Lawrence Berkeley National Laboratory. We describe the packaging procedure, the infrastructure we have developed for characterization and testing of CCDs, including flatness, dark current, read noise, linearity and gain, quantum efficiency vs. wavelength from 400 to 1000 nm, charge transfer inefficiency, persistance, and diffusion length. We provide the initial results, including tests in a full-scale prototype camera vessel.

022.05

Mountaintop Software for the Dark Energy Survey

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The DES mountaintop software must perform several tasks:
* Collect image data from the 496 megapixel camera and collect the associated environmental metadata.
* Collect guider data (guiding is done with CCDs on the focal plane) and send correction signals to the Blanco telescope control system.
* Perform sufficient real-time monitoring, analysis, and user interfaces to assure the quality of the data being taken and to allow both automatic and manual configuration and sequencing of the apparatus.

To facilitate community access, DES mountaintop software must be maintainable by CTIO staff. To the extent possible we are employing software packages that are either commercial standards or developed and maintained by CTIO.

022.06

Application of the Dark Energy Survey Data Management System to the Blanco Cosmology Survey Data

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The Dark Energy Survey (DES; operations 2010-2016) will image 5000 deg2 of the southern sky using a new 3 deg2 imager (DECam) for the CTIO Blanco 4-m telescope. The total data volume after the end of the survey will exceed 1 peta-byte, which requires our data management system (DMS) to offer a high degree of automated processing. Our DMS leverages the existing high performance computing infrastructure to meet the project's goals. The DESDMS consists of (1) processing pipelines with built in quality assurance testing, (2) a distributed archive to support automated data processing and calibration, (3) a catalog archive database to support scientific analysis, (4) web portals for control, monitoring, user data access and scientific analysis, and (5) hardware platforms required for operations.

We have tested our early version of DMS using both of the simulated DECam data from Fermilab and the observed data from the Blanco Cosmology Survey (BCS), which is a 45-night NOAO survey program. The aim of BCS is to study the cosmic acceleration using the galaxy cluster survey (in coordination with APEX, ACT and SPT) and the galaxy power spectrum. The BCS employs the MOSAIC-II imager currently installed on the Blanco telescope to carry out the deep, griz photometric survey of two 50 deg2 patches of the southern sky. The flexibility and scalabity of our DMS allows the automatic reduction of the BCS data to be done on local workstations, which is convenient because of the two orders of magnitude lower data volume compared to DES.

We report our preliminary results from reducing the BCS data for the first two observing semesters with our DESDMS. We present survey completeness limits, astrometric and photometric accuracy, photometric redshift estimates and a preliminary summary of optical cluster finding and the galaxy angular power spectrum.

022.07

Analyzing the Focus Sensor Images for ODI at WIYN

Robert P. Nowicki[1]
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The WIYN (Wisconsin, Indiana, Yale, & NOAO) is building the One Degree Imager (ODI) for its 3.5m telescope at Kitt Peak. ODI is a wide field imager that is focusing on delivering the excellent image quality of the WIYN telescope. Maintaining good telescope focus is essential for the success of this instrument. A proposed technique for focusing ODI is using a CCD sensor that is tilted with respect to the instrument's focal plane. We numerically analyzed images obtained with a prototype focus camera using several methods to determine the location of the best-focused stars. Specifically, a least chi-squares fit was used to fit a second order polynomial to the plot of FWHM versus pixel position along the CCD for the stars taken in these focus sensor images. Once ODI is operational at WIYN, one can use this algorithm to find the best FWHM and its position along the CCD, and feed this information back to the telescope control system. These numerical methods were implemented in the scripting language tcl/tk because of its easily built user interfaces and ready acceptance at Kitt Peak Observatory.

R.P.N.'s research was supported by the NOAO/KPNO Research Experiences for Undergraduates (REU) Program which is funded by the National Science Foundation through Scientific Program Order No. 3 (AST-0243875) of the Cooperative Agreement No. AST-0132798 between the Association of Universities for Research in Astronomy (AURA) and the NSF.

022.08

QUOTA sees First Light at WIYN!

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The WIYN consortium is building the One Degree Imager (ODI) for its 3.5m telescope, located at Kitt Peak. ODI will deliver WIYN's excellent seeing over a one square degree field of view, and further enhance the image quality by actively compensating tip/tilt image motion using Orthogonal Transfer Array CCDs. These devices allow to move electrons in the detector in both the x and y directions in 1' big cells.

QUOTA (Quad-OTA) is a prototype camera for ODI, featuring an array of four OTA detectors with 8kx8k pixels (instead of 64 for ODI, resulting in 32kx32k pixels). We report from QUOTA's successful first light campaign as a static imager in October 2006 and subsequent engineering runs at the WIYN telescope.

022.09

Fast Guiding with the Quad OTA

Brian J. Brondel[1], D. R. Harbeck[2], S. B. Howell[2], A. Yeatts[2]
[1]Indiana University, [2]National Optical Astronomy Observatories.

The Quad Orthogonal Transfer Array (QUOTA) camera is the newest instrument to be added to the WIYN 3.5-meter telescope at Kitt Peak National Observatory. QUOTA is designed to exploit the excellent quality of the WIYN site and optics, accommodating the best reachable seeing conditions of 0.4 arc-seconds at appropriate sampling. As the precursor to the WIYN One Degree Imager, QUOTA is a testbed for techniques that the WIYN telescope will eventually employ in ODI to realize its full potential over a one square degree field. A necessary step in achieving such high image quality is the use of fast guiding, a strategy that will improve seeing by providing high frequency tip-tilt corrections to the image.

The QUOTA Guide Core software computes the shift in an image based on data from small guide windows read rapidly from the chip. The Guide Core must support reading this window at cycles of up to 50 Hz, although we will target 20 Hz for initial commissioning. During each cycle the software must use the video feed to compute the necessary shift and formulate a shift command to send to the camera -a demanding task that must be accomplished very quickly. The software must also extract as much information from the guide window images as possible, since the guide data are potentially of scientific value. We have examined techniques for achieving the effective guiding needed to reach the full potential of the QUOTA system.

022.10

The WIYN Serendipity Project: High Speed Guide Star Photometry at the WIYNObservatory

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The WIYN Observatory currently operates a prototype orthogonal transfer CCD array camera called OPTIC. During fall 2006, a next generation OTCCD camera, QUOTA, will begin commissioning as a pathfinder toward the implementation of a one-degree OTCCD camera (the One-Degree ImagerODI) to be on-line at WIYN in 2009. Orthogonal transfer CCD arrays use rapid readout of a set of guide stars to perform on-chip tip/tilt corrections. The use of OTCCDs allow tip-tilt correction over the entire focal plane, not simply a small central area. Images of the guide stars are obtained at rates as fast as 100Hz although 20-30 Hz is typical. These guide star images are often seen as scientifically uninteresting, as mere tools to get the best possible image quality for the scientific object. The Serendipity project will make use of the guide star video images to study bright star stellar variability without any loss of telescope time. We have developed a method to perform real-time photometry of the guide star image streams, providing a light curve of the guide star and allowing the destruction of the video files,

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saving time and storage space. In this paper we outline OTCCDs at WIYN, describe our photometric methods, and explore the science possibilities offered by the WIYN Serendipity Project.

022.11

The Quest for Precision Ground-Based Astronomy:The CCD/Transit Instrument with Innovative Instrumentation (CTI-II)

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Precision ground-based photometric and astrometric measurements enable new astrophysical research programs. The CCD/Transit Instrument with Innovative Instrumentation (CTI-II) is the second generation of a 1.8-m stationary, meridian pointing telescope fundamentally capable of millimagnitude photometry and milliarcsecond astrometry. Our goal is demonstrably to attain and maintain this precision in practice.

The optical design for this telescope is complete and a unique real-time metrology system is being tested. An innovative focal plane mosaic including real-time focus feedback is being finalized. We discuss the telescope system design considerations, support instrumentation and calibration techniques that allow this precision, even for measurements made through Earth's turbulent and turbid atmosphere. Ancillary instrumentation includes weather stations, cloud monitors, optical and structural metrology and monitoring instruments, a microbarograph array, an atmospheric extinction lidar and a system of cameras capable of providing real-time extinction measurements.

The stationary, fully automated CTI-II uses the time-delay and integrate (TDI) readout mode operated at the sidereal rate on a mosaic of CCD detectors to nightly generate a five bandpass, 1° wide (declination) image, nominally 120° long (corresponding to observing for an eight-hour night) strip image of the sky to limiting magnitudes fainter than 21 per bandpass. After one year CTI-II will have completed observation of a small circle on the sky at a declination of +28°.

The CTI-II data, approximately 200 gigabytes nightly, will enable a large number of astrophysical research programs including Galactic astronomy based upon motions and parallaxes of stars in the solar neighborhood, discovery and synoptic monitoring of black-hole related variability in the cores of galaxies, and the discovery of targets of opportunity based upon either luminosity variability (e.g. supernovae) or motion (e.g. asteroids and comets).

CTI-II is being designed and implemented as part of the Near Earth Space Surveillance Initiative (NESSI), funded by AFRL.

022.12

The Unique Optical Design of the CTI-II Survey Telescope

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The CCD/Transit Instrument with Innovative Instrumentation (CTI-II) is being developed for precision ground-based astrometric and photometric astronomical observations. The 1.8m telescope will be stationary, near-zenith pointing and will feature a CCD-mosaic array operated in time-delay and integrate (TDI) mode to image a continuous strip of the sky in five bands. The heart of the telescope is a Nasmyth-like bent-Cassegrain optical system optimized to produce near diffraction-limited images with near zero distortion over a circular1.42 deg field. The optical design includes an f/2.2 parabolic ULE primary with no central hole salvaged from the original CTI telescope and adds the requisite hyperbolic secondary, a folding flat and a highly innovative all-spherical, five lens corrector which includes three plano surfaces.

The reflective and refractive portions of the design have been optimized as individual but interdependent systems so that the same reflective system can be used with slightly different refractive correctors. At present, two nearly identical corrector designs are being evaluated, one fabricated from BK-7 glass and the other of fused silica. The five lens corrector consists of an air-spaced triplet separated from follow-on air-spaced doublet. Either design produces 0.25 arcsecond images at 83% encircled energy with a maximum of 0.0005% distortion.

The innovative five lens corrector design has been applied to other current and planned Cassegrain, RC and super RC optical systems requiring correctors. The basic five lens approach always results in improved performance compared to the original designs. In some cases, the improvement in image quality is small but includes substantial reductions in distortion. In other cases, the improvement in image quality is substantial. Because the CTI-II corrector is designed for a parabolic primary, it might be especially useful for liquid mirror telescopes.

We describe and discuss the CTI-II optical design with respect to our survey and other potential astronomical applications.

022.13

LCOGT.net: A Global Telescope Network to Keep Astronomers in the Dark

Stuart F. Taylor[1], T. M. Brown[1], W. Rosing[1], R. Ross[1], J. Farrell[1]
[1]Las Cumbres Observatory Global Telescope.

The Las Cumbres Observatory Global Telescope is a privately supported planned network of medium-sized (2m) telescopes, longitudinally located to ″keep you in the dark all of the time''. The observatory is in the process of completing major upgrades to its two 2m telescopes, FTN and FTS. These are the two telescopes that have been completed, among the nearly identical telescopes that will eventually form a global network longitudinally distributed to provide continuous night-time coverage. The upgrades of FTN and FTS are intended to improve image quality and reduce noise from the CCD cameras. FTN and FTS are being fitted with new CCD cameras, work on the enclosures will provide improved thermal control, and a warping harness has been used to reduce the astigmatism of the FTN secondary. We are in the process of evaluating the impact of these improvements on the performance of our telescopes.

022.14

The Discovery Channel Telescope: Construction and Design Progress, January 2007

Thomas A. Bida[1], R. L. Millis[1], B. W. Smith[1], E. W. Dunham[1], H. Marshall[1]
[1]Lowell Obs..

The Discovery Channel Telescope (DCT) is a 4.2m telescope under construction in northern Arizona. The DCT is located at a new site near Happy Jack at 2361m elevation, which was selected following a lengthy site testing campaign that demonstrated DIMM-characterized median ground-level seeing of 0.84-arcsec FWHM. The DCT science mission includes targeted studies of astrophysical and solar system objects utilizing RC and Nasmyth-mounted imaging and spectroscopic instrumentation, and wide-field surveys of KBO's, NEA's, and astrophysical objects with a 2-degree FOV prime focus camera.

The DCT facility enclosure and control buildings will be completed soon, including the telescope mount and dome supports, major machinery infrastructure, the instrument laboratory, control and computer rooms, and the auxiliary building for the mirror coating plant. Meanwhile, the effort for final figuring and polishing of the 4.3m ULE meniscus primary mirror blank began in August 2006 at the University of Arizona College of Optical Sciences. The primary mirror and its design support, and the integrated telescope mount model, were finite-element analyzed to optimize the design of the mirror and top-end support configurations. The primary mirror axial and tangential actuators will be fabricated in early 2007 and utilized in the final figure and polish cycle. The prime focus camera design has been refined to achieve atmospheric dispersion-compensated 0.25-arcsec images at 1-degree field radius, from B to I-band, at reduced cost through simplification of glasses to standard types and utilization of spheres on all but two lens surfaces.

The Discovery Channel Telescope is a project of the Lowell Observatory with major financial support from Discovery Communications, Inc. (DCI). DCI plans ongoing television programming featuring the construction of the telescope and the research ultimately conducted with the DCT. Lowell Observatory and Discovery Communications are actively seeking additional partners in the project; interested parties should contact R. L. Millis, Director.

023: HAD IV
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

023.01

History of the Spitzer Mission

George Rieke[1]
[1]*Univ. of Arizona.*

The Spitzer Telescope was launched more than 20 years after the original announcement of opportunity was released. During this long gestation period, the mission took a wide variety of forms and had to survive many political and managerial environments within NASA and in the US Government generally. Finally, approval to build the telescope was won at the height of the faster-better-cheaper era, but completing it extended beyond this phase. This poster shows the key steps in preserving the mission and why decision makers viewed it positively at critical points when it might have been killed. In the end, the scope of the mission was reduced by a factor of about five while still preserving much of its science capabilities. This reduction required a new way to streamline the science objectives by adopting a limited number of key programs and requiring that all features be justified in terms of those programs. This philosophy provided decision rules to carry out necessary descopes while preserving a coherent set of capabilities. In addition, the faster-better-cheaper guidelines requires use of a small launch vehicle, which was only possible by the invention of a new “warm launch” telescope concept, in which the telescope would cool primarily by radiation into space after launch. Both of these concepts are critical to the approach to future missions such as JWST.

This work is partially supported by contract 1255094 from JPL/Caltech to the University of Arizona.

023.02

The Role of Eclipse Expeditions in Early French and Australian Radio Astronomy

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In the late 1940s and early 1950s, France and Australia were both very actively involved in solar radio astronomy. One of the problems was to find the resolution to successfully investigate the association of coronal radio emitting regions with sunspots and other photospheric features, and solar eclipse expeditions came to play a key role in this quest. By observing an eclipse from geographically-spaced localities it was possible to accurately determine the positions of the radio-emitting regions, and the overall observations could also be used to investigate the form and size of the radio corona.

Between 1948 and 1952 French and Australian radio astronomers mounted five different solar eclipse expeditions, which contributed significantly to our understanding of the solar corona and radio-optical associations. This poster paper will review these expeditions by examining the personnel involved, their equipment, the observations made and the scientific results.

023.03

Seth Nicholson’s First Satellite Discovery: Jupiter IX and His Orbit for It

Donald E. Osterbrock[1]
[1]*UCO/Lick Observatory.*

Seth B. Nicholson was a graduate astronomy student at the University of California in Berkeley when he discovered his first satellite in 1914. He was later to discover three more, after he had joined the Mount Wilson Observatory staff following his PhD in 1915.

Nicholson had begun his thesis on the problem of computing an improved orbit for J VIII, which had been discovered by Melotte in England in 1908, a distant irregular satellite like J VI and J VII. Nicholson was taking photographic plates to measure the position of J VIII in the summer of 1914 with the Crossley 36-inch reflector of Lick Observatory. He was a teaching assistant at Berkeley that summer, but would go up to Mount Hamilton to observe on weekends in the dark of the moon, traveling by rail, stage (an automobile on a regular schedule between San Jose and the observatory) and interurban trolley car, and sleeping in a shed near the Crossley dome. He first saw J IX as a much fainter object with the same motion as J VIII on a plate he took in late July 1914, and realized it must be another satellite of the giant planet.

Nicholson obtained his first orbit of J IX, which had by then become his new thesis topic, in September, and published a paper on it in early 1915. Its orbit, like that of J VIII, was retrograde and irregular, but it was considerably fainter. Nicholson, a loyal student of Armin O. Leuschner, the head of the Berkeley Astronomy Division, used his teacher’s ″short method″ (or analytic method) to calculate the orbit.

SUNDAY

023.04

The Guilford-Carleton Eclipse Expedition of 1900

Thomas R. English, III[1]
[1]*Guilford Tech. Community College.*

The solar eclipse of 1900 May 28 provided an opportunity for American astronomers to make observations from home soil, as the shadow tracked across the southeastern United States from New Orleans to Norfolk. Eclipse parties were scattered throughout the southern states, including large-scale scientific teams traveling to sites in Georgia and North Carolina. These major operations, staffed by groups from Yerkes, Princeton, USNO, and Lick, featured multiple observing programs and all the modern techniques they could manage.

In addition to the major astrophysical endeavors, there were many smaller parties in the field in 1900 that resembled the more casual eclipse expeditions that were characteristic of a few decades before. In these efforts, relatively small groups of observers used modest instruments and made mostly visual observations, and the expedition was as much a social event as it was a scientific venture. One such group was the party from Carleton College and Guilford College that observed from a fruit farm in Southern Pines, NC.

At the turn of the century, the Goodsell Observatory at Carleton College in Minnesota was an important regional astronomical facility that had provided weather and time data for over 20 years, and was the site of publication of Popular Astronomy, a widely circulated astronomical journal. At Guilford College, on the other hand, the astronomy course was taught by the school’s Treasurer, and there were no significant astronomical facilities.

The presentation will explain how these two schools came to combine efforts to study the 1900 solar eclipse, and will summarize the events of the trip and the observations made.

This research was supported in part by the Herbert C. Pollock Award of the Dudley Observatory.

023.05

The North American Astronomical Photographic Plate Preservation & Digitization Center Current Status

Wayne Osborn[1], M. Castelaz[2], J. D. Cline[2], R. E. Griffin[3], T. Barker[2]
[1]*Central Michigan Univ.,* [2]*Pisgah Asronomical Research Institute,*

[3]*Dominion Astrophysical Observatory, Canada.*

The North American Astronomical Photographic Plate Center (NAPPC) was established at the Pisgah Astronomical Research Institute in 2004. The goal of the Center is to help preserve astronomical photographic data, first by serving as a long term repository for astronomical plate collections and eventually by digitizing the plate material of interest for research projects. In the three years of existence, the Center has received over 25,000 plates. The largest collections are CTIO 4-m plates, CTIO and Warner and Swasey direct and objective prism Schmidt plates, and U. Michigan spectra. Preliminary catalogues of the plates are being developed and placed on line (http://www.pari.edu/library/astronomical-plate-center). A small source of funding has been secured to support this work. Instructions will be available from the authors on the steps to follow for individuals or observatories wishing to archive plates at the Center.

023.06

Astronomy Education Review: **A Five-Year Progress Report**

Andrew Fraknoi[1], S. Wolff[2]
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For the last five years, we have been publishing (with support from NOAO, NASA, the AAS, and the ASP) an on-line journal/magazine called *Astronomy Education Review,* focusing on astronomy and space-science education and outreach. It can be found at: http://aer.noao.edu This project, the first of its kind in our field, has made it possible to elaborate, encourage, and support -in one convenient location -the literature of astronomy education research, together with discussions of some of the key issues that professionals in the field are grappling with. (In this sense, the journal resembles *Science* or *Nature.)*

We present statistics about the 164 papers and articles published in the first nine issues of the journal and about its international readership. We also discuss the future plans for this publication and the role that the AAS community can play in supporting it.

024: SIM Science
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

024.01

The Exoplanet Host Star Gamma Cephei: Orbit of the Binary and Mass of the Substellar Companion

Guillermo Torres[1]
[1]*Harvard-Smithsonian, CfA.*

The bright K1 III-IV star Gamma Cephei has been reported previously to have a possibly substellar companion in a 2.5-yr orbit. It also has a stellar companion in a much wider orbit that has not been seen directly until now. Here we determine for the first time the three-dimensional orbit of the stellar companion accounting also for the perturbation from the closer object. The analysis combines new and existing radial velocity measurements with intermediate astrometric data from the Hipparcos mission (abscissa residuals) as well as ground-based positional observations going back more than a century. The mass of the stellar companion is inferred to be about 0.36 solar masses (M4 dwarf) for an assumed primary mass of 1.18 solar masses (established from a careful reanalysis of its physical properties), and the orbit of Gam Cep B is eccentric ($e = 0.41$) and has a period of 66.8 yr. The star is expected to be about 6.4 mag fainter than the primary in the K band. The minimum mass of the closer companion is 1.43 Jupiter masses, but the inclination angle of its orbit is unknown. Taking advantage of the high-precision Hipparcos observations we are able to place a dynamical upper limit on this mass of 16.9 Jupiter masses at the 3-sigma confidence level, confirming that it is substellar in nature. SIM will be able to directly measure the wobble due to the planet and establish its mass unambiguously. Our work shows that its orbit (semimajor axis = 1.9 AU) is only 9.8 times smaller than the orbit of the secondary star (the smallest ratio among exoplanet host stars in multiple systems), but it is stable if coplanar with the binary. Partial support is acknowledged from NASA's MASSIF SIM Key Project (BLF57-04) and NASA Origins grant NNG04LG89G.

024.02

Astrometric Detection of Terrestrial Planets in the Habitable Zones of Nearby Stars with SIM PlanetQuest

Joseph Catanzarite[1], M. Shao[1], A. Tanner[1], S. Unwin[1], J. Yu[1]
[1]*Jet Propulsion Laboratory.*

SIM PlanetQuest is a space-borne Michelson interferometer with a 9 m baseline, currently slated for launch in 2016. One of the principal science goals of the mission is the astrometric detection and orbital characterization of terrestrial planets in the habitable zones of nearby stars. Differential astrometry of the target star against a set of reference stars lying within a degree will allow measurement of the target star's reflex motion with astrometric accuracy of one micro-arcsecond in a single measurement.

In this study, we define survey strategies and planet-search target lists adapted to different occurrence frequencies of terrestrial planets in the habitable zone. We introduce the joint periodogram as a tool for astrometric planet detection, and assess SIM's sensitivity for detection of terrestrial planets in the habitable zone using realistic target star lists and testbed-validated assumptions about instrument performance.

We find that for the best 120 planet-search targets, SIM PlanetQuest will be able to detect Earth-size planets (or smaller) around 6 stars, planets of 2 Earth masses (or smaller) around 30 stars, and planets of ~triple Earth's mass (or smaller) around all 120 stars.

For details of this study, see Catanzarite, et al. 2006 PASP 118:1322-1342.

We conclude that SIM PlanetQuest will be capable of probing populations of terrestrial and ice giant planets residing in the habitable zones of a large sample of stars within 30 pc. SIM PlanetQuest's scientific discoveries will potentially unveil the erstwhile hidden regime of rocky planets, allowing the first thorough checks of predictions of theories of planet formation.

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA.

024.03

Masses of Exoplanets from Doppler Spectroscopy and HST Astrometry

Jacob Bean[1], B. E. McArthur[1], G. F. Benedict[1]
[1]*Univ. of Texas, Austin.*

Mass is the most important physical property to know for extrasolar planets because it is the one property that distinguishes a star's companion as a bona-fide planet rather than a brown dwarf or even a low-mass star. Additionally, planetary masses provide useful boundary conditions for models of planetary formation and evolution as mass is a critical component in determining a planet's instantaneous characteristics and past and future evolution. In order to determine exoplanets' true masses, we currently use the Hubble Space Telescope Fine Guidance Sensors to obtain measurements of the astrometric elements (perturbation semi-major axis and inclination) of nearby stars that host candidate planets. Because of the long perturbation period of our targets, these mass determinations rely on Doppler velocity measurements to establish the planetary orbital parameters. Unknown shorter-period planets can introduce velocity changes that could be misconstrued as noise and lead to deriving incorrect orbital parameters for the known planets. Consequently, we carry out high-cadence Doppler spectroscopy observations subset of our targets with the Hobby-Eberly Telescope at McDonald Observatory. We present here refined orbital parameters and limits on undetected planets for a subset of our target systems from combining our new data with legacy velocities from planet search programs. We also present preliminary three dimensional models and exoplanet masses for some of our targets from combining the astrometric and spectroscopic data. This research is a technique demonstration of direct relevance to the Space Interferometry Mission, which will be able to discover new exoplanets and precisely measure their masses using astrometry alone. Support for this work was provided by NASA through grants GO-10610 and GO-10989 from the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS5-26555.

024.04

Clandestine Companions of Nearby Red Dwarfs

Todd J. Henry[1], D. W. Koerner[2], W. C. Jao[1], J. P. Subasavage[1], P. A. Ianna[3], RECONS
[1]Georgia State Univ., [2]Northern Arizona University, [3]University of Virginia.

During the RECONS parallax program at the CTIO 0.9m, we have accumulated more than six years of astrometric data on red dwarfs in the southern sky. Eighty red dwarfs within 10 pc, including more than two dozen new discoveries by our team, are being followed to reveal the telltale perturbations caused by unseen companions.

The advent of modern CCD technology yields substantial improvement in the detection of low mass companions over the classic studies done using photographic plates. The current ASPENS (Astrometric Search for Planets Encircling Nearby Stars) program is capable of finding hidden companions with masses as low as 10 Jupiters. Here we report the first results of the ASPENS effort, including a few intriguing systems with orbital periods of several years.

Nearby red dwarfs are prime candidates for NASA's Space Interferometry Mission (SIM) because the astrometric perturbations are largest for planets orbiting nearby stars of low mass. In addition, new multiple red dwarf systems can be targeted for mass determinations, thereby providing points on a comprehensive mass-luminosity relation for the most populous members of the Galaxy.

These long-term observations began in 1999 as an NOAO Surveys program, and are continuing via the SMARTS Consortium. This work has been supported by the National Science Foundation (AST 98-20711 and 05-07711), NASA's Space Interferometry Mission, Georgia State University, and Northern Arizona University.

024.05

Crowded Field Astrometry with SIM

Sridharan Rengaswamy[1], R. Allen[1]
[1]STScI.

The presence of faint background stars within the 3″ field-of-view (FOV) of SIM confuses the measurements and introduces errors that can be significantly larger than the precision with which the measurements are expected to be made. Earlier studies on understanding the nature and magnitude of these errors have indicated that the errors depend upon the disposition of the sources within the FOV, baseline orientation, instrumental throughput, spectral energy distribution of the stars and the number of spectral channels used for recording the data. However, these earlier studies have not incorporated the actual measurement processthe measurement of intensity over the FOV as a function of path delay, in the case of confused fields. We report results of a detailed study undertaken in an effort to model the measurement process as accurately as possible and identify the approaches that can be used in order to obtain the best fit to the measured data. We plan to use this model to account for the error introduced by the confusing sources.

025: Solar System
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

025.01

Small Lnding Pobes for In-situ Characterization of Asteroids and Comets

Dennis Ebbets[1], R. Dissly[1], R. Reinert[1]
[1]Ball Aerospace & Tech. Corp..

Future space missions to small solar system objects such as asteroids and comets may include probes that can land to enable characterization of both the surface and interior. In many cases more than one probe may be desired to sample different regions or to work together as a network of sensors. This poster describes a design concept for such a probe under study at Ball Aerospace. The probes are roughly the size of a basketball, allowing for several to be carried by a rendezvous spacecraft and deployed individually. They will survive a freefall to the surface, impacting with a velocity of several meters / second. Deployable panels on the nominally spherical body ensure self-righting to an operational orientation. Each probe accommodates a payload of several kilograms, optimized for its particular investigation. Candidates include imagers, accelerometers, X-Ray spectrometers, sample collection and examination, and possibly pyrotechnic charges for seismic excitation or cratering experiments. The probe provides a standard suite of services such as battery power, data management and communications with the rendezvous spacecraft. We are also studying options for mobility, such as "hopping", and for anchoring to the surface of a micro-gravity body. Such a basic probe could become a low cost component of future missions that would enable a rich spectrum of in-situ investigations to a large number of target bodies.

025.02

Search for Satellites around Ceres

Allyson Bieryla[1], J. W. Parker[1]
[1]Southwest Research Institute.

The discovery of a satellite orbiting an asteroid is important in helping to determine the density of the primary body. This lends clues to the asteroid's composition as well as allows the asteroid to be placed in a taxonomy group. We conducted a satellite search around Ceres using HST images from 2004 and ground-based, Palomar images from 2006. In our initial search, no candidate objects were found in the Hill Sphere around Ceres. The detection limit for satellites was determined by placing fake objects with random number, position, and magnitudes in each image. The artificial images were then searched for objects in the same manner as the original images. If we assume that a satellite would have the same albedo as Ceres, we can say that it is likely (at the 90% detection limit) that there are no objects larger than 1 km in diameter orbiting Ceres in the HST images out to a distance of 15,000 km. Similar analysis is currently being done on the Palomar data, and at this meeting we will report our results of the satellite detection limits covering the entire Hill Sphere.

025.03

Searching for Asteroids with 8 micron Spitzer Space Telescope Data

Edward L. Wright[1], B. Mohlie[2]
[1]UC, Los Angeles, [2]RPI.

Previous studies have estimated the number of asteroids with diameters greater than 1 km, but this number varies greatly in different papers and few predictions have been made about the number of asteroids with diameters smaller than 1 km. This paper uses data from the Spitzer Space Telescope to look for asteroids in 8 micron images. Two asteroids are found in the Spitzer observations ofthree dark spots that are well off the ecliptic. The distance andhence size of these asteroids is quite uncertain, but they areprobably less that 1 km in diameter. The number of asteroids (smaller than 1 km) found in this paper agrees with an extrapolation of the number predicted by data on asteroids larger than 1 km from the SDSS Moving Object Catalog.

025.04

Correlating Arecibo Radar and IRTF Near-Infrared Spectral Observations of 105 Artemis

Heather M. Hanson[1], E. S. Howell[2], C. Magri[3], M. C. Nolan[2]
[1]University of Wyoming, [2]Arecibo Observatory, Puerto Rico, [3]University of Maine at Farmington.

We have coordinated radar observations with spectral observations of 105 Artemis, a low-albedo main-belt asteroid. Previous spectra indicate that 105 Artemis is a C-type asteroid with hydrated minerals on the surface at some rotational phases but not at others. Serendipitous radar observations showed radar albedo changes which seem to suggest that the hydrated areas have higher radar albedo than anhydrous areas. The near-infrared spectra from

0.8--4.1 microns obtained at the IRTF on 6 March 2006 indicate a combined water/OH absorption band with average depth of 89 +/0.03 percent due to hydrated silicates on the surface.The radar images of 105 Artemis are remarkably complex, showing bright glints and irregular features that may be linked to the reflectivity of the surface, and therefore the composition instead of the shape of the asteroid. In order to link the observations together, the amateur astronomy community has helped observe the lightcurve. The rotation period of 105 Artemis is 37.18 +/0.02 hours, substantially longer than the previous estimate of 16.8 hours. Using this rotation period, we link the spectra and radar observations together, which were made 6 weeks apart. The viewing geometry can be determined for the radar images using the rotation period and observed frequency bandwidth. A simple elliptical model has been developed to describe the areas of 105 Artemis that have been observed. Results of these combined observations will be presented.

025.05

Orbits of Binary Near-Earth Asteroids from Radar Observations

Heidi E. Brooks[1]
[1]Reed College.

The orbits of binary systems can be used to determine the masses of the objects. Radar delay-Doppler imaging of near-Earth binary asteroid systems were used to obtain measurements of their densities, using the orbit-derived masses and image-derived sizes. Results are presented for 2003 YT1, 2002 BM26, and 2006 GY2.

Assuming circular orbits of the secondaries, the following orbital periods were derived: 2003 YT1, 36.7 ±1.8 hours; 2002 BM26, either 12.5 ±0.2 or 25.8 ±0.3; and 2006 GY2, 11.7 ±0.2 hours. A large amount of sky coverage had been obtained for 2003 YT1, and its rotation rate had been previously determined by light curve information. These extra pieces of information, along with the use of a modeling program called Shape allowed constraints to be placed on the geometry of the system. From there the mass and volume of the primary were calculated to be (1.27 ±0.39)*10^12 kg and 0.63 ±0.10 km^3, respectively, resulting in a final estimate of the density to be 2.01 ±0.70 g/cm^3.

025.06

Differential Photometry of Asteroids 252 Clemintina, 329 Svea, 334 Chicago, 596 Scheila, 517 Edith, 521 Brixia and 713 Luscinia.

Elise C. Jutzeler[1], E. Hausel[2], A. Burke[3], M. Leake[4]
[1]SUNY Geneseo, [2]University of Wyoming, [3]Vassar College, [4]Valdosta State University.

Partial light curves acquired from differential photometry analysis of various taxonomic C-type asteroids provide data useful for examining inherent characteristics of each asteroid. The data result in rotational period values consistent with previous values published at the Minor Planets Center website. All observations represent asteroids that have been scarcely observed and are in need of additional observations. Analysis of 334 Chicago provides a nearly complete light curve representing qualities of the asteroid for a small phase angle. The procedure for observing 334 Chicago also results in a good way to match up differential photometric values over consistent nights of observation. The results should be combined with spectroscopic data to determine water of hydration of each asteroid and how photometric values may vary over phase angle, temporal position of periodic rotation and evolution of the main belt asteroids. The data was collected at the SARA 0.9 m telescope at KPNO during the nights of January 5-6, 2005 and June 15-18, 2006. The research was funded by a partnership between the National Science Foundation (NSF AST-0552798) Research Experiences for Undergraduates (REU) and the Department of Defense (DoD) ASSURE (Awards to Stimulate and Support Undergraduate Research Experiences) programs.

025.07

Beyond the Main Belt: Properties of Solar System Objects using the Sloan Digital Sky Survey

Shannon Schmoll[1], Z. Ivezic[1], M. Juric[2]
[1]Univ. of Washington, [2]Princeton University.

Recently, SDSS has reinvigorated the research of asteroid color properties by producing a large volume of accurate color data to several magnitudes fainter completeness limit than available before. To date, SDSS has observed over 200,000 moving objects in five photometric bands. The resulting moving object catalog (′′SDSSMOC′′) can be downloaded from http://www.sdss.org/science/. We used SDSSMOC to search for, and study properties of solar system objects whose observed angular velocity indicates distances between the main belt and the Kuiper Belt. Extensive visual selection was used to clean the candidate list from various contaminants. We summarize the results of this search and discuss a color vs. semi-major axis relationship for asteroids beyond the main belt.

025.08

Asteroid Families in the Sloan Digital Sky Survey Moving Object Catalog

Alex Parker[1], Z. Ivezic[1], M. Juric[2], R. Lupton[2]
[1]University of Washington, [2]Princeton University.

Asteroid families, traditionally defined as clusters of objects in orbital parameter space, often have distinctive colors. We improve the separation of family members from background interlopers by using color measurements for 23,264 objects available in the Sloan Digital Sky Survey Moving Object Catalog. We find that about 50% of asteroids belong to 36 families that are clustered in multi-dimensional space spanned by colors and orbital parameters. This fraction increases from about 35% to 60% as the the limiting asteroid size drops below ~25 km, as predicted by earlier work. We examine the asteroid size distributions for the identified families and find that they can typically be modelled by a power-law, although there is a non-negligible fraction of families (25 %) that require a ′′broken″ power-law. We also find that the size distribution within a family depends on the distance from the family core such that larger objects are more prevalent closer to the core.

025.09

The Canada-France Ecliptic Plane Survey: Strategy, Details and Results

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Over the last three years, the Very Wide component of the CFHT Legacy Survey has repeatedly observed ~400 square degrees of sky to a depth of R~23.3, with a cadence optimized for the detection of KBOs. CFEPS uses this data to search for and track KBOs. We review the design of the Ecliptic Survey, demonstrating the need for the timing sequence used, and illustrate why a large FOV mosaic camera is required for 1-year recoveries to avoid orbital biases.

Presently CFEPS is just over half completed; discovery operations have concluded, but objects must still be tracked to determine accurate orbits. The first data release (named L3) of objects discovered in 2003 has just occured, since these now have orbits with semimajor axes known to 0.1 percent accuracy. The L3 data release is composed 74 KBOs detected in 94 square degrees; 55 KBOs were tracked to 4 oppositions. Of the 55 objects tracked, 34 are classical belt objects, 17 are resonant, 2 are scattered disk members and 2 appear to be from the extended scattered disk.

The driving goal of the CFEPS project is to provide a well-characterized survey of the Kuiper belt that does not suffer from a hidden 'tracking' bias and can therefore be used to test theoretical models of the Kuiper belt. The CFEPS team is providing a survey simulator that will allow modelers to directly compare their orbit distributions to that seen with CFEPS. We present limits on the intrinsic inclination distribution of the classical belt as an example.

This work is based in part on data products produced at CFHT and the Canadian Astronomy Data Centre as part of the Canada-France-Hawaii Telescope Legacy Survey, a collaborative project of NRC and CNRS.

025.10

New and Improved Ephemerides of Nix and Hydra During the 1985 to 1990 Mutual Events Between Pluto and Charon

Garrett Elliott[1], D. J. Tholen[2]
[1]The Ohio State University & Institute for Astronomy, University of Hawaii, [2]Institute for Astronomy, University of Hawaii.

Acknowledging the non-Keplerian orbits for the Plutonian moons Nix and Hydra due to significant perturbations by Charon, new ephemeris positions were calculated to assist with their detection in previous observations of the Pluto system. To compensate for unknown albedo and density, we varied their masses from $1.0x10^{16}$ kg to $2.5x10^{18}$ kg to allow for extremes of Pluto-like albedo and a water-ice density to comet-like albedo and Pluto-like density, respectively. New ephemeris positions of Nix and Hydra should allow us to identify them in stacked images from archival Hubble Space Telescope data. Also, the coplanar orbits of Nix, Hydra, and Charon result in a shared season of mutual events. In Pluto and Charon mutual event observations made between 1985 and 1990, Nix or Hydra mutual events with Pluto may have been unknowingly observed. Although mutual events between Nix or Hydra and Charon did occur, the focus of the observations during this time was on the events between Charon and Pluto. This situation makes for the possibility that there were observations of one of these Nix or Hydra and Charon events very remote.

Support for this work was provided by the National Science Foundation through the Research Experience for Undergraduates program at the University of Hawaii's Institute for Astronomy.

025.11

Obtaining An MPC Observatory Code For Arkansas Tech University

Jason Ahrns[1], J. W. Robertson[1]
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We report on our experiences in obtaining an official Minor Planet Center observatory code for the Arkansas Tech University Astronomical Observatory. Information is presented on the equipment and techniques used to provide the MPC with accurate coordinates of minor planets using a small campus observatory with undergraduate students resulting in a successful designation of H49 for the ATU observatory by the MPC.

025.12

Constraining the Rotational Period for Component C of the Periodic Comet 73P/Schwassmann-Wachmann 3

Shaye Storm[1], N. Samarasinha[2], B. Mueller[3], T. Farnham[4], Y. Fernandez[5], A. Kidder[6], D. Snowden[6], M. A'Hearn[4], W. Harris[6], M. Knight[4], J. Morgenthaler[6], C. Lisse[7], F. Roesler[8]
[1]MIT, [2]NOAO & PSI, [3]PSI, [4]UMD, [5]UCF, [6]U of Wash, [7]APL/JHU, [8]U of Wisc.

Comet 73/Schwassmann-Wachmann 3 was imaged from May 3-10, 2006 UT with the narrowband H-B and broadband R filters. Observations were done at the 4-meter Mayall telescope on Kitt Peak, when the comet was near its perigee passage. Extensive temporal coverage of the two brightest fragments (Components B and C) was obtained over the observing run in addition to occasional monitoring of other selected fragments.

We investigated the gas coma morphology of Component C using the CN filter, and the dust morphology using the BC, GC, and RC filters. The detailed coma morphology of the features was identified with the help of multiple image enhancement techniques. We analyzed the time evolution of the coma features in order to constrain the rotational period of the nucleus. Preliminary constraints resulted in a rotational period of 8.8 ± 0.3, 13.2 ± 0.3, and 27.2 ± 0.3 hours. It is likely that the 27.2 ± 0.3 hours period may be an alias of the first constrained period. We will compare our results with other investigators using different techniques (e.g. Radar data by Nolan, et al. 2006; HST data by Toth et al. 2006, Radio data by Kuppers et al. 2006).

SS's research was supported by the NOAO/KPNO Research Experiences for Undergraduates (REU) Program, which is funded by the National Science Foundation (NSF) through Scientific Program Order No. 3 (AST-0243875) of the Cooperative Agreement No. AST-0132798 between the Association of Universities for Research in Astronomy (AURA) and the NSF. NS was supported by the NASA Planetary Atmospheres Program.

025.13

Comet 73P/Schwassmann-Wachmann 3: O(1D) and H2O Production Rates

Tanya L. Hall[1], E. J. Mierkiewicz[2], L. M. Haffner[2], F. L. Roesler[2], W. M. Harris,[3], G. J. Madsen[4]
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In May 2006, comet 73P/Schwassmann-Wachmann 3 (SW3) made the closest approach (0.075 AU) to the Earth of a short period comet in more than 75 years. During the comet's 1995/1996 apparition it split into several fragments and, as of March 2006, SW3 was in eight major pieces. From May 1, 2006 through May 6, 2006 we performed a series of [OI] and NH_2 (near 6300 Å) observations of the two brightest fragments, SW3-B and SW3-C, using the dual-etalon Fabry-Perot spectrometer that comprises the Wisconsin H-alpha Mapper (WHAM). At the time of our observations the Doppler shift of the comet was within a few km/s of the spectral resolving limit of WHAM (12 km/s), and great care was needed to isolate the blended cometary [OI] emission from the bright terrestrial [OI] emission line. In this poster we will discuss our analysis procedure and our preliminary total $O(^1D)$ production rates. Given the photodissociation of H_2O and OH as sources of $O(^1D)$, we will also present an estimate of the H_2O production rates for fragments SW3-B and SW3-C based on our WHAM $O(^1D)$ observations.

This work was supported by the National Science Foundation's REU program and the Department of Defense's ASSURE program through NSF Award AST-0453442

SUNDAY

025.14

GALEX Observations of Comet 9P/Tempel 1 During Deep Impact

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GALEX observations of comet 9P/Tempel 1 using the near ultraviolet (NUV) objective grism were made before, during and after the Deep Impact Event that occurred on 4 July 2005 at 05:52 UT. The NUV channel provides usable spectral information in a bandpass covering 2200 -3200 Å with a point source spectral resolution of R ~ 100. The primary spectral features in this range include a solar continuum scattered from cometary dust and emissions from OH and CS molecular bands near 3090 and 2575 Å. In particular, the CS emission is unique to this bandpass. The observations allow the evolution of these spectral features to be tracked over the encounter. We will discuss our procedure for extending the *GALEX* absolute calibration to the wavelength region longward of 3000 Å where the modest ''red leak'' in the Cs_2Te photochathode is nevertheless high enough to provide good detection efficiency for OH emission. In general, the NUV emissions observed from Tempel 1 throughout the encounter are much lower than those observed by *GALEX* from comet C/2004 Q2 Machholtz (Morgenthaler et al. DPS 2005). Production rates for the dust and molecules detected by *GALEX* in Tempel 1 will be derived and compared to other observations.

025.15

Wide-field spectroscopic observations of comet C/2004 Q2 (Machholz) by GALEX

Jeffrey P. Morgenthaler[1], W. M. Harris[1], M. R. Combi[2], P. D. Feldman[3], H. A. Weaver[4]
[1]Univ. of Washington, [2]Univ. of Michigan, [3]Johns Hopkins Univ., [4]Johns Hopkins University/APL.

Comet C/2004 Q2 (Machholz) was observed by the Galaxy Evolution Explorer (GALEX), UT 2005 March 1. The GALEX satellite, a NASA Small Explorer (SMEX) mission, designed to map the history of star formation in the Universe (Martin et al. 2005), is also well suited to cometary coma studies because of its high sensitivity and large field of view. Improved spacecraft aspect information, recently made available to our Guest Investigator team has allowed us to accurately take out cometary motion and co-add all 4 orbits of grism observations. The resulting increase in S/N from previous analyses (Morgenthaler et al. 2005) and the availability of on-orbit calibration (Morrissey et al. 2005) allow us to establish preliminary production rates and scale lengths for the bright UV cometary features seen in the data. We use simple Haser models, with scale lengths modified to emulate the vectorial model (Combi et al. 2004) to map coma emission from several species, including OH and CS in the NUV (175--310 nm) and C I in the FUV (135--175 nm). This work was supported by the GALEX guest investigator program.

025.16

The Effect of the Sun's Early Environment on the Oort Cloud and Comet Showers

Nathan A. Kaib[1], T. Quinn[1]
[1]Univ. Of Washington.

Using direct numerical integrations, we model the formation of the Oort Cloud in three different open cluster environments. Observations indicate that stars typically form in regions of much higher density than the galactic field environment. Contrary to this, most simulations of the Oort Cloud formation have assumed an unvarying galactic setting identical to the one the Sun currently occupies. The enhanced stellar encounters associated with a more realistic primordial environment, however, affect both Oort Cloud trapping efficiencies and the abundance of the inner Oort Cloud. Furthermore, the number of bodies occupying the inner Oort Cloud determines the intensity of modern day comet showers, and in this way the Sun's birthplace environment has had a significant influence on Earth's habitability. This work investigates which type of stellar birthplace yields cometary impact rates that are optimal for life on Earth. This work has been funded by the NASA Astrobiology Institute and the NSF.

025.17

Distribution of Ethane and Methane Emission on Neptune

Heidi B. Hammel[1], M. L. Sitko[1], G. S. Orton[2], T. Geballe[3], D. K. Lynch[4], R. W. Russell[4], I. de Pater[5]
[1]Space Science Institute, [2]JPL, [3]Gemini, [4]The Aerospace Corp., [5]UC Berkeley.

We have obtained the first simultaneous midand near-infrared images of Neptune. With our mid-infrared images (7 and 11.6 microns) taken at the Gemini North 8-meter telescope in July 2005, we identify the two source regions for Neptune's ethane emission: a compact bright region within a few degrees of the south pole and a nearly-uniform bright planetary limb. Upper stratospheric methane emission is also confined to the polar region. This bright pole is the first direct imaging evidence for strong dynamical circulation in the upper stratosphere of Neptune. Our near-infrared images (1.6 and 2.2 microns) with the Keck II 10-meter telescope probe deeper atmospheric levels and show a completely different brightness distribution. The dominant brightness comes from sunlight reflecting from methane-ice clouds in the planet's mid-latitude regions. The two sets of data together demonstrate that the stratospheric ethane and methane emissions are uncorrelated with the deeper tropospheric clouds. HBH acknowledges support for this work from NASA grants NAG5-11961, NAG5-10451, and NNG06GI25G.

025.18

Origin of the Moon

Peter D. Noerdlinger[1]
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Rather than originating in a giant impact, the Moon may have begun as a co-formed object with Earth, of mass ~1/54 that of Earth, including an iron core. That core was pitted from the proto-Moon by a Roche stripping process. It is necessary to assume that the outward spiralling of the proto-Moon due to tidal friction was arrested due to a change in Earth spin (probably due to impact of a third body) that created a situation like that of Phobos and Mars, such that the month was less than the sol. Inside the Roche limit, the proto-Moon shed its mantle into a disk of rock, which was driven out past the Roche limit by the tidal action of the remaining lunar core and mantle. When stripping reached the dense iron core, it went briefly into abeyance but the core still drove out the disk before it disintegrated into a ring. Out beyond the Roche limit for rock, the Moon quickly re-formed out of the rock disk. Its tidal interaction with the iron ring drove the latter onto the Earth, while much of the energy went into driving the Moon out to larger distance and larger eccentricity (Bethell, Wisdom and Zuber 2006), starting not long after the Moon re-formed. The Moon ends in orbit with the month longer than the sol, so it spirals out.

025.19

Velocity Resolved Observations of the Extended Lunar Sodium Tail

Michael R. Line[1], E. J. Mierkiewicz[1], F. L. Roesler[1], L. M. Haffner[1], R. J. Oliversen[2]
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We have recently obtained the first velocity resolved sodium D2 (5889.950 Å) line profile observations of the extended lunar sodium tail observed in the anti-lunar direction within 2-18 hours from new Moon. These observations were made in March, April, and September, 2006 from Pine Bluff (WI) Observatory (PBO) with a double etalon Fabry Perot spectrometer. The PBO Fabry-Perot is coupled to a siderostat with a circular 1.5 degree field-of-view on the sky, and samples a 75 km/s spectral interval with ~3.5 km/s spectral resolution at 5890 Å.

The average observed radial velocity of the lunar sodium tail in the vicinity of the anti lunar point was ~12 km/s from geocentric zero; the average Doppler width of a single Gaussian fit to the emission line was ~8 km/s. Our current work involves mapping the spatial distribution of this emission over an ~8 degree field on the sky using a grid of observations with steps of 6 minutes in right ascension (α) and 1.5 degrees in declination (δ). In this poster we will present recent data and a series of channel maps which highlight the kinematic distribution of the 5889.950 Å emission in ~4 km/s velocity slices.

This work is partially supported by the National Science Foundation through grants ATM-0228465 and ATM-0535433.

025.20

Advanced Computer Modeling of the Lunar Plasma Environment in the Dynamic Terrestrial Magnetosphere

Erika Harnett[1], R. Winglee[1], J. Halekas[2]
[1]Univ. Of Washington, [2]Univ. Of California Berkeley.

While the solar wind interaction with the Moon has been studied since the first spacecraft missions to the Moon, little work has been done to quantify the lunar near space environment when the Moon is inside the Earth's magnetosphere. This is important though as oxygen ions can be accelerated up to MeV energies in the Earth's magnetotail. Advanced 3D multi-fluid model in conjunction with Lunar Prospector data is used to quantify the plasma environment when the Moon is in the Earth's magnetotail from quiet to storm conditions. The multi-fluid model incorporates ion cyclotron and multi-ion species effects similar to hybrid codes but the fluid treatment enables grid refinement down to as small as 100 km. This high resolution is unique to the multi-fluid modeling, enabling the model to resolve the lunar near space environment in the context of the global terrestrial magnetosphere. Spectrograms of trajectories near the Moon and through the lunar wake show significant difference in the characteristics of the electrons, the light ions and the heavy ions. This implies that the behaviour of heavy ions can not be inferred from electron measurements. Results will be presented that address the composition, energy, density, and velocity of ions near the Moon for (a) quiet conditions and (b) sub-storm/storm conditions, and the overall geometry of the cavity and wake region of the Moon, specifically noting asymmetries of the wake for different incident terrestrial magnetospheric plasma conditions.

025.21

3D Multi-Fluid Simulations of the Solar Wind Interaction with Mercury's Magnetosphere

Ariah R. Kidder[1], R. M. Winglee[1], E. M. Harnett[1]
[1]*University of Washington.*

In preparation for the arrival of NASA's MESSENGER spacecraft at Mercury, 3D numerical simulations are used to predict Mercury's magnetospheric response to forcing from the solar wind. The multi-fluid model includes both heavy and light ion populations, and differs from the terrestrial magnetosphere in that Mercury's magnetic field is much weaker and solar wind conditions, including dynamic pressure and interplanetary magnetic field (IMF), are much higher. The model predicts that the access of the solar wind to the surface at Mercury is highly asymmetric and dependent on the strength and direction of the IMF. In particular, during southward IMF much of the dayside magnetic field can be eroded and jets/plumes of heavy ions outflow from the surface and move out into the solar wind. Development of substorms and storms in association with flux ropes similar to those at Earth are also seen to occur, but the time scale for their development is much shorter than at Earth. Formation of a symmetric ring current is not seen due to interactions of the plasma with the planet's surface.

025.22

3D Multi-fluid Simulations of Titan's Plasma Interaction

Darci Snowden[1], R. Winglee[1]
[1]*University of Washington.*

Using a 3D multi-fluid simulation we show that finite ion gyroradius effects are extremely important in characterizing the plasma interaction at Titan. The multi-fluid method is ideal for studying Titan's plasma interaction with Saturn's magnetosphere because it incorporates ion cyclotron and multi-ion species effects similar to hybrid codes but the fluid treatment enables grid refinement down to as small as 26 km. Ion gyroradius effects are shown to cause an increase in energetic ions incident upon Titan's ionosphere in two regions: on the Saturn facing side of Titan's magnetosphere, where Saturnian ions interact with an extended mass loaded region, and on the wake side of Titan's ionosphere, where the trajectories of pick-up ions cause them to flow back towards the ionosphere with high velocities. Ion gyroradius effects also are important in describing the outflow of ions into Saturn's magnetosphere. In our simulation, pick-up ions from the Saturn facing side of the ionosphere form ion beams that flow away from the tail of the induced magnetosphere. These ion effects can be seen in sample spectrographs generated from our simulation, which we compare to Cassini plasma spectrometer results. To ground-truth our model, sample magnetometer data from a single simulation is compared to Cassini magnetometer data from the TA, TB and T3 flybys.

026: Star Clusters I
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

026.07

Age Distribution of Galactic Globular Clusters using HST Snapshot Photometry

YoungDae Lee[1], S. Rey[1], Y. B. Kang[1], S. Kim[1]
[1]*Chungnam National Univ., Republic of Korea.*

We present relative ages for a sample of Galactic globular clusters (GCs) using their color-magnitude diagrams (CMDs) observed with the HST/WFPC2 camera in the F439W and F555W bands. The ages are obtained by differential comparison of the CMDs of GCs using Δ(B-V) method, the color difference between main-sequence turnoff and the lower red-giant branch. All metal-poor GCs with [Fe/H] $<$ -1.7 show old (~12 Gyr) ages and are coeval. Intermediate-metallicity clusters (-1.7 $<$ [Fe/H] $<$ -0.8) are on average 2 Gyr younger than the most metal-poor counterparts, with a large age dispersion and a total age range of ~2 Gyr. We also discuss the correlation of relative ages with the horizontal-branch morphologies of GCs.

026.08

The Deepest UV Observations of a Globular Cluster: Preliminary Results for NGC 6681

Jennifer L. Connelly[1], D. R. Zurek[1], M. M. Shara[1], C. Knigge[2], A. Dieball[2], K. S. Long[3]
[1]*American Museum of Natural History,* [2]*University of Southampton, United Kingdom,* [3]*Space Telescope Science Institute.*

The globular cluster NGC 6681 (M70), a post-core-collapse galactic cluster, has been imaged extensively in the nearand far-ultraviolet with HST as a calibration target for both STIS and ACS. An aggregate dataset of 605 UV exposures taken on 53 occasions yields the deepest nearand far-UV survey of a globular cluster to date. Reduction and analysis of this massive, multi-epoch dataset allows for the study of the hot stellar populations within the cluster core. If present, cataclysmic variables (CVs), low-mass X-ray binaries (LMXBs), blue stragglers (BSs), hot white dwarfs, and extreme blue horizontal branch (EBHB) stars may be investigated in the UV images. EBHB and BS stars are believed to be the result of close stellar interactions -the former posited to be the result of mass exchange and the latter created via direct collisions or merger events. Close binary objects such as CVs and LMXBs may act to effectively heat their host cluster as encounters with passing single stars cause the loss of binding energy ("hardening") in the binary orbit and an increase in the translational motion of the interacting cluster star. Characterization of the hot stellar populations is thus essential to testing current formation scenarios and understanding the dynamical evolution of globular clusters. Preliminary color-magnitude diagrams constructed using the STIS near-UV and far-UV observations are presented here.

SUNDAY

026.09

The Evolution of Horizontal Branch Stars in the Core Region of M15

Jessica E. Castora[1], E. L. Sandquist[1]
[1]*San Diego State Univ..*

We present a detailed study of the horizontal branch (HB) of the core region of the globular cluster M15 (NGC 7078), using archival HST (Hubble Space Telescope) data covering out to 2.2 arcminutes from the center of M15. The HB distribution in I-band was determined and compared with synthetic models of evolved stars tabulated by Cassisi et al. 2004. We focus on the ratio $R_2 = N_{AGB}/N_{HB}$, which is sensitive to semiconvection in the cores of HB stars and to the rate of the $^{12}C(\alpha, \gamma)^{16}O$ reaction in the latter stages of the HB phase. The R_2 value from the M15 distribution was computed to be 0.123 $\pm$ 0.019, which is in agreement with the value predicted by appropriate synthetic models of both the primary and secondary HB peaks (0.0110 $\pm$ 0.011). This result suggests either that extreme blue HB stars produce AGB stars at approximately the same rate as redder HB stars, or that HB stars just bluer than the instability strip are relatively more effective at producing AGB stars and therefore partially compensate for the lack of AGB stars produced by extreme blue HB stars. We will also discuss the cluster AGB-manqué stars to attempt to constrain where it is on the HB that stars begin to avoid a subsequent AGB stage.

026.10

The Evolved Stars of the Globular Cluster M 55

Carlos Vargas Alvarez[1], E. Sandquist[1]
[1]*San Diego State Univ..*

We have compiled literature data for the AGB, HB, and upper RGB stars in the globular cluster M 55 (NGC 6809) covering from the core out to more than 7.5 arcmin. We also examined the number ratios of stars in different evolutionary phases. While other population ratios appear to have values consistent with predictions from synthetic HB models, the $R_2 = N_{AGB}/N_{HB}$ *ratio is about 3σ away from the expected value. M 55 has an HB morphology similar to that of M 5, a cluster that also exhibits a high* R_2 *value. We discuss the meaning of this discrepancy and its relation to HB and AGB lifetimes.*

026.11

Washington Photometry of NGC 6441

Joanne D. Hughes[1], G. Wallerstein[2], A. Bossi[1], W. McDougald[1], R. Covarrubias[2]
[1]Seattle Univ., [2]University of Washington.

We present Washington photometry of the unusual metal rich globular cluster NGC 6441. Using the available IRAS maps and independent reddening measurements, we model the effects of variable interstellar extinction. This process reduces the uncertainties in the age and metallicity estimates of the cluster population. We compare the stellar content of the cluster with that of NGC 6388, which also has a horizontal branch with both a red clump and an extended blue tail. These are the only two relatively metal-rich clusters that exhibit this trait, which may be due to variations in age, metallicity or helium content, mass loss, or rotation effects.

026.12

Spitzer Observations of Galactic Globular Clusters

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[1]Harvard-Smithsonian, CfA, [2]University of Minnesota, [3]INAF-Osservatorio Astronomico di Roma, Italy.

Preliminary results from two Spitzer Space Telescope projects on Galactic globular clusters are presented. In the first project, Spitzer/MIPS imaging is used to search for cold intracluster dust in a sample of clusters. The second project involves the construction of IRAC color-magnitude diagrams to search for mass loss among RGB and AGB stars.

026.13

Do the Large Magellanic Cloud and Milky Way Globular Clusters Share a Common Origin?

Bradley E. Tucker[1], K. A. Olsen[2], B. Blum[2]
[1]Univ. Of Notre Dame, [2]Cerro Tololo Inter-American Observatory, Chile.

We obtained infrared spectroscopy between 1.5552 and 1.5600 microns, of six metal poor red giant stars in NGC 2019, a globular cluster in the LMC, with the Phoenix high-resolution spectrograph at the 8.1-m Gemini South telescope. Current [Fe/H] estimates, based on medium-resolution Ca-triplet spectroscopy and CMD-fitting, disagree by 0.6 dex. In addition, studies of the LMC's globular cluster system performed with the Hubble Space Telescope suggest that the LMC and Milky Way globular clusters have ages within 1 Gyr of each other. Spectral synthesis was carried out in order to calculate accurate oxygen and iron abundances. We used V and I photometry in conjunction with Padova stellar isochrones to calculate the stellar effective temperatures, bolometric corrections, gravities, and luminosities. We were not able to independently measure the microturbulent velocities, and so they were estimated using stellar luminosities and gravities. Preliminary analysis shows a mean [O/Fe] of 0.35 ± .10 for NGC 2019, which is similar to values found in old globular clusters of the Milky Way.

026.15

CN and CH Bandstrengths in Bright Globular Cluster Red Giants

Sarah L. Martell[1], G. H. Smith[1]
[1]UC Santa Cruz.

We present preliminary results from a survey of CN and CH bandstrengths in bright red giant stars (M_V~-1.5) in Galactic globular clusters. Our cluster sample spans a wide metallicity range, from M92 ([Fe/H]=-2.28) to M71 ([Fe/H]=-0.73). The data were all taken using the Shane 120-inch telescope and the Kast spectrograph at Lick Observatory; the homogeneity of the sample makes it ideal for a comparative study of carbon depletion (and therefore deep mixing rate) as a function of stellar metallicity. Thus far we have measured molecular bandstrength indices for CH and CN, as well as indices for Ca and Mg lines; the task of converting the index measurements to carbon and nitrogen abundances will require comparisons with synthetic spectra. The molecular CN index behaves as expected from a study of the literature: within individual clusters, it varies significantly from star to star. The data also allow us to examine the dependence of the Ca and Mg indices on cluster metallicity at a given M_V. The index M_{HK} shows clear sensitivity to [Fe/H] across the full metallicity range of our sample. A similar study is also in progress involving analogous stars in the open clusters NGC 188, NGC 2158, NGC 6791, and NGC 7789 (-0.3 < [Fe/H] < +0.3).

026.16

Why Haven't Dense Globular Clusters Lost More Mass?

Guido De Marchi[1], F. Paresce[2], L. Pulone[2]
[1]ESA, The Netherlands, [2]INAF, Italy.

We report on the discovery of a surprising correlation between the shape of the stellar global mass function (GMF) of globular clusters (GCs) and their central concentration parameter $c=\log(r_t/r_c)$. This result is based on the analysis of a sample of twenty Galactic GCs with solid GMF measurements from deep HST or VLT data. Clusters of low central concentration tend to have a flatter GMF than high-concentration objects and must therefore have lost a conspicuous fraction of their original stars via evaporation or tidal stripping. Conversely, all high concentration clusters in the sample have a steep GMF, which we infer does not deviate substantially from the IMF. This correlation is counter-intuitive, since the same two-body relaxation mechanism that drives a cluster towards higher central density and possibly core collapse should also eventually cause its dissolution via evaporation. Therefore, more concentrated clusters should have lost a larger fraction of their stars and have a shallower GMF than low concentration clusters, contrary to what is observed. Even if the leading cause of cluster dissolution is not evaporation but tidal stripping (via disc or bulge shocking), these mechanisms should in any case accelerate the evolution of a cluster towards higher central concentration. It is possible that the GCs that have lost a significant fraction of their original mass and have already undergone core collapse have also recovered a normal radial density profile. If true, this implies that we may have so far seriously underestimated the number of post core-collapse clusters and that an unknown number of them may be lurking in the Milky Way. The relevance of the observed structure and central concentration of clusters as indicators of their dynamical state would then be undermined as would our understanding of the past and future evolution of the Galactic GC system.

026.17

GRAPE6 Simulations of Star Cluster Evolution with a Hard Binary Population

James E. Maxwell[1], H. N. Cohn[1], P. M. Lugger[1], S. D. Slavin[2]
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We report on a program of N-body simulations of star cluster evolution that is being carried on GRAPE6 systems at Indiana University and Purdue University Calumet. We are simulating idealized star clusters that evolve well beyond core collapse both with and without a primordial population of hard binaries. The goal of this work is to understand the evolution of an X-ray binary population in the environment of a collapsed-core globular cluster such as M15, M30, or NGC 6397. Combined Hubble and Chandra observations of these clusters have revealed substantial populations of X-ray binaries, with spatial distributions that extend well outside of the collapsed cores where the these binaries are likely to be formed by dynamical interactions. Thus, we are investigating the evolution of the spatial distribution of the binary distribution with a particular focus on the diffusion of hard binaries to increasingly large radial offsets from the cluster center. We find a correlation between binary age and its location within the cluster, consistent with the observation that the lower luminosity, older cataclysmic variables in NGC 6397 are typically located farther from the cluster center than the higher luminosity, younger ones.

027: Stellar Populations I
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

027.01

A Survey of Local Group Galaxies Currently Forming Stars: UBVRI Photometry of Stars in Seven Dwarfs and a Comparison with the Entire Sample

Philip Massey[1], K. A. Olsen[2], P. W. Hodge[3], G. H. Jacoby[4], R. T. McNeill[5], R. C. Smith[6], S. B. Strong[7]
[1]Lowell Obs., [2]NOAO, Chile, [3]Univ of Washington, [4]WIYN, [5]Smith College, [6]NOAO, [7]Univ of Texas.

Studies of the resolved stellar content of nearby galaxies provide the only direct way of determining the effect that metallicity (and other environmental factors) play in the formation and evolution of massive stars. Using the 4-m telescopes at Kitt Peak and Cerro Tololo, we have completed a UBVRI survey of stars in M31 and M33 (Massey et al 2006 AJ, 131, 2478) and the seven dwarfs, IC10, NGC 6822, WLM, Sextans B, Sextans A, Pegasus, and Phoenix (newly presented here). In all, we have obtained photometry of 606,547 stars (in B, V, and R, with many having U and/or I as well.) We expect that these data and images will serve as the ″finding charts″ for 8-m spectroscopic studies for decades to come. Here we provide comparisons of the CMDs of these galaxies with those of the Magellanic Clouds, and derive improved values of reddenings using the blue supergiants. Plus, of course, we include some incredibly pretty pictures.

027.02

Halpha Emission Line Stars in M31, M33 and Seven Local Group Dwarfs

Reagin T. McNeill[1], P. Massey[2], K. A. Olsen[3], P. W. Hodge[4], G. H. Jacoby[5], C. Blaha[6], R. C. Smith[7], S. B. Holmes[8]
[1]Smith College, [2]Lowell Observatory, [3]NOAO, Chile, [4]University of Washington, [5]WIYN, [6]Carleton College, [7]NOAO, [8]University of Texas.

While there are many ideas as to how differing galactic environments affect the formation and evolution of massive stars, the numbers of stars with known physical properties outside the Milky Way are too scarce to provide much insight. For instance, we have a very poor idea as to the actual number of Luminous Blue Variables (LBVs) in nearby galaxies, since these have mostly been found on the basis of strong photometric variability over a span of a few decades. But, we know that the Galactic LBVs P Cygni and Eta Car had their last major photometric upsets centuries ago. Were these stars located in a nearby galaxy, we might well be unaware of them. In order to help rectify this situation, we have used the recent UBVRI catalogs of M31 and M33 (Massey et al. 2006) and seven dwarf galaxies in the Local Group (Massey et al. 2007) in conjunction with data from narrowband filters centered on Halpha, [SII] and [OIII] to select Halpha emission sources with similar characteristics to the known LBVs. This search uncovered over 300 potential Halpha emission sources in M31 and M33, and 41 potential Halpha emission sources in the dwarf galaxies. Many of the most promising objects in M31 and M33 were observed spectroscopically at WIYN in September, revealing a wealth of new LBVs and Wolf-Rayet stars. In our poster we will outline our selection method and show some of the newly found emission-lined stars.

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027.03

H-alpha Photometric Survey of M33

Cindy Blaha[1], P. Massey[2], P. Hodge[3], R. Martin[1], L. Gavilan[1], A. Adhikari[1]
[1]Carleton College, [2]Lowell Observatory, [3]University of Washington.

We present the results of a photometric survey of optical emission line regions in M33. Using data from the Local Group Galaxy Survey (LGGS see Massey et al, 2006)), we created continuum-subtracted H-alpha, [OIII] and [SII] emission line images and used flux contours on the H-alpha images to define emission line regions. To date, we have obtained photometric measurements for over 2850 H -alpha emission regions, with a faint flux limit of 10 $^{-15}$ ergs-sec^{-1}-cm^{-2} in the outer regions of the galaxy. Our global H II region luminosity function displays a broad peak centered at a luminosity of 6 x 10 ^{35} ergs-sec^{-1} and extends to fainter luminosities than previously published surveys. We used the H-alpha-defined emission regions to determine fluxes for the [OIII] and [SII] images and created RGB images combining the calibrated emission images from all three filters. These RGB emission line images are being used with our [OIII]/ H-alpha and [SII]/ H-alpha line ratios and published catalogs to develop visual diagnostic tools to identify H II regions, planetary nebulae and supernova remnants in M33. Additional results from the LGGS data are being presented elsewhere at this meeting; see Massey et al and McNeill et al.

SUNDAY

027.04

The Search for Optical Counterparts to Supersoft X-ray Sources near the Nucleus of M31

Sarah Scoles[1], B. Patel[2], R. DiStefano[3], J. Liu[3], P. Barmby[3], F. Primini[3]
[1]Agnes Scott College, [2]Tufts University, [3]Center for Astrophysics.

Members of a subclass of X-ray sources called supersoft sources (SSSs) have luminosities greater than 10^{36} erg/s, soft broadband spectra, and emit little or no emission above 1 keV. Their physical natures are likely to be varied , and optical identification is key to understanding the kinds of sources that comprise SSSs. Approximately 1000 SSSs are thought to be located within the bulge of M31, and an analysis by DiStefano in 2004 idenified twenty-one near its galactic nucleus. Using archival HST data, we searched for optical counterparts for these SSSs. Although we were not able to identify a definite counterpart for any of these sources, we used color-magnitude diagrams (CMDs) to analyze the photometric properties of the candidates and compare them to the properties of the optical sources within three arcseconds of the SSSs. Isochrones of varying metallicities were overlaid on these CMDs to determine the age and nature of the optical sources. In addition to this analysis, we created CMDs for all of the HST data from this region of M31, which provided the most thorough photometric analysis of its nuclear area. At least three of the SSSs_r1-25, r2-12, and r2-61_live in a population of highly luminous red stars, and they are most likely symbiotic binaries whose red giant donor stars emit in the optical wavelengths. The process used to identify these optical counterparts can be applied to any search for the optical identification of SSSs. Research made possible by the NSF REU program and SAO.

027.05

The Magellanic Bridge: The Nearest Purely Tidal Stellar Population

Jason R. Harris[1]
[1]Steward Observatory.

I report on observations of the stellar populations in twelve fields spanning the region between the Magellanic Clouds, made with the Mosaic camera on the 4-meter telescope at the Cerro-Tololo Inter-American Observatory. The two main goals of the observations are to charaterize the young stellar population (which presumably formed in situ in the Bridge and therefore represents the nearest stellar population formed in tidal debris), and to search for an older stellar component (which would have been stripped from either Cloud as stars, by the same tidal forces which formed the gaseous Bridge). I determine the star-formation histories of the young inter-Cloud populations, which provides a constraint on the timing of the gravitational interaction which formed the Bridge. I do not detect an older stellar population belonging to the Bridge in any of our fields, implying that the material that was stripped from the Clouds was very nearly a pure gas.

027.06

Surface Brightness Fluctuations of Old Stellar Systems in UV and Optical Passbands as Population Indicators

HyeJeon Cho[1], Y. Lee[1], S. Yoon[1]
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Originally invented as an extragalactic distance estimator, surface brightness fluctuations (SBFs) also serve as a powerful tool applied to investigate stellar population properties of early-type galaxies and globular clusters. Using Yonsei Population Synthesis models, we hereby present new theoretical predictions for far-UV to near-IR SBFs of old stellar systems. The main asset of our models is the realistic consideration of the systematic variation in temperature distribution of the horizontal-branch as a function of metallicity as well as age. In the light of the new models, we find that when the distance to a system is independently known, SBFs in shorter wavelength range (i.e., UV to B-band) are fully capable of examining the presence and temperature distribution of hot horizontal-branch stars and their progenies.

027.07

First Stars as a Possible Origin for the Helium-rich Population in ω Cen

Ena Choi[1], S. K. Yi[1]
[1]Yonsei Univ., Republic of Korea.

The most massive Galactic globular cluster ω Cen appears to have two, or perhaps more, distinct main sequences. Its bluest main sequence is at the centre of debate because it has been suggested to have an extremely high helium abundance of $\Delta Y \sim 0.4$. The same helium abundance is claimed to explain the presence of extreme horizontal branch stars of ω Cen as well. This demands a relative helium to metal enrichment of $\Delta Y/\Delta Z \sim 70$; that is, more than one order of magnitude larger than the generally accepted value, *1 5*. Candidate solutions, namely, AGB stars, massive stars, and supernovae, have been suggested; but in this study, we show that none of them is a viable channel, in terms of reproducing the high value of $\Delta Y/\Delta Z$ for the constrained age difference between the red and blue populations. Essentially no populations with an ordinary initial mass function can produce such a high $\Delta Y/\Delta Z$ *because they all produce metals as well as helium.* As an alternative, we investigate the possibility of the stochastic ''first star'' contamination to the gas from which the younger generation of ω Cen formed. This requires the assumption that Population III star formation episode overlaps with that of Population II. While the required condition appears extreme, very massive objects in the first star generation provide a solution that is at least as plausible as any other suggestions made before.

027.08

Measuring the Luminosity Function of Low-Mass Stars with Matched Survey Datasets

Kevin R. Covey[1], J. J. Bochanski[2], S. L. Hawley[2], J. Davenport[2], I. Reid[3], D. Golimowski[4]
[1]Harvard Smithsonian Center for Astrophysics, [2]University of Washington, [3]Space Telescope Science Institute, [4]Johns Hopkins University.

We present an initial measurement of the luminosity and mass functions of low mass stars as constructed from a catalog of matched Sloan Digital Sky Survey (SDSS) and 2 Micron All Sky Survey (2MASS) point sources. We have assembled a photometric catalog of 25,000+ matched SDSS and 2MASS point sources, spanning over 30 square degrees on the sky. We have also obtained follow-up spectroscopy, complete to J=16, of 500+ low mass dwarf candidates within a 1 square degree sub-sample, and thousands of additional dwarf candidates in the remaining 29 square degrees. This spectroscopic sample verifies that less than 1% of the photometric catalog is affected by incompleteness, contamination, or bias. Using this sample, we derive the luminosity and mass functions of low-mass stars over nearly a decade in mass ($0.7\ M_{solar} < M_* < 0.1\ M_{solar}$), and compare our findings to previous results. Having validated this method to generate a low mass luminosity function from matched SDSS/2MASS datasets, future studies will enable extending this technique to the entirety of the SDSS/2MASS overlap.

027.09

Substructure in the Galactic Halo

Kenneth W. Carrell[1], R. Wilhelm[1]
[1]Texas Tech University.

New and exciting evidence for stellar substructure is being discovered in our Galactic halo. This presentation will highlight the development of a more rigorous and quantitative way to characterize some of these structures. The use of kinematic, spatial and chemical abundance data for a large sample of stars along with a novel clustering technique will be used to achieve this goal. Some preliminary results will also be shown.

027.10

Globular Cluster Tidal Streams: An Observational Study

William L. Powell[1], A. Lauchner[1], R. Wilhelm[1], A. McWilliam[2]
[1]Texas Tech Univ., [2]Carnegie Observatories.

Globular cluster tidal streams are of interest for what they can tell us of the dynamical evolution of the clusters and of our Galaxy. Recent studies have used photometric and statistical subtraction methods to attempt to separate potential streams from the field stars that contaminate the samples. We chose instead as our primary method to use photometry to select blue stars that match the horizontal branch of the clusters. We then make spectroscopic observations of these candidates to determine their metallicity and radial velocities. Combining these results with the photometric data offers a better picture of the structure and validity of tidal streams. We present photometric and spectroscopic results for several globular clusters and their surrounding fields. Data were obtained at McDonald Observatory, Kitt Peak, and Las Campanas Observatory. SDSS data were also used.

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028: The SDSS Supernova Survey
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

028.01

Object Classification and Photometric Supernova Typing in the SDSS-II SN Survey

Benjamin E. Dilday[1], SDSS-II Supernova collaboration
[1]Univ. of Chicago.

The SDSS-II SN Survey is presently completing the 2nd of a 3-year campaign primarily focused on discovering and obtaining well-measured light curves of Type-Ia SNe. In addition to SNe the survey detects a great many other objects, both physical (e.g. asteroids, AGN) and non-physical (e.g. diffraction spikes). Identifying Type-Ia SN candidates from among these objects is an important component of the survey, allowing us to obtain rapid spectroscopic follow-up. Initial identification of promising SN candidates relies largely on human inspection of objects, but we have made progress towards an automated routine to distinguish different classes of objects based upon a single detection. With multiple photometric epochs, we have a highly efficient system to distinguish among SN types by fitting the light-curve to a library of SN templates. This poster describes the process of identifying Type-Ia SN candidates rapidly and efficiently from among the thousands of objects detected in every night of observation.

028.02

Photometry and Light Curves for the SDSS-II SN Survey

Jon A. Holtzman[1], SDSS-II Supernova Collaboration
[1]*New Mexico State Univ..*

The SDSS-II SN Survey is detecting large numbers of supernovae. We discuss the techniques that are being used to extract brightnesses of these supernovae, including a new scene modelling technique that does not use template-subtracted images, and has the capability to work with data from multiple telescopes. We also describe how the data, which are often taken under non-photometric conditions, are calibrated onto the standard SDSS system. We present some information relative to the understanding of the absolute calibration of the SDSS system. Finally, we show some of the derived light curves.

028.03

Follow-up Spectroscopy for the SDSS-II SN Survey

Chen Zheng[1], SDSS-II Supernova Collaboration
[1]*KIPAC.*

The SDSS-II Supernova Survey team have pursued extensive follow-up spectroscopy campaigns at a number of telescopes (especially HET, APO, Subaru, MDM, NTT, SALT, WHT and KECK). The observations to date (Fall 2005, 2006) have yielded spectra of several hundred SNe, focusing on type Ia's, but including classification spectra and synoptic monitoring of a variety of other supernova types, as well. The Ia data, in particular, allow us to explore the diversity of SN spectra and make connections with the SDSS-measured light curves. In our sample, dominated by supernovae at redshifts ~0.1-0.35, most spectra have significant contamination from the host galaxy, making host subtraction a critical step for the SN identification and subsequent spectral analysis. In this update, we describe spectral results from 2005 and 2006, emphasizing our efforts to improve host galaxy subtraction with PCA methods and describing some spectral diversity in the SN Ia sample.

028.04

Core Collapse Supernova in the SDSS Supernova Survey

David Cinabro[1]
[1]*Wayne State University.*

While the the primary focus of the SDSS-II supernova survey is Type Ia's a large sample of core collapse supernovae is also gathered. We will show some of the excellent core collapse light curves we have observed and discuss the challenges we face in doing science with this sample including measuring a core collapse rate, and producing improved spectral energy distributions for the various types of core collapse supernovae.

028.05

Exploring the Variable Sky with SDSS

Branimir Sesar[1], Z. Ivezic[1], R. H. Lupton[2], J. E. Gunn[2], G. R. Knapp[2], C. M. Rockosi[3], M. Juric[2], J. A. Smith[4], G. Miknaitis[4], H. Li[4], D. Tucker[4], D. J. Schlegel[5], D. Finkbeiner[6], N. Padmanabhan[2]
[1]*Univ. Of Washington,* [2]*Princeton University,* [3]*University of California,* [4]*Fermilab,* [5]*LBNL,* [6]*Harvard University.*

We quantify the variability of faint unresolved optical sources using a catalog based on multiple SDSS imaging observations. The catalog covers the so-called equatorial stripe 82 (Dec<1.27 deg) in the RA range 20h 34' to 4h 00', and contains 58 million photometric observations in the SDSS ugriz system for 1.4 million sources that were observed at least 3 times in each of the gri bands. In each photometric bandpass we compute various photometric statistics such as rms scatter, chi-square per degree of freedom, skewness, kurtosis, minimum and maximum observed magnitude, and use them to select and study variable sources. We find that at least 2% of faint optical sources appear variable at the 0.05 mag level simultaneously in the g and r bands. About 80% of the variable population are quasars and RR Lyrae stars, although they represent only 3.5% of the sources in the adopted magnitude-limited sample (g<20.5). We will discuss in detail our selection methods and the distribution of sources in the multi-dimensional magnitude-color-variability space.

029: Variable Stars
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

029.01

The Selection of RR Lyrae Stars Using POSS and SDSS

Oliver J. Fraser[1], J. R. Barton[1], B. J. Oldfield[1], T. P. Biesiadzinski[1], D. A. Horning[2], J. A. Baerny[1], F. Kiuchi[1], D. Krogsrud[1], D. S. Longhurst[1], L. P. McCommas[1], J. A. Scheidt[1], R. Covarrubias[1], K. Covey[1], C. Laws[1], B. Sesar[1], Z. Ivezic[1]
[1]*Univ. of Washington,* [2]*Bainbridge High School.*

We test a method for identifying candidate RR Lyrae stars based on a comparison of POSS and SDSS photometry (Sesar et. al. 2005). Our candidate stars range in SDSS g magnitude from 14.4--16, or a distance of 6--12 kpc. Follow-up photometry obtained at Manastash Ridge Observatory typically includes 30-40 points per light curve. We find that at least two thirds of our sample of 23 objects are clearly variable, with light curves consistent with RR Lyrae. Candidate RR Lyrae were selected using stars that had brightened at least 0.3 magnitudes between POSS and SDSS, and which had SDSS magnitudes and colors consistent with the cuts in Ivezic et al. 2004.

029.02

Using RR Lyrae Stars to Proble the M33 Halo

Barton J. Pritzl[1], M. Buttermore[1], A. Saha[2], E. D. Skillman[3], K. A. Venn[4], H. L. Morrison[5], E. W. Olszewski[6]
[1]*Macalester College,* [2]*NOAO,* [3]*University of Minnesota,* [4]*University of Victoria, Canada,* [5]*Case Western Reserve University,* [6]*Steward Observatory.*

M33 appears to have a small field halo population. With most of its globular clusters being younger and more metal-rich than the Milky Way's halo clusters, this suggests that mergers played a minor role in its past. We have taken observations of three fields along the SE minor axis of M33 to search for RR Lyrae stars and use these variable stars to determine whether they belong to the disk or the halo. We present the RR Lyrae stars we have detected and discuss their distribution in M33.

029.03

The V-R Color of RR Lyrae Stars at Minimum Light

Andrea M. Kunder[1], B. Chaboyer[1], A. Layden[2]
[1]*Dartmouth College,* [2]*Bowling Green State University.*

We present preliminary R-band light curves for 15 local field RR Lyrae variable stars. The intensity mean magnitudes and light amplitudes are obtained for each star. Using corresponding V-band light curves from the literature and supplemented with new photometry, (V-R) colors at minimum light are determined for a subset of these stars. The use of (V-R) colors at minimum light as a means for measuring interstellar reddening is discussed. From 18 stars with a wide range of metallicities and pulsation periods, the mean dereddened RR Lyrae color at minimum (V-R) light is determined. The rms scatter indicates the precision to determine the interstellar reddening. Any dependence of color on metallicity or amplitude is too weak to be formally detected. This data is useful to calibrate the reddening in the MACHO RR Lyrae databases, taken in the V and R bands.

029.04

Photometric Observations of RR Lyrae Stars at Red Buttes Observatory

Frances Rivera[1], R. Ressler[1], K. Kinemuchi[1], H. A. Smith[2]
[1]University of Wyoming, [2]Michigan State University.

We present our photometric observations and results of field ab-type RR Lyrae (RRab) stars. These RRab stars were mined from the Northern Sky Variability Survey (NSVS) and were selected from a subsample list where the period had been indeterminate due to too few observations and period aliasing. The photometric data were collected at the Red Buttes Observatory (University of Wyoming). Supplemental data were obtained at the Michigan State University Observatory. In addition, data from the All-Sky Automated Survey were combined with our datasets. New period solutions, amplitudes and mean magnitudes are determined for these RRab stars. With these updated parameters, a full photometric analysis can be completed.

This project is funded through the University of Wyoming REU-SURAP program.

029.05

SMC RR Lyr Abundances from Ca*by* Photometry

Scott R. Baird[1], H. A. Smith[2], S. C. Keller[3], K. H. Cook[4], A. R. Walker[5]
[1]Benedictine College & University of Kansas, [2]Michigan State University, [3]Mount Stromlo Observatory, Australia, [4]Lawrence Livermore National Laboratory, [5]Cerro Tololo Inter-American Observatory, Chile.

The CTIO 4-m MOSAIC2 imager was used with the Ca and Stromgren *b* and *y* filters to examine RR Lyrae stars in two regions of the Small Magellanic Cloud. The regions are centered at (RA, Dec) values of (00:37:44, -73:08:12) and (01:02:23, -72:24:00). Preliminary processing of the frames was done using IRAF mscred, while photometry was obtained using Stetson's DAOphot II and ALLSTAR. RR Lyr stars in the fields are identified from the list of variable stars in the SMC found by the MACHO project. The magnitudes are used to make two color indices, *b-y* and hk = Ca 2*b* + *y*. By locating these stars in the hk/*b-y* color-color diagram their chemical compositions are determined.

029.06

A Photometric Study of Starspot Evolution on HIP 106231

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HIP 106231 (LO Pegasi) is a single K8 young solar analog with a 10.17-hour rotation period. Prior Doppler imaging and photometric studies have established the presence of a polar spot with projections down to middle latitudes. BVRI CCD images of the star were obtained on the nights of July 16, 17 and 18 and August 3, 5 and 6, 2006. Aperture photometry was performed to generate light curves. The light curves were inverted to produce surface maps via an algorithm which makes no a priori assumptions regarding the number of spots or their shapes. We present maps illustrating spot evolution over the observation period.

029.07

Variable Stars in the LMC Globular Cluster NGC 1754

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[1]Michigan State University, [2]Transylvania University, [3]Pontificia Universidad Catolica de Chile, Chile, [4]Macalester College.

We have used BVI observations taken with the SMARTS 1.3m telescope and with the SOAR telescope to identify variable stars in the vicinity of the old LMC cluster NGC 1754. We present light curves and periods for the variables and classify the variables according to type. The probability that the RR Lyrae stars found in the neighborhood of NGC 1754 actually belong to the cluster is discussed. Unlike most globular clusters of the Milky Way halo, many of the old star clusters of the LMC have Oosterhoff intermediate properties. The Oosterhoff classification of field and cluster RR Lyrae stars near NGC 1754 is considered. We thank the NSF for partial support of this research.

029.08

The Secret Lives of Cepheids: Discovery of Strong FUV Emissions in the Classical Cepheids Polaris and beta Dor

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We report on the surprising recent discovery of strong FUV emissions in two bright, nearby Classical Cepheids from analyses of *FUSE* archival observations. Polaris (V = +1.98, F7 Ib-II, P = 3.97-d; d ~ 132-pc) and beta Dor (V = +3.77, F6 Ia; P = 9.84-d; d ~ 350-pc) are currently the only two Cepheids to have been observed with *FUSE*, and beta Dor is the only one to have multiple spectra. The *FUSE* wavelength region is ideal for such a study since it is uncontaminated by the continua of these F supergiants. Both Cepheids show strong C III (977, 1176) and O VI (1032, 1038) emissions, indicative of 50,000 500,000 K plasma, well above the photospheric temperatures. Also, more remarkably, beta Dor displays variability in the FUV emission strengths which appears to be correlated to its 9.84-d pulsation period. **This phenomenon has never before been observed in Cepheids**. The FUV studies are presented along with our recent *Chandra* X-ray observation of Polaris, in which an X-ray detection (log Lx = 28.8 ergs/sec) was found. Further FUV/X-ray observations have been proposed with *FUSE/XMM* to unambiguously determine the origin and nature of the observed high energy emissions from the targets, possibly arising from warm winds, shocks, or pulsationally induced magnetic activity. The initial results of this study will be discussed, along with their impact on understanding the structure, heating, dynamics and possible magnetic activity of Cepheid (and related Hybrid Star) atmosphere.

We gratefully acknowledge support for this project from *NASA* grant *Chandra-GO6-7011A* and *NSF* grant *AST05-07542*.

029.09

Correlation of R Cassiopeia's SiO Maser Properties

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Silicon monoxide masers originate in the circumstellar environment of many long period variable stars. Silicon monoxide emission from R Cassiopeia has been observed over several stellar periods in the v = 0, 1, 2, and 3, J=1-0 transitions. The integrated intensities have been analyzed for correlations. Since the masers are observed to occur at different distances from the star, the correlations constrain the possible pumping mechanisms.

029.10

APT Observations of the Bright Cepheid HD 32456

William Z. Taylor[1], R. J. Dukes, Jr.[1]
[1]College of Charleston.

In 1996 an analysis of Hipparcos observations revealed that the star HD 32456 was a Cepheid variable with a period of 3.29 days. Further photometric observations confirmed this and enabled the period to be refined to 3.2942 days. An inspection of the photometric light curves show relatively small scatter indicating that this is a singly periodic Cepheid. However, since approximately 10% of Cepheids with periods less than 5 days are double mode and there are only 22 double mode Cepheids known it seems important to verify this. We therefore decided to place this star on the observing program of the Four College Consortium Automatic Photometric Telescope in order to investigate the possible presence of a secondary period. During the 1998 observing season we obtained 274 Stromgren *uvby* observations of this star spread over one hundred days. A preliminary analysis of the data revealed that it was one of the shortest period fundamental mode Cepheids with a slight indication of a second period with a value close to that expected for a first overtone. Therefore additional 526 observations were obtained during the 2005-2006 observing seasons. Combining all observations gave no indication of a first overtone term. Separate analysis of the two sets of data yielded slightly different frequencies with a 1996 value of 0.30348 c d^{-1} and a 2006 value of 0.30351 c d^{-1} . The latter is essentially identical to that from the combined data set as well as that of the archival study of Berdnikov et al. (IBVS, 4375, 1996). The question therefore is whether or not there is a relatively short term period variation. Observations are continuing in an attempt to answer this question. This work has been supported by a NSF Grants AST95-28906 and AST05-07551.

029.11

Frequency Determination for the Slowly Pulsating B Star, HD21071, From Combined Geneva and Stromgren Photometry

Melissa Sims[1], R. J. Dukes, Jr.[1]
[1]*College of Charleston.*

This project is comparison of several studies done on the variable star HD21071, which was previously determined to be Slowly Pulsating B star by Waelkens, et. al. (Astron. Astrophys. 330, 215-221, 1998) with a suggested period of .841 day (1.19 c d^{-1}). Several later studies including Mills, L. R., et. al. (BAAS 31, 1482, 1999) and Andrews, J. E, et. al. (AAS Meeting 203, #83.14, 2003) confirmed the .841 period and tentatively suggested other possible periods based on new data, including 0.704 day (1.42 c d^{-1}), 0.775 day (1.29 c d^{-1}), and 1.14 day (0.878 c d^{-1}) periods. This project merges Geneva *V* data and data from the *y* filter from the FCAPT data in the Stromgren *uvby* system by using a bilinear transformation from Harmanec et. al. (Astron. Astrophys. 369, 1140, 2001). Frequencies were determined using the Period04 program, which utilizes a least square fitting technique, to determine frequencies in the two data sets separately. We then analyzed the merged data set resulting in confirmation of the periods found in the individual data sets. The reality of the these frequencies was tested using multiple methods including least squares analysis and a check of the signal to noise ratio. We would like to thank Connie Aerts and Peter De Cat for providing the Geneva data as well as a copy of their preliminary analysis of this data. This work has been supported by NSF Grant AST-0071260 & AST-050755

029.12

Frequency Determinations of Five Slowly Pulsating B Stars

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[1]*College of Charleston.*

We report the analysis of the slowly pulsating B stars HD1976, HD25558, HD199122, HD222555, and one suspected one, HD44112. These stars have been observed since late 1999 by the Four College Consortium Automatic Photoelectric Telescope (FCAPT). After reducing the data using standard APT techniques we have analyzed it for periodicity using several different period determination programs including Period04 and a version of the CLEAN algorithm. We have confirmed 5 distinct periods for HD1976, 2 periods for HD25558, 3 periods for HD44112 and one possible candidate, 3 periods for HD199122 and 3 candidates, and 5 periods for HD222555, with 4 candidates. The signal-to-noise ratio as defined by Period04 for these frequencies is significantly higher than the value of 4 which is generally accepted as indicating an actual period. Observations are continuing on this group of stars. This work has been supported by a College of Charleston Research Presentation Grant and NSF Grants AST95-28906 and AST05-07551.

029.13

Spitzer 24µ and 70µ Imagery of Symbiotic Stars with Extended Nebular Ejecta

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[1]*IPAC/SSC,* [2]*CUA/GSFC,* [3]*Lund Obs., Sweden,* [4]*CUA,* [5]*CUA/UDC/GSFC.*

We have surveyed seven symbiotic stars which have extended optical nebulosity, using the Spitzer MIPS detector to obtain images at 24µ and 70µ with resolutions of ~3 and ~5 arc seconds respectively, covering fields several arc minutes across. The presence of extended optical emission in some symbiotics, in addition to theoretical considerations, suggests that many, if not all, symbiotics may have a history of ejection events. MIPS imagery has allowed a sensitive search for any older, colder dust surrounding symbiotics which could be much more extended than optical emission studies indicate, permitting an investigation of possible ejection events which may not yet have been detected by other means. In addition, cold dust can be a tracer of neutral gas. We have detected 24µ and 70µ extended emission around two of our targets. The sensitivity of this search places a strong constraint on possible extended dust where no emission is detected.

029.14

Fast-Drifting Radio Bursts Seen on the Flare Star AD Leo with the Arecibo Observatory

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[1]*University of Maryland,* [2]*National Radio Astronomy Observatory.*

We report on observations of two radio bursts at wavelengths 18--27 cm seen on the flare star AD~Leonis with the Arecibo Observatory in April 2005. These observations are unique in providing the highest time resolution (1 ms) and largest instantaneous contiguous frequency coverage ($\Delta\ \nu$ ~ 400 MHz) of stellar radio bursts. The second radio burst on April 9, 2005 near 01:14:50 UT, exhibited a combination of fast-drifting radio bursts and diffuse emission. A comparison of this data degraded to 10 ms time resolution with previous radio bursts (reported in Osten & Bastian 2006) reveals numerous similarities. However, when examined at the highest time resolution, the drifting radio bursts have predominantly negative slopes (the bursts appear at high frequency and drift to lower frequencies), with a characteristic drift rate of ~ 3 GHz/s. We discuss this new finding in light of possible coherent emission mechanisms, and suggest that these properties are consistent with plasma radiation from beams of accelerated particles traversing AD Leo's low corona.

029.15

VLA Imaging of Cyngus X-3 Jets at 8.5 GHz

Catherine A. Whiting[1], M. Rupen[2], A. Mioduszewski[2]
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Cygnus X-3 is a famous relativistic jet source, which often undergoes large radio flares of up to 30 Janskys. Previous observations (Mioduszewski et al. 2001, ApJ, 553) of this source with the Very Long Baseline Array (VLBA) showed strong evidence for a one-sided southern jet, while Very Large Array (VLA) observations (Martí et al. 2006, A&A, 451) showed a double-sided jet, stronger to the north. This is puzzling, since other famous microquasar sources have always been consistent in showing highly symmetric, double-sided jets. To address this issue, multi-epoch VLA imaging before and after two major flares of Cygnus X-3 at 8.5 GHz will be presented and compared with previous radio observations. After a flare of about one Jansky we observed a double-sided jet, dominated strongly to the south, but after a later flare of 17 Janskys we observed a double-sided jet, dominated to the north. We will discuss further the nature of the apparent changes in jet dominance and whether these variations are due to the source itself or its environment or some combination of both. We will also discuss jet speed, flux evolution, and the first detection of linear polarization in this source.

029.17

Photometric and Spectroscopic Observations of Two delta Scuti Variable: V919 Herculis and V927 Herculis

Charles R. Phillips[1], E. G. Hintz[1]
[1]*Brigham Young University.*

SUNDAY

We will present new results for two less studied delta Scuti variable stars: V919 Her and V927 Her. 11 nights of photometric observations of V919 Her, in filters B and V, were made at the 0.4-m David Derrick Telescope (DDT) of the Orson Pratt Observatory (OPO), the 0.4-m telescope of the BYU West Mountain Observatory (WMO), and the 1.8-m Plaskett telescope of the Dominion Astrophysical Observatory (DAO). Eight nights of photometric observations of V927 Her, in filters B and V, were made at the 0.4-m DDT of the OPO, and the 1.8-m Plaskett telescope of the DAO. Spectroscopic observations of both stars were made at the 1.2-m McKellar telescope of the DAO. The recently published period for V919 Her is 0.1037 days. Two closely spaced periods of 0.1305 and 0.1250 days have been published for V927 Her. With very little published about either star, this data will extend the baseline of both stars, and will allow us to investigate these periods, as well as frequencies, amplitudes, and radial velocities.

We acknowledge funding from a research assistantship from the BYU College of Physical and Mathematical Sciences.

029.18

An Analysis of the Variable Star V577 Ophiuchi

Christine Forsyth[1], E. G. Hintz[2]
[1]Bryn Mawr College, [2]Brigham Young Univ..

New data were obtained for the variable star V577 Ophiuchi. This is an eclipsing binary system with the primary component being a delta Scuti variable, which leads to a complicated light curve. The new data were obtained on the 0.4-m David Derrick Telescope of the Orson Pratt Observatory on the BYU campus. These new data were combined with previous observations from the same system to examine the pulsational and orbital parameters for the system.

This research was conducted as part of a summer Research Experience for Undergraduates program held at BYU. We would like to acknowledge NSF grant PHY-0552795.

029.19

Rotational Velocities of delta Scuti Variable Stars

Tabitha C. Bush[1], E. G. Hintz[1]
[1]Brigham Young Univ..

Spectra in the region of H-beta have been obtained for a sample of 243 of the 245 known delta Scuti variable stars which are north of -10 degree declination and brighter than 13th magnitude. We have also obtained a sample of rotational velocity standards in the same spectral region. From this we are assembling a catalog of rotational velocities for delta Scuti variables. We are studying and comparing two previously published methods for determining these rotational velocities. We will use one or both of these methods to calculate rotational velocities for all stars in our sample. In addition, we will determine the H-beta color index for all of the stars in our data set.

029.20

The Curious Case of GSC3196-641: Double-mode RR Lyrae or a Spotted Rotating Star?

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[1]Univ. of Minnesota, [2]Univ. of Saskatchewan, Canada, [3]American Association of Variable Star Observers.

GSC 3196-641 (α=21 41 25.412, β=+43 43 23.86) is a curious variable star that is not strictly periodic. It shows modulations in the light curve which suggest either double-mode pulsations or star spots. It may be associated with a ROSAT X-ray source. A low-resolution spectrum indicates it is a G7III-type star but does not show the CaII H & K line emission that one would expect from coronal activity. In this poster we present precision photometric observations, low-resolution spectra and frequency analysis.

030: YSO / Star Formation I
AAS Poster, Sunday, 9:20am-6:30pm, Exhibit Hall 4

030.01

Stellar and Circumstellar Properties of Class I Protostars

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[1]Rice University, Lowell Observatory, [2]Lowell Observatory, [3]Rice University, [4]Institute for Astronomy, University of Hawaii.

We present a study of the stellar and circumstellar properties of Class I sources using low-resolution (R~1000) near-IR spectroscopy. We measure key spectral lines and features in 8 objects and fit models generated from standard star spectra to the protostellar spectra to obtain values for visual extinction, K-band excess, and estimates for the spectral type, all of which are found to be consistent with typical Class I protostellar values. Some properties for certain stars found in our analysis vary from values presented in the literature; we discuss and analyze the origin of these differences. We determine extinction to each target star using 3 different methods, compare the resulting values, and speculate as to why they are discrepant. Our results illustrate the value of low-resolution spectroscopy in the study of protostars and their environments; however, the optimal approach to this type of investigation may ultimately involve a combination of highand low-resolution near-infrared and mid-infrared observations. This work has been supported in part by NSF grant AST-0453611.

030.02

An Unbiased Statistical Study of Herbig AeBe Eystems in the X-rays Using Chandra

Murad Hamidouche[1], S. Wang[1], L. W. Looney[1]
[1]Univ. of Illinois.

We report a statistical study of an X-Ray emission toward Herbig AeBe stars of a large sample of 22 sources using Chandra. The choice of sources is thoroughly arbitrary as more than half of the observations are serendipitous. The sensitivity and high angular resolution of Chandra allow an unprecedented study of X-Ray emission toward Herbig AeBe stars. About 68% of the sample are detected in the X-Ray. The estimated luminosities are within the range Log Lx = 28 33 ergs/s, mostly higher than T Tauri stars, but overlapping the range of T Tauri stars. The estimated plasma temperatures are mostly in the soft X-Ray band. Comparing the X-Rays to the stellar properties, we deduce a ratio of Lx/L_{bol} = -5.4$\pm$1. This value is higher than OB stars but lower than lower-mass late stars. No apparent correlation was found with the stellar rotational velocity allowing us to exclude solar like magnetic activity as the origin of the X-Rays. The deduced wind kinetic energy is $\approx$100 times higher than L_X, but our deduced temperatures are relatively high to be produced by such a kinetic energy. This suggests that the wind shock model does not appear to be responsible for the X-Rays. The X-Ray luminosity of Herbig AeBe stars when compared to T Tauri stars have a different distribution at an 82% confidence level; we suggest that the typical X-Ray emission of Herbig AeBe stars does not come from unseen late-type stars companions. If these X-Rays are emitted by the Herbig stars, they must have magnetic activity.

We acknowledge support from the Laboratory for Astronomical Imaging at the University of Illinois and NSF AST 0228953. We would like to thank Alessandro Gardini and Rosa Williams for their interesting comments.

030.03

Search for Close Binaries of Herbig Ae/Be Stars

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[1]Pontificia Universidad Catolica de Chile, Chile, [2]UC Santa Cruz, [3]CTIO, Chile, [4]Gemini South Observatory, Chile, [5]Macalester College.

We present the analysis of high-resolution near-infrared adaptive optics images of a sample of 42 Herbig Ae/Be (HAEBE) stars. HAEBE stars are pre-main sequence stars with spectral type B through F, which show emission lines and NIR excess associated to a circumstellar disk.

HAEBE stars are intermediate-mass stars with masses between 2 and 8 solar masses, in between low-mass and high-mass stars, and as such a deeper

understanding of the formation of HAEBE stars, will be important for modeling the formation of stars as function of mass.

Moreover, information on the multiplicity of pre-main sequence stars poses additional constraints on star formation models, as presumably the primary and its companions form at the same time.

Here we present results of a search for close companions to known HAEBE stars

using NIRI/Altair at Gemini North. Companions can be detected as close as 0.1 arcsec and up to 5 magnitudes fainter in the best conditions. We have analyzed 42 stars, of which 17 binaries were found with typical detection limits rho $>$ 0.087 for small dK and dK $<$ 9.7 for larger rho. Objects as faint as dK $=$ 5 could be detected at rho $>$ 0.3.

030.04

Wide-Field NIR Polarimetry of the Orion Nebula

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[1]National Astronomical Observatory, Japan, [2]Tokyo University of Science, Japan, [3]Kyoto University, Japan, [4]Nagoya University, Japan, [5]University of Hertfordshire, United Kingdom.

The Orion Nebula and its associated population of stars are amongst the best studied objects in the sky. The HII region excited by the Trapezium, the two massive young sources, IRc2 and BN, the Bright Bar, and the Orion Nebular Cluster are best clearly seen in recent infrared images. However, wide-field infrared/optical imaging was scant in this famous region. We have conducted wide-field (8’x8’) polarimetric imaging in near-infrared (JHKs bands, simultaneously) with our IRSF/SIRIUS instrument in South Africa. The polarization images contain a wealth of information, including: a very extended bipolar infrared reflection nebula (IRN), illuminated by a cluster of young stars; several other, smaller-scale, IRN systems around less-massive young stars including the famous optical source theta 2 Ori C; and a number of unresolved systems around young stars and brown dwarfs showing possible intrinsic polarizations. We have also performed aperture polarimetry of 500 point-like sources, which reveals the detailed magnetic field structure within the cloud. They are compared with the far-infrared and submillimeter polarimetry.

030.05

Spitzer IRAC and MIPS Observations toward High-mass Star Forming Regions

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Spitzer IRAC and MIPS observations toward high-mass star forming regions are presented. With the photometry from the IRAC and 2MASS, we derive the magnitude-color and color-color diagrams to investigate evolutionary stages of the YSOs in the fields. Toward sources well resolved in MIPS 24μm and/or 70μm, we fit their SEDs combining the (sub)mm data and subsequently estimate their total luminosities. By comparing the IRAC images with the (sub)mm continuum emission and CO molecular outflows, we study the dynamical interaction of massive young stars with the surrounding environment.

030.06

Lithium Depletion in the Beta Pictoris Moving Group

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We present a study of lithium depletion in twelve late-type pre-main-sequence stars in the coeval Beta Pictoris Moving Group (BPMG). The age of this group (~12 Myr) is well constrained because all of the stars in the sample have Hipparcos distances. We have determined Li abundances for these K and M stars using equivalent width measurements of the 6707.8 Angstrom Li I line from new high-resolution, high-S/N echelle spectra, and we compare these abundances to models of pre-main-sequence Li depletion by Baraffe et al. (1998), D’Antona & Mazzitelli (1997, 1998), and Siess, Dufour, & Forestini (2000). Significantly more lithium depletion is observed in the sample than is predicted for a group of this age. In particular, the discrepancy between the predicted and the observed lithium abundances increases with decreasing effective temperature, suggesting a problem with theories describing pre-main-sequence lithium depletion. Our data indicate that M stars deplete lithium more rapidly than predicted, which could make M-type post-T-Tauri stars difficult to identify. In addition, we compare our results to the work of Song, Bessell, & Zuckerman (2002) on HIP 112312. In contrast to that work, we did not observe the lithium depletion boundary of the BPMG; none of the three M4.5 stars in the sample showed evidence of lithium (log N(Li) $<$ -0.5), indicating a lithium depletion boundary later than M4.5, further underscoring the gap between age estimates from lithium depletion and those from theoretical evolutionary tracks.

We gratefully acknowledge the support of the National Science Foundation through grant AST-0307830.

030.07

A Search for OH Maser Emission In Bright-Rimmed Clouds

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We present a radio wavelength study of OH maser lines toward 46 bright-rimmed clouds in search of star formation activity. Observations were made using the National Radio Astronomy Observatory (NRAO) Green Bank Telescope (GBT) at frequencies of $\nu = 1612$ MHz, 1665 MHz, 1667 MHz, and 1721 MHz. This study yielded a low detection rate of OH masers toward these regions. OH masers are efficient tracers of young star formation, so this result is puzzling if the scenario of induced intermediateand high-mass star formation within these regions is correct. Further investigation is needed in order to determine the star forming nature of these bright-rimmed clouds.

030.08

A Mid-Infrared Survey of Class I/Flat-Spectrum Binary/Multiple Systems

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We have obtained new mid-infrared observations of 65 Class I/Flat-Spectrum (F.S.) objects in the Perseus, Taurus, Chamaeleon I and II, Rho Ophiuchi, and Serpens dark clouds. These objects represent a subset of the young stellar objects (YSOs) from our previous near-infrared multiplicity surveys. We detected 45/48 (94%) of the single sources, 16/16 (100%) of the primary components, and 12/16 (75%) of the secondary/triple components of the binary/multiple objects surveyed. The composite spectral energy distributions (SEDs) for all of our sample YSOs are either Class I or F.S., and, in 15/16 multiple systems, at least one of the individual components displays a Class I or F.S. spectral index. However, the occurrence of mixed pairings, such as F.S. with Class I, F.S. with Class II, and, in one case, an F.S. with a Class III (Cha I T33B), is suprisingly frequent. Such behavior is not consistent with that of multiple systems among T Tauri stars (TTS), where the companion of a classical TTS also tends to be a classical TTS, although other mixed pairings have been previously observed among Class II YSOs. Based on an analysis of the spectral indices of the individual binary components, there appears to be a higher proportion of mixed Class I/Flat-Spectrum systems (65-80%) than that of mixed Classical/Weak Lined T Tauri systems (25-40%), demonstrating that the envelopes of Class I/Flat-Spectrum systems are rapidly evolving during this evolutionary phase. We report the discovery of a steep spectral index secondary companion to ISO-Cha I 97 (Alpha > +3.9), detected for the first time via our mid-infrared observations. The secondary component of this system is a member of a rare class (one of four known) of very steep spectral index YSOs, those with Alpha > +3.

030.09

CO Emission from the Inner Regions of Disks with Dust Clearing

Joanna M. Brown[1], G. A. Blake[1], C. Salyk[1], A. C. Boogert[2]
[1]Caltech, [2]AURA/NOAO-South, Chile.

The inner regions of protoplanetary disks (R<50AU) are likely to be the most active regions of planet formation and thus to hold the key to understanding the formation of solar systems like our own. The two most popular theories of planet formation involve generating planets through gravitational instability (Boss 2003) or via the core-accretion scenario in which cores accrete gas and dust and generate gaps in the disk (Pollack et al. 1996). There is a small sample of disks which, based on their SEDs, appear to have cleared most of the small dust grains out of the inner disk. One obvious question is, what is the state of the gas in the inner region?

CO is a good gas tracer in protoplanetary disks as it is abundant but easier to observe with ground based telescopes than molecular hydrogen. We have used NIRSPEC on Keck II to obtain high resolution spectra (R~25,000, v=12.5 km/s) of the 4.7 micron CO v=1-0 fundamental emission band. Optically thick 12CO emission is seen from the majority of the sample while 13CO is not detected. Thus, we get decent bounds on the CO mass surface density and fairly rigorous lower bounds on the total mass surface density by assuming most of the cosmically available carbon is locked up as CO. With NIRSPEC, the lines are spectrally resolved and the line profiles can be used to locate the gas within the disk. The various line strengths reflect the populations of the different energy rotational levels and provide information about the energy and temperature structure of the gas within the disk as well as an estimate of the alpha viscosity parameter assuming steady state accretion. All this information allows a reconstruction of the inner disk region which can then be compared with the predictions from planetesimal/oligarchic growth models.

030.10

Fission of Rapidly Rotating Protostars

Jennifer L. Lozier[1], S. Michael[2], R. H. Durisen[2], J. N. Imamura[3]
[1]Mount Union College, [2]Indiana University, [3]University of Oregon.

It has long been conjectured that close binary star systems might form through the fission of a rapidly rotating and contracting protostar (for a review see Durisen & Tohline 1985). Protostars that are axisymmetric beyond the point of dynamic bar-like mode instability do not fission (Imamura et al. 2000), but contracting non-axisymmetric protostars might encounter bifurcations of surface shape leading to fission. In addition, they may be susceptible to hydrodynamic instabilities, first described by Lebovitz & Lifschitz (1996), whose nonlinear effects are still unknown. We will present a series of hydrodynamic simulations of rapidly rotating polytropic protostars to investigate fission in contracting protostars. The initial model is an equilibrium configuration with $T/|W| \approx 0.14$, where T is the rotational kinetic energy and W is the total gravitational energy. It is given a bar-like $\cos(2\varphi)$ density perturbation with an amplitude of .02, .10 or .25. These perturbed polytropes are then cooled by reducing the polytropic constant K where $P = K\rho^{1+1/n}$. *Here P is the pressure, ρ is the density and n is the polytropic index, here chosen to be 3/2. As the polytrope contracts, we find no strong signal of a growing instability. All simulations evolve through to the dynamic bar-like mode instability point at $T/|W| \approx 0.27$ and produce a ring around a bar, not a binary. However, there is some indication of amplitude growth at a $T/|W| \approx 0.22$. We are investigating this growth further with follow-up simulations that start at an equilibrium model with a $T/|W| \approx 0.22$. This enables us to study growth in this regime with higher resolution and slower contraction rates.*

This work has been supported by the National Science Foundation through grant AST-0452975 (astronomy REU program to Indiana University).

030.11

Formaldehyde Emission From Protostellar Region L1448IRS3

Claire M. Davy[1], J. Mangum[2], A. Wootten[2]
[1]Bryn Mawr College, [2]NRAO.

Accurate measurements of temperature and density are essential in determining whether there are stars forming in a protostellar region and, if so, what the evolutionary state and physical characteristics of these protostars might be. Formaldehyde is a proven molecular probe for this purpose. Measurements of two formaldehyde transitions obtained at the BIMA interferometer and the IRAM 30 meter radio telescope have been used to derive the temperature structure within the L1448IRS3 protostellar region. A model of this temperature structure has been derived by constraining the physical conditions within L1448IRS3 using a monte carlo radiative transfer model to simulate the formaldehyde radiative transfer and molecular excitation in the cloud. With this kinetic temperature information we have gained a better understanding of the physical state of L1448IRS3.

030.12

A Search for Young Stellar Objects in the Horsehead Nebula

Brendan P. Bowler[1], W. H. Waller[1], S. T. Megeath[2], B. M. Patten[3], M. Tamura[4]
[1]Tufts University, [2]University of Toledo, [3]NSF, CfA, [4]NAOJ, Japan.

We present the preliminary results of a study to determine the state and extent of star formation in the Horsehead Nebula (B33). B33 is thought to be in a unique evolutionary phase as an emergent Bok globule still in contact with the dark cloud L1630. The nearby massive star Sigma Orionis irradiates this photodissociation region, casting B33 in silhouette against the background HII region IC434. The spatial extent and evolutionary phases of any young stars in and around B33 reflects the history and future of this globule. Deep near-infrared images of B33 in the JHK_S bands with the InfraRed Survey Facility's 1.4m telescope in Sutherland, South Africa, have revealed 18 candidate YSOs based on excesses of near-infrared emission, indicative of warm circumstellar disks, as seen on the near-infrared color-color diagram. Two more candidate young stars have been identified from two unpublished, archival HRI and PSPC ROSAT X-ray observations of the region. We will use mid-infrared photometry from the Spitzer Space Telescope to confirm that these candidates are bona fide YSOs and to ascertain their evolutionary class. This project was made possible in part by the Massachusetts Space Grant Consortium and the Tufts Summer Scholars Program.

030.13

Outflow Evolution in Turbulent Clouds

Andrew Cunningham[1], A. Frank[1], A. C. Quillen[1], E. G. Blackman[1]
[1]University of Rochester.

We present 3D hydrodynamic simulations of the evolution of time-decaying protostellar outflows that are immersed in a turbulent background. These simulations were carried out using the AstroBEAR AMR MHD code. This work represents the first results in a program of "ecological studies" of star formation where the cloud, stars and outflows are viewed as a coherent interacting system. We isolate outflow-cloud feedback mechanisms by simulating the long-term evolution of extinct fossil outflow cavities as they are shredded and subsumed into their environment. We consider the deposition of energy and momentum from the outflow into the parent cloud via E(k) power spectra and globally integrated kinetic and thermal energies to quantify time dependent jet-cloud feedback process. These results are used to interpret observations of multiple outflow systems, including the long-term evolution and decay of the outflow sources.

030.14

Protostellar Outflows and their Influence on the Star Formation Process

Hector G. Arce[1]
[1]Am. Museum of Natural History.

Outflows from young stellar objects originate very close to the forming star, and thus they must interact with the infalling envelope surrounding the protostar and disk. Since circumstellar envelopes are the main mass reservoir of low-mass protostars, outflow-induced perturbations must have a significant effect on the final mass of the nascent star. Circumstellar envelopes have sizes in the order of 1000 AU, corresponding to approximately 10″ in the nearest star-forming regions. Detailed studies of the impact of outflows on the envelope and the infalling gas therefore require high spatial resolution millimeter interferometer observations. Moreover, the combination of infall and outflow motions, rotation, and turbulence, in the presence of steep density gradients on very small scales, in turn demands both high spectral resolution and observations of a number of molecular species which trace different density and kinematic regimes. I present recently obtained data from millimeter and sub-millimeter interferometer studies that show the impact outflows have on the circumstellar envelope. In particular, our results demonstrate that outflows play a major role in the envelope dispersal process and help end the infall stage. In addition, we show how outflows have an influence on the abundance of different molecules in the envelope.

This work is supported by an NSF Astronomy and Astrophysics Postdoctoral Fellowship under award AST-0401568.

030.15

Photometric Monitoring of the PMS Object Walker 90

Michael D. Joner[1]
[1]Brigham Young Univ..

It has long been known that the interesting pre-main sequence object Walker 90 (V590 Mon) located in the young open cluster NGC 2264 displays photometric variability on many time scales. We present BVRI and H-alpha photometry from a variety of epochs in order to better understand the nature and scale of these variations. The majority of the observations were secured using the 0.8-m telescope at the Tenagra robotic observatory in southern Arizona during the past four observing seasons.

We acknowledge partial support for this work from the AAS in the form of a Small Research Grant. We also thank the Department of Physics and Astronomy at Brigham Young University for continued support of this research.

030.16

The Taurus Spitzer Legacy Project

Deborah Padgett[1], M. Fukagawa[2], L. Rebull[1], A. Noriega-Crespo[1], S. Carey[1], K. Stapelfeldt[3], L. Hillenbrand[1], T. Huard[4], S. Terebey[5], D. Hines[6], T. Brooke[1], C. McCabe[3], M. Guedel[7], G. Knapp[8], M. Audard[9], F. Menard[10], J. Monin[10], C. Dougados[10], N. Evans[11], L. Allen[4], S. Strom[12], P. Harvey[11]
[1]California Institute of Technology, [2]Nagoya University, Japan, [3]Jet Propulsion Laboratory, [4]Harvard-Smithsonian Center for Astrophysics, [5]California State University, Los Angeles, [6]Space Science Institute, [7]Paul Sherrer Institut, Switzerland, [8]Princeton University, [9]University of Geneva, Switzerland, [10]Observatoire du Grenoble, France, [11]University of Texas, [12]NOAO.

Lacking young stellar clusters and luminous OB stars, Taurus hosts a distributed mode of low-mass star formation that has proven particularly amenable to observational and theoretical study. In 2005, our team mapped the central 30 square degrees of the main Taurus cloud using the IRAC and MIPS cameras on the Spitzer Space Telescope. Next spring, we will map an additional 14 square degrees of Taurus with Spitzer. Together, these images will form the largest contiguous Spitzer map of a single star-forming region (and any region outside the galactic plane). Our Legacy team is currently generating re-reduced mosaics and source catalogs, which will be available to the community in 2006 and 2007. The Spitzer survey is a central and crucial part of a multiwavelength study of the Taurus cloud complex that we have performed using XMM, CFHT, and the Sloan Digital Sky Survey. The seven photometry data points from Spitzer allow us to characterize the circumstellar environment of each object, and, in conjunction with NIR photometry, construct a complete luminosity function for the cloud members that will place constraints on the initial mass function. We present a preliminary catalog of several hundred thousand IRAC and thousands of MIPS sources. Initial results from our study include new disks around brown dwarfs, new low luminosity YSO candidates, and new Herbig-Haro objects.

030.17

Millimeter-Wavelength Methanol Masers in New Galactic Sources

Jenna J. Lemonias[1], V. Strelnitski[2], P. Pratap[3]
[1]Vassar College, [2]Maria Mitchell Observatory, [3]MIT Haystack Observatory.

We used the ARO 12-m radio telescope at Kitt Peak, AZ, to search for new millimeter-wavelength, high-rotational-excitation methanol masers at 146.6 and 156.8 GHz in nine galactic sources: DR21, DR21N, DR21(OH), NGC7538M, NGC7538S, NGC7538W, NGC7538(IRS9), W75N, and W75N(OFF). Some of these sources were recently discovered by one of us (P.P.) as new sources of the 44 GHz methanol maser line. The 146.6 GHz line was detected in all the sources except W75N(OFF). The 156.8 GHz line was detected in DR21, DR21(OH), NGC 7538(IRS9), and W75N. The total radial velocity interval of detectable spectral features is typically less than 5 km s^{-1}. The low-intensity broad spectral ′′pedestal” (due to thermal radiation from the surrounding cloud or the overlapping of narrow masing components) is seen in both lines. Strong narrow components were seen only in the 146.6 GHz line. For the four sources where both lines were detected, the 147/157 peak intensity ratio varies in broad limits, from approximately 1 to more than 15. Available statistical equilibrium calculations of methanol level populations allow one to suppose that the 147/157 ratio may be a steep function of the gas density and/or temperature in the masing condensations. If this hypothesis is correct, the 147/157 line ratio may become a sensitive probe of physical conditions in Class I methanol masers, along with the 44/36 GHz ratio first proposed as a diagnostic tool by one of us (P.P.). More statistical equilibrium calculations are needed to make this potential probe a quantitative one. This project was supported by the NSF/REU grant AST-0354056 and the Nantucket Maria Mitchell Association.

030.18

Class I Methanol Masers in the DR21 Star Forming Complex

Samantha Hoffmann[1], P. Pratap[2], V. Strelnitski[3]
[1]Texas Lutheran University and MIT Haystack Observatory, [2]MIT Haystack Observatory, [3]Maria Mitchell Observatory.

Class I methanol masers are found near regions of young star formation and are thought to be collisionally excited. They are usually found to be situated in molecular outflows. Several Class I masers, at frequencies of 36 and 44 GHz, were found in a large scale survey of several molecular clouds with the Haystack 37-m radio telescope. One of the newly discovered masers (DR21N), situated 3’ north of the strong maser source in DR21OH, was imaged with the VLA. The maser positions were compared with multi-band images from the Spitzer Space Telescope and there appears to be a spatial correlation between the masers and an infrared source, which shows strong emission in the 8μ band. The relationship between the masers and the infrared emission in the entire DR21 complex will be examined.

In addition, further examination of the 44 and 36 GHz maser lines and the implications of the line ratios for the evolutionary state of the YSO will be presented. There are indications that sources in which the 36 GHz maser emission is enhanced are at an earlier evolutionary stage than those sources in which the 36 GHz maser is weak or non-existent. These results can be used to put constraints on the maser excitation models.

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The REU program at MIT Haystack Observatory is funded by the National Science Foundation.

030.19

Short-term Variations in the Class I Methanol Maser Line at 44 GHz

Preethi Pratap[1], S. Hoffmann[1], V. Strelnitski[2]
[1]MIT Haystack Obs., [2]Maria Mitchell Observatory.

Class I methanol masers are found near regions of young star formation and are thought to be collisionally excited. They are usually found to be situated in molecular outflows. Some indication of long term variability has been reported previously. In this paper we will present evidence for variations in the intensity of the Class I methanol masers at 44 GHz on timescales of a few hours or less. A serendipitous observation by Strelnitski et al. with the ARO 12-m telescope (see Strelnitski et al at this meeting) indicated the possibility of short time-scale variations in the Class I 147 GHz transition of methanol toward DR21OH and DR21N. An examination of data from the Haystack 37-m telescope taken over a 7-day period in January 2006 appeared to confirm these variations. Follow-up observations with the 37-m telescope of several maser sources in the DR21 star forming complex, the W75N complex and OMC-2 were performed in October 2006. Evidence of variation on timescales of a few hours or less was found. These results will be presented. Implications of these new results for the physical conditions in the maser regions and the excitation mechanisms will also be presented.

Undergraduate research at MIT Haystack Observatory is supported by a grant from the National Science Foundation.

030.20

A New Low-Mass, Pre-Main Sequence Eclipsing Binary in Orion:Precise Mass Determinations of System Components

Phillip Cargile[1], K. G. Stassun[1], R. Mathieu[2]
[1]Vanderbilt Univ., [2]Universtiy of Wisconsin.

We present a double-lined orbit solution for a new low-mass eclipsing binary system in the Orion star-forming region. Our observations include radial velocities derived from optical high-resolution spectroscopy. The orbit solution presented here permits the determination of precise empirical masses for both components of the system. There is strong evidence that this system is a member of the Orion Nebula Cluster, and therefore has an age of only a few million years. The system exhibits both strong Li and a center-of-mass velocity consistent with cluster membership. This newly discovered system is thus of particular interest because it includes two low-mass stars which will provide useful constraints for testing the predictions of current theoretical models of pre-main sequence stellar evolution. There is also strong evidence in our data for a wide tertiary component of the system with a period of ~20 yrs, but its presence does not significantly affect the precision of the mass determinations.

030.21

Star Formation in Bright-Rimmed Clouds

Sarah Ballard[1], L. Allen[2], R. Gutermuth[2]
[1]UC Berkeley, [2]Harvard-Smithsonian Center for Astrophysics.

We identify and classify populations of young stellar objects (YSO) in eighteen Bright-Rimmed Clouds (BRC) observed by Spitzer with IRAC (at 3.6, 4.5, 5.8, and 8.0 μm) and MIPS (at 24 and 70 μm). Our sample was selected from the BRC catalogs of Sugitani et al. (1991, Northern Sample, and 1994, Southern Sample). Each cloud in that catalog contains an IRAS point source, evidence that star formation had occurred or is occurring there. We analyze the spatial distribution of the clusters and the types of YSO present, as well as the bolometric luminosity and temperature for sources with good detections at 70 μm. We discuss the correlation between ratio of classes of YSO in the clouds and the evolutionary stage of the cluster. We also investigate bolometric temperature of sources as an indication of evolutionary stage, and find that the results agree with the classifications from color space. Finally, we compare the positions and luminosities of the IRAS point sources with the IRAC and MIPS sources. We find that the luminosities agree to within an order of magnitude.

031: Clickers in Astronomy Teaching
AAS Special, Sunday, 10:00-11:30am, 201

Chair

Douglas K. Duncan[1]
[1]Univ. of Colorado.

031.01

Success and Failure Using Student Response Systems: ″Clickers″

Douglas K. Duncan[1]
[1]Univ. of Colorado.

This talk will explain why the use of clickers is spreading so fast in astronomy, give those who have not used clickers practical advice on how to start, and suggestions to more experienced clicker users how to optimize their results.

All session attendees WILL GET TO TRY OUT CLICKERS, using two different clicker systems. Why clickers are proving so valuable will be discussed with data about student learning gains and student attitudes about clickers, which are remarkably positive. “Watch-outs” concerning the most common problems with clickers will be given. Questions session attendees have about clickers will be tabulated, and the final half hour of the session devoted to answering those questions.

031.02

Clickers at UMass: a successful program of campus-wide implementation

Stephen Schneider[1]
[1]UMass.

In the early 1990s, the Physics Department of the University of Massachusetts was a testing ground for one of the forerunners of the modern classroom response systems. Today, UMass is one of largest users of the wireless descendants of this system, with “clickers” being used across all disciplines. In Astronomy (and many other departments) we use clickers primarily in our large lecture classrooms. We have found that they can be used to

(a) engage students in making predictions about classroom experiments.

(b) encourage cooperative work with other students to develop mathematical and reasoning skills.

(c) help students explore their own misconceptions.

(d) All of the above. [correct answer!]

Our early uses of clickers showed that simple testing of student knowledge was often perceived negatively as, in effect, “just taking attendance.” However, when students are challenged with difficult and interesting problems, the classroom response system is a positive addition to classroom teaching. Several successful examples, using demos, experiments, and even horoscopes, are shown, and the process involved in developing a strong campus-wide program at UMass is described.

031.03

To Click or Not to Click is Not the Question: How Research with Clickers Develops a Better Understanding of When Learning Happens in Your Classroom

Edward Prather[1], T. F. Slater[1], G. Brissenden[1], E. F. Dokter[1]
[1]Univ. of Arizona.

The *Conceptual Astronomy and Physics Education Research* (CAPER)

Team at the University of Arizona has been conducting an investigation into the use of wireless, personal responder devices, or clickers, in the large enrollment, non-science majors, introductory astronomy course, ASTRO 101. The use of clickers is consistent with the National Research Council's emphasis on student metacognition in that they can be used to promote a learner-centered classroom environment which incorporates appropriate and immediate assessments for both students and instructors. In addition to using clickers for taking attendance, rapid-feedback quizzes, and for Peer Instruction (*ConceptTests*), we are using clickers to conduct active research. Specifically, we are using clickers to assess student understanding after traditional lecture and after students engage in learner-centered activities (not related to using clickers). Our data illustrates that clickers may serve as a reliable research tool to establish exactly when significant learning is taking place in your course. Furthermore, students report that clickers are beneficial to their understanding, contribute to their exam grades, and enhance their interest in course topics, even when used as research tools. In essence, students are, at least patricianly, attributing their success in their courses to the use of clickers which are being implemented to gather data in the same manner as the more traditional Scantron form. We will also present anecdotal results which suggest that students more fully engage intellectually with astronomy concepts when asked to vote with colored cards because they are more personally accountable for their responses when the professor can, in real time, "see" if they are correct or not. This observation motivates us, as a community of astronomy education researchers, to more carefully examine which sorts of questions and which types of feedback mechanisms can have the greatest impacts on student learning and attitudes.

031.04

Interactive Learning and ″Clickers″

Alexander Rudolph[1]
[1]*California Polytechnic Univ..*

A growing body of evidence demonstrates that student understanding and retention of key concepts in science can be dramatically improved by using "Interactive Learning" techniques. Interactive learning is a way to get students more actively involved in their own learning than by simple lecture alone. I will focus on one type of interactive learning activity, known as "Think-Pair-Share". After a brief (10-20 minute) lecture on a topic, students are asked a conceptually challenging multiple-choice question. After they answer, if there is sufficient disagreement, the students discuss the question in small groups after which they answer the same question again. Frequently, the percentage of correct answers goes up, indicating that the active role of speaking and listening, together with peer instruction, has helped students better grasp the concept being tested. If disagreement persists, or if students continue to have questions, a short, class-wide discussion can be held.

Clickers provide an excellent means to collect students' answers to "Think-Pair-Share" questions in real time. Although clickers are not essential, they do provide some advantages over alternatives such as flash cards: answers are completely anonymous (though you as instructor can record individual responses); you can display a histogram of results immediately, either before or after group discussion, providing immediate feedback; by recording the results, you can give students credit for their participation in class.

In this talk, I will model "Think-Pair-Share" with the audience using clickers, show results from my classes before and after group discussions, share results of a student survey on "Think-Pair-Share" and clickers, describe other uses of clickers (e.g., taking attendance, surveys, test administration) and highlight some of the pros and cons of clickers v. flashcards.

032: The SDSS Supernova Survey
AAS Special, Sunday, 10:00-11:30am, 204

Chair

Joshua Frieman[1]
[1]*Fermi Nat'l. Accelerator Lab..*

032.01

Overview of the SDSS Supernova Survey: the First Two Seasons

Andrew C. Becker[1]
[1]*Univ. of Washington.*

The SDSS-II Supernova Survey is one component of the 3-year SDSS extension, and will operate between September and November, 2005 through 2007. This time domain survey monitors 300 square degrees centered on the celestial equator (SDSS Stripe 82) between +/60 degrees in RA and +/1.25 degrees in DEC. Each of two strips are imaged every other night, weather and moon permitting. The goal of the survey is to fill the ″redshift desert″ (z between 0.1 and 0.35) between the low and high-redshift Type Ia supernovae samples with a homogeneous, well sampled, and well calibrated set of 5-passband lightcurves. Half-way through the survey, we have more than 200 spectroscopically confirmed Ia supernovae. We review here the technical and scientific benchmarks of the survey, and emphasize its potential to provide the first fully self-contained dark energy analysis using Type Ia supernovae.

032.02

SDSS SN Hubble Diagram: First Cosmology Results

Hubert Lampeitl[1], SDSS-II Supernova collaboration
[1]*Space Telescope Science Institute.*

The SDSS Supernova Survey has revealed a 129 spectroscopically confirmed SNe of Type Ia in 2005 the first year of its regular operation. These SNe in the redshift range between 0.05 and 0.4 populate a yet only sparsely sampled region of the Hubble diagram and therefore connecting the available nearby SNe data to observations carried out at higher redshifts. For a large fraction of these SNe multi filter light curves in many cases starting well before maximum were obtained. This allows to calculate robust estimates of the luminosity distance by using well established techniques to reduce the intrinsic scatter in absolute SNe brightness and thus to measure the expansion history of the universe in the above mentioned redshift interval. We will present results on cosmological parameters derived from the SDSS SN data alone and in combination with other SNe surveys and also in combination with independent cosmological probes like baryon acoustic oscillations or the WMAP results.

032.03

The Supernova Ia Rate at z~0.1

Richard Kessler[1]
[1]*University of Chicago.*

The SDSS-II supernova survey is a rolling search of 300 square degrees with a redshift range extending slightly beyond 0.3. For $z < 0.12$, the efficiency is nearly 100% for the detection and spectroscopic identification of Type Ia supernova. We use this complete sample to measure the volumetric rate with average redshift $= 0.09$.

032.04

Peculiar Supernovae in the SDSS-II SN Survey

Jose L. Prieto[1], SDSS-II Supernova Survey Collaboration
[1]*Ohio State University.*

In its first two seasons, the SDSS-II SN Survey is finding and following-up a large number of Type Ia SNe suitable for Cosmological studies. Due to the large survey volume, we have also found and followed-up with spectroscopy peculiar objects that do not fit in the category of ″normal″ Type Ia, Type Ib/c or Type II supernovae. Two remarkable examples of the 2005 fall season are SN2005gj, a thermonuclear SN strongly interacting with its dense circumstellar medium, and SN2005hk, a possible pure deflagration Type Ia event. These two objects will be very important to constrain and study possible progenitors and explosion mecha-

SUNDAY

nisms of Type Ia supernovae. We will present the optical light curves and spectroscopic properties of these supernovae, as well as other peculiar objects found in the first two seasons of the survey.

032.05

Studies with 'Purely Photometric' Supernovae from SDSS-II

Masao Sako[1], SDSS-II Supernova Survey Collaboration
[1]*Univ. Pennsylvania.*

In addition to over two hundred spectroscopically confirmed supernovae (SNe), the SDSS-II SN Survey has discovered a comparable number of SN candidates that were not followed up spectroscopically during the Fall search seasons. We describe our procedures for defining this photometric SN sample and discuss its possible use for studying SN rates and correlations between SN and host galaxy properties, and the potential role of purely photometrically observed supernovae as cosmological distance indicators. We also comment on the subsample of SN candidates for which we have obtained an optical spectrum and redshift of the host galaxy.

033: HAD I
HAD Special, Sunday, 10:00-11:30am, 6A

Chair

Donald K. Yeomans[1]
[1]*JPL.*

033.01

Astronomical Instruments of Ignazio Porro (1801-1875)

Peter Abrahams[1]
[1]*Independent.*

Instrument maker Ignazio Porro is remembered today by the Porro prism system used in binoculars. He also designed and fabricated a wide range of instruments, including astronomical telescopes. An advanced mounting system used oil under pressure to relieve friction. In 1857, his 52 cm (20 inch) aperture refractor was the largest telescope in the world. Helioscopes included polarizing attachments, using unsilvered diagonals and Nicol prisms. Porro made use of his instruments, observing eclipses and discovering a new star in the Trapezium.

033.02

The Discovery of an 1862 Drawing of M 51, the Whirlpool Nebula

Jay B. Holberg[1], W. Tobin[2]
[1]*Univ. of Arizona,* [2]*Vannes, France.*

An early drawing of the spiral galaxy Messier 51 in Canes Venatici has recently come to light. The drawing was made on 25 April 1862 by Jean Chacornac (1823-1873), at the Paris Observatory, using Léon Foucault's then newly completed 80-cm silvered-glass reflector. Chacornac's observation of M 51 was among the first results from the new telescope announced to the Académie des Sciences by observatory director Urbain Verrier in 1862. Although the existence of the drawing was known from Le Verrier's description, the original had never been located. The circumstances surrounding the origin and the discovery of this drawing will be discussed and a brief comparison will be made with other nineteenth century drawings and photographs of M 51.

033.03

Radar and Meteors: Controversy over the Origin of Meteors in Postwar Astronomy

Woodruff T. Sullivan, III[1]
[1]*Univ. of Washington.*

After World War II radio physicists and engineers discovered that radar reflections were readily obtained off the ionized trails left by meteors. The group led by Bernard Lovell at the Jodrell Bank Experimental Station of Manchester University, England, led the effort to design radar transmitters, receivers, and antenna systems that could better understand these reflections. First, an entire suite of *daytime* meteor showers was found to accompany the familiar nighttime showers. Next, associating with meteor astronomers such as Fred Whipple, Ernst Öpik, and Cuno Hoffmeister, Lovell found that his radar data could contribute to a longstanding controversy in the field: was there any portion of the meteors whose speeds indicated that they were on hyperbolic orbits and therefore of interstellar origin (i.e., >72 km/s), or did all meteoroids originate within the solar system? By 1953 the Jodrell Bank radar astronomers' huge samples of echoes and measured speeds of meteors indicated that there were in fact no interstellar interlopers. This settled the question for most workers in the field, although Opik and Hoffmeister did not give in.

033.04

Frank Ross's Early Orbits of the First Irregular Satellites of Saturn and Jupiter

Donald E. Osterbrock[1]
[1]*UCO\Lick Observatory.*

Frank E. Ross, later the inventor of the wide-angle lens, photographic photometer, and correcting lens for large reflecting telescopes, developed for the 200-inch, that bear his name, was also an expert on celestial mechanics. After earning his PhD at Berkeley in 1901, he worked in Washington as chief assistant to Simon Newcomb, the leading astronomer of his time, until the latter's death in 1909.

W. H. Pickering, who had discovered Phoebe, the first distant, irregular satellite of Saturn, was unable to calculate an orbit for it. He asked Newcomb to do it, but the ″grim dean of American astronomy″ was too busy, and turned the task over to Ross to do, mostly on his own time. The young assistant succeeded, but spent many sleepless nights on the job. He and his brother Walter were also running a cigar store in Washington at the time.

Charles D. Perrine at Lick Observatory discovered J VI and J VII, the first two similar satellites of Jupiter, in 1904 and 1905, and could not obtain satisfactory orbits for them either, even with Director W. W. Campbell's help. Ross then calculated their orbits also, again at a tremendous cost of effort. He used log tables, pencil and paper, and a simple adding machine for his computing tasks, as all ″computers″ (persons) did at that time. These three satellites were the first to be discovered by photography.

034: Accretion, Accretion Disks and Outflows
AAS Oral, Sunday, 10:00-11:30am, 613-14

034.02

High Velocity Outflows in Quasars

Paola Rodriguez[1], F. Hamann[1], D. Nestor[2]
[1]*Univ. of Florida,* [2]*Univ. of Cambridge, United Kingdom.*

Active Galactic Nuclei are believed to be powered by accretion onto a Super-Massive Black Hole. In order to have material falling into the SMBH, angular momentum conservation requires a counterpart for this accretion that is fueling the SMBH in the AGN. Outflows might play an essential role in active galactic nuclei. They show common occurance, both in quasars (30%-40% in optically selected quasars) and Seyfert galaxies (approx. 60%), but might be obiquitous if, they subtend a small angular distance in the sky. Moreover, they bring information from the AGN inner regions, which is not accesible through other ways. Although for more than a decade models have included material outflowing from an accretion disk around a SMBH, surprisingly there is no consensus in our understanding of basic properties like the acceleration mechanism(s), launch radii, mass loss rates, terminal velocities, etc. We are involved in a program to derive basic dynamical characteristics for some well-studied individual flows, and, in particular, we are interested in High Velocity (HV) outflows since they will present unique challenges for the above mentioned theoretical models. In order to do so, we have developed the first systematic accounting of CIV outflow lines, taking advantage of Sloan Digital Sky Survey data (SDSS) DR4. We will present the result of our study of a nearly unexplored part of AGN parameter space: HV winds with v>10,000 km/s but small velocity dispersions (narrow absorption lines), previously attributed to unrelated (intervening) gas, but that recent statistical studies confirm to be (approx. 36%) AGN winds.

034.04

The Hard X-ray Spectral Slope as an Accretion-Rate Indicator in Radio-Quiet Active Galactic Nuclei

Ohad Shemmer[1], W. N. Brandt[1], H. Netzer[2], R. Maiolino[3], S. Kaspi[2]
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We present new XMM-Newton observations of two luminous and high accretion-rate radio-quiet active galactic nuclei (AGNs) at z~2. Together with archival X-ray and rest-frame optical spectra of three sources with similar properties as well as 25 moderate-luminosity radio-quiet AGNs at z<0.5, we investigate, for the first time, the dependence of the hard (>~2 keV) X-ray power-law photon index on the broad H_β emission-line width and on the accretion rate across ~3 orders of magnitude in AGN luminosity. Provided the accretion rates of the five luminous sources can be estimated by extrapolating the well-known broad-line region size-luminosity relation to high luminosities, we find that the photon indices of these sources, while consistent with those expected from their accretion rates, are significantly higher than expected from the widths of their H_β lines. We argue that, within the limits of our sample, the hard-X-ray photon index depends primarily on the accretion rate.

034.05

Accretion Disk Temperatures and Continuum Colors in QSOs

Erin W. Bonning[1], G. A. Shields[2], S. Salviander[2], L. Cheng[2], K. Gebhardt[2]
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Accretion disks around super-massive black holes are widely believed to be the source of the optical/UV continuum in many classes of active galactic nuclei. We study the relationships between the optical/UV continuum colors and the characteristic disk temperature as inferred from the AGN bolometric luminosity and black hole mass. AGN disk models show that, as expected, hotter disks should have bluer continua, notwithstanding random disk inclinations. However, observed colors of SDSS AGN spectra generally do not show the expected trend and in some cases show a reverse trend of redder colors with increasing disk temperature. Possible causes of this discrepancy will be discussed.

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034.06

Interpreting the Variability of Double-Peaked Emission Lines using Accretion Disk Models

Helene Flohic[1], M. Eracleous[1]
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We explore the impact of different accretion disk structures on the profiles of double-peaked emission lines observed in Active Galactic Nuclei (AGN), and their variability. We create accretion disk emissivity functions for stochastic disk structures (clumpy disk and clumpy spiral arm) and compute the emission line profile that would be observed for such disks. We then compare the computed line profiles and their variability as the structure rotates to data collected over several decades.

034.01D

Revisiting Standard Helium-like X-ray Diagnostics

Ryan Porter[1], G. Ferland[1]
[1]Univ. Of Kentucky.

A complete model of helium-like line and continuum emission in astrophysical plasmas has been incorporated into the plasma simulation code CLOUDY. All elements between He and Zn are treated, any number of levels can be considered, and a full treatment of radiative and collisional processes is included. This includes photoionization from all levels, line transfer including continuum pumping and destruction by background opacities, scattering, and collisional processes. The model is calculated self-consistently with the ionization and thermal structure of the surrounding nebula. The result is a complete line and continuum spectrum of the plasma. Here we focus on the ions of the sequence and reconsider the standard helium-like X-ray diagnostics. We perform numerical calculations of the line ratios as a function of ionizing flux and hydrogen density. In particular, we demonstrate that the R-ratio is a good density indicator only for a known ionization fraction and can become optically thick for large column densities. We also introduce the notion that the R-ratio is a measure of ionizing flux. This, in turn, allows for a measure of the obscured UV continuum, assuming a given continuum shape.

SUNDAY

034.03D

A Sptizer Infrared and Chandra X-ray study of LINERs: A Link Between Star Formation, AGN Fueling, and Mass Accretion

Rachel Dudik[1], S. Satyapal[1], R. M. Sambruna[2], E. Dwek[2], M. Gliozzi[1]
[1]George Mason Univ., [2]Goddard Space Flight Center.

We present a multi-wavelength *Sptizer* Infrared and *Chandra* X-ray study of 82 Low Ionization Nuclear Emission Line Regions (LINERs). This sample includes Infrared-bright (IR-bright) galaxies and therefore is not limited to optically bright sources. We find that 50% of our sample show a compact, hard X-ray nuclear point source indicative of an active nucleus (AGN). We also find that typical optical diagnostics of AGN (e.g. Broad Hα, Hβ etc.) miss a large portion of the AGN LINER population—especially in the IR-bright population. We compared the host galaxy properties and the properties of the central source in our AGN-LINERs. We find a significant correlation between the far-IR (FIR) Luminosity / IR-brightness of the host galaxy and the Eddington Ratio of the AGN that extends over many orders of magnitude in L/LEDD. Using *Spitzer* observations we investigated what fraction of the FIR is attributable to star formation and what portion is attributable to the AGN. We find that the FIR emission is extended in many galaxies and originates in star forming regions. Our results may therefore imply a fundamental link between the mass accretion rate (M_{dot}), as measured by the Eddington ratio, and the star formation rate (SFR), as measured by the FIR luminosity. We further find that the correlation extends to other AGN subclasses, a result that may have significant consequences on our understanding of galaxy formation and black hole growth.

035: Astrobiology & The Solar System
AAS Oral, Sunday, 10:00-11:30am, 611-12

035.01

Near-Infrared Spectra of UV Photolyzed Astrophysical Ice Mixtures

Perry A. Gerakines[1], C. R. Richey[1]
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The interstellar ices and the icy planets and satellites of the Solar System are exposed to ultraviolet and particle irradiation from various sources, driving a non-thermal chemistry. Mid-IR (λ = 2.5-25μm) laboratory spectroscopic studies of ice analogs indicate a complex series of chemical reactions can take place in these environments, but there is a dearth of spectroscopic analyses that have included laboratory spectra of photolyzed ices. Since our experimental equipment has the ability to take both near-IR (λ = 1.0-2.5μm) and mid-IR spectra of the same ice sample, we are able to combine both techniques for maximal information. The goal of the laboratory study described here is to create thick (10-100μm) UV-photolyzed ices by various methods, which will be described. A new, closed-cell technique that allows UV photolysis within the cell will be described and preliminary results of this technique will be shown. Although the focus of this work is toward icy environments within the solar system, it does have bearing on the near-infrared spectra of interstellar materials, which have appeared in the recent literature. Both environments will be discussed. This material is based upon work supported by the National Aeronautics and Space Administration under Grant No. NNG05GG95G issued through the Outer Planets Research Program.

035.02

Detection of 13C Isotopomers of Molecule HC7N

Glen Langston[1], B. Turner[1]
[1]*NRAO.*

The ^{13}C substitutions of molecule HC_7N were observed in TMC-1 using the J 12 → 11, 13 → 12 rotational transitions in the frequency range 12.4 to 13.6 GHz. We detect the ^{13}C isotopic species in the average of a number of weak rotational transitions. We describe a search for large cyanopolyyene molecules in TMC-1 using the 100m Robert C. Byrd Green Bank Telescope (GBT). The capabilities of the GBT 11 to 15 GHz observing system are described along with a discussion of numerical methods for averaging observations of a number of weak spectral lines to detect new interstellar molecules.

Based on the observation of TMC-GB we find the abundance ratio ^{13}C /C is 1/87 with 1σ range 1/122 to 1/68. Based on the observation of TMC-HC9 N the abundance ratio ^{13}C /C is 1/132 with 1σ range 1/176 to 1/106. Averaging the measurements from the two positions yields abundance ^{13}C/C is 1/108 with 1σ range 1/136 to 1/90.

We acknowledge funding by the National Science Foundation to support the National Radio Astronomy Observatory.

035.03

Life on Mars? Reinterpretation of the Viking Life Detection Experiments: A Possible Biogenic Origin of Hydrogen Peroxide

Dirk Schulze-Makuch[1], J. M. Houtkooper[2]
[1]*Washington State University,* [2]*Justus-Liebig University, Germany.*

Many of the results of the Viking life detection experiments remain puzzling to this day. Here, we present a hypothesis that would explain the Viking observations remarkably well: putative Martian organisms might incorporate H_2O_2 into their intracellular liquids as adaptation to Martian environmental conditions. Contrary to common belief, H_2O_2 is used by many terrestrial organisms for diverse purposes (e.g., metabolism (*Acetobacter peroxidans*)), as defense mechanism (Bombardier beetle), and also to mediate diverse physiological responses such as cell proliferation, differentiation, and migration. This adaptation would have several advantages such as a providing a low freezing point, a source of oxygen, and hygroscopicity, allowing an organism to obtain water vapor from the Martian atmosphere. It would explain many of the puzzling Viking observations such as (1) the lack of organics detected by GC-MS, (2) the lack of detected oxidant(s) to support a chemical explanation, (3) evolution of O_2 upon wetting (GEx experiment), (4) limited organic synthesis reactions (PR experiment), and (5) the gas release observations made (LR experiment; Table). Our hypothesis of Martian organisms that would utilize a H_2O_2-H_2O mixture as an intracellular liquid is of great consequence for future missions searching for extant life on Mars such as the Mars Phoenix, ExoMars, and Mars Science Laboratory missions, and future sampling return missions. Rather than exploring in the equatorial belt, where temperatures might allow liquid water to exist for only brief periods of time, life may well exist in temperate or sub-arctic regions, where temperatures are colder and the atmosphere contains more water vapor.

Table. Comparison of (traditional) chemical explanation and H_2O_2-H_2O hypothesis for Viking results

Question	Chemical Explanation	H_2O_2-H_2O hypothesis
Lack of organic molecules	The organics have been oxidized to nonvolatile salts of benzenecarboxylic acids, and perhaps oxalic and acetic acid.	Upon death of the organisms by heating, the organics are spontaneously oxidized by H_2O_2 with no or very little organic residue. Non-biology bound organic molecules are oxidized chemically and/or consumed by organisms.
Lack of oxidant	There is some yet unidentified mechanism producing H_2O_2 or other oxidants. The oxidant might be present in form of a compound that has no analog on Earth.	The H_2O_2 in the H_2O_2-H_2O mixture is part of the biochemistry of the putative Martian organisms. It would provide sufficient oxidizing potential to explain the Viking results.
Release and partial resorption of O_2, CO_2, and N_2 in the Gas Exchange experiment	Evolution of O_2 on humidification was suggested to involve one or more reactive species such as ozonides, superoxides, and peroxides. CO_2 production in the wet mode can be interpreted to be related to the oxidation of nutrient organic compounds and N_2 release can be interpreted to be related to an initial N_2 desorption from soil by water vapor and subsequent resorption in liquid water.	The release of O_2 (and possibly CO_2 to a lesser degree) can be interpreted as the result of an energy-producing metabolism. Upon humidification it could point also to the decomposition of dying Martian biota, as could the increase of N_2. The decrease of N_2 can be understood as biological fixation.
Synthesis of organic material in Pyrolytic Release experiment	No consistent explanation has been provided, but attempts to explain the observations include instrument malfunction, incorporation of ^{14}CO into carbon suboxide polymer preformed on the Martian surface, and reduction of ^{14}CO by H_2O_2 in the surface material.	Some of the putative organisms were able to metabolize and synthesize organic compounds before they died due to hyperhydration.
Responses in the Labeled Release experiment	Laboratory test on Earth using inorganic oxidants and clay minerals simulated many of the key findings.	Limited metabolism before the organisms died due to hyperhydration, osmotic pressure, and/or heat shock.

035.04

New Exploration on What is Life?

D. K. Perkins[1]
[1]*Saratoga, CA.*

Astrobiologists are seeking other life in the universe and we have found over 200 other stars with planets orbiting them. Yet the very definition of *life* evades us. Where does it begin or end? We cannot yet bind it to fixed parameters. We have also located over 150 organic molecules in space. As well the remarkable discovery has been made that a light spectrum taken through the interstellar dust toward the centre of our galaxy has characteristics similar or identical to the "light fingerprint", the spectra of particular types of terrestrial bacteria.

Charles Birch, Emeritus professor of biology at Sydney University, has discerned that "matter appears to be life-like, rather than life being matter-like". (Birch, 1999) In the work of the Russian biophysicist, Victor G. Gorshkov, he discusses the "role of the biota" in regulating through genetic programming the environment and eco-systems. (Gorschkov, 2000)

In his work on the Gaia hypothesis, James Lovelock, discusses the perception of the dynamic adaptive cybernetic processes that substantiate the functioning of the entire collective global "organism", utilizing what we call the biota as well as all diverse ecosystems to achieve its organic creative synergism.

Yet with all the complexity of our current sciences we have yet to truly understand or find a conclusive definition for life. What role do magnetic fields such as those produced by spinning black holes or magnetars have in the generation of life in cosmos? What in fact is life? A complex geometry uttering the universe or an emergent property of organisms? What is alive? What is now being studying in *complexity theory* is how all forms seem to essentially arise "spontaneously", to emerge from the void state as unique mathematical identities. What can this tell us about the nature of life itself?

035.05

Charge-Exchange Induced X-rays in the Martian Exosphere

Dimitra Koutroumpa[1], R. Lallement[1], R. Modolo[2], G. Chanteur[2], V. Kharchenko[3]
[1]*Service D'Aéronomie, France,* [2]*Centre d'Etude des Environnements Terrestre et Planétaires, France,* [3]*Harvard-Smithsonian Center for Astrophysics.*

We study the EUV/soft X-ray emission induced by charge transfer between solar wind highly charged ions and neutral H and O of the Martian exosphere. Results are obtained using three-dimensional hybrid simulations of the global plasma environment of Mars, including photoionization and electron impact ionization of neutral H and O coronae. We calculate projected emission maps from different vantage points and show how X-ray emission localization traces the Martian shock and magnetic barrier structures. We also compare the different heavy ion contributions to the emission, as well as the secondary charge exchange component.

035.06

Science Results from the Stardust Comet Sample Return Mission: Large Scale Mixing in the Solar Nebula and the Origin of Crystalline Silicates in Circumstellar Disks

Donald E. Brownlee[1], Stardust Mission Team
[1]*Univ. of Washington.*

The first year of laboratory analyses of Kuiper belt materials returned to Earth by the Stardust comet sample return mission have provided important new information on: A) large-scale mixing in the solar nebula and B) the origin of crystalline silicates in circumstellar disks. Most of the >5μm solid particles collected by the mission are mineral grains or assemblages of high temperature minerals that condense at 1400K or above. The most extreme particle is a "Calcium Aluminum Inclusion" composed of refractory Ca, Al and Ti rich minerals. Like nearly identical components found in primitive meteorites, this particle shows a striking enrichment in 16O. The presence of these phases, linked by isotopic and minor element composition to rare components in meteorites, is direct evidence for radial transport of large solid grains from the center of the solar nebula to the Kuiper belt. Most of the mineral grains recovered by Stardust have solar isotopic composition and they have rather exotic minor element compositions. It appears that, like their meteoritic analogs, they formed by combinations of condensation and igneous processes and almost certainly not by the annealing of amorphous interstellar silicates, a formation process widely championed for the origin of crystalline silicate grains observed in disks and comets.

035.07

Simulating Supernova Injection of Short Lived Radionuclides with Consideration of the Solar Birth Environment

Keith W. Davis[1], M. D. Leising[1]
[1]*Clemson Univ..*

The existence of short-lived radionuclides (SLRNs) in the early solar system above their background galactic abundances is well accepted. Studies into the relative abundances and possible sources for radioisotopes indicate a model with three separate sources for the total abundance of SLRNs: the background galactic value, material from some nearby stellar source, and in-situ creation by the early active Sun. A type II SN may be the most likely source for the stellar component, specifically ^{60}Fe. The geometric details of the stellar birth are largely unknown despite evidence that the presolar cloud was not isolated. From a hydrodynamic perspective, the injection of SLRNs may be difficult because of intervening material between the core and the explosion necessary to slow the shock speed enough that the core is compressed rather than shredded. For the SN component it is vital to understand how SN ejecta can reach a core and whether certain SN/cloud environments are precluded by the hydrodynamics. We present Zeus-2D simulations studying the possibility of SLRN injection into a presolar core that is part of a larger cloud complex.

036: Black Holes
AAS Oral, Sunday, 10:00-11:30am, 608-10

036.01

Quasi-Periodic Oscillations and Spectral Behaviour of XTE 1859+226. QPO Frequency Spectral Index Correlation and the Mass of the Central Object.

Nikolai Shaposhnikov[1], R. Fiorito[2], L. Titarchuk[3]
[1]*NASA's GSFC,* [2]*NASA's GSFC/UMD,* [3]*NASA's GSFC/GMU/NRL.*

We investigate the evolution of timing and spectral properties of XTE 1859+226 during its 1999 outburst. We consider the formation of energy spectrum in terms of Comptonization model and the formation of Fourier power density spectrum in terms of disk perturbation diffusion propagation model. We found strong correlations between QPO frequency and energy spectral index similar to observed in other BH binaries. We establish the saturation effect claimed to be black hole signature. We also estimate a mass of central black hole using a method of QPO-index correlation scaling.

036.02

Fundamental Parameters of Galactic Black Holes from SIM Planetquest

Xiaopei Pan[1], S. Shaklan[1]
[1]*JPL.*

Black holes are fundamantal objects across all mass scales, from a few to billions of solar masses. Galactic black holes provide unique oppertunities to understand the physics of accretion, relativistic jets, and nuclear matter densities in detail, and are crucial to investigate the formation and evolution of massive stars. However, fundametal parameters of black holes, such as mass, distance, and dynamical motion, still have large uncertainties(some

SUNDAY

may reach 60%). This work demonstrates that the orbital inclination of black holes can be determined by SIM PlanetQuest to a precision of 2%, and masses to a precision of $< 3\%$. Different techniques to find the birth places of black holes are compared.

036.03

Black Hole Formation in Galactic X-Ray Binaries

Bart Willems[1], T. Fragos[1], V. Kalogera[1]
[1]*Northwestern University.*

In recent years, an increasing number of proper motions have been measured for Galactic black hole X-ray binaries. When supplemented with accurate determinations of other system parameters, these kinematical constraints harbor a wealth of information on compact object formation, such as wether or not black holes receive kicks at birth. In this presentation, we present constraints on the formation of the black hole X-ray binaries GRO J1655-40 and XTE J1118+480. We particularly explore the origin of the compact objects in these X-ray binaries by modeling the ongoing mass transfer phase, tracing the motion in the Galaxy back to the birth site of the black hole, and examining the dynamics of core-collapses of the black hole progenitor.

036.07

Seeing the Wiggle: High Resolution Imaging of SS433 with the VLBA

Amy J. Mioduszewski[1], M. P. Rupen[1]
[1]*NRAO.*

SS433 is the best known example of a precessing jet. As well as the large scale precession there is also a smaller nutation seen in the optical lines. We observed SS433 over 17 days in August 2005 with the Very Long Baseline Array. These observations were part of a larger X-ray and optical spectroscopy campaign. SS433 was observed with the VLBA at 15 GHz, giving a resolution of less than 1 mas (3 AU). Another advantage of the high frequency is that the core region is much less affected by absorption, and can be imaged directly. The images presented here show that the inner 5 mas of the jet look very similar from day to day, apart from a slight change in position angle. This is especially interesting because, with jet proper motions of 7-10 mas/day, this inner jet should be completely renewed each day. The position angle shift in the inner jet is very similar to the nutation seen in the optical lines, the first time this effect has been imaged.

The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

036.08

Recent Optical Observations of the Microquasar SS 433

Todd C. Hillwig[1], D. Gies[2]
[1]*Valparaiso Univ.,* [2]*Georgia State Univ..*

Recent optical observations of the microquasar SS 433 will be presented. The observations include spectra taken with the Gemini North, Hobby-Eberly, and KPNO 2.1-m telescopes. Results will be discussed in the larger context of a multiwavelength collaboration involving simultaneous X-ray spectra (*Chandra*), radio imaging (VLBA), and optical spectra. The goal of the multiwavelength program is a better understanding of the parameters of this unique system, including jet production and behavior and the characteristics of the two components of the binary system.

Funding was provided by the National Science Foundation through grant AST-0607432

036.06D

Gravitational Waves From The Hierarchical Buildup Of Intermediate Mass Black Holes

Miroslav Micic[1], S. Sigurdsson[1], K. Holley-Bockelmann[1], T. Abel[2]
[1]*Pennsylvania State Univ.,* [2]*Stanford University.*

Using high-resolution N-body simulations in LambdaCDM universe, we have constructed dark matter structure's merger tree that traces evolution of dark matter halos, their subhalos and massive black holes (MBH) formed from Population III stars. Such early black holes, formed at redshifts $z > 10$, could be the seed black holes for the many SMBH found in galaxies in the local universe. Mergers of MBH may be a prime signal for long wavelength gravitaional wave detectors. We study trajectories of MBH, formation of MBH binaries and calculate gravitational strain amplitude as a function of redshift. We also explore the implications of kick velocities conjectured by some formation models. The central concentration of early black holes in present day galaxies is reduced if they are born even with moderate kicks of tens km/s. The modest kicks allow the black holes to leave their parent halo, which consequently leads to dynamical friction being less effective on the lower mass black holes as compared to those still embedded in their parent halos. Therefore, merger rates may be reduced by more then an order of magnitude. We quantify the role of kicks on black hole merger rates. Our results also apply to black holes ejected by the gravitational slingshot mechanism.

037: Dark Matter, Dark Energy and Lensing
AAS Oral, Sunday, 10:00-11:30am, 605-07

037.01

The Search for Dark Matter and New Physics using the Gamma Ray Large Area Space Telescope (GLAST) Large Area Telescope (LAT)

Lawrence L. Wai[1], GLAST LAT Collaboration
[1]*Kavli Institute for Particle Astrophysics and Cosmology.*

The LAT collaboration Dark Matter and New Physics Working group has been developing approaches for the indirect detection of in situ annihilation of dark matter. Our work has assumed that a significant component of dark matter is a new type of Weakly Interacting Massive Particle (WIMP). The pair annihilation of WIMPs results in the production of high energy gamma rays ($E > 1$ GeV) that can be well measured in the GLAST LAT. These searches involve strategies for observation of the galactic center, galactic halo (optimized diffuse all sky analysis), galactic satellites (high latitude slightly extended sources), and cosmological signals in the extragalactic diffuse. The spectra of these potential signals are non-powerlaw, considerably harder than most astrophysical sources, and have an endpoint at the mass of the WIMP. In addition, there is the possibility to observe lines from annihilation into γ-γ and/or γ-Z^0 final states. The estimates of LAT sensitivity depend upon the WIMP model, the dark matter halo model, and various astrophysics backgrounds. Thus estimates of LAT sensitivity can vary over orders of magnitude depending on the astrophysical search region and which particle dark matter models are chosen. Conversely, if particle dark matter is observed, a new observational window can be opened upon galactic dark matter substructure. Preparations for these searches and other types of new physics searches will be presented.

037.02

Gamma-rays from Dark Matter in the Galactic Center

Douglas P. Finkbeiner[1]
[1]*Harvard University.*

Four types of high-energy signals in the Milky Way have surprised us in recent years: (1) EGRET observed GeV gamma-rays in excess of those expected from simple Galactic models, (2) WMAP observed an apparent hard synchrotron excess towards the inner Galaxy, (3) HEAT observed a higher than expected positron/electron ratio near Earth at tens of GeV, and (4) SPI observed a stronger 511 keV annihilation line in the Galactic center than expected. Items (1) and (2) may be explained by an extra (in additional to the ″usual″ shock-accelerated) population of electrons (and positrons) in the inner Galaxy at 10s to 100s of GeV, and (3) and (4) may be related to these. The necessary population is a steady state solution (calculated using GALPROP to simulate CR propagation and interaction with the interstellar medium) for an injection function that could be provided by WIMP annihilation. I will show that reasonable WIMP parameters can fit the data, given some caveats. I will also give a scenario that could cascade this population down to lower energies to produce (4), explain what other observation consequences it would have, and show why it is unlikely.

037.03

Discovery of a Dark Matter Ring in the Core of the Galaxy Cluster CL0024+17 at z=0.4

Myungkook J. Jee[1], H. C. Ford[1], G. D. Illingworth[2], R. L. White[3], T. J. Broadhurst[4], D. A. Coe[1], G. R. Meurer[1], A. van der Wel[1], ACS Science Team
[1]Johns Hopkins Univ., [2]University of California, Santa Cruz, [3]Space Telescope Science Institute, [4]Tel Aviv University, Israel.

We present a comprehensive mass reconstruction of the z = 0.4 rich galaxy cluster CL0024+17 from Advanced Camera for Surveys data, unifying both strongand weak-lensing constraints. The weak-lensing signal from a dense distribution of background galaxies (~120 per arcmin^2) across the cluster enables the derivation of a high-resolution parameter-free mass map. The strongly-lensed objects tightly constrain the mass structure of the cluster inner region on an absolute scale, breaking the mass-sheet degeneracy. The mass reconstruction of CL0024+17 obtained in such a way is remarkable. It reveals a ring-like dark matter substructure at r~75″ surrounding a soft, dense core at r<50″. We interpret this peculiar sub-structure as the result of a high-speed line-of-sight collision of two massive clusters 1-2 Gyr ago. Such an event is also indicated by the cluster bimodal velocity distribution. Our numerical simulation with purely collisionless particles demonstrates that such density ripples can arise by radially expanding, decelerating particles that originally comprised the pre-collision cores. ACS was developed under NASA contract NAS5-32865, and this research was supported by NASA grant NAG5-7697.

037.04

Evidence for a New Force in the Dark Sector?

Glennys R. Farrar[1], R. A. Rosen[1]
[1]New York Univ..

We study the kinematics of dark matter using the massive cluster of galaxies 1E0657-56. The velocity of the ″bullet″ subcluster has been measured by X-ray emission from the shock front, and the masses and separation of the main and sub-clusters have been measured by gravitational lensing. The velocity with gravity alone is calculated in a variety of models of the initial conditions, mass distribution and accretion history; it is much higher than expected, by at least 2.4 sigma. Following Hayashi and White analysis, the probability of so large a subcluster velocity in cosmological simulations with no new force is estimated to be 10^{-7}. A long range force with strength about 0.4 0.8 times that of gravity would provide the needed additional acceleration.

037.05D

Simulations of Dark Matter Bound to the Solar System

Annika Peter[1]
[1]Princeton Univ..

Many experiments are ongoing or are planned to detect WIMP-like dark matter for which the signal depends sensitively on the dark matter distribution function as seen by an observer on Earth. In addition to a population of dark matter streaming through the solar system from the galactic halo, Damour & Krauss (1999) have postulated a population of dark matter bound to the solar system by weak interactions with nuclei in the sun. In this paper, I will discuss a set of simulations of the orbits the particles captured to the solar system by this mechanism. I will discuss the implications of this bound population on direct and indirect detection experiments.

037.06

Dark Energy Search: Current Status and Future Prospects

Yun Wang[1]
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The cause for the observed acceleration in the expansion of the universe is unknown, and referred to as ″dark energy'' for convenience. Dark energy could be an unknown energy component, or a modification of Einstein's general relativity. This dictates the measurements that are optimal in unveiling the nature of dark energy: the cosmic expansion history H(z), and the growth history of cosmic large scale structure G(z). I will examine the most promising methods for probing dark energy, and discuss recent results and future prospects.

This work is supported in part by NSF CAREER grant AST-0094335.

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037.07

Dark Matter in Galaxy Cluster 1E0657-56: Measuring the Invisible With Gravitational Lensing

Marusa Bradac[1], D. Clowe[2], A. Gonzalez[3], P. Marshall[1], W. Forman[4], C. Jones[4], M. Markevitch[4], S. Randall[4], T. Schrabback[5], D. Zaritsky[6]
[1]KIPAC/Stanford, [2]Ohio University, [3]University of Florida, [4]Harvard-Smithsonian Center for Astrophysics, [5]AIfA, Germany, [6]Steward Observatory.

The cluster of galaxies 1E0657-56 has been the subject of intense ongoing research in the last few years. This system is remarkably well-suited to addressing outstanding issues in both cosmology and fundamental physics. It is one of the hottest and most luminous X-ray clusters known and is unique in being a major supersonic cluster merger occurring nearly in the plane of the sky, earning it the nickname ″the Bullet Cluster″. I will present our measurements of the composition of this system, show the evidence for existence of dark matter, and describe limits that can be placed on the intrinsic properties of dark matter particles. In addition, I will explain how this cluster offers a serious challenge to MOdified Newtonian Dynamics (MOND) theories.

038: Feedback and Mergers in Galaxy Evolution AAS Oral, Sunday, 10:00-11:30am, 3B

038.01

AGN Feedback Regulating Early-type Galaxy Evolution

Kevin Schawinski[1], S. Khochfar[1], S. K. Yi[2], S. Kaviraj[1], GALEX Science Team
[1]Oxford Astrophysics, United Kingdom, [2]Yonsei University, Republic of Korea.

We present observations of SDSS early-type galaxies observed by the Galaxy Evolution Explorer satellite (GALEX). The GALEX Near-UV filter is extremely sensitive to small amounts of residual star-formation. We find that the likelyhood of early-type galaxies undergoing such residual star-formation is highly correlated with their velocity dispersion. We derive an empirical relation for a critical black hole mass above which the outflows from supermassive black holes suppress star formation in galaxies by heating and expelling cold gas and apply this relation in a semi-analytic model of galaxy formation to investigate the importance of AGN feedback for early-type evolution.

038.02D

Star Formation and Supernova Feedback in Smoothed Particle Hydrodynamic Simulations of Galaxy Formation

Gregory S. Stinson[1], T. Kaufmann[2], T. Quinn[1], C. Christensen[1], J. Wadsley[3], S. Kazantzidis[4]
[1]Univ. Of Washington, [2]Univ. of California, Irvine, [3]McMaster University, Canada, [4]KITP.

Using physically motivated recipes for star formation and supernova feedback, we examine smoothed particle hydrodynamic simulations of isolated, virialized halos with masses ranging from 10^9 to 10^{13} $M_\odot$. The effect of supernova feedback is strongly apparent in the low mass halos. 10^9 $M_\odot$. These halos show star formation that happens in bursts. These bursts drive 1% of the halo gas mass out of the virial radius. Small amounts of gas are driven out of halos up to 10^{10} $M_\odot$. High mass halos exhibit a lower efficiency of turning gas into stars because the virialized gas starts at a temperature where cannot efficiently use atomic line emission to cool.

038.03

The Evolution of the Massive Galaxy Luminosity Function Over Half of Cosmic History

Richard J. Cool[1], D. J. Eisenstein[1]
[1]Univ. of Arizona.

The popular model for the formation of early-type galaxies is the hierarchical merging scenario. However, the details of the frequency and efficiency of merging are not yet known, particularly in dense environments. The high-mass end of the galaxy luminosity function, as the extreme example of the merging phenomenon, is the most sensitive to various merger model assumptions. While L* early-type galaxies are being observed in ever-growing numbers even at moderate redshifts with the advent of many new deep redshift surveys, the most massive systems are very rare and thus any pencil-beam survey will be severely limited by cosmic variance at the high mass end. By taking advantage of the 1 degree diameter field available for multi-object spectroscopy with the Hectospec spectrograph on the MMT, we have completed a spectroscopic survey of ~5 square degrees targeting massive early-type galaxies out to z~0.8. Pairing our observations at z~0.8 with a sample of massive galaxies at low-redshift from the Sloan Digital Sky Survey, we measure the evolution of the luminosity function of the most massive galaxies over half of the history of the universe and use this measurement to constrain the merger histories of the most massive galaxies.

038.04

Understanding Galaxies in Pairs

Elizabeth J. Barton[1], A. R. Zentner[2], J. S. Bullock[1], R. H. Wechsler[3]
[1]UC, Irvine, [2]KICP and U. Chicago, [3]KIPAC and Stanford University.

Both observations and high-resolution models of galaxy interactions show that close galaxy-galaxy pericentric passes torque galaxies and trigger global bursts of star formation. Catalogs of galaxies in close pairs are rich in galaxies that have had close galaxy-galaxy passes already. However, pair catalogs also necessarily include interlopers, galaxies that have not yet had their first close pass, and projections within a looser group. We probe the evolution of galaxies in pairs using a model for the detailed evolution of substructure in cosmological halos. The model couples cosmological simulations to an analytic subhalo model that tracks substructure within parent halos by integrating the orbits of galaxies. The code describes the last major merger and all the pericentric passages of subhalos with their host halos. In order to aid the interpretation of galaxy pair catalogs, we characterize (1) the fraction of galaxies in observed pairs that will have already had a close pericentric pass, (2) the strength of that pass, (3) the amount of time the pair will continue without merging, and (4) the dependence of these quantities on the observable orbit and environment parameters. We also present prescriptions for relating galaxy pair counts to the merger rate of luminous galaxies.

038.05D

Dynamic and Spatial Properties of Satellites in Isolated Galactic Systems

Abel Diaz[1], R. Wilhelm[1]
[1]Texas Tech University.

Using the NYU Value-Added Galaxy Catalog (NYU-VAGC) I examine the line-of-site velocity dispersion of satellite galaxies orbiting larger, isolated, primary galaxies. The line-of-sight dispersion can be directly compared to the functional form of three models (NFW, MOND and a relic neutrino based model) that diverge at large distances allowing discrimination between models. I find that the velocity dispersion decreases with projected distance from the primary. From the data I find no evidence of the Holmberg effect. Satellite galaxies tend to be isotropic both at small projected distances from the primary galaxy and at large projected distances (at the 1 sigma level) from the primary galaxy. However, I do find that the distribution of early type satellites tends to decline more steeply than the late type satellites in a high magnitude primary sample. I was also able to examine the line-of-sight velocity dispersions in two directions: parallel to the plane of the galaxy and perpendicular to the plane of the galaxy along the axis of rotation. From sampling the velocity profiles of primary galaxies at different tilt angles relative to the axis of rotation, I find that the velocity distribution of satellites is isotropic about the primary, suggesting that the dark matter halo is spherical in shape.

038.06

The Asymmetric Relations among Galaxy Color, Structure, and Environment

Alejandro D. Quintero[1], A. Berlind[2], M. R. Blanton[2], D. W. Hogg[2]
[1]Steward Observatory, [2]New York University.

We investigate the dependences of galaxy star-formation history and galaxy morphology on environment, using color and H-alpha equivalent width as star-formation history indicators, using concentration and central surface brightness as morphological indicators, and using clustocentric distance as an environment indicator. Clustocentric distance has the virtue that it can be measured with very high precision over a large dynamic range. We find the following asymmetry between morphological and star-formation history parameters: star-formation history parameters relate directly to the clustocentric distance while morphological parameters relate to the clustocentric distance only *indirectly* through their relationships with star-formation history.This asymmetry has important implications for the role that environment plays in shaping galaxy properties and it places strong constraints on theoretical models of galaxy formation. Current semi-analytic models do not reproduce this effect.

038.07

The Role of Galaxy Interactions and Mergers in Star Formation at z<1.3: Mid-Infrared Properties in the Spitzer First Look Survey

Carrie Bridge[1], P. N. Appleton[2], C. J. Conselice[3], P. Choi[2], L. Armus[2], D. T. Fadda[2], S. Laine[2], F. R. Marleau[2], R. G. Carlberg[1], G. Helou[2], L. Yan[2]
[1]University of Toronto, Canada, [2]Spitzer Science Center, [3]University of Nottingham, United Kingdom.

By combining the 0.12 square degree F814W *Hubble Space Telescope* (HST) and *Spitzer* MIPS 24um imaging in the First Look Survey (FLS), we investigate the interactions and merging properties of Mid-Infrared bright and faint sources at $0.2<z<1.3$. The fraction of 24um detected, optically selected close pairs increases with redshift, $N_c=0.25\pm0.10$ at z~1, in contrast to 0.11 $\pm$0.08 at z~0.4, while galaxies below 0.1mJy at 24um show an N_c consistent with zero at all redshifts. Using the 24um flux to derive the Far-IR luminosity we find that paired galaxies (early stage mergers) are responsible for 27$\pm$9% of the IR luminosity density resulting from star formation at z~1 while morphologically classified (late stage) mergers make up 34$\pm$11%. This implies that 61$\pm$14% of the infrared luminosity density and in turn ~40% of the star formation rate density at z~1 can be attributed to galaxies at some stage of a major merger. We argue that 24um detected galaxies with fluxes $>$0.1mJy are on average 5 times more likely to be in a

close galaxy pair between 0.2<z<1.3 than galaxies below this flux limit, and close pairs/mergers in a LIRG/ULIRG phase are important contributors to the IR luminosity and star formation rate density of the Universe at z~1.

039: Starburst Galaxies: Analogs of Lyman Break Galaxies? AAS Oral, Sunday, 10:00-11:30am, 6B

039.01

The Young and The Dustless: Constraining the Star Formation History and Dust Content of Ultraviolet Luminous Galaxies using GALEX UV and Radio Observations

Antara Basu-Zych[1], D. Schiminovich[1], Galex Science Team
[1]Columbia University.

Ultraviolet Luminous Galaxies have been identified as intensely star-forming, nearby galaxies -as local analogs to Lyman Break Galaxies. We investigate the radio properties of 46 compact UVLGs, along with ultraviolet observations and optical spectral data. Comparing the UV star formation rate to the star formation rate derived from the radio continuum, we find that these systems are underluminous in the radio; we detect only half of the UVLGs. We interpret this result in terms of both star formation history and dust content. Our analysis includes comparison samples of multiwavelength data from the First Look Survey and from the SDSS-GALEX matched catalogs. We conclude that compact UVLGs are young and show lower dust attenuation than average given their current rate of star formation.

039.02D

A FUSE Survey of Starburst Galaxies: Galactic Feedback from Star Formation

John P. Grimes[1], T. Heckman[1], A. Aloisi[2]
[1]Johns Hopkins Univ., [2]Space Telescope Science Institute.

We present results from a *FUSE* survey of local starburst galaxies. We combine ongoing observations from the *FUSE* Starburst Legacy Project with archival observations to create the largest sample to date (~50) of far-ultraviolet (FUV) galaxy spectra.

In contrast to the local universe where observations of galaxies in the FUV are limited by atmospheric absorption, relatively large samples of star forming galaxies have been observed at high redshifts. Rest wavelength FUV observations of Lyman break galaxies (LBGs) provide important insights into galaxy formation and evolution. The FUV wavelength regime is rich in absorption features that probe the characteristics of galactic outflows, the inter-stellar medium (ISM), and stellar content. FUV observations can help constrain outflow velocities, energetics, and the chemical composition of galactic outflows.

Outflows from LBGs also play a role in reionizing the universe and enriching the IGM. Our sample provides an important benchmark to compare LBGs to our local galaxy population. The proximity of our galaxies also allows us to assemble a complimentary multiwavelength (e.g. X-ray) data set that is not possible at high redshifts.

Preliminary results from our study include evidence that the outflow speeds of neutral and low ionization lines increase with the star formation rate (SFR). The OVI absorption line is also significantly broader and more blueshifted than the lower ionization lines. This is consistent with OVI production at the interface between the hot outrushing gas and the cooler ions. These results show that our study provides a unique view of starburst galaxies that will play an important role in constraining galaxy formation and evolution.

039.03

HST/STIS Spectroscopy of Ionized Gas in the M82 Starburst Core

Linda J. Smith[1], M. S. Westmoquette[2], J. S. Gallagher, III[3], R. W. O'Connell[4], D. J. Rosario[4], R. de Grijs[5]
[1]Space Telescope Science Institute, [2]University College London, United Kingdom, [3]University of Wisconsin-Madison, [4]University of Virginia, [5]University of Sheffield, United Kingdom.

High angular resolution spectra obtained with HST/STIS in the starburst region allow a unique study of the base of the M82 wind with a spatial resolution of ~ 1 pc. The spectra are analyzed to yield ionized gas kinematics, electron densities and, where H beta measurements are available, interstellar reddening. Radial velocities follow the main M82 rotation curve defined by dense gas, indicating that the optically bright regions are in the main starburst zone. Within these regions we find H alpha often consists of narrow and broad components, with only modest velocity offsets from each other. This can be understood as a signature of mass loading of warm ionized gas into the high pressure hot ISM that is prominent in and around the starburst clumps. Variations in line widths and intensities occur on scales of a few pc, consistent with models where compact star clusters are important factors in structuring the ISM. We discuss these results in the context of starburst clumps and their constituent compact young star clusters driving a wind in the barred starburst galaxy that is M82.

039.04

Spitzer ISM Studies of Low Metallicity Starbursts

Brian O'Halloran[1], S. Satyapal[1], R. Dudik[1]
[1]George Mason Univ..

The presence of massive stars within starbursts undoubtedly plays a huge role in determining the physical conditions within the local ISM. High-mass stars formed within typical starbursts drastically affect the dynamics of the surrounding interstellar medium (ISM) through not only the release of ionizing photons which destroy molecular material, but also through supernova (SNe) explosions which provide thermal and kinetic energy input into the ISM. Using mid-IR fine structure line ratios, we previously determined the presence of strong anti-correlations which suggested that strong supernova-driven shocks are indeed present within low metallicity galaxies, and the PAH deficit within these objects may indeed be linked to the presence and strength of these shocks. However, it has not as yet been conclusively proved that shocks are the dominant process behind the PAH deficit. As a consequence, we use an expanded sample of archival Spitzer IRS data to further probe the nature of the ISM within dwarf starburst galaxies and the underlying causes of the PAH deficit, using a range of additional mid-IR ISM diagnostics.

040: Stellar Populations AAS Oral, Sunday, 10:00-11:30am, 3A

040.01D

Detailed Properties of Populous Clusters in the Large Magellanic Cloud

Aaron J. Grocholski[1], A. Sarajedini[1], A. A. Cole[2], D. Geisler[3], K. A. Olsen[4], G. P. Tiede[5], V. V. Smith[6], C. L. Mancone[1]
[1]Univ. of Florida, [2]Univ. of Minnesota, [3]Univ. de Concepcion, Chile, [4]CTIO, Chile, [5]Bowling Green State Univ., [6]US Gemini Project, Chile.

We present results from a program aimed at better understanding the ages, velocities, metallicities and distances of populous clusters in the LMC. In an effort to update previous [Fe/H] determinations, we have used the FORS2 instrument on the VLT to obtain near infrared spectra for more than 200 stars in 28 LMC clusters. The absorption lines of the Ca II Triplet were then used to calculate velocities and abundances for a sample of clusters spanning a large range of ages (~ 1-13 Gyr) and metallicities (-0.3 ≥ [Fe/H] ≥

-2.0). To calculate cluster ages, we have compiled deep optical photometry for 15 LMC clusters using a combination of published photometry, VLT/FORS2 images and archival HST/WFPC2 images. These data, in conjunction with our derived metallicities, have allowed us to determine accurate cluster ages via main sequence fitting with theoretical isochrones. Finally, we have used the K-band luminosity of core helium burning red clump (RC) stars to determine distances for 17 LMC clusters. Using ISPI on the CTIO 4m, we obtained near infrared (JK) photometry down to K ~ 18.5, which allowed us to measure the apparent K-band RC magnitude of each cluster. In addition, age and abundance can be used to predict the absolute K-band RC magnitude of a given cluster; thus, we have combined the apparent and absolute magnitudes with cluster reddenings and calculated the distance to each individual cluster. These distances are used to probe the structure of the LMC as traced by its cluster population.

This work is supported by NSF CAREER grant AST-0094048 to Ata Sarajedini.

040.02

Theoretical Realization of Near-IR Photometry of Magellanic Star Clusters

Hyun-chul Lee[1], G. Worthey[1]
[1]*Washington State Univ..*

We have investigated how integrated photometric properties of Magellanic Clouds star clusters compare with current theoretical stellar population models. Especially, we examine their near-infrared photometry and contrast them with several theoretical models in the literature. We find that there are significant differences among models. These angularities are traced back to the stellar evolution uncertainties at high masses where convective core overshooting prevails and thermally pulsing asymptotic giant branches are important.

Support for this work was provided by the NSF through grant AST-0307487, the New Standard Stellar Population Models (NSSPM) project.

040.03D

Self-Consistent Stellar Evolution Models with Updated Physics and Variable Abundances

Aaron L. Dotter[1], B. Chaboyer[1], E. Baron[2], J. W. Ferguson[3], D. Jevremovic[2], H. Lee[4], G. Worthey[4]
[1]*Dartmouth College,* [2]*University of Oklahoma,* [3]*Wichita State University,* [4]*Washington State University.*

Results from stellar evolution calculations using updated input physics, a detailed equation of state, and model atmosphere boundary conditions in a state of the art stellar evolution code are presented. The stellar evolution models cover evolutionary phases from the pre-main sequence to the onset of thermal pulsations on the asymptotic giant branch. The results are applied to study a variety of topics including: globular cluster age determinations using the data from the HST-ACS Galactic Globular Cluster Survey, the effects of separately enhancing individual elements on the morphology of isochrones in the H-R diagram, very low mass stars in NGC 6397, and stellar population models.

040.04D

Bulge Formation Scenarios vs. the Observations

Grant Newsham[1]
[1]*The Ohio State University.*

Recent metallicity and abundance determinations in the nuclear bulge allow a detailed comparison with scenarios of bulge formation. We employ the YREC stellar evolution code to generate model color-magnitude diagrams with a wide variety of assumptions about the duration of star formation, helium enrichment and age spread, and compare these to large photometric studies in the optical and infrared. Our models incorporate the latest observationally determined abundances. In particular, we explore the usefulness of the temperature and abundance distribution along the horizontal branch to constrain formation scenarios. We previously employed these methods to investigate hypotheses of high helium-abundance subpopulations in Omega Centauri.

040.05

White Dwarfs in the Galaxy

Stephane Vennes[1], A. Kawka[2]
[1]*Florida Institute of Technology,* [2]*Astronomical Institute AV CR, Czech Republic.*

Studies of white dwarf stars contribute to our understanding of star formation and evolution in our Galaxy. We are exploring the properties of a distant white dwarf population in the Galactic disk (V >18) uncovered in the 2dF Quasar Redshift Survey (2QZ). We complemented the original 2QZ spectra obtained at the Anglo Australian Telescope with optical (Sloan) and ultraviolet (GALEX) data. Based on a model atmosphere analysis, we determine detailed parameters (effective temperature, surface gravity and composition) for nearly 1,000 catalogued stars. The selected white dwarfs are relatively young, owing to the blueand UV-excess selection criteria, and belong to a thin-disk population. Their effective temperatures exceed 10,000K corresponding to cooling ages below 1 Gyr. Based on these data, we present a study of the white dwarf luminosity function and Galactic scale-height distribution using various absolute luminosity indicators, and explore the relative luminosity functions of hydrogen-rich (DA) and non-DA white dwarfs. We also discuss the properties of peculiar objects (low-mass, magnetic, high-mass white dwarfs) and examine the incidence of late-type companionship to white dwarfs. This research is supported by the Grant Agency of the Czech Republic (205/05/P186) and by a NASA/GALEX grant NNG05GL42G, and by the College of Science at the Florida Institute of Technology.

041: Integrating Mechanics with Computer Modeling AAPT Invited, Sunday, 10:00-11:30am, 616

Chair

Wolfgang Christian[1]
[1]*Davidson College.*

041.01

Computation in Classical Mechanics with Easy Java Simulations (EJS)

Anne J. Cox[1]
[1]*Eckerd College.*

Let your students enjoy creating animations and incorporating some computational physics into your Classical Mechanics course. This talk will demonstrate the use of an Open Source Physics package, Easy Java Simulations (EJS), in an already existing sophomore/junior level Classical Mechanics course. EJS allows for incremental introduction of computational physics into existing courses because it is easy to use (for instructors and students alike) and it is open source. Students can use this tool for numerical solutions to problems (as they can with commercial systems: Mathcad and Mathematica), but they can also generate their own animations. For example, students in Classical Mechanics use Lagrangian mechanics to solve a problem, and then use EJS not only to numerically solve the differential equations, but to show the associated motion (and check their answers).

EJS, developed by Francisco Esquembre (http://fem.um.es/Ejs/), is built on the OpenSource Physics framework (http://www.opensourcephysics.org/) supported through NSF DUE0442581.

041.02

Introducing Computational Approaches in Intermediate Mechanics

David M. Cook[1]
[1]Lawrence University.

In the winter of 2003, we at Lawrence University moved Lagrangian mechanics and rigid body dynamics from a required sophomore course to an elective junior/senior course, freeing 40% of the time for computational approaches to ordinary differential equations (trajectory problems, the large amplitude pendulum, non-linear dynamics); evaluation of integrals (finding centers of mass and moment of inertia tensors, calculating gravitational potentials for various sources); and finding eigenvalues and eigenvectors of matrices (diagonalizing the moment of inertia tensor, finding principal axes), and to generating graphical displays of computed results. Further, students begin to use LaTeX to prepare some of their submitted problem solutions. Placed in the middle of the sophomore year, this course provides the background that permits faculty members as appropriate to assign computer-based exercises in subsequent courses. Further, students are encouraged to use our Computational Physics Laboratory on their own initiative whenever that use seems appropriate.

(Curricular development supported in part by the W. M. Keck Foundation, the National Science Foundation, and Lawrence University.)

042: Physics: Something for Everyone
AAPT Invited, Sunday, 10:00-11:30am, 303

Chair

Kenneth Heller[1]
[1]Univ of Minnesota.

042.01

The Physics Force Physics for Ages 6 to 106

E. D. Dahlberg[1], C. Falco[2], I. K. Schuller[3]
[1]University of Minnesota, [2]University of Arizona, [3]University of California San Diego.

The presentation will provide highlights of The Physics Force, a superb outreach program of the University of Minnesota. The Force connects the University to K-12 education (students, teachers, and parents) and the general public. Its purpose is to increase both the number of students interested in pursuing science and math related careers, and for students and the public to have an increased general interest in science. The majority of attendees are k-6 students. The stated mission is to show that Science is Fun, Science is Interesting, and Science is Understandable. Growing over fifteen years, the attendance now averages more than 30,000/year students, teachers, and the general public. In the last three years, more than 2% of the total population of Minnesota attended a performance. The Physics Force is simultaneously entertaining and educational. Performances consist of quick paced demos that follow the physics; meaning the experiments are orchestrated to build on each other and teach a physics concept with little explanation provided (but with humor added). They have also gained national and international recognition. They performed at Disney's Epcot Center, have been on the extremely successful German public TV program Knoff-Hoff and were selected as one of the APS outreach programs for the World Year of Physics. In an attempt to make their presence at a school more lasting and for those schools they couldn't visit, The Physics Circus pre and post show materials and videos of most of the demonstrations are available on the web (http://www.physics.umn.edu/outreach/pforce/) (click on Physics Circus).

042.02

The Science of Optics; the History of Art

Charles M. Falco[1]
[1]University of Arizona.

Recently, renowned artist David Hockney observed that certain drawings and paintings from as early as the Renaissance seemed almost ″photographic″ in detail. Following an extensive visual investigation of western art of the past 1000 years, he made the revolutionary claim that artists even of the prominence of van Eyck and Bellini must have used optical aids. However, many art historians insisted there was no supporting evidence for such a remarkable assertion. In this talk, Falco will show a wealth of optical evidence for his claim that Hockney and he subsequently discovered during an unusual, and remarkably-productive, collaboration between an artist and a scientist. He will also discuss the unique properties of the ″mirror lens,″ and some of the implications this work has for the history of science as well as the history of art. These discoveries convincingly demonstrate optical instruments were in use-by artists, not scientists-nearly 200 years earlier than previously even thought possible, and account for the remarkable transformation in the reality of portraits that occurred early in the 15th century.

042.03

Science as Entertainment: Making of a Scientific Movie

Ivan K. Schuller[1]
[1]UC, San Diego.

There is a great need to present and explain science to the general public. The movie entitled ″When things get small″ about Nanoscience, is aimed at the general, not necessarily scientifically literate, public. This is done through the use of humor, analogies and entertainment in general. This creative collaboration arose from a joint project between a scientist, a TV produce and an actor. We will discuss some of the pitfalls in making scientific movies and an attempt at correcting these. This movie has been shown many times on TV, had several major showings at several venues world wide, is downloadable from the web and has won two Tellys (a major TV award).

043: Optics Education in the Middle Schools
AAPT Special, Sunday, 10:00-11:30am, 310

Chair

Robert T. Sparks[1]
[1]National Optical Astronomy Observatory.

043.01

LITE, Optics, Color and Vision

Kenneth Brecher[1]
[1]Boston University.

Over the past several years, as part of Project LITE Light Inquiry Through Experiments, we have developed hands-on (and eyes-on) resources for use in introductory undergraduate astronomy courses. These center on light, optics, color and visual perception. Many of the materials can also be used in K through 12 and informal science education settings, particularly our kit of inexpensive optical materials that is integrated with a set of Java applets. The combined kit and software gives students the chance to do actual experiments concerning geometrical and physical optics, fluorescence, phosphorescence, polarization and other topics by making use of the light emitted from computer screens. We have also developed over 200 Flash applets that allow students to directly explore many aspects of visual perception. In this presentation, we will demonstrate a variety of these physical and perceptual interactive experiences. All of the software can be found at http://lite.bu.edu. Project LITE is supported by Grant #DUE-0125992 from the NSF Division of Undergraduate Education.

043.02

Science beyond the Classroom: Hands-On Optics and the Boys and Girls Club

Erin F. Dokter[1], C. Walker[2], C. Peruta[1], C. Ubach[1], R. Sparks[2], S. Pompea[2]
[1]University of Arizona, [2]National Optical Astronomy Observatory.

In Summer and Fall 2006, the Hands-On Optics program of the National Optical

Astronomy Observatory (NOAO) teamed up with two local Boys and Girls Clubs in the Tucson area to conduct informal education programs for elementary and middle school aged children. Hands-On Optics (HOO) is a collaborative program

funded by NSF to create and sustain a unique, national, informal science

education program to excite students about science by actively engaging them in optics activities. The program was designed especially to reach underserved

students. In this talk, the successes and challenges of implementing these programs will be discussed, as well as the lessons learned in the process,

which may be applied to other partnerships between EPO providers and informal learning venues.

043.03

Middle School Optics Education: Hitting the Target or Impedance Mismatch?

Stephen M. Pompea[1], C. E. Walker[1], R. T. Sparks[1]
[1]National Optical Astronomy Observatory.

Traditionally, optics has been taught to upper-level students. Where can optics-related education topics best be used in the pre-high school curriculum? Is optics better introduced in an informal or formal education setting? What can be done about educator content knowledge, or lack thereof? What is the proper use of inquiry-oriented and investigatory activities? How can optics industry volunteers play an educational role?

This talk describes the educational design and programmatic decisions made by the Hands-On Optics (HOO) project in an attempt to address these questions. HOO is a collaborative 4-year program to create and sustain a unique, national, informal science education program to excite students about science by actively engaging them in optics activities. HOO grew from a series of regional planning workshops and a planning grant investigating these questions. The project partners are SPIE-The International Society for Optical Engineering, the Optical Society of America (OSA), and the National Optical Astronomy Observatory (NOAO).

The Hands-On Optics program has developed a series of six educational modules with full classroom-ready kits covering a variety of topics. These standards-based activities and demonstrations have been successfully used in a variety of settings including after-school clubs, science centers, and Boys and Girls Clubs. HOO content covers the concepts of reflection, image formation, polarization, ultraviolet and infrared light, and communication on a laser beam.

Funding is by the NSF ISE program. Project PI is Anthony M. Johnson, University of Maryland Baltimore County.

044: Interactive Lecture Demonstrations using Physics Suite Materials
AAPT Panel, Sunday, 10:00-11:30am, 617

Chair

David Sokoloff[1]
[1]University of Oregon.

045: Innovations in High School Physics, Part I
AAPT Special, Sunday, 10:00-11:30am, 307-08

Chair

Thomas F. Haff[1]
[1]Issaquah High School.

045.01

Seattle Area High School Astronomy Projects: 4 local teachers present their work with students.

Eric C. Muhs[1]
[1]Roosevelt High School.

4 Seattle area high school teachers will present work with students as part of the opening session of High School Teacher Day. Vince San Pietro of Shorecrest HS will discuss a project involving teachers and students in characterizing RR Lyrae candidate stars using the University of Washington's Manastash Ridge Observatory. Rebecca Fowler of Skyline HS will present her work with student teams in the Team America rocketry contest. Phil Cooper, also of Skyline, will talk about a telescope making project. And Eric Muhs of Roosevelt HS, will show a student-built, free-floating, self-orienting robot that flew aboard NASA's zero gravity airplane last May.

046: Innovations in Teaching Astronomy
AAPT Oral, Sunday, 10:00-11:30am, 615

Chair

Janelle M. Bailey[1]
[1]Univ. Nevada, Las Vegas.

046.01

Survey Instrument Probing Student Understanding of the Greenhouse Effect

John M. Keller[1], T. F. Slater[2], E. E. Prather[2]
[1]Cal Poly San Luis Obispo, [2]University of Arizona.

Through student interviews and multiple iterations of open-ended and multiple-choice surveys (involving over 3,600 undergraduate non-science majors), we have developed at multiple-choice survey instrument for assessing undergraduate student understanding of the atmospheric greenhouse effect. Central topics include: 1) the energies of light given off by the sun and absorbed and given off by Earth's atmosphere and surface, 2) energy balance, 3) abundant greenhouse gases, 4) mental models of how the greenhouse effect works, and 5) distinctions between the natural greenhouse effect and global warming. We have also developed a lecture tutorial activity focused on several of these topics. The final survey instrument has been validated using standard survey metrics and an expert review process. We offer this survey instrument to the science education community as a research tool for assessing the impact of instruction on student understanding of the greenhouse effect.

046.02

Misconceptions in Astronomy and Physics

Andy Veh[1]
[1]Kenai Peninsula College.

Most people know about the seasons, our moon's phases, gravitation, the centrifugal force and the Bernoulli effect. But too many give wrong explanations because they were misinformed by peers, family, friends and the occasional teacher, or simply because the wrong explanation of Earth being closer to the Sun in the summer makes sense. In physics and astronomy we need to emphasize the correct explanations, employing the teaching and

correct usage of the scientific method with as many visuals, demonstrations and animations as it takes. A teaching presentation regarding the gravitational force, Newton 2, and Newton 3 for the Earth and Moon system will be shown, exemplifying the author's approach.

046.03

Ranking Tasks for Assessing Conceptual and Quantitative Understanding in Astronomy

Edward E. Prather[1], T. F. Slater[1], D. Loranz[2]
[1]University of Arizona CAPER Team, [2]Truckee Meadows Community College.

A challenge for astronomy teachers is to deeply and meaningfully assess students' conceptual and quantitative understanding of astronomy topics. In an effort to evaluate students' understanding, members of the Conceptual Astronomy and Physics Education Research (CAPER) Team are creating and field-testing innovative approaches to assessment. Leveraging both astronomy and physics education research, we are creating a series of assessment tools that require students' to place items or quantities in a rank order from "greatest to least." These conceptually challenging tasks span the entire domain of topics and highlight the most important physical laws taught in a typical introductory astronomy course for non-science majoring undergraduates. When completed, these ranking tasks will be able to be delivered via paper-and-pencil tasks or a drag-and-drop computer interface a series of assessment tasks that are capable of determining the depth of student understanding in astronomy.

Ref: Hudgins, David W., Prather, Edward. E., Grayson, Diane J., Derck P. (2006). Effectiveness of Collaborative Ranking Tasks on Student Understanding of Key Astronomy Concepts, The Astronomy Education Review, 5(1):1-22.

046.04

Sorting Tasks and Vocabulary-in-Context Activities for Assessing Introductory Astronomy Understanding

Timothy F. Slater[1], D. Loranz[2], E. E. Prather[1]
[1]University of Arizona CAPER Team, [2]Truckee Meadows Community College.

One of the most ardent challenges for astronomy teachers is to deeply and meaningfully assess students' conceptual and quantitative understanding of astronomy topics. In an effort to uncover students' actual understanding, members and affiliates of the Conceptual Astronomy and Physics Education Research (CAPER) Team at the University of Arizona and Truckee Meadows Community College are creating and field-testing innovative approaches to assessment. Leveraging from the highly successful work from physics education research, we are creating a series of tasks where students categorize a list describing common astronomical events or phenomenon; or vocabulary terms into context rich categories or conceptually rich sentences. These intellectually challenging tasks are being created to span the entire domain of topics in introductory astronomy for non-science majoring undergraduates. When completed, these sorting tasks and vocabulary-in-context activities will be able to be delivered via a drag-and-drop computer interface.

046.05

Visual Activities for Assessing Non-science Majors' Understanding in Introductory Astronomy

Daniel Loranz[1], E. E. Prather[2], T. F. Slater[2]
[1]Truckee Meadows Community College, [2]University of Arizona CAPER Team.

One of the most ardent challenges for astronomy teachers is to deeply and meaningfully assess students' conceptual and quantitative understanding of astronomy topics. In an effort to uncover students' actual understanding, members and affiliates of the Conceptual Astronomy and Physics Education Research (CAPER) Team at the University of Arizona and Truckee Meadows Community College are creating and field-testing innovative approaches to assessment. Leveraging from the highly successful work on interactive lecture demonstrations from astronomy and physics education research, we are creating a series of conceptually rich questions that are matched to visually captivating and purposefully interactive astronomical animations. These conceptually challenging tasks are being created to span the entire domain of topics in introductory astronomy for non-science majoring undergraduates. When completed, these sorting tasks and vocabulary-in-context activities will be able to be delivered via a drag-and-drop computer interface.

046.06

A New Chart and Teaching Materials on Cosmology from CPEP

G Samuel Lightner[1], M. Cherney[2], G. Aubrecht[3], R. Reiland[4]
[1]Westminster College, [2]Creighton University, [3]The Ohio State University, [4]Shady Side Academy.

The Contemporary Physics Education Project (CPEP), a volunteer non-profit corporation of educators and scientists that has been developing materials to support the introduction of contemporary physics topics into high school and college introductory physics for 20 years, recently introduced a teaching chart on cosmology: *The History and Fate of the Universe*. This talk will feature this chart and the activities and materials that are being developed to support the chart. Featured also will be the Universe Adventure, an internet tutorial related to the chart coming on line through the efforts of collaborating scientists at Lawrence Berkeley National Laboratory. (www.CPEPweb.org)

046.07

Asteroids and LSST EPO

Robert T. Sparks[1], S. K. Croft[1], S. M. Pompea[1]
[1]National Optical Astronomy Observatory.

We are developing a pilot educational outreach program in support of the Large Synoptic Survey Telescope (First Light approximately 2012). An important component will be student research using visible & near infrared color photometry to characterize Near Earth Objects, newly discovered asteroids, and other interesting asteroids of known orbits. The project is being designed for Middle school students and enter the curriculum via Earth Science, using asteroid science to teach concepts including the nature and development of terrestrial rocks, meteorites, and asteroid types; earth processes, formation of the Earth, Moon, and solar system, the nature and possible use of near earth resources, and the connection between asteroid impacts and life on earth. We will discuss some of the early work with teachers observing asteroids at Kitt Peak National Observatory as well as future plans using precursor data such as the Sloan Digital Sky Survey.

047: Pierce Prize in Astronomy
Plenary, Sunday, 11:40am-12:30pm, Ballroom 6

047.01

Bubbles, Bow Shocks and *B* Fields: The Interplay Between Neutron Stars and Their Environments

Bryan M. Gaensler[1]
[1]The University of Sydney, Australia; Harvard-Smithsonian Center for Astrophysics.

Young neutron stars embody Nature's extremes: they spin incredibly rapidly, move through space at enormous velocities, and are imbued with unimaginably strong magnetic fields. Since their progenitor stars do not have any of these characteristics, these properties are presumably all imparted to a neutron star during or shortly after the supernova explosion in which it is formed. This raises two fundamental questions: how do neutron stars attain these extreme parameters, and how are their vast reservoirs of energy then

SUNDAY

dissipated? I will explain how multi-wavelength observations of the environments of neutron stars not only provide vital forensic evidence on the physics of supernova core collapse, but also spectacularly reveal the winds, jets, shocks and outflows through which these remarkable objects couple to their surroundings.

048: Cool Astronomy For Everyone
AAS Special, Sunday, 2:00-3:30pm, 613-14

Chair

Susana E. Deustua[1]
[1]American Astronomical Society.

048.01

Fusion Confusion: Assessing What Students Know (and Don't Know) About Stars

Janelle M. Bailey[1], E. E. Prather[2], B. Johnson[2], T. F. Slater[2]
[1]Univ. Nevada, Las Vegas, [2]Univ. Arizona.

"A star is just a white dot in the sky!" Have you heard this from one of your students? Do they all think this? How can you know what other ideas they might have about stars? Determining what students understand about various topics is a developing area of astronomy education research. College nonscience majors in introductory astronomy courses were surveyed to find out what they know about star properties and formation; these ideas were later used to develop the "Star Properties Concept Inventory," a multiple-choice instrument that can be used in such courses to investigate the extent to which your students hold these same ideas. In this talk, you'll find out what students know about the various properties of stars; how stars form; and what we mean by "fusion confusion."

048.02

Transients in 10 seconds or less: catching Gamma-Ray Bursts in the act with ROTSE

Eli S. Rykoff[1]
[1]Univ. of Michigan.

Gamma-Ray Bursts (GRBs) signal the violent deaths of massive stars. We see these death throes as a massive flux of gamma-rays lasting just a few tens of seconds. Such bursts are detected by NASA satellites several times a week at random locations on the sky. Optical observations of GRBs requires constant readiness and extremely rapid response. I will talk about why GRBs are so short, and describe the global network of fast, tireless, automated telescopes we have built to chase down GRBs while they happen-the Robotic Optical Transient Search Experiment. The ROTSE array, with telescopes in remote locations on four continents, catches GRBs early and often, getting to over a third of all GRBs quickly, and imaging them within 7 seconds of their satellite detection.

049: Cosmic Microwave Background
AAS Special, Sunday, 2:00-3:30pm, 6A

Chair

John Mather[1]
[1]NASA Goddard Space Flight Center.

049.01

Introduction to the Cosmic Microwave Background

Marc Kamionkowski[1]
[1]Caltech.

I will review some basic theory of the cosmic microwave background (CMB), focussing in particular on the polarization of the CMB. I will discuss some background, review recent results, and their implications for the early Universe. I will then provide some of the motivation for pursuing future CMB polarization experiments, emphasizing in particular the connections with the theory of inflation.

049.02

CMB Anisotropies with the SZA

Matthew Sharp[1], J. Carlstrom[1], J. Cartwright[1], C. Greer[1], D. Hawkins[2], R. Hennessy[1], M. Joy[3], J. Lamb[2], E. Leitch[4], M. Loh[1], D. Marrone[1], A. Miller[5], T. Mroczkowski[5], S. Muchovej[5], C. Pryke[1], B. Reddall[1], M. Runyan[1], D. Woody[2]
[1]KICP, U. Chicago, [2]OVRO, Caltech, [3]NASA, [4]NASA / Caltech, [5]Columbia.

The Sunyaev-Zel'dovich Array (SZA) is a new, eight-element, interferometric array dedicated to observations of the CMB anisotropy at arcminute scales and the Sunyaev-Zel'dovich (SZ) effect from galaxy clusters. The SZA has been operating at 30 GHz at the Owens Valley Radio Observatory since mid 2005. During this first year of operation, the SZA has focused on an SZ survey for galaxy clusters over several square degrees and measurement of the CMB angular power spectrum over multipoles spanning ~2000 to ~8000.

On arcminute angular scales, the anisotropy in the CMB is dominated by secondary contributions, including the Sunyaev Zel'dovich effect of galaxy clusters. The magnitude of these contributions is strongly dependent on the value of sigma_8. Measurements showing power attributed to secondary CMB anisotropy have been reported by the CBI team at l ~ 2500 (Readhead, 2003) and by the BIMA team at l ~ 5000 (Dawson, 2006), and the SZA measurement will build on this earlier work.

Observations of several fields have now been completed by the SZA with sufficient depth to tightly constrain the power spectrum in this regime. The data have been taken in such a way as to allow the removal of contamination from the ground. Follow-up work with the VLA provides a detailed understanding of the contribution of point sources to the measurement. Jackknife tests have been used to demonstrate that measured power is coherent and persistent over months, consistent with CMB anisotropy.

After a brief review of the current status of the instrument and observations, this talk will focus on the measurements of the CMB anisotropy power.

049.03

New measurements of the CMB polarization anisotropy at small angular scales from CAPMAP

Lewis D. Hyatt[1], CAPMAP Collaboration
[1]Princeton.

The CAPMAP array of correlation polarimeters was expanded to its full design after a prototype experiment successfully reported in 2004 a 2σ detection of CMB E-mode polarization anisotropy consistent with the concordance model at $l \approx 1000$. After an enlargement of the 90-GHz array from four to twelve receivers and the addition of a comparably sensitive array of four 40-GHz receivers, the experiment was re-deployed on the Crawford Hill 7-Meter Antenna in Holmdel, NJ for the Winter 2004-Spring 2005 observing season. The 16 polarimeters each observed for $\approx$1200 hours after cuts in a ring scan around the NCP, covering a patch of diameter 1.5°. Analysis of the subsequent data set, which has a net five-fold improvement in sensitivity, will be complete by the end of 2006 and will yield a significantly stronger result, improving current knowledge of the EE power spectrum in the range $500 \leq l \leq 1500$ and shedding new light on astronomical foregrounds.

049.04

Report on BICEP's First Season Observing the Cosmic Microwave Background from South Pole

K. W. Yoon[1], P. A. Ade[2], D. Barkats[1], J. O. Battle[3], E. M. Bierman[4], J. J. Bock[3], H. C. Chiang[1], C. D. Dowell[3], L. Duband[5], G. S. Griffin[1], E. F. Hivon[6], W. L. Holzapfel[7], V. V. Hristov[1], B. G. Keating[4], J. M. Kovac[1], C. Kuo[1], A. E. Lange[1], E. M. Leitch[3], P. V. Mason[1], H. T. Nguyen[3], N. Ponthieu[8], Y. D. Takahashi[7]
[1]California Institute of Technology, [2]University of Wales, United Kingdom, [3]Jet Propulsion Laboratory, [4]U. C. San Diego, [5]CEA, France, [6]IPAC, [7]U. C. Berkeley, [8]IAS, France.

BICEP is a small-aperture polarimeter which began observing the CMB from South Pole in January 2006. BICEP's 25 cm refracting telescope feeds an array of 49 polarization-sensitive bolometer pairs operating at 100 and 150 GHz. A three-axis mount provides azimuth-scanning modulation, elevation coverage from 45 degrees to zenith, and boresight rotation of the entire instrument for polarization systematic error control. We report on the first winter observations of the CMB and Galaxy at degree angular scales.

BICEP is funded by NSF/Office of Polar Programs, Caltech, JPL, and the estate of J. Robinson.

049.05

Status of the QUAD Experiment

Sarah Church[1]
[1]Stanford University/KIPAC.

The QUaD (QUEST at DASI) experiment comprises a 31-pixel polarization-sensitive bolometric camera mounted on a 2.6m telescope at the South Pole. QUaD has completed two seasons of observations designed to measure the polarization of the Cosmic Microwave Background (CMB). I will report on the status of QUaD data analysis and interpretation. QUaD is a collaboration between institutions in the US, the UK and Ireland and is funded by the NSF, PPARC and Enterprise Ireland.

049.06

The Future of CMB Polarization: Report of the CMB Task Force

Rai Weiss[1]
[1]MIT.

A brief summary of the findings of a Task Force on CMB research will be presented. The task force was organized by NSF, NASA and DoE and presented a final report to the agencies in 2005/2006. The principal findings and recommendations of the Task Force will be discussed. The principal recommendations of the Task Force include:

1) A well coordinated and joint agency program of ground based, balloon borne measurements leading to a new space mission designed to measure the polarization patterns of the CMB to a level limited by the astrophysical foreground.

a) A significant component of such a program is the measurement of the polarization of the foregrounds which interfere with the cosmological measurements.

b) A strong modelling program to include the foregrounds, gravitational lensing leading to E to B mode mixing and estimation of systematic errors to optimize the design of a space mission.

c) A coordinated polarization sensitive receiver development program including detector arrays, optical coupling and read-out multiplexing techniques.

2) A strong continuing ground based program to measure small scale temperature anisotropy and the Sunyaev-Zel'dovich effect.

049.07

NASA CMBPOL Mission Studies

Jamie Bock[1], G. F. Hinshaw[2], P. T. Timbie[3]
[1]NASA/JPL, [2]NASA/GSFC, [3]U. Wisconsin.

Gravitational waves produced during the epoch of Inflation, an exponential expansion of space-time occurring in the first moments after the Big Bang, may produce a detectable polarization signal in the Cosmic Microwave Background with a distinctive divergence-free B-mode pattern. Detecting the existence or absence of this gravitational wave background, a principal long-term goal of NASA's Beyond Einstein Program, would probe the physical mechanism responsible for Inflation, and is expected to be detectable if inflation is associated with the energy scale of grand unification theories. The scientific importance and technical pathway leading to a space-borne CMB polarization experiment is described in a recent NSF/NASA/DOE CMB Task Force (CMBTF) report. A space-borne experiment offers the all-sky coverage, high sensitivity, and wide frequency coverage needed to detect the power spectrum characteristic of inflationary gravitational-wave polarization, and to distinguish it from local polarized foregrounds. We summarize three NASA mission study concepts that have been carried out to investigate experimental approaches to probing CMB polarization. We find that the scientific goals outlined by the CMBTF report can be carried out in a baseline space-borne mission using demonstrated technologies and experimental techniques. Several rapidly advancing technologies would allow the formulation of a mission with improved capabilities.

050: NSF Astronomy Division Senior Review Outcome AAS Special, Sunday, 2:00-3:30pm, 6B

Chair

Eileen D. Friel[1]
[1]NSF.

050.01

NSF Astronomy Division Senior Review Outcome

G W. Van Citters[1]
[1]NSF.

Over the past year, the Astronomy Division at NSF has been carrying out a review of its portfolio and an examination of the balance of investments in the various facilities AST supports. The primary goal of the review and the adjustment of balance that will result is to enable progress on the recommendations of the Decadal Survey and other community reports while preserving, or even growing, a healthy core program of astronomical research. A committee of representatives from the community, chaired by Roger Blandford, worked extensively over the period October 2005 October 2006 to develop and formulate its recommendations. Their report is expected to be completed and provided to NSF in November 2006. During this session, NSF representatives will discuss the report and its recommendations, and describe the development of an implementation plan. Initial presentations by NSF staff and the committee Chair will be followed by an open forum for discussion.

051: HAD II: Case Studies in How 20th Century Observatory Directors Got Chosen HAD Special, Sunday, 2:00-3:40pm, 611-12

Chair

Karl Hufbauer

051.01

Lowell Observatory Enters the Twentieth Century—in the 1950s

Joseph S. Tenn[1]
[1]Sonoma State Univ..

By the 1950s the Lowell Observatory was stagnant. The three senior astronomers had been there for decades, and they were no longer doing much research or publishing. Yet they jealously guarded the telescopes and prevented younger colleagues from using them effectively. V.M. Slipher, director since 1916, had been a very productive astronomer in his youth, when he was guided by founder Percival Lowell, but now he devoted his remaining energies to his many business interests. The observatory's sole trustee, a nephew of the founder, was busy with his business and politics in Massachusetts and slow to exert authority in Flagstaff. Finally, after C.O. Lampland died and V.M. and E.C. Slipher were in their seventies, the trustee decided that he had to make a change. He brought in mathematician Albert Wilson, who had been leading the Palomar Sky Survey for Caltech. One of Wilson's qualifications seems to be that he was acceptable to the Slipher brothers. Wilson started the observatory on the road to modernity but ran into personal problems as well as difficulty managing observatory personnel, and he resigned after three years. John Hall became director in 1958, just as the American reaction to Sputnik made abundant federal resources available to science. In his nineteen years as director Hall completely revived the historic institution and brought it into the late twentieth century.

051.02

The Evolution of the National Radio Astronomy Observatory into a User Based Observatory

Kenneth I. Kellerman[1], E. Bouton[1]
[1]NRAO.

The NRAO was conceived in the mid 1950s as a state-of-the-art facility to allow the United States to compete in the exciting radio astronomy discoveries then taking place in the U.K., the Netherlands and Australia. Otto Struve, the first NRAO director in Green Bank, was chosen to lead the Observatory research program. During Struve's tenure as director, nearly all of the research was carried out by NRAO staff members resident at the Green Bank Observatory. However, under Dave Heeschen, who served as NRAO Director from 1961 to 1978, the number of visitor programs gradually increased; the NRAO scientific staff become more involved in visitor support than in doing their own research, and users became more dependent on instruments and techniques developed by NRAO, often not even coming to the Observatory for their observations.

Currently, about half of the observing time on NRAO facilities is allocated to observers from foreign institutions -institutions with which NRAO was built to compete.

051.03

Michigan Turns to Leo Goldberg

Rudi P. Lindner[1]
[1]U. Michigan.

The death of Heber D. Curtis at the beginning of 1942 emphasized the difficult circumstances facing Michigan's astronomy program. There were no funds to figure or mount the 98″ pyrex blank; the 37″ reflector labored under floodlights; and the war sapped the graduate program. For a number of years the staff argued over the best path for the future, goaded by the unwelcome intervention of the ″amateurs″ McMath and Hulbert. The administration brought in outside consultants, attempted to prevent the observatory staff from making separate arrangements, trawled in western waters without success, and took conflicting advice on the future direction of the science. In 1946 the university leadership had, as well, to consider the aftermath of the war: new possibilities in physics, new funding opportunities, a booming student population, and the encapsulation of the observatory within the medical campus. At this time, Leo Goldberg was on the McMath-Hulbert staff, had little to do with the Ann Arbor community, and was considered to be an outsider, beholden to astrophysical theory and his promoters at Harvard. Leo Goldberg's rise from relative obscurity, his transformation from assistant to leader, and the university leadership's assessment of the possibilities for the transformation of a midwest, urban, and traditional program form the topic of this paper, based upon the Michigan and Harvard archives as well as the memories of Goldberg's cohort.

051.04

A Referendum on the State of Astronomy at Harvard: *Choosing Harlow Shapley's Successor*

David H. DeVorkin[1]
[1]Smithsonian Inst..

Harlow Shapley, the Director of the Harvard College Observatory for over three decades, was scheduled for retirement in 1952. His predecessor, E. C. Pickering, had held the office for some 42 years. Therefore naming successors at Harvard was something of a rarity, and as a result, the process engaged many issues that illuminate how astronomy as a profession changed during Shapley's tenure, and the changing place of Harvard astronomy within the profession. Harvard's case was not unique--similar issues were raised at other major American observatories when it came time for a change in administration--but no American Observatory was scrutinized as closely as was Shapley's, or as sharply. Despite Shapley's wishes, echoed by his senior staff, for a quick decision on a successor, Harvard President James B. Conant asked J. Robert Oppenheimer to form a blue ribbon review panel to assess the state of astronomy at Harvard before a search for a new director could take place. The committee, mainly physicists, came back with a brutal assessment. My paper will outline this assessment and examine its recommendations as indicators of how the norms, standards and practices of the American astronomical profession were undergoing profound change in the Cold War era. This research has been supported in part by a grant from the Naitonal Science Foundation.

051.05

Changing the Guard Slowly: Yale 1963-1975

Virginia Trimble[1]
[1]U. C. Irvine.

Yale's was the first copy of the Principia to arrive in America, and astronomy was sporadically taught there from the 1740s onward. Perhaps this extended tradition was a contributing factor in the long and somewhat troubled transition from nearly-pure emphasis on ″the old astronomy″ of positions, proper motions, and such to ″the new astronomy″ or astrophysics. In an era when many departments were growing rapidly and new astrophysics PhDs were much in demand (even I received 5 offers for 1968-69, though being a small green Martian or female was not thought an advantage then), Yale managed to acquire and rapidly de-accession a remarkable number of folks of great ability, based on their later records. The habit has, perhaps, not yet been entirely overcome. Some details will be explored and some analogies drawn with another institution (Cambridge University), which experienced even greater metamorphic pains. My starting date here is the hiring of Norman Baker and Myron Lecar; the end point the arrival of Beatrice Tinsley; and I may or may not name other names.

052: AGN Populations
AAS Oral, **Sunday**, **2:00-3:30pm**, **3A**

052.01

The Infrared Properties of galaxies and Quasars at z~6

Yuexing Li[1], L. Hernquist[1], D. Finkbeiner[1]
[1]Harvard-Smithsonian, CfA.

The early, luminous quasars form through hierarchical, gas-rich galaxy mergers. I will present the infrared properties of quasars and progenitors at z~6.

052.02

X-ray Spectral Properties from Chandra Observations of SDSS QSOs to z=5

Paul J. Green[1], W. A. Barkhouse[2], T. L. Aldcroft[1], D. Kim[1], A. Mossman[1], G. Richards[3], M. Weinstein[4], ChaMP Collaboration
[1]SAO, [2]UIUC, [3]Princeton, [4]PSU.

AGN unification models spawned in the optical are now confronted with multiwavelength data that break the simplest Type I/II dichotomy. For instance, some broad emission line (optical Type I) AGN (BLAGN) are found to show significant X-ray absorption, and some narow line AGN (NLAGN) show none. Some of the absorbed BLAGN are explained as BALQSOs, but some are not. We cross-correlate the largest intermediate depth Chandra X-ray survey, the ChaMP, with a new SDSS photometric quasar catalog (extending to fainter mags and higher redshifts than the spectroscopic sample), and study the X-ray spectral properties of luminous broad line quasars. This constrains the absorbed fraction, identifies new BALQSO candidates, and tests claims of decreased absorption with increasing luminosity. We also contrast the X-ray spectral properties of this sample with those of an X-ray-selected BLAGN sample from the ChaMP.

052.03D

Properties of Millijansky Radio Source Hosts

Brian Stalder[1]
[1]University of Hawaii.

Here is presented a survey of 52 millijansky radio sources from the VLA-FIRST survey within the isoplanatic patch (r < 25'') of bright (11<V<12) natural guide stars appropriate for high-order adaptive optics correction. A large fraction of these should be high redshift (z ≥1) galaxies, suitable for probing the spheroid formation at early epochs. Using multi-band photometric redshifts, a subsample of 17 high-redshift candidates were selected for high spatial resolution imaging using the Subaru AO+IRCS system. Surface brightness distributions of the AO data were constructed and fit with both PSF-convoled exponential and de Vaucouleurs profiles. This has provided a statistically significant sample for examining the dynamical and stellar population evolution of massive spheroids at high redshift.

052.04

Searching for the Sources Responsible for the Unresolved 6-8 keV Cosmic X-ray Background

Aaron T. Steffen[1], W. N. Brandt[1], D. Alexander[2], S. Gallagher[3], B. Lehmer[1]
[1]Penn State Univ., [2]Durham University, United Kingdom, [3]UCLA.

Using the 2 Ms *Chandra* Deep Field North, the deepest X-ray observation to date, we employ X-ray stacking techniques to constrain the maximum 6-8 keV flux that can be contributed by the X-ray undetected Great Observatories Origins Deep Survey (GOODS) sources from both *Hubble's* Advanced Camera for Surveys (ACS) and *Spitzer's* Infrared Array Camera (IRAC) source catalogs. We compare the combined X-ray flux of these sources with recent models of the Cosmic X-ray Background (CXB) and show that the ″missing″ 6-8 keV CXB cannot be completely recovered from the integrated X-ray emission from the known optical and infrared sources in the field.

052.05

Swift/Burst Alert Telescope(BAT) Hard X-ray Survey

Jack Tueller[1], C. Markwardt[2], R. Mushotzky[3], Swift Survey Team
[1]NASA's GSFC, [2]UMd/NASA/GSFC,, [3]NASA/GSFC.

The BAT instrument on Swift is a wide field (70° X 100°) coded aperture instrument with a CdZnTe detector array sensitive to energies of 14-200 keV. Each day, the BAT survey typically covers 60% of the sky to a detection limit of 30 milliCrab. BAT makes hard X-ray light curves of similar sensitivity and coverage to the X-ray light curves from XTE/ASM, but in an energy range where sources show remarkably different behavior. Integrating the BAT data produces an all sky map with a source detection limit at 15 months of a few X 10-11 ergs cm-2 s-1, depending on the exposure. This is the first uniform all-sky survey at energies high enough to be unaffected by absorption since HEAO 1 in 1977-8. BAT has detected >200 AGN and >180 galactic sources. At high galactic latitudes, the BAT sources are usually easy to identify, but many are heavily absorbed and there are a few quite surprising identifications. The BAT selected galaxies can be used to calculate LogN/LogS and the luminosity ! function for AGN which are complete and free from common systematics. Several crucial parameters for understanding the cosmic hard x-ray background are now determined.

052.06

The DRaGONS Survey: A Search for High Redshift Radio Galaxies and Heavily Obscured AGNs

Samuel Schmidt[1], A. Connolly[1], A. Hopkins[2]
[1]University of Pittsburgh, [2]University of Sydney, Australia.

We present the first results from the Distant Radio Galaxies Optically Non-detected in the SDSS (DRaGONS) survey. Using a novel selection technique for identifying high redshift radio galaxy (HzRG) candidates, a large sample is compiled using bright radio sources from the Faint Images of the Radio Sky at Twenty centimeters (FIRST) survey having no optical counterpart in the Sloan Digital Sky Survey (SDSS). Near-infrared (NIR) K-band imaging with the FLAMINGOS instrument on the Mayall telescope at Kitt Peak allows preliminary identification of HzRG candidates through the well-known K-z relation. Redshifts based on a linear fit to the K-z Hubble diagram give a mean redshift for our sample of z=2.5 and a median redshift of z=2.0, showing that this method should be very efficient at identifying a large number of HzRGs. This selection is also sensitive to a previously unseen population of anomalously red radio galaxies (r-K>6.5-7), dubbed Red DRaGONS, which may indicate significant obscuration at moderate redshifts. These obscured objects can be used to test the completeness of QSO surveys to the effects of reddenning. More than ten percent of our sample falls into this category, which may represent a sizable radio loud population missing from current optically selected AGN samples.

052.07

Spitzer/IRS Spectra of GOODS AGN

Jeffrey Van Duyne[1], C. M. Urry[1]
[1]Yale University.

IRS Spectra of GOODS AGN

Infrared emission from AGN comes from dust heated by black hole accretion and/or star-formation. Separating the contributions in optical/UV light can be difficult, particularly when obscuration is high; mid-infrared spectra are less affected by obscuration and thus offer diagnostics of the underlying power source(s). We present Spitzer IRS spectra of 10 IR-bright, hard X-ray-selected AGN from the GOODS-North field, spanning the redshift range 0.485<z<2.005. Spectra were obtained with the deep Long and Short-Low modules, in exposures of 4-8 hours duration, resulting in a S/N ratio of ~8-10 per pixel. The observed PAH features, silicate absorption, and infrared continua offer clues to distinguish reprocessed torus emission from the stellar-heated dust component. Combining with extensive GOODS imaging data at radio, sub-mm, infrared, optical and X-ray wavelengths, we place limits on the star-formation rates, Eddington ratios, and bolometric luminosities of the sample, and compare with lower-redshift samples to probe the evolution of the dust-enshrouded phase of AGN activity.

This work was supported by NASA JPL/Spitzer grant RSA 177278. This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA JPL/Spitzer grant RSA 177278.

052.08

Probing Faint Active Galaxies at Redshifts 6 7 and above

Anton M. Koekemoer[1], J. Bergeron[2], D. Alexander[3], W. Brandt[4], R. Chary[5], C. Conselice[6], S. Cristiani[7], E. Daddi[8], M. Dickinson[9], D. Elbaz[8], N. Grogin[10], G. Hasinger[11], V. Mainieri[12], E. Treister[13], C. M. Urry[14]
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The advent of deep and wide multi-wavelength surveys provides unprecedented new opportunities to search for very high redshift active galactic nuclei by constructing samples of sources that are detected at X-ray wavelengths but completely undetected at optical wavelengths to very deep limits. I will describe recent work on constructing samples of candidate AGN at or beyond redshift 6 7, such as the ′EXO's selected from deep multiband X-ray/HST/IR surveys including GOODS and similar large projects. The optical flux limits are combined with IR detections, together with X-ray fluxes, to model the spectral energy distributions of the sources and help discriminate intermediate-redshift interlopers from the rare number of likely high-redshift sources. The resulting constraints on the number of candidate AGN at or above redshift 7 are used to examine the evolution of the AGN luminosity function at high redshift, with corresponding implications for the co-evolution of galaxies and their central black holes.

053: Distant Works: Cosmology, Large Scale Structure and Gravitational Waves
AAS Oral, Sunday, 2:00-3:30pm, 6D

053.01

Discovery of Faint Radio Structures over 50 Square Degrees Down to 3 arcmin Scales near the NGP

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We present a deep, 8° diameter, 0.4 GHz radio image near the North Galactic Pole using a first time combination of the Arecibo 305-m telescope and the wide-angle interferometer at the DRAO. The uniquely complementary nature of these two instruments permits a distortion-free image sensitive to radiation on all scales from 8° down to that of an individual galaxy halo at the 100 Mpc distance of the Great Wall, all in a single pointing. Faint, previously unseen diffuse patches of distributed radio ′′glow'' are detected, well above our detection limit, and on a range of angular scales. The emission could compete with CMB fluctuations as a CMB foreground at high multipole scales around 30GHz *if* its radio spectrum continues up to these GHz bands. This new faint radio emission appears to be a mix of foreground Galactic, and extragalactic ′′glow''. The latter implies i.g. magnetic field strengths at or above 0.1 microgauss on Mpc scales in certain areas. A striking anticorrelation is also found between the diffuse radio glow and some regions of high optical galaxy surface density. This suggests that cosmological Large Scale Structure (LSS), normally defined by the baryonic (and/or dark) matter density, is not uniquely traced by the faint continuum radio glow. More likely, the radio glow is a proxy for IGM energy density, at least in the low redshift universe. Its detailed relation to the WHIM, and diffuse X-ray glow is unclear, and must await future, more sensitive detectors for these latter two IGM components. Support for this project is acknowledged from the DOE's LDRD program at LANL, the Natural Sciences and Engineering Research Council of Canada (NSERC), and the National Science Foundation.

053.03D

Crawling the Cosmic Web: An Exploration of Filamentary Structure

Nicholas A. Bond[1], M. A. Strauss[1], R. Cen[1]
[1]Princeton Univ..

By analyzing the smoothed density field and its derivatives on a variety of scales, we can select strands from the cosmic web in a way which is consistent with our common sense understanding of a ″filament″. We present results from a twoand three-dimensional filament finder, run on both CDM simulations and a section of the SDSS spectroscopic sample. In both data sets, we will analyze the length and width distribution of filamentary structure and discuss its relation to galaxy clusters. Sources of contamination and error, such as ″fingers of god″, will also be addressed.

053.04

A Direct View of the Large-Scale Distribution of Mass, from Weak Gravitational Lensing in the HST COSMOS Survey

Richard Massey[1], J. Rhodes[1], A. Leauthaud[2], R. Ellis[1], N. Scoville[1], A. Finoguenov[3]
[1]CalTech, [2]Laboratoire d'Astrophysique de Marseille, France, [3]Max Planck Institut fur Extraterrestrische Physik, Germany.

We present the first direct maps of the large-scale distribution of mass in the Universe. Measurements of weak gravitational lensing from the Hubble Space Telescope COSMOS survey directly trace the 3D distribution of mass, regardless of its nature or state. They reveal a filamentary network of structures that encompass large voids and meet in massive clusters of galaxies. By comparing this to the stellar mass density from optical and near-infrered observations, and to the distribution of hot gas from XMM observations, we explore the complex relationship between dark matter and the baryons. The HST COSMOS Treasury program was supported through NASA grant HST-GO-09822 and the HST ACS CTE calibration program was supported through NASA grant HST-AR-10964.

053.05

Effects of Baryons and Dissipation on the Matter Power Spectrum

Douglas Rudd[1], A. Zentner[1], A. Kravtsov[1]
[1]University of Chicago.

Future weak-lensing experiments will measure the matter power spectrum at moderate (k ~ 1 h/Mpc) scales with percent level accuracy, a regime where the influence of dissipational baryon physics becomes important. Cosmological simulations which include the relevent baryonic physics demonstrate that these processes have important effects on the structure of dark matter halos and a measurable effect on the matter power spectrum. We show that the effect on the power spectrum is dominated by the change in the concentration of dark matter halos and this effect must be understood in order to use weak-lensing surveys for constraints on dark-energy.

053.06D

Upper Limit Map of a Stochastic Background of Gravitational Waves

Stefan Ballmer[1]
[1]California Institute of Technology.

Data from the LIGO S4 science run was analyzed for an anisotropic background of gravitational waves using a method that is optimized for point sources. This is appropriate if, for example, the gravitational wave background is dominated by astrophysical sources. No signal was seen. Upper limit maps were produced assuming two different power laws for the source strain power spectrum. As an application, I also focused on the position of Sco-X1, the closest low-mass X-ray binary. Since its expected signal is a narrow line at twice the unknown spin frequency, I set a frequency dependent limit on the gravitational wave strain arriving from that source. The author gratefully acknowledges the support of the LIGO Laboratory, which in turn is funded by the United States National Science Foundation.

053.07

Analytical and Numerical Models of Turnaround Densities in ΛCDM

Alan Peel[1], E. Shaya[1]
[1]*Univ. of Maryland.*

We will present numerical calculations of gravitating systems in a ΛCDM universe and determine the range of densities required to achieve turnaround. We use the Numerical Action Method to examine realistic models of up to 5 galaxies forming a group originating in a nearly homogeneous expanding medium. We show the effects of tidal fields and nonspherical, nonlinear interactions. We provide a fitting formula for the turnaround mass as a function of Λ based on analytical calculation of spherical infall. The fitting formula provides a ratio of the turnaround density with Λ to that given by the conventional formula for $\Lambda=0$. This work is part of an effort to study the mass distributions in nearby groups to model future SIM observations of transverse motions of galaxies.

054: EXIST
AAS Oral, Sunday, 2:00-3:30pm, 3B

054.01

Black Hole Finder Probe to EXIST:Surveying Black Holes in Space and Time

Jonathan E. Grindlay[1], EXIST Team
[1]*Harvard-Smithsonian, CfA.*

The Energetic X-ray Imaging Survey Telescope (EXIST) has completed a concept study to be the Black Hole Finder Probe in NASA's Beyond Einstein Program. EXIST would carry out an unprecedented survey for black holes in both space and time. With all-sky imaging across the hard X-ray band (3-600 keV) made possible by two very large area and wide-field coded aperture telescopes, the High Energy Telescope (see Hong et al) and Low Energy Telescope (see Kaaret et al), EXIST views the *entire sky each 95min orbit* and locates all detected (>5sigma) sources to <12arcsec, permitting direct idenfications. We review the primary science objectives: i) to reveal both obscured AGN and the accretion luminosity of the universe as well as dormant AGN by the their tidal disruption of stars; and ii) the birth of stellar black holes by GRBs at the highest redshifts for new constraints on Pop III stars and probes of cosmic structure. With both sensitivity and field of view ~10X better/larger than Swift, EXIST would measure ~30,000 AGN and ~1000 GRBs per year. EXIST will continuously map the Galaxy for stellar BHs undergoing transient accretion in binaries as well as obscured young SNR (from Ti-44 emission) and novae (from 511 keV flares); the Local Group for possible IMBHs in ULX sources; and the population of magnetars undergoing superflares in galaxies out to the Coma cluster. EXIST would complement and extend greatly the survey science of GLAST, eROSSITA, LSST and LISA and provide the hard X-ray context for Con-X and XEUS. The mission technology is well developed, and both requirements and costs are understood so that it should be a strong contender for an early start in the Beyond Einstein Program. The EXIST Concept Study was supported by NASA Grant NNG04GK33G.

054.02

The Low-Energy Telescopes on EXIST

Philip E. Kaaret[1], B. Ramsey[2], J. G. Jernigan[3], R. A. Remillard[4], R. E. Rothschild[5], J. Hong[6], J. E. Grindlay[6]
[1]*Univ. of Iowa,* [2]*NASA/MSFC,* [3]*SSL/UC Berkeley,* [4]*MIT,* [5]*UCSD,* [6]*Harvard.*

The low-energy telescopes on EXIST are a coded aperture system that will continually image the 5-30 keV sky with 1' angular resolution and 12″ source localization accuracy. The good source localization accuracy is essential to uniquely identify counterparts to obscured AGN and gamma-ray bursts. A total detector area of about one square meter with 200 micron square pixel is required. We are evaluating two silicon-based technologies capable of achieving the required performance: active pixel sensors with integrated DEPFET readout, and fully pixellated hybrid sensors with CMOS readout multiplexers optimized for X-ray detection.

054.03

The High Energy Telescopes on EXIST

JaeSub Hong[1], J. E. Grindlay[1], EXIST team
[1]*Harvard Univ..*

The high energy telescopes (HETs) on EXIST will monitor the hard X-ray sky (10-600 keV) with a large field of view (65x154 deg), scanning almost the entire sky in each orbit. The continuous sky coverage with sensitive hard X-ray imaging detectors is essential to increase the possibility of capturing elusive high red-shift GRBs, highly obscured AGNs and interesting transients of various time scales. HETs consist of arrays of coded-aperture telescopes, employing $6m^2$ of CZT detectors. HETs will provide 0.05 mCrab sensitivity in 10 150 keV band and 0.5 mCrab in 150 keV 600 keV. The fine pixellation (1.2mm) of CZT detectors will allow 5' resolution and 1' localization for 5 sigma source. The technology being developed for HETs will be tested through a balloon borne pathfinder experiment ProtoEXIST. We report the recent progress of CZT detector development.

054.04

Blazars and the Cosmic Diffuse IR Background with EXIST

Paolo S. Coppi[1], EXIST Science Team
[1]*Yale Univ..*

With its ability to do deep all-sky monitoring and with its extended hard X-ray energy response, EXIST will be an ideal partner for ground-based and space-based gamma-ray telescopes such as HESS, VERITAS, and GLAST. Simultaneous gamma-ray/EXIST observations of blazars will place strong constraints on the emission mechanisms and physical conditions in blazars, which have proven more complex and extreme than previously thought. If we can understand in detail the origin of blazar emission, we should be able to predict a blazar's intrinsic gamma-ray spectrum. Knowing this spectrum has important implications for cosmology since sufficiently energetic gamma-rays pair can produce on the cosmic infrared background and are effectively absorbed. A comparison of a blazar's observed and intrinsic spectrum constrains the amount of absorption that occurred, ie., it limits the intensity of the cosmic infrared background which in turn constrains when and how much star formation activity occurred in the universe.

054.05

Gamma Ray Bursts as Cosmological Probes with EXIST

Dieter Hartmann[1], EXIST Team
[1]*Clemson Univ..*

The EXIST mission, studied as a Black Hole Finder Probe within NASA's Beyond Einstein Program, would, in its current design, trigger on ~1000 Gamma Ray Bursts (GRBs) per year (Grindlay et al, this meeting). The redshift distribution of these GRBs, using results from Swift as a guide, would probe the $z > 7$ epoch at an event rate of > 50 per year. These bursts trace early cosmic star formation history, point to a first generation of stellar objects that reionize the universe, and provide bright beacons for absorption line studies with groundand space-based observatories. We discuss how EXIST, in conjunction with other space missions and future large survey programs such as LSST, can be utilized to advance our understanding of cosmic chemical evolution, the structure and evolution of the baryonic cosmic web, and the formation of stars in low metallicity environments.

054.06

Uncovering Obscured AGN with EXIST and Other Hard X-Ray Surveys

C. M. Urry[1], E. Treister[2], S. Virani[1]
[1]Yale Univ., [2]European Southern Observatory, Chile.

Deep multiwavelength surveys reveal that most Active Galactic Nuclei are obscured by moderate to high column densities of gas and dust, as suggested also by local AGN Unification and the spectral shape of the X-ray ′′background.” This implies large numbers of hard X-ray sources that are missed by current, mid-range X-ray observations but will easily be found with EXIST. Incorporating the latest results on the luminosity and redshift dependence of the obscured fraction, we describe the expected 10-100 keV number counts of AGN and highlight the contributions that EXIST, as well as earlier missions like INTEGRAL, Swift, NuSTAR, and GLAST, will make to understanding cosmic black hole growth.

This work was supported by the Centro de Astrofisica FONDAP and NASA/INTEGRAL grant NNG05GM79G.

055: ISM/Molecular Clouds
AAS Oral, Sunday, 2:00-3:30pm, 608-10

055.01

Comparison of 13CO Line and Far-Infrared Continuum as a Diagnostic of Dust and Molecular Gas Physical Conditions --Implications for the N(H2)/I(CO) Conversion Factor

William F. Wall[1]
[1]INAOE, Mexico.

Far-infrared continuum data from the COBE/DIRBE instrument were combined with Nagoya 4-m 13CO J=1-0 spectral line data to infer the multiparsec-scale physical conditions in the Orion A and B molecular clouds, using 140mic/240mic dust color temperatures and the 240mic/13CO J=1-0 intensity ratios. Two-component models fit the Orion data best. The models require that the dust-gas temperature difference is 0+/-2 K. If this surprising result applies to much of the Galactic ISM, except in unusual regions such as the Galactic Center, then there are a number implications. These include dust-gas thermal coupling that is commonly factors of 5 to 10 stronger than previously believed and an improved explanation for the N(H2)/I(CO) conversion factor or X_factor.

This improved formulation for the X-factor quantifies the statement that the velocity-integrated radiation temperature of the 12CO J=1-0 line, I(CO), ″counts″ optically thick clumps using the formalism of Martin et al. (1984). One important suggestion of this formulation is that virialization of entire clouds is irrelevant. The densities required to give reasonable values of the X-factor are consistent with those found in cloud clumps (i.e. roughly 10^3 H_2 cm^{-3}). Thus virialization of clumps, rather than of entire clouds, is consistent with the observed values of the X-factor. And even virialization of clumps is not strictly required; only a relationship between clump velocity width and column density similar to that of virialization can still yield reasonable values of the X-factor. The underlying physics is now at the scale of cloud clumps, implying that the X-factor can probe sub-cloud structure.

While this formulation improves upon that of Dickman et al. (1986), it has shortcomings of its own. These include uncertainties in defining the average clump density and neglecting certain complications, such as non-LTE effects, magnetic fields, turbulence, etc.

055.02

Continuity between Magnetic Fields in GMCs and Large-scale Galactic Magnetic Fields

Giles G. Novak[1], M. Krejny[1], H. Li[2], D. T. Chuss[3], P. G. Calisse[4]
[1]Northwestern Univ., [2]Harvard-Smithsonian Center for Astrophysics, [3]NASA-Goddard Space Flight Center, [4]Cardiff University, United Kingdom.

The magnetic fields that permeate star-forming Giant Molecular Clouds (GMCs) may play important roles in the star formation process. Submillimeter polarimetry has been used by many investigators to map magnetic fields in GMCs. Generally these maps cover only a very small fraction of a GMC’s sky area, but our SPARO experiment at South Pole has for the first time produced maps of GMC fields that extend over a significant fraction of the GMCs’ sky areas. Therefore, for the first time, it has become possible to observe the global magnetic fields of GMCs. We have found that there is a statistically significant correlation between the direction of these global GMC fields and the orientation of the Galactic plane (Li et al. 2006, Ap. J. 648, 340). This suggests that the GMC formation process tends to preserve the magnetic field direction. However, here we focus on an alternative hypothesis: Could the correlation between the GMC fields and Galactic plane orientation originate in the predicted tendency for GMCs to inherit Galactic angular momentum and to thus spin up about axes that are perpendicular to the Galactic plane? Based on recent measurements of GMC rotation axes, we argue that this hypothesis is not likely to be correct. Thus, our SPARO data indicate that there is indeed continuity between GMC fields and large-scale Galactic fields.

055.03

Temporal Variations of Charge-Exchange induced Heliospheric X-rays: Constraints on the Local Interstellar X-ray Background

Rosine Lallement[1], D. Koutroumpa[1], F. Acero[2], J. Ballet[2], V. Kharchenko[3], R. Pepino[3], A. Dalgarno[3]
[1]Service D’Aéronomie, France, [2]Commissariat à l’Energie Atomique, France, [3]Harvard-Smithsonian Center for Astrophysics.

We study the EUV/soft X-ray emission generated by charge transfer between solar wind heavy ions and interstellar H and He neutral atoms in the inner Heliosphere. We first present heliospheric maps for average stationary solar wind, depending on solar cycle phase, solar wind anisotropies and composition, line of sight direction and observer position. In a second step we introduce time dependence. A series of simulations of the X-ray intensities variations due to temporary solar wind enhancements are compared with XMM Newton recorded spectra at different intervals in the period 2000-2003. Results show that the heliospheric component can explain a large fraction of (if not all) the line intensity below 1.3 keV, strongly attenuating the need for soft X-ray emission from the Local Interstellar Bubble. We finally briefly discuss the potential role of charge-transfer X-ray emission from other astrophysical objects.

055.04

Spitzer Observations of the Lupus Molecular Cloud

Nicholas L. Chapman[1], L. Mundy[1], N. J. Evans, II[2], c2d team
[1]Univ. of Maryland, [2]Univ. of Texas.

We present maps of the Lupus molecular cloud complex at 24, 70, and 160 microns using the Spitzer Space Telescope. These clouds were observed as part of the Spitzer Legacy Science Program, ′′From Molecular Cores to Planet-Forming Disks′′ (Evans et al. 2003). Utilizing the 2MASS catalog in addition to the Spitzer wavelengths, we made K vs. K-[24] and [24] vs. [24]-[70] color-magnitude diagrams. Significant background galaxy contamination exists among those objects with positive K-[24] and [24]-[70] colors. We used SWIRE observations of the Elais N1 region to separate candidate young stellar objects from background galaxies. Some of these YSO candidates are discussed individually.

Support for this work, utilizing data from the ′′Cores to Disks′′ Spitzer Legacy Science Program, was provided by NASA through contract 1224608 issued by the Jet Propulsion Laboratory, California Institute of Technology, under NASA contract 1407.

055.05

The COMPLETE Calibration of 12CO and 13CO in Perseus

Jaime E. Pineda[1], P. Caselli[1], A. A. Goodman[1], E. Rosolowsky[1], J. B. Foster[1]

[1]Harvard-Smithsonian Center for Astrophysics.

We use COMPLETE molecular line maps, ^{12}CO and ^{13}CO (1-0) data, together with the extinction map, derived using the NICER algorithm, to study the properties of the gas in the whole Perseus Molecular Complex. We derive LTE ^{13}CO column densities and a linear conversion to estimate the extinction. Comparing with previous results in the same region we find similar ^{13}CO abundances but significant differences in the threshold extinction value (A_{Vo}), above which ^{13}CO is detected. This suggests that differences in the environment (especially in the impinging radiation field) may cayse the observed local changes in abundance, dust and gas temperature as well as A_{Vo}.

In addition, we present new NH_3 and CCS data recently obtained with the GBT and perform a comparison between the different tracers, in particular between central velocities, line widths, and excitation temperatures. Abundance ratios across the Perseus Complex will also be presented and correlated with differences in A_{Vo}, to check if different environmental properties also affect the embedded dense cores.

JEP is supported by a student support grant from the National Radio Astronomy Observatory and by the National Science Foundation through grant #AF002 from the Association of Universities for Research in Astronomy, Inc., under NSF cooperative agreement AST-9613615 and by Fundación Andes under project No. C-13442. JBF is supported by a student support grant from the National Radio Astronomy Observatory.

055.06

Advancing Nebular Astrophysics through Near-Infrared Spectroscopic Mapping

William H. Waller[1], A. Kutyrev[2], R. Silverberg[2], B. Woodgate[2], L. Allen[3]
[1]Tufts Univ., [2]NASA Goddard Space Flight Center, [3]Center for Astrophysics.

Infrared continuum surveys, optical emission-line surveys, and radio CO and HI surveys have revealed the star-forming ISM as a complex ″froth″ of shells, filaments, blobs, and myriad ″working surfaces″ whose origin and evolution remain poorly understood. The generic relations between these nebular structures and the embedded star clusters that have been discovered in abundance throughout the Galaxy by the Spitzer Space Telescope have yet to be deciphered. To address these challenges, we consider the options for carrying out wide-field narrow-band imaging surveys of the near-infrared line emission from the Milky Way and other nearby star-forming galaxies. The near-IR part of the EM spectrum is rich with diagnostic nebular emission features. We draw from the experiences gained from the ABU/SPIREX near-IR telescope that operated in Antarctica in the late 1990s, and from the Brackett-Alpha Mapper (BAM) -a Fabry-Perot spectrometer that successfully measured kinematics of the warm-ionized hydrogen gas in the northern Milky Way. Options for deploying a multi-line near-infrared spectroscopic mapper on SOFIA, high-altitude balloons, and the lunar surface will be discussed.

055.07

Mapping Enrichment in M33

Erik Rosolowsky[1], J. D. Simon[2]
[1]Harvard-Smithsonian, CfA, [2]California Institute of Technology.

I present initial results from the M33 Metallicity Project -a spectrophotometric atlas of over 500 HII regions in the southwest of M33 conducted using the multi-slit capabilities of the LRIS instrument on the Keck I Telescope. The observational data have sufficient sensitivity to detect the temperature-sensitive auroral lines such as [OIII] λ4363 Å and [SIII] λ6312 Å in over 100 of the HII regions. Detecting these faint lines allows the direct measurement of temperatures, obviating the need to rely upon strong-line diagnostics such as R23 to measure metallicity. These new observations yield a relatively shallow oxygen abundance gradient of -0.03 ± 0.003 dex per kpc, in good agreement with infrared measurements of the neon abundance gradient. The spatially dense sampling of the HII regions also permit mapping of the enrichment on large scales in the galaxy. The enrichment pattern does not appear to be azimuthally symmetric but rather shows enhanced abundance correlated with the star formation along the southwest spiral arm. In addition to highlighting a potential systematic effect in measuring metallicity gradients, these azimuthal variations may provide constraints on the degree of mixing in the turbulent interstellar medium.

056: Space Mission Concepts and Instrumentation AAS Oral, Sunday, 2:00-3:30pm, 605-07

056.01

Flight Calibration of the Galaxy Evolution Explorer (GALEX)

Patrick Morrissey[1], GALEX Science Team
[1]Caltech.

We present current performance results for the Galaxy Evolution Explorer (GALEX), a NASA mission that is performing a survey of the sky in two ultraviolet bands. The GALEX instrument comprises a 50 cm diameter modified Ritchey-Chretien telescope with imaging and objective-grism spectroscopic modes that feed a pair of large-format microchannel-plate-intensified, delay-line readout detectors. Simultaneous 2-color imaging of the large 1.2 degree field is achieved with an innovative optical system

including a thin-film multilayer dichroic beamsplitter, which complements the bandpass-defining characteristics of a Lyman-alpha blocking filter and CsI cathode in the 23 nm-wide FUV band centered at 154 nm, in parallel with a

red-blocking filter and CsTe cathode in the 80 nm-wide NUV band centered at 230 nm. Flight calibration based on three years of observations has significantly improved the instrument performance, especially in the areas of astrometric accuracy, photometric precision and image resolution. GALEX continues to meet its requirements for resolution, efficiency, astrometry, bandpass definition and survey sensitivity. Hardware issues with the FUV detector are being managed successfully with impacts to mission efficiency but not data quality. We describe recent results as they pertain to the GR2 and GR3 public data releases and outline plans for further improvement.

GALEX (Galaxy Evolution Explorer) is a NASA Small Explorer, launched in April 2003. We gratefully acknowledge NASA's support for construction, operation, and science analysis for the GALEX mission.

SUNDAY

056.02

Optical Performance of Designs for a Large Aperture Far-Infrared Telescope

Paul Goldsmith[1], B. Khayatian[1], C. M. Bradford[1], M. Dragovan[1], W. Imbriale[1], R. Lee[1], C. Paine[1], H. Yorke[1], J. Zmuidzinas[1]
[1]JPL.

We have developed two designs for a large single aperture far-infrared space telescope. Achieving the ultimate sensitivity in the far infrared (30 to 300 microns wavelength) requires a telescope cooled to 4 K with a large collecting area. The performance of the system can be degraded by radiation from dust in the solar system ("zodi"), from the Milky Way, and from the spacecraft. It is thus critical to understand the response of any telescope design at angles far from the direction of peak response. We have carried out detailed calculations of the radiation pattern from two different telescope designs for a 10m diameter aperture. This is the nominal diameter of the Single Aperture Far InfraRed (SAFIR) telescope, but can easily be extended to the 6m by 4m aperture proposed for the Cryogenic Aperture Large Infrared Space Telescope Observatory (CALISTO). The first design is the on-axis (symmetric) telescope as described in the SAFIR Vision Mission (VM) Report, while the second is off-axis (unobscured). The calculations, which have been carried out at a wavelength of 1mm, utilize a combination of physical optics/physical theory of diffraction (PO/PTD) and geometrical optics/geometrical theory of diffraction (GO/GTD). The on-axis SAFIR VM design has a relatively large subreflector (0.09 fractional area obscuration) and its feed legs obscure 0.027 of the collecting area. Relative to this inefficient geometry, the unobscured design has higher gain by a factor of 1.45 (1.6 dB) with a 12 dB edge taper Gaussian illumination. It is also characterized by a far lower sidelobe level. The off-axis design is preferable in

terms of aperture efficiency and its lower scattered radiation at large angles from the main beam, thus minimizing coupling to the sunshield and allowing observation of a large portion of the sky without compromising sensitivity as a result of extraneous pickup.

056.03

Science Priorities of the RadioAstron Space VLBI Mission

Glen Langston[1], N. Kardashev[2], International Space VLBI Collaboration
[1]NRAO, [2]Astro Space Center, Russian Federation.

The main scientific goal of the RadioAstron Space VLBI mission is study of Active Galactic Nuclei (AGN), Masers and other astronomical objects with unprecedented angular resolution, up to few millionths of an arcsecond. The resolution achieved with RadioAstron will allow study the following phenomena and problems:

* Central engine of AGN and physical processes near super massive black holes providing an acceleration of cosmic rays size, velocity and shape of emitting region in the core, spectrum, polarization and variability of emitting components;

* Cosmological models, dark matter and dark energy by studying dependence of above mentioned AGN's parameters with redshift, and by observing gravitational lensing;

* Structure and dynamics of star and planets forming regions in our Galaxy and in AGN by studying maser and Mega maser radio emission;

* Neutron (quark?) stars and black holes in our Galaxy, their structure and dynamics by VLBI and measurements of visibility scintillations, proper motions and parallaxes;

* Structure and distribution of interstellar and interplanetary plasma by fringe visibility scintillations of pulsars;

The RadioAstron mission uses the satellite SPECTR (astrophysical module), developed by Lavochkin Association of Russian Aviation and Space Agency (RASA). This module will be used in several other scientific missions. The total mass of the scientific payload is about 2500 kg, of which the unfolding parabolic 10-m radio astronomy antenna's mass is about 1500 kg, and scientific package holding the receivers, power supply, synthesizers, control units, frequency standards and data transmission radio system. The mass of the whole system (satellite and scientific payload) to be carried into orbit by the powerful ″Zenit-2SB″-″Fregat-2CB″ launcher is about 5000 kg.

The RadioAstron project is an international collaboration between RASA and ground radio telescope facilities around the world.

056.04

Telescope to Observe Planetary Systems (TOPS): A High Efficiency Coronagraphic 1.2-m Visible Telescope

Olivier Guyon[1], J. R. Angel[2], C. Bowers[3], J. Burge[2], A. Burrows[2], J. Codona[2], T. Greene[4], M. Iye[5], J. Kasting[6], H. Martin[2], D. W. McCarthy[2], V. Meadows[7], M. Meyer[2], E. A. Pluzhnik[1], N. Sleep[8], T. Spears[9], M. Tamura[5], D. Tenerelli[10], R. Vanderbei[11], B. Woodgate[3], R. A. Woodruff[10], N. J. Woolf[2]
[1]Subaru Telescope, [2]University of Arizona, [3]NASA GSFC, [4]Ames Research Center, [5]National Astronomical Observatory of Japan, Japan, [6]Pennsylvania State University, [7]IPAC, [8]Stanford University, [9]LOGYX, [10]Lockheed Martin, [11]Princeton University.

The Telescope to Observe Planetary Systems (TOPS) is a proposed space mission to image in the visible (0.4-0.9 micron) planetary systems of nearby stars simultaneously in 16 spectral bands (resolution R~20).

With a 1.2m visible telescope, the proposed mission achieves its power by exploiting the most efficient and robust coronagraphic and wavefront control techniques. A Phase-Induced Amplitude Apodization (PIAA) coronagraph, combined with an efficient focal plane wavefront sensing scheme, will allow TOPS to detect planets within 2 lambda/d (~0.2″) with nearly 100% throughput and the full angular resolution of the 1.2m telescope. An ongoing laboratory experiment has successfully demonstrated high contrast coronagraphic imaging within 2 lambda/d with the PIAA coronagraph / focal plane wavefront sensing scheme envisionned for TOPS.

For the ~10 most favorable stars, TOPS will have the sensitivity to discover 2 R_E rocky planets within habitable zones and characterize their surfaces or atmospheres through spectrophotometry. Many more massive planets and debris discs will be imaged and characterized for the first time.

056.05

Availability of Calibration Sources for Measuring Spacecraft Angular Position with Sub-Nanoradian Accuracy

Walid A. Majid[1], D. Bagri[1]
[1]JPL/Caltech.

Precision measurements are now capable of determining the angular position of spacecrafts in the sky with accuracies of 2-5 nanoradians using compact radio sources of at least a few hundred milli-Jansky flux density at 8.4 GHz for calibration. Further improvements in position measurement accuracy may be possible with use of appropriate calibrators near the direction of the spacecrafts even if the calibrators are much weaker (a few milli-Jansky) in flux density. In this talk we discuss the calibrator flux density required to achieve sub-nanoradian astrometric accuracy and attempt to estimate the density of suitable calibrators, using existing source count surveys. We point out, however, that the fraction of these sources that are suitable for use as calibrators is not well understood and requires further study at both X (8.4 GHz) and Ka (32 GHz) bands.

056.07

Future In-Space Operations for Astronomy

Harley A. Thronson[1]
[1]NASA Goddard Space Flight Center.

Our most ambitious free-space space astronomy endeavors can be realized using architectures that could come out of the Vision for Space Exploration. Future in-space operations (FISO) encompass assembly and construction, testing, servicing and maintenance activities in free-space. It is the enabling strategy for large optical and mechanical systems that cannot be autonomously deployed out of a single launch vehicle, and those high value systems for which lifetime enhancement (upgrades, maintenance, repairs) can offer value.

Long-range priority goals in astronomy require filled apertures far larger than under development for the JWST. Since these are vastly greater in diameter than can be accommodated within plausible future launch vehicles, complex in-space deployment or assembly will be essential to achieve future goals for astronomy. As the in-space success with the Hubble Space Telescope has demonstrated, human involvement can dramatically benefit service and maintenance of astronomical facilities in space. Advances in capabilities in robotics will augment and complement this.

FISO involves advanced systems for space telerobotics, automated rendezvous and docking, power/propulsion, keep-alive utilities (power, comm, nav, attitude, station-keeping, etc), special-purpose tools, environmental protection and verification equipment. In-space operations can make effective use of the technology, facilities and capabilities being created *if* future applications are anticipated, since FISO is a natural extension of current ESAS and VSE planning.

057: Young Stellar Objects
AAS Oral, Sunday, 2:00-3:30pm, 6C

057.01D

A Wide-field Search for Intermediate-age Pre-Main Sequence Stars near Taurus and Upper Scorpius

Catherine L. Slesnick[1], J. M. Carpenter[1], L. A. Hillenbrand[1]
[1]Caltech.

We have conducted a wide-field (~200 square degrees) B,R,I photometric monitoring campaign to identify new young and intermediate-age objects towards both the Taurus (1 Myr) and Upper Scorpius (5 Myr) star-forming regions. Candidates were chosen for follow-up optical spectroscopy to confirm membership and youth based on placement on optical and nir color-magnitude and color-color diagrams. Our primary goals are 1) to identify new 3-10 Myr-old stars suitable for follow-up studies of disk, accretion, rotation and activity properties, and 2) to asses the spatial and mass distributions of these objects within their respective star-forming regions. Our work will provide insight into several aspects of star formation, including the evolution of circumstellar material as stars evolve past the classical T Tauri phase, the universality of the low mass/substellar IMF, and the kinematics of stars as they are forming in their parental molecular clouds.

057.02

Mid-IR Spectral Survey of High Mass Protostellar Objects

Murray F. Campbell[1], T. K. Sridharan[2], J. L. Hora[2], M. Kassis[3], H. Beuther[4], R. T. Brooks[1], S. Fung[1], L. C. Johnson[1], J. M. De Buizer[5]
[1]Colby College, [2]Center for Astrophysics, [3]Keck Observatory, [4]Max-Planck-Institut fur Astronomie, Germany, [5]Gemini Observatory, Chile.

Spectra with R=100 have been obtained between 8 and 13 μm of 11 high-mass protostellar objects (HMPOs) using MIRSI on the IRTF. The HMPOs are members of the survey of Sridharan (2002 ApJ 566, 931) that we had first found to be bright and compact in N band (10.5 μm) and 24.8 μm imaging on the IRTF. The spectra fall in three groups: 1. Deep silicate (9.7 μm) absorption with strong emission at both 8 and 13 μm (5 HMPOs), 2. Weak silicate absorption with a weak peak at 8.5 μm, and stronger emission at 13 μm (2 HMPOs), and 3. Approximately flat emission at 8 μm, rising to longer wavelengths (4 HMPOs). Spectra of members of each group are presented. We also present simple three component models that fit the spectra and the 24.8 μm photometry. The model components are hot dust in emission, warm dust in emission, and cold dust in extinction. The hot and warm components give estimates of the amount of gas and dust near each HMPO. The cold component gives estimates of the overlying column density and Av to each HMPO.

057.03D

The Evolution of the Multiplicity of Young Stellar Objects

Michael S. Connelley[1], B. Reipurth[1], A. Tokunaga[1]
[1]Univ. of Hawaii.

We have conducted a high resolution infrared survey of a large sample of Class I protostars to determine their binary frequency distribution from ~60 AU to 5000 AU. Our goal was to address the question: ″Do stars form in isolation?″. To do this, we compiled a new sample of 267 nearby candidate Class I objects from across the whole sky, and observed those visible from Mauna Kea at H, K, and L' with a median resolution of 0.34″ at L'. Our survey found 90 companions to 207 targets. In addition to being consistent with previous studies showing a strong binary excess over the solar-type main-sequence population, we have also observed a binary excess at wider and closer separations than previous studies. Our research is the first to have observational evidence for dynamical evolution through changes in the binary frequency distribution within the Class I lifetime, as well as differences in the protostellar binary statistics between star forming regions. This research was funded by the NASA IRTF.

057.04D

The State and Evolution of Isolated Dense Molecular Cores

Jens Kauffmann[1]
[1]Harvard-Smithsonian CfA.

We will present highlights from our recent millimeter dust emission and Spitzer imaging surveys of nearby ($<$ 500 pc) isolated dense molecular cores, the sites of low-mass star formation. The sample studied includes starless and protostellar cores and allows to compare their properties in a homogenous manner.

One aim of our research is to understand how the mass distribution in dense cores controls the presence or absence of young forming stars. A detailed analysis reveals necessary (but not sufficient) conditions for active star formation to be possible. Also, a significant fraction of the cores is not stable to gravitational collapse if only supported by thermal and turbulent pressure. This might hint at significant support from magnetic fields. Furthermore, class 0 and class I protostars covered by our surveys cannot be uniquely discriminated, suggesting a revision of criteria used to assign infrared classes.

Finally, we report the discovery of L1148-IRS, a candidate Very Low Luminosity Object (VeLLO; $L < 0.1\ L_{\mathrm{sun}}$) in the L1148 dense core. If L1148-IRS is indeed a VeLLO, then it is an interesting one. This would be the first known VeLLO with a definitely subsolar and possibly even substellar final mass ($< 0.25\ M_{\mathrm{sun}}$). Moreover, the formation of L1148-IRS could not be understood in the framework of the quasistatic evolution of dense cores. Based on our survey data we briefly review the properties of known VeLLO cores and discuss their formation.

057.05

Gemini NIFS Integral Field Spectroscopy of YSO Environments: Spatially Extended Molecular Hydrogen Emission in the Inner 200 AU

Tracy L. Beck[1], P. McGregor[2], M. Takami[3]
[1]Gemini North Observatory, [2]RSA&A, Australian National University, Australia, [3]Subaru Observatory.

We present near infrared 2.0-2.4 micron R~5000 integral field spectroscopy at adaptive optics (0.″1) spatial resolution of six Classical T Tauri stars: T Tau, DG Tau, XZ Tau, HL Tau, RW Aur and HV Tau C. Molecular hydrogen v=1-0 S(1) (2.12 micron) emission is detected in all stars, and we find that the majority of the H_2 is not spatially coincident with continuum emission. The distribution and kinematics of the v=1-0 S(1) emission are investigated, as are the emission line ratios from several H_2 features detected in the spectra. The data are placed in the context of multiple characteristics for disk-like versus outflow-like emission in order to study the excitation mechanisms and physical environments of the H_2. The molecular hydrogen within 200 AUs of these stars is largely consistent with emission in the inner regions of the known Herbig-Haro energy flows and walls of the outflow cavities.

057.06

Application of Medical Imaging Software to the 3D Visualization of Astronomical Data

Michelle A. Borkin[1], A. A. Goodman[2], M. Halle[3], D. Alan[1], J. Kauffmann[2]
[1]Initiative in Innovative Computing, Harvard University, [2]Initiative in Innovative Computing/Harvard Smithsonian Center for Astrophysics, [3]Initiative in Innovative Computing/Harvard Medical School.

The AstroMed project at Harvard University's Initiative in Innovative Computing (IIC) is working on improved visualization and data sharing solutions applicable to both the fields of astronomy and medicine. The 3D Slicer and OsiriX medical imaging programs have been used to make isosurface and volumetric models of spectral line data cubes from the COMPLETE Survey of Star Forming Regions. Both programs are open source and built on the ITK and VTK toolkits. We have already used 3D Slicer and OsiriX on COMPLETE's 150,000-spectrum (8-square degree) spectral line maps of Perseus, both to detect outflows and to better understand the cloud structure. One particularly illuminating result shows how existing 3D astronomical ″segmentation″ algorithms (e.g. CLUMPFIND) often break up the cloud into structures humans (and possibly physics) would not select as most meaningful. Future work for AstroMed includes continuing to make 3D Slicer more compatible with astronomical data, and continuing to apply it to these and other astronomical research projects. All IIC developed tools, as well as 3D Slicer and OsiriX, are freely available, through iic.harvard-.edu.

058: Context Rich Lab Problems AAPT Oral, Sunday, 2:00-3:30pm, 617

Chair

Terry Singleton[1]
[1]*University of Alberta, Canada.*

058.01

Undergraduate Labs for Biological Physics: Brownian Motion and Optical Trapping

Kelvin Chu[1], A. Laughney[1], J. Williams[1]
[1]*University of Vermont.*

We describe a set of case-study driven labs for an upper-division biological physics course. These labs are motivated by case-studies and consist of inquiry-driven investigations of Brownian motion and optical-trapping experiments. Each lab incorporates two innovative educational techniques to drive the process and application aspects of scientific learning. Case studies are used to encourage students to think independently and apply the scientific method to a novel lab situation. Student input from this case study is then used to decide how to best do the measurement, guide the project and ultimately evaluate the success of the program. Where appropriate, visualization and simulation using VPython is used.

Direct visualization of Brownian motion allows students to directly calculate Avogadroâ€™s number or the Boltzmann constant. Following case-study driven discussion, students use video microscopy to measure the motion of latex spheres in different viscosity fluids arrive at a good approximation of N_A *or* k_B.

Optical trapping (laser tweezer) experiments allow students to investigate the consequences of 100-pN forces on small particles. The case study consists of a discussion of the Boltzmann distribution and equipartition theorem followed by a consideration of the shape of the potential. Students can then use video capture to measure the distribution of bead positions to determine the shape and depth of the trap.

This work supported by NSF DUE-0536773.

058.02

Alternatives to Traditional Labs: a Discovery Lab Based on A*nalogy*

Mark I. Liff[1]
[1]*Philadelphia University.*

In search for alternatives to traditional labs, it is worthwhile to turn to the creativity research. Analogy is believed by many to be at the heart of creativity. A discovery lab that requires use of analogy had been developed. A basis of the lab is a re-discovery of Gough-Joule effect of contraction of stretched rubber upon heating. The difficulties of designing an analogybased lab are discussed. The students' reaction to the unusual lab is analyzed. The data suggest that the students need to be provided with the base for analogy use. They also need to be given directions for the search of solution by changing and modification of analogies, and weeding out the misleading ones and selectively retaining productive analogies. This study shows that thought processes of divergent nature--commonly accessible only to experts--can be employed under the discussed conditions by novices as well.

058.03

Student Understanding Difficulties Research-based on Conceptual and Numerical Labs

Sergio Flores[1]
[1]*University of Juarez.*

Most of students come to introductory physics courses with a wrong idea about the way the world works. A set of research-based labs designed to confront these wrong student ideas in a conceptual context would help to asses their performance in the numerical session of the second part of the same physcs lab Results will be shown to measure the efficiency of the this learning technique through the comparison the the result of tye first part of the lab (based on a conceptual perspective) to the result of the second part of the same lab (based on a numerical perspective).

058.04

Teaching Optics Topics in College Physics Laboratory*

Roman Y. Kezerashvili[1]
[1]*Physics Department, New York City College of Technology, CUNY.*

We propose a list of designed experiments that could be presented at the laboratory class in the second semester of College and University Physics courses to study properties of light. The study of light can be organized into three domains: geometric optics, wave optics and quantum optics. These domains are not strictly disjoint. In the sets of experiments for the first domain students study the laws of reflection and refraction of light by measuring the dependence of the angles of reflection and refraction on the angle of incident, spherical mirrors and lenses, geometric optics of human eye. In the sets of experiments for the second domain students study the wave properties of light: dispersion, interference, diffraction and polarization. Experiments designed to verify the Malus's law and measure the Brewster's angle, determine the wavelength of laser light and study the interference on a transmission and reflection diffraction grating, diffraction on the different size slits and wires. The purposes of experiments for the third domain are to study the spectral lines of different gases, determine the Rydberg's constant from the spectrum of hydrogen atom, and verify the laws of the photoelectric effect and Einstein's quantum idea. The objectives of all experiments are to show the real action of physics laws, help students better understand and visualize the subject of the lecture.

**Supported by US Department of Education grant P120A060052*

058.05

A Laboratory on Pulse Trains, Counting Statistics, and the Central Limit Theorem for Physics Students

David B. Pengra[1]
[1]*University of Washington.*

We have developed an advanced undergraduate laboratory exercise that measures arrival times between cosmic-ray detections in a scintillator array and uses a LabVIEW application to analyze the statistics in terms of single-interval times, multiple-interval times, and numbers of pulses arriving in fixed-length intervals. The exercise clearly shows the exponential form of the Poissonian interval distribution and the progression of the Poisson distribution towards a normal distribution both in terms of the distribution of events per fixed interval and intervals per number of events. We can also use the software to run simulations of arrival times for statistical distributions other than Poissonian and show that the development of the normal distribution that obtains for large measurement intervals is not special to Poissonian processes but occurs for many random distributions: a vivid demonstration of the central limit theorem.

058.06

Crafting a Gauss Gun Demonstration

Matthew E. Blodgett[1], E. D. Blodgett[1]
[1]*University of Wisconsin River Falls.*

A Gauss Gun launches a ferromagnetic projectile using a pulsed electromagnet. This demonstration provides a nice counterpoint to the popular Thompson's jumping ring demonstration, which launches a nonferromagnetic ring via repulsion of an induced current. The pulsed current must be short enough in duration so that the projectile is not retarded by lingering current in the launch solenoid, but also large enough to provide a suitably impressive velocity. This project involved an iterative design process, as we worked through balancing all the different design criteria. We recommend it as a very nice electronics design project which will produce a very portable and enjoyable demonstration. AAPT sponsor Earl Blodgett.

058.07

Using a Tube of Fire to Demonstrate Various Gas and Wave Properties.

Don B. Cameron[1]
[1]University of Denver High School.

A demonstration will be made of a apparatus called ″dancing fire″. Directions for building this from readily available materials will be provided as well. The presentation will include discussion of the physics behind the demonstration as well as the uses for this apparatus in lecture. Translation of longitudinal and transverse waves will be discussed as well as pressure and volume changes.

058.08

My Top Ten List of Labs and Demonstrations

Paul Robinson[1]
[1]San Mateo High School.

Labs serve a variety of functions; some introduce a topic, others provide computational reinforcement of important concepts, while other yield surprising results. Some, however, make an indelible impression on students. I will share some of my personal favorites, including “Bull’s Eye”, “The Flying Pig”, “The Anatomy of a Homer”, “Hot Balls”, “Cold Stuff” and others and give reasons why I think they are favorites with my students as well.

058.09

My Most Annoying Demonstration

Joseph M. Mosca[1]
[1]Embry-Riddle Aeronautical University.

After demonstrating various wave phenemona of pulses and continuous wavetrains in elastic media (slinky, springs, tuning forks etc.) students are still struggling with the concepts of standing waves, reflection and transmission at free and fixed boundaries, interference at nodes and antinodes, and the difference between transverse and longitudinal waves. In this simple demonstration we will overcome any misconceptions concerning these topics.

059: Innovations in High School Physics, Part II AAPT Oral, Sunday, 2:00-3:30pm, 307-08

Chair

Eric C. Muhs[1]
[1]Roosevelt High School.

059.01

Keeping Seniors Engaged During The Last Week Of School

Thomas F. Haff[1]
[1]Issaquah High School.

During the last week of classes at Issaquah High School, the students are pulled in lots of different directions as they get ready for graduation day. Even amid senior teas, yearbook signing, photos, graduation practice and such, the students at I H S are still engaged to the very last day doing meaningful physics with the “Physics Scavenger Hunt”. This time tested activity has been a tradition at I H S and something the students actually look forward to. Last year, about twenty students stayed after school on the final day of classes just to put on their final touches. This activity may be for you.

059.02

Thank You for Flying the Vomit Comet

Gregory A. DiLisi[1], R. Dempsey[2], L. A. DiLisi[3], G. Santo[4]
[1]John Carroll University, [2]Johnson Space Center, [3]Parker Hannifin Corporation Nichols Airborne Division, [4]Beaumont High School.

We describe our flight aboard NASA’s C9 *“Weightless Wonder,”* more affectionately known as *“The Vomit Comet.”* The C9 is NASA’s aircraft that creates multiple periods of microgravity by conducting a series of parabolic maneuvers over the Gulf of Mexico. Our experiment examined the stability of *“liquid bridges,”* small strands of fluid suspended between two supports, as they entered and exited microgravity. The flight was co-sponsored by AAPT, APS and NASA’s Reduced Gravity Program.

059.03

Physics on Wheels: Teaching Mechanics by Riding a Bicycle

Hezi Yizhaq[1], G. Baran[1]
[1]Environmental High School, Israel.

We developed a set of activities for teaching physics for high school students by riding a bicycle equipped with Polar s725x cycling system. This sophisticated system can measure and store data like speed, cadence, altitude, distance and power exerted by the rider during a ride. The basic idea is that students can perform experiments and feel the various physics forces which working directly on their bodies. This experience will increase their motivation to study physics. The ability of the Polar 725s system to measure the power delivered by the rider to the chain opens new opportunities for teaching the uneasy topics of work, energy, power and mechanical efficiency. Among the activities, students will investigate the difference in the characteristics between sport bike and mountain bike like the rolling friction and drag coefficients and will investigate the influence of the mass on the terminal speed of a bike going downhill. Our results show that this speed scale as the square root of the total mass, in agreement with the theory. In another activity, students will find out their mechanical efficiency during uphill riding by using energy considerations and the power and the altitude data they collected by Polar s725x cycling system.

059.04

High School Student Scientists Researching Pulsars at the CGWA

Adrienne Rodriguez-Zermeno[1]
[1]University of Texas at Brownsville.

Modern astronomy offers the means to excite high school students about science. During the 21st Century Astronomy Ambassadors program high school students experienced what it is like to be a scientist by becoming a part of the international effort to detect gravitational waves using pulsar timing. This summer enrichment program enabled the Center for Gravitational Wave Astronomy(CGWA) to actively engage students through research experiences. Online databases played an important role in the students’ research projects. Actual pulse profiles were downloaded from the European Pulsar Network, while information about physical properties of radio pulsars was obtained from the Australia Telescope National Facility pulsar catalogue. The teams used the data to study the pulsar pulse morphology and analyze the polarization properties of radio pulsars. This connection to a real world astronomy problem was a powerful experience for these students.

059.05

Metricize Yourself

Maria K. Falbo[1]
[1]Cardinal Gibbons High School.

In lab and homework, students should check whether or not their quantitative answers to physics questions make sense in the context of the problem. Unfortunately it is still the case in the US that many students don’t

SUNDAY

have a “feel” for ºC, kg, cm, liters or Newtons. This problem contributes to the inability of students to check answers. It is also the case that just “going over” the tables in the text can be boring and dry. In this talk I’ll demonstrate some classroom activities that can be used throughout the year to give students a metric context in which quantitative answers can be interpreted.

059.06

Mini-Labs

Marc Kossover[1]
[1]*The Jewish Community High School of the Bay.*

Many high school physics teachers avoid lab activities since they seem to be so time consuming, and even after all the effort, many students still seem to miss the point. Demonstrations are popular because they are shorter than formal labs, but students still don’t seem to get the point, or worse get the wrong point. An alternative approach is the mini-lab, a short lab activity that tries to investigate just one small idea at a time. While some mini-labs are stand alone, many can be sequenced together to create a comprehensive investigation of a topic. This presentation will give advice on how to create mini-labs from scratch, as conversions from demonstrations, and from breaking down formal labs. We will also look at how to sequence them successfully.

059.07

International Physics Summer Camp for High School Students

Damian T. Pope[1], B. Korsunsky[2]
[1]*Perimeter Institute for Theoretical Physics, Canada,* [2]*Weston High School.*

Each year for the past three years, Perimeter Institute for Theoretical Physics in Waterloo, Ontario, Canada, has staged an annual physics summer camp for high school students worldwide. Known as the International Summer School for Young Physicists (ISSYP), it attracts students from all corners of the globe and this year had attendees from 15 countries and 5 continents.

The camp is aimed at motivated students around the age of 16 and is a two-week immersion into the exciting world of cutting-edge physics today. It covers topics such as dark matter, superstring theory and quantum computers, and exposes attendees to some of the very latest research results. It includes lectures, tutorials, laboratory visits and small-group projects and, in addition to teaching new material, strives to give students a deeper appreciation of the true nature of science. Throughout, attendees have a great deal of interaction with the institute’s scientists.

This presentation will give an overview of the camp including the material taught within it, its impact on students and the goals of the program. More information about the camp can be found at: http://www.youngphysicists.ca

059.08

Student Measurements of Cosmic Rays on an International Scale

Robert S. Peterson[1]
[1]*QuarkNet/Education Office / Fermi National Accelerator Lab.*

As part of the QuarkNet Collaboration, teachers and students capture cosmic ray data using scintillator hardware the students construct. These data support student inquiry into cosmic ray flux, provide coincidence timing of cosmic ray showers, measure muon lifetime, and analyze their cosmic ray detector performance. Students share these data with others by using a browser friendly “e-Lab” portal. After three years, the QuarkNet “e-Lab” portal contains over 7000 days of cosmic ray data from 70 high schools. The nature of web based tools and data retrieval allow anyone with an Internet connection to engage freely the available resources investigating cosmic rays. The Internet now allows international students to participate in the Collaboration. With the coming of the LHC in CERN and plans underway for siting the ILC, particle physics includes more international institutions. QuarkNet supports this international effort by sharing resources with teachers and students abroad. This talk examines the new inclusion of distant students who contribute their data from around the globe with time synchronous coverage. Simultaneous data strengthens the questions students can examine. Examples of global research questions will be covered, and examples given of student research. Additional international members may join; account procedures will be described.

059.09

The Next Best Thing to Having Your Own Accelerator: How QuarkNet Can Help

Kris Whelan[1]
[1]*Lawrence Berkeley National Laboratory.*

In 2007, a set of experiments in particle physics will begin at CERN, the European particle physics laboratory near Geneva, Switzerland. The Large Hadron Collider (LHC) will be going online and detectors such as ATLAS will be getting ready to collect data. An international collaboration of physicists is hoping to learn more about the nature of matter and the processes that shape our universe. They can then examine the debris of proton collisions to reveal information about fundamental particle processes. QuarkNet is working to disseminate information about this and other experiments that are a part of the LHC. We are planning are to give workshops to teachers about using real LHC data for analysis by students. I will present an overview of the experiment and will discuss opportunities which may be available for teachers and students. There is also the possibility of forming international collaborations of students and teachers which will be able to share and discuss their results. I will also have handouts, posters and DVDs (with several ATLAS movies) available free of charge for all participants.

QuarkNet is funded by the National Science Foundation and the U.S. Department of Energy Office of Science.

060: Physics Education with Vpython
AAPT Poster, Sunday, 2:00-3:30pm, 303

Chair

Ruth Chabay[1]
[1]*North Carolina State University.*

060.01

Using VPython to Apply Mathematics to Physics in Mathematical Methods

Dedra Demaree[1], J. Eagan[1], P. Finn[1], B. Knight[1], J. Singleton[1], A. Therrien[1]
[1]*College of the Holy Cross.*

At the College of the Holy Cross, the sophomore mathematical methods of physics students completed VPython programming projects. This is the first time VPython has been used in a physics course at this college. These projects were aimed at applying some methods learned to actual physical situations. Students first completed worksheets from North Carolina State University to learn the programming environment. They then used VPython to apply the mathematics of vectors and differential equations learned in class to solve physics situations which appear simple but are not easy to solve analytically. For most of these students it was their first programming experience. It was also one of the only chances we had to do actual physics applications during the semester due to the large amount of mathematical content covered. In addition to showcasing the students’ final programs, this poster will share their view of including VPython in this course.

060.02

VPython applications for Teaching Physics

Roberto B. Salgado[1]
[1]Syracuse University Department of Physics.

VPython, a real-time 3D graphics module for the Python programming language, provides a simple but powerful programming environment for physics educators and students. On the website listed below, we provide a small but growing collection of interactive visualizations and simulations (along with their VPython source code) that we have written for teaching physics. In the poster, we will demonstrate our examples in wave interference, kinematics, electromagnetism, relativity, tensor visualization, and nonlinear dynamics. (http://physics.syr.edu/~salgado/software/vpython/ also features a list of the growing community of VPython websites.)

060.03

Charming VPythong Simulations

Eric W. Pepin[1], R. P. Olenick[1]
[1]University of Dallas.

The University of Dallas Department of Physics requires a sophomore-year computational course for all physics majors. The course introduces students to modeling classical and quantum systems with appropriate numerical methods. Students, as part of a course project, have developed charming visual simulations that have then been refined and used to educate subsequent undergraduates. In this poster session we will present several VPython simulations ranging from baseball pitches as viewed from around the field to quantum scattering and from galaxy formation to dielectric breakdown. We will discuss how they are used to make underlying concepts in physics more understandable.

060.04

Visual Basic VPython Interface: Charged Particle in a Magnetic Field

Chandra Prayaga[1]
[1]University of West Florida.

A simple Visual Basic (VB) to VPython interface is described and illustrated with the example of a charged particle in a magnetic field. This interface allows data to be passed to Python through a text file read by Python. The first component of the interface is a user-friendly data entry screen designed in VB, in which the user can input values of the charge, mass, initial position and initial velocity of the particle, and the magnetic field. Next, a command button is coded to write these values to a text file. Another command button starts the VPython program, which reads the data from the text file, numerically solves the equation of motion, and provides the 3d graphics animation. Students can use the interface to run the program several times with different data and observe changes in the motion.

061: Faint Structures in Nearby Galaxies Plenary, Sunday, 3:40-4:30pm, Ballroom 6

061.01

Faint Structures in Nearby Galaxies: Studies of Galaxy Formation at z=0

Julianne Dalcanton[1]
[1]Univ. of Washington.

Galaxies are not simple superpositions of disks and spheroids. Instead, most galaxies host additional faint stellar components that can be traced with either low surface brightness imaging or photometry of individual resolved stars. I will discuss the growing body of evidence that these faint diffuse structures are a ubiquitous by-product of galaxy formation, and show how measurements of their structures, kinematics, and stellar populations place constraints on the early assembly of galaxies.

062: The Assembly of Galaxies and Their Black Holes Plenary, Sunday, 4:40-5:30pm, Ballroom 6

062.01

The Assembly of Galaxies and Their Black Holes: A New Paradigm for Hierarchical Galaxy Formation?

Rachel S. Somerville[1]
[1]Max-Planck-Institut fuer Astronomie, Germany.

One of the most profound discoveries in modern astronomy is that most galaxies host supermassive black holes (SMBH), and that the properties of the SMBH and their hosts seem to be intimately connected. Even more intriguing is that the activity we witness via accretion onto SMBH (quasars and Active Galactic Nuclei; AGN) and the observed star formation activity both seem to rise and fall over cosmic history in almost perfect synchronization. Moreover, both star-forming galaxies and AGN show the same ″downsizing″ trend: the activity drops earlier and more rapidly in more massive objects. In the theoretical arena, a ″new paradigm″ has emerged in which galaxies and their black holes grow in tandem, and black holes are responsible for regulating star formation and thus shaping many of the basic relationships between galaxy properties. In this picture, AGN feedback is invoked to solve a host of long-standing and thorny problems suffered by Cold Dark Matter (CDM) models of galaxy formation. For example, it has been suggested that AGN feedback could shut down cooling flows and quench star formation in massive galaxies, producing the observed bimodality in galaxy colors, morphologies, and star formation histories. I will discuss these problems and assess the proposed solution, particularly focussing on the issue of whether CDM models with AGN feedback can simultaneously reproduce the observed properties of galaxies and AGN at both low and high redshift, as probed by recent multiwavelength deep surveys.

SUNDAY

063: The Future of the Core Curriculum AAPT Invited, Sunday, 6:30-8:00pm, 616

Chair

Michael Theonnessen[1]
[1]Michigan State University.

063.01

The Future of the Core Curriculum in Graduate Education

Michael Thoennessen[1]
[1]Michigan State University.

The recent report of the Joint AAPT/APS Task Force on Graduate Education in Pysics reported that the traditional graduate physics curriculum consists of a “core” of required courses that includes Classical Electrodynamics, Quantum Mechanics, Classical Mechanics, and Statistical Mechanics. Anecdotal evidence suggests that some graduate physics departments have changed or eliminated these requirements, or made other changes such as the elimination or “watering down” of the comprehensive exam. It also has been argued that physics departments need to modernize the curriculum, noting that the traditional core has not changed for 50 years.

A panel consisting of Prof. Ken Heller (University of Minnesota), Prof. Michael Paessler (North Carolina State) and Minesh Bacrania (LLNL) as the chair of the APS Forum on Graduate Student Affairs representing the graduate students will discuss the future of the core curriculum.

064: When Was the Last Time 5000 College Students Gave You Feedback on Your High School Physics Course?
AAPT Invited, Sunday, 6:30-8:00pm, 307-08

Chair

Wayne Fisher[1]
[1]Myers Park High School.

064.01

Does Taking Physics Pay Off Later in Chemistry and Biology Courses?

Philip M. Sadler[1], R. H. Tai[2]
[1]Harvard-Smithsonian Center for Astrophysics, [2]University of Virginia.

The relationship between performance of 8474 students enrolled in introductory college biology, chemistry, or physics courses and their prior high school course-taking in physics is investigated in 122 randomly-selected undergraduate classrooms. Employing multiple linear regression, models are constructed that control for variation in student background, socio-economic status, and students' prior achievement in mathematics and English. A small effect size (ES = 0.13 SD, $p = 0.01$) is found for each year of school coursework in the same subject as a college course in biology, chemistry, or physics. No statistically significant relationship is found ($p = 0.05$) for any cross-disciplinary preparation, including that of differing amounts of high school physics preparation on college chemistry or biology performance. Our findings do not provide support for the view that students will be better prepared for taking high school chemistry and biology by taking physics in ninth grade.

064.02

High School Teaching and College Performance: Looking for Connections

Robert H. Tai[1]
[1]Univ. of Virginia.

How much impact does high school have on college? Are decisions about classroom activities and student work in high school physics associated with student performance in college physics? In our paper, we look at several aspects of high school physics including laboratory experiences, homework activities, and classroom activities and their association with college physics grades. Our results revisit in greater depth and earlier analysis carried out a decade earlier.

064.03

Gender Differences in Introductory University Physics Performance: The Influence of High School Physics Preparation and Affect

Zahra Hazari[1]
[1]Harvard Smithsonian Center for Astrophysics.

The attrition of females studying physics after high school has been a continuing concern for the physics education community. If females are well prepared, feel confident, and do well in introductory college physics, they may be inclined to study physics further. This quantitative study uses HLM to identify factors from high school physics preparation (content, pedagogy, and assessment) and the affective domain that predict female and male performance in introductory college physics. The study includes controls for student demographic and academic background characteristics, and the final dataset consists of 1973 surveys from 54 introductory college physics classes. The results highlight high school physics and affective experiences that differentially predict female and male performance. These experiences include: learning requirements, computer graphing/analysis, long written problems, everyday world examples, community projects cumulative tests/quizzes, father's encouragement, family's belief that science leads to a better career, and the length of time students believe that high school physics would help in university physics. There were also experiences that similarly predict female and male performance. The results paint a dynamic picture of the factors from high school physics and the affective domain that influence the future physics performance of females and males. The implication is that there are many aspects to the teaching of physics in high school that, although widely used and thought to be effective, need reform in their implementation in order to be fully beneficial to females and/or males in college.

065: Astronomy and the Two-Year Colleges
AAPT Special, Sunday, 6:30-8:00pm, 615

Chair

Theo Koupelis[1]
[1]University of Wisconsin Colleges.

065.01

Community College's CAN do Research A Decade of Eclipse Expeditions

Jon M. Saken[1]
[1]Appalachian State Univ..

Gale force winds, ravenous Tsetse flies and duct-tape equipment repairs. Now that's science! This talk will describe the triumphs and disasters over almost a decade of world-wide astronomical expeditions involving community college students, faculty and K-12 teachers chasing one of nature's most spectacular shows a total solar eclipse. The impact of this kind of field science on the participants and the wider community, along with other lessons learned along the way, will also be discussed, as we present ideas to encourage others to join in the fun.

065.02

What's in the Neighborhood?: Using Science/Technology/Society (STS) Instructional Strategies in an Introductory Community College Astronomy Class

Lawrence R. Kellerman[1]
[1]Illinois Central College.

Two goals guide the instruction in many introductory astronomy classes with labs at community colleges. One goal is to enhance the understanding of astronomy; the second goal is to provide opportunities for students to increase their science literacy. Given the many pedagogical strategies available, the presenter has identified using a Science/Technology/Society (STS) approach as the most effective method for reaching those goals. The STS approach provides students the opportunity to "construct" an appropriate understanding of the many concepts, theories and laws related to the understanding of astronomy while at the same time allows the faculty member to facilitate their learning using specific content, learner centered instructional strategies and alternative forms of assessment. Using the results of two specific units developed and implemented in an introductory four-hour astronomy course, the presenter will provide evidence supporting the use of STS instruction in meeting and/or exceeding the two goals above.

065.03

NASA Center for Astronomy Education: Building a Community of Practice

Gina Brissenden[1], E. Prather[1], T. F. Slater[1], W. M. Greene[2], M. Thaller[3]
[1]Univ. of Arizona, [2]JPL, [3]CalTech.

The NASA Center for Astronomy Education (CAE) is devoted to the professional development of introductory college astronomy instructors teaching at community colleges. The primary goal is building a ″community of practice.″ Evaluation results suggest this community of practice model is effective at improving instructional practices, particularly in settings where

instructors feel isolated from their peers. For community college faculty this isolation can be quite real. Many are the only astronomer, if not the only scientist, at their institution. In addition, they may be adjunct instructors who have no office, no institutional email address, nor appear in the campus directory. CAE works to prevent this sense of isolation by building both actual and virtual communities for these instructors, as well as provide actual and virtual professional development opportunities. CAE's major effort is providing multi-tiered ″Teaching Excellence Workshops″ offered at national and regional venues. Ongoing support is offered through the CAE website. Instructors can learn about, and register for, upcoming workshops. They can engage in discussions about educational issues and share best practices with peers using the moderated discussion group AstroLrner@CAE. CAE also provides an updated article ″This Month's Teaching Strategy" which is a reflection on teaching strategies discussed in the workshops. Instructors can also find their peers through the online map of US community colleges offering introductory astronomy courses. Lastly, CAE Regional Teaching Exchanges facilitate local, and sustained, community building. CAE is supported by the NASA/JPL Navigator Public Engagement Program and the Spitzer Space Telescope Education and Public Outreach Program.

065.04

Teaching Astronomy at Lewis and Clark Community College

David A. Cornell[1]
[1]*Principia College.*

Lewis and Clark Community College (LCCC) is a two-year college with ″Tech Prep″ programs in automotive technology, child development, drafting, office technology, and health occupations. LCCC invited me to teach astronomy as a temporary faculty member during fall semester 2006. As professor emeritus in physics with 40 years' teaching experience, I happily accepted the invitation. This talk describes the experience, emphasizing the way it served as an outreach to the community.

065.05

Free Resources for Teaching with Technology

Michelle A. Strand[1]
[1]*Southeast Community College.*

One of the major problems with using technology in the classroom is the expense for the computers and programs. But using technology doesn't have to consume your entire budget. I have compiled a wide variety of physics computer resources that are available on the web at no cost to you. These resources and their potential applications will be shown.

066: Effective Features of Online Tutorials AAPT Special, Sunday, 6:30-7:30pm, 303

Chair

Gerald W. Meisner[1]
[1]*UNC Greensboro.*

066.01

PhET's Research-based Guidelines for Design and Use of Interactive Simulations

Katherine K. Perkins[1], W. K. Adams[1], C. E. Wieman[1], PhET Team
[1]*University of Colorado at Boulder.*

Interactive computer simulations are emerging as a powerful new tool for engaging students in learning. The effectiveness of using simulations, however, depends on both the design of the simulation and how it is used with students. Thus, design and use must be well grounded in research on how people learn, interface design, and student learning in physics. For instance, effective simulations will be able to engage students in exploration where they actively work to make sense of what they see. Students construct their understanding with feedback provided through their interaction with the simulation. The Physics Education Technology (PhET) project has developed over 60 simulations for use in teaching physics, math, chemistry, and physical science [1,2]. (All sims are free online). As part of this development process, our research has built on the existing literature with results from interviews of over 165 students and studies of student use of simulations in diverse environments. Here, we present our findings from these research efforts in the form of research-based guidelines for designing effective simulations and for developing activities that engage students in effective learning with the simulations.

[1] http://phet.colorado.edu

[2] PhET is supported by the National Science Foundation, the Hewlett Foundation, and the Kavli Foundation.

066.02

Virtual Labs and Virtual Worlds

Ted Boehler, Ed.D.[1]
[1]*Coastline Community College.*

Virtual Labs and Virtual Worlds

Coastline Community College has under development several virtual lab simulations and activities that range from biology, to language labs, to virtual discussion environments. Imagine a virtual world that students enter online, by logging onto their computer from home or anywhere they have web access. Upon entering this world they select a personalized identity represented by a digitized character (avatar) that can freely move about, interact with the environment, and communicate with other characters.

In these virtual worlds, buildings, gathering places, conference rooms, labs, science rooms, and a variety of other "real world" elements are evident. When characters move about and encounter other people (players) they may freely communicate. They can examine things, manipulate objects, read signs, watch video clips, hear sounds, and jump to other locations. Goals of critical thinking, social interaction, peer collaboration, group support, and enhanced learning can be achieved in surprising new ways with this innovative approach to peer-to-peer communication in a virtual discussion world.

In this presentation, short demos will be given of several online learning environments including a virtual biology lab, a marine science module, a Spanish lab, and a virtual discussion world.

Coastline College has been a leader in the development of distance learning and media-based education for nearly 30 years and currently offers courses through PDA, Internet, DVD, CD-ROM, TV, and Videoconferencing technologies. Its distance learning program serves over 20,000 students every year.

sponsor Jerry Meisner

066.03

Electric Circuits in a Virtual Environment

Gerald W. Meisner[1], H. Hoffman[2], M. Turner[3]
[1]*UNC Greensboro,* [2]*Science Lab Courseware,* [3]*Hebrew Academy.*

Online tutorials present opportunities that are difficult to replicate elsewhere. A virtual environment permits carefully scripted material, driven by exemplary pedagogy; tutoring by branching at check points and directed by PER delineated misconceptions and laboratory experience; the ability of each user to make mistakes and to engage in all aspects of learning (making errors, collecting data, graphing, analyzing, drawing conclusions); being able to deploy carefully constructed physics models in visually rich and unusual settings outside the 'laboratory'; the ability of students to record not only their data, but also their ideas, doubts, questions and conclusions in a easily searchable data format; the ability of faculty to respond to student questions and conclusions in a manner timely to both parties. We will show how 'Electric Circuits', one of the tutorials in LAB-Physics, satisfies the above conditions. Student responses will be given.

066.05

Measuring Learning from hints in Web-based Socratic Tutor

Young-Jin Lee[1], D. E. Pritchard[1]
[1]*Massachusetts Institute of Technology.*

We present a study of the usefulness of various hints implemented in a Web-based homework tutor MasteringPhysics. Problem solving skill of students and difficulty of problems were first determined by applying Item Response Theory (IRT) to the first answers of students working on homework problems of an introductory Newtonian physics course. The usefulness of hints were then measured by the changes in their problem solving skill on the second attempt at answering the problems they had previously failed after they went through different learning paths, e.g. using different hints provided by the online tutor. We found that the changes in problem solving skill depended strongly on the learning paths students took. The most effective path (about plus 1.8 standard deviation above untutored expectation) was for students who requested hints and subtasks prior to attempting to answer. They may be displaying metacognitive ability.

066.06

Impact of Inquiry-Oriented Curriculum Materials Modified to Provide Better Access for Special Needs Students

Julia K. Olsen[1], T. F. Slater[1]
[1]*University of Arizona.*

In early 2006, the Lawrence Hall of Science conducted a national field-test of a new GEMS space science curriculum package for middle school students which they had developed. LHS collected preand post-test data for each unit based on student work samples. These data were tagged with whether or not students had an individualized education plan. During this field-testing, we modified a subset of the curriculum materials so that they could be delivered via computer mediated instruction for the students in a subset of the field-test classrooms in order to determine if the students in the classrooms using the curriculum modified for computer mediated instruction scored differently on the assessments than students in the larger assessment database. Results suggest that many students, not just those with special needs, demonstrate greater achievement gains using materials modified using the principles of best practice for special needs students.

067: High School Curriculum Issues AAPT Oral, Sunday, 6:30-8:00pm, 310

Chair

Beverly Cannon[1]
[1]*Highland Park HS.*

067.01

Active Physics Problem Based Learning for High Schools

Arthur Eisenkraft[1]
[1]*Univ of Massachusetts Boston.*

Active Physics bridges research and practice. This NSF supported curriculum project uses a 7E instructional model and a problem based learning approach. Students learn physics on a need to know basis as they construct solutions to challenges such as developing a sport that can be played on the moon, creating an appliance package for developing countries, designing a light and sound show, or building a museum exhibit. In addition to meeting the content requirements of an introductory physics course, there is also an emphasis on engineering design principles and on essential questions. The excitement and frustration of trying to bridge research and practice will be discussed.

067.02

***Physics First*: Why You Should Consider It at Your High School**

Alan P. Gnospelius[1]
[1]*Design and Technology Academy.*

The Design and Technology Academy is an Urban Magnet School, with a diverse population of 450 students. We are part of the Northeast Independent School District (enrollment=63,000) and we are located in San Antonio, Texas.

The Academy was founded in 1999, and has used *Physics First* as the introductory science course for our students. Students are placed into Regular or Pre-AP Physics based on their math level. For all of our students, this is a school of choice.

We will present data that cement the concept of *Physics First* aggregated over 6 years of results on a state mandated test in science. Our comparison groups are similiar schools within the geographic area that have magnet status, and regular high schools within the area that do not use the *Physics First* concept.

The presentation will have handouts, and selected charts and graphs using a Powerpoint presentation.

067.03

A TIME for Physics First in Missouri

Meera Chandrasekhar[1], K. Manivannan[2], D. Kosztin[1], S. Torres[3]
[1]*University of Missouri,* [2]*Missouri State University,* [3]*Columbia Public Schools.*

We describe an initiative funded by the Missouri Department of Elementary Secondary Education to introduce Physics First (PF) in Missouri Schools. A TIME for Physics First (Academy for Teachers Inquiry and Modeling Experiences for Physics First) is a partnership between universities and several Missouri school districts. The curriculum we have designed and used for professional development is research-based and includes inquiry and modeling methods. Three-week summer content academies are conducted; teachers implement PF in their 9th grade classrooms, receive in-class mentoring, conduct lesson-study in professional learning teams, mentor protégés, and attend follow-up sessions and conferences. The 60 teachers who attended the first academy will return for two more summers. PF lessons and assessments are currently being used by the teachers. Their input will be used to revise the curriculum. We will present findings from the first year of the project.

067.04

What To Do After The AP Test: How About Household Electricity?

John P. Lewis[1]
[1]*Glenbrook South High School.*

A problem AP Teachers continually face is how to keep the students engaged for the two weeks that follow the AP Exam. I've developed a unit which introduces the students to the basic wiring of lamps, switches, doorbells and other common household electric needs. Replacing pencils and calculators with screwdrivers and wire-strippers provides an opportunity for the students to develop a skill in which very few are proficient. The week-long unit culminates in making a table lamp from scratch that is powered by a household circuit the students have wired. The unit seems effective in keeping the students engaged in physics while at the same time developing a lifelong proficiency which should prove very useful in their future homes. I'll share the curriculum I've developed and provide some examples of students' labwork and take-home projects.

067.05

Introduction to Physics of the Universe in AP Physics Classrooms

Stephanie L. Allen[1]
[1]*Hope College.*

Often students have difficulty understanding the connections that must be made between old and new concepts. This curriculum is designed to lead AP Physics students through this process with gamma ray bursts. Students will participate in various discussions, demonstrations, exercises and activities that lead them through universe basics, life cycles of stars, black holes, the electromagnetic spectrum, and they will learn about various NASA observatories. Ultimately, this will result in a better understanding of how astrophysicists have come to understand the gamma ray burst. This series of lessons was created for the three to four weeks after the AP Physics exam. The curriculum was developed through gathering resources from various scientific organizations, developing new ideas and speaking with scientists at NASA Goddard Space Flight Center. The result is a manual of lesson plans, activities and answer keys for teachers to use in their own classrooms.

067.06

Using the Hypothesis Method in Learning Physics

Genrikh Golin[1]
[1]*Touro College & Franklin Delano Roosevelt HS.*

The development of creative abilities of high school students can be achieved by introducing into the theaching process some techniques for active learning of physics. Among these the hypothesis metod is of special value.It involves both mastering some basic ideas concerning the hypothesis in science and developing particular skills for applying this knowledge in the students' cognitive activity. For the students to master the method of hypothesis the most important thing is to develop the students' skills to independently advance and verify hypotheses. These skills are based on conclusions derived from the previously known facts, laws and theories by deductive extropolation, and by extending these laws and theories to new phenomena and facts. The logical sequence can be represented as follows: A problem situation--advancement of hypothesis --substantiation of the hypothesis---experimental proof of the hypothesis. The paper contains a few examples showing the logic and mechanism of incorporating this method into the presentation and explanation of a new topic.

067.07

Inservice Preparation of High School Physics Teachers

Stephen T. Thornton[1], R. A. Lindgren[1]
[1]*University of Virginia.*

Our outreach efforts for K-12 teachers includes nine different one-credit hour courses especially designed for K-8 teachers and two courses designed especially for middle school physical science teachers. However, our primary effort is to teach nine different courses for current and prospective high school physics teachers. All courses are for graduate credit at the 600-level for teacher education professionals. During the past year we have instructed 315 teachers in 17 courses, 230 of these being in seven courses for high school physics teachers. We teach five online distance learning courses and four summer residence courses for those pursuing physics content knowledge and for those in our Master of Arts in Physics Education (MAPE) degree program. We have graduated 13 teachers in the past year and currently have over 60 candidates in the program. Degree candidates include other certified science teachers desiring to teach physics, middle school teachers desiring to move to high school physics, career crossovers, current teachers desiring a master's degree, as well as others. The MAPE degree will be described. A synopsis of the course offerings will be given, and statistics of the annual number of teachers taking courses, numbers of courses, teacher numbers, and teacher MAPE graduates will be discussed.

068: Insights into Mechanics and Sound
AAPT Oral, Sunday, 6:30-8:00pm, 617

Chair

G. Samuel Lightner[1]
[1]*Westminster College.*

068.01

Some Aspects of the Physics of Shooting a Basketball

John J. Fontanella[1]
[1]*U. S. Naval Academy.*

The flight of a basketball is considered.[1] Video analysis of the path and spin for several shots was carried out. It is shown that four forces are required to reproduce the trajectory: gravity, buoyancy, the drag force and the Magnus force. The relative contribution of each force is determined. The model is used to evaluate what it is that good shooters do. For a foul shot, the approach speed (speed when the basketball is just above the rim), launch speed, and launch angle were calculated. It is found that the minimum in the approach speed occurs at a launch angle closer to the experimental values for good shooters than does the minimum in the launch speed. This suggests the hoopothesis that a good shooter strives for the "softest" shot.

1. J. J. Fontanella, *The Physics of Basketball*, The Johns Hopkins University Press, Baltimore, 2006.

068.02

Period-Speed Analysis of a Pendulum

Barbara M. Hoeling[1], Y. Kostov[1], R. Morshed[1], P. Siegel[2]
[1]*Pomona College,* [2]*Cal Poly Pomona.*

For a simple pendulum consisting of a spherical bob suspended by thin cords, we simultaneously carry out precision measurements of the period, T, and the maximum linear velocity, v_{max}, of the bob. By expanding T in terms of v_{max}^2, we verify the large angle dependence of the period and carry out an accurate analysis of the effect of air friction on a sphere. We find that the force due to air friction is well described by two terms: one linear and one quadratic in velocity. We investigate the dependence of each term on the sphere's diameter for Reynold's numbers from 250 to turbulent flow.

068.03

Optical Measurement of the Acceleration Due to Gravity

Bill Crummett[1]
[1]*Centre College.*

A Michelson interferometer that employs a He-Ne laser and corner reflectors has been constructed. One arm of the interferometer is vertical and the corner reflector falls in a three foot acrylic tube vacuum chamber. By counting interference fringes over two time intervals that begin simultaneously but have different durations, the free-fall acceleration can be computed from the fringe counts for the two intervals, the time interval durations, and the laser wavelength. The value obtained for the free fall acceleration in our laboratory is 9.7970 ± 0.0004 m/s^2. This talk will provide additional details about the apparatus and its resolution.

068.04

Why the Magnetic Levitation can be Observed only in a Constrained Case in PASCO's Magnetic Levitation Apparatus?

Xiao Xie[1], P. P. Gu[1], Z. Y. Wang[1], Z. Xie[1]
[1]*Hunan University, China.*

By analysing the interaction of horizontal component of magnetic field and the eddy current in conductor under the magnet, a novel noncontact driving mode is invented that a non-ferromagnetic moving conductor can drive the magnet to rotate. A homemade apparatus has been developed that can be used for experiment teaching and classroom demo. The relationship between the rotation speed of permanent magnet and the linear speed of aluminum disc is measured. The drag force, torque and lift force acted on the magnet are revealed that are produced by the interaction of magnet and moving non-ferromagnetic conductor. Finally the inexplicit explanation on the principle of magnetic levitation experimental apparatus by PASCO company is clarified and the reason is presented for that the lift phenomena can be oberved only in some constrained situation.

Key Words: permanent magnet, non-magnetic moving conductor, noncontact driving

PACC Code: 4110F

068.05

Wavelength Dependent End Correction for a Resonating Air Column

Henry Kuhlman[1], C. Hansen[1]
[1]Southern Adventist University.

Using an FFT to carefully measure the frequency of the fundamental mode of resonance, and accounting for the temperature dependence of the velocity of sound in air, we obtained fundamental resonance wavelengths for cavities of varying lengths in both closedand open-pipe configurations. The end correction, EC, is the difference between the measured pipe length and the effective cavity length, L_{eff} (2 λαμ$\delta\alpha$ and 4 λαμ$\delta\alpha$ for open and closed pipes respectively). Preliminary results indicate that this end correction can be expressed as, EC = k λαμ$\delta\alpha$ + e D, where k and e are empirically determined constants and D is the inner diameter of the pipe.

068.06

Amplifier Distortion

David Keeports[1]
[1]Mills College.

By definition, a high fidelity amplifier's instantaneous output voltage is directly proportional to its instantaneous input voltage. While high fidelity is generally valued in the amplification of recorded music, nonlinearity, also known as distortion, is desirable in the amplification of some musical instruments. In particular, guitar amplifiers exploit nonlinearity to increase both the harmonic content and sustain of a guitar's sound. I will discuss how both modifications in sound result from saturation of triode tubes and transistors. Additionally, I will describe the difference in the symmetry of saturation curves for transistors and tubes and the reason why tube guitar amplifiers are generally considered to be superior to solid-state amplifiers. Finally, I will discuss attempts to use solid-state electronics to replicate the sound of tube amplifiers.

068.07

Exact Relativistic to Non-Relativistic Transformation via an Effective Potential

James P. Crawford[1], J. Shubila[1]
[1]Penn State University.

We present a simple method for transforming a relativistic dynamical system into a non-relativistic dynamical system by introducing the "non-relativistic effective potential." Thus, we are able to gain insight into the effects of relativity on particle dynamics by relying on our non-relativistic intuition. In particular, the particle velocity cannot exceed the speed of light because the effective force (negative gradient of the effective potential) approaches zero as the particle velocity approaches c. We demonstrate the procedure for several cases including the quadratic potential (Hooke's Law spring) and a linear potential (string).

068.08

New Ideas for Teaching Relativity: a unified derivation of the Doppler Effect

Roberto B. Salgado[1]
[1]Syracuse University Department of Physics.

Space-Time Trigonometry is a unified treatment of the geometry of Euclidean space, Galilean spacetime, and Minkowskian spacetime that provides a new framework for teaching relativity. (Details are described in a poster available at the website below.) Using a single spacetime diagram, together with a generalization of our Euclidean geometric intuition, we present a new unified derivation of the longitudinal Doppler Effect in the Galilean and Special Relativistic cases. (Details at http://www.aapt-doorway.org/SalgadoPoster/SalgadoPoster.htm)

069: AIP Gemant Award Lecture
Plenary, Sunday, 7:00-8:30pm, Ballroom 6

Chair

James J. Stith[1]
[1]American Institute of Physics.

069.01

Einstein's Legacy to Astronomy: From Black Holes to the Expanding Universe

Marcia Bartusiak[1]
[1]MIT.

Albert Einstein placed a formidable imprint on astronomy. Not since the time of Isaac Newton, three centuries ago, has a single individual so influenced the field. Many of the great astronomical findings of the 20th century--the expanding universe, compact stars, origin of the Sun's power, black holes, gravitational lensing, dark energy, gravity waves--are rooted in the physics that Einstein so brilliantly deduced. This illustrated presentation, the Gemant Award Lecture sponsored by the American Institute of Physics, will provide a guided tour through the cosmos and explain how our understanding of the universe was transformed by Einstein's theories of special and general relativity.

070: The Coming Revolutions in Particle Physics
Plenary, Monday, 8:30-9:20am, Ballroom 6

Chair

Lila Adair[1]
[1]Piedmont College.

070.01

The Coming Revolutions in Particle Physics

Chris Quigg[1]
[1]Fermi National Accelerator Laboratory.

Wonderful opportunities await particle physics over the next decade, with new instruments and experiments poised to explore the frontiers of high energy, infinitesimal distances, and exquisite rarity. I will review the insights of the decade just past and show how they lead us to the brink of a new period of rapid and profound discovery. We expect answers to questions that speak to our understanding of the everyday world: why are there atoms? why chemistry? why stable structures? and even what makes life possible? We are probing the meaning of identity for the fundamental particles: what makes an electron an electron, a neutrino a neutrino, and a top quark a top quark? Important clues, including the remarkable neutrality of atoms, lead us to investigate the unity of the two main classes of matter, the quarks and leptons. Gravity and particle physics, long separate disciplines, are enjoying a stimulating reunion, and we are learning how to investigate—with experiments—new conceptions of spacetime.

We look forward to the Large Hadron Collider at CERN to explore the a new and critical energy scale of one trillion electron volts. If we are inventive enough, we may be able to follow the LHC's rich menu with the physics opportunities offered by a linear electron-positron collider, a (muon storage ring) neutrino factory, and experiments that use natural sources. I expect a remarkable flowering of experimental particle physics, and of theoretical physics that engages with experiment.

071: Poster Session II
AAPT Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

071.01

Student Exploration of Scientific Literature

Erin K. McCamish[1], T. McKay[1], M. Geramita[1], E. Percha[1]
[1]*University of Michigan.*

A new kind of assignment is being used to show introductory physics students how what they're learning relates to topics of current research. Students in a new "Physics for the Life Sciences" course at the University of Michigan are asked to search several different electronically available research journals for articles which relate to topics being discussed in class. Each student is assigned a separate set of issues, so they find a wide variety of articles. During the term they are asked to extract increasingly complex information from the articles as the term progresses. At each stage, peer assessment and feedback on their work is part of the process. At the end of the term, each student creates an assignment for their peers based on one of the articles they have read. These assignments serve multiple purposes. They introduce students to the scientific literature, teach them about various aspects of research articles, show them direct connections between introductory physics and current research, and challenge them to design workable, challenging problems for their peers. Results of the first semester of the project and recommendations for future work will be discussed.

071.02

Inquiry-Based, Hands-on In-class Astronomy Activities

Rebecca Lindell[1], T. Foster[1]
[1]*Southern Illinois University Edwardsville.*

At Southern Illinois University Edwardsville, we have restructured our introductory astronomy course to include hands-on inquiry-based in-class group activities. These activities utilize a learning cycle approach to cover specific astronomical concepts that traditionally resist conceptual change, such as phases of the moon and seasons, or that students have difficulty mastering, such as Hubble's law and the Hertzsprung-Russell diagram. Each group activity is designed to be completed during one 50-minute class period and utilize hands-on equipment whenever possible. In this poster, we will discuss the design and implementation of these group activities into our introductory astronomy course, as well as results of evaluation of the successfulness of these activities at promoting conceptual understanding and reasoning skills.

071.03

Innovate Use of SCALE-UP for Teaching General Education Astronomy

Luke Keller[1], M. Rogers[1]
[1]*Ithaca College.*

Current development at Ithaca College is focused on transforming our general education astronomy courses from lecture-based into hands-on, active-learning courses by using the SCALE-UP model. SCALE-UP (Student Centered Activities for Large Enrollment University Physics) pioneered at North Carolina State University expands the successes of Studio Physics (developed at RPI) to large enrollment courses. Studio Physics does away with the usual lecture/recitation/laboratory sessions by having one dynamic, active-learning environment for approximately 40 students. SCALE-UP expands this model to accommodate 100+ students by using large round tables usually seating nine students who work in groups of three. Classes meet three times per week with each class blending lecture, hands-on activities, group problem solving, and the use of student polling devices. It is expected that this mode of teaching astronomy will lead to a better understanding of astronomy and the nature of science. We just finished renovating two existing classrooms and two storerooms to create a 99-seat active learning room. This poster will present the steps we took from initial planning meetings to our current curriculum development stage. We will highlight how we obtained administration buy-in, obtained funding, and planned the renovation with our facilities staff. We will also present our plans for curriculum development and assessment of our efforts.

071.04

Promoting Stellar Writing: An Astronomy/English Learning Community

Frank Dudish[1], R. Lacina[1]
[1]*Delta College.*

We have combined a college, freshman-level English composition class and an introductory astronomy class to form a Learning Community. We share the same students and have coordinated our assignments to have the two classes build on each other. The structure of science and the logical nature of scientific argument are used to actively engage students in critical thinking in composition. Synergistically, writing also deepens students' appreciation of the nuances of scientific reasoning. In this presentation, we will discuss the processes of designing and implementing such a learning community, including the details of how we have coordinated the students, meeting times and assignments. We will describe how we have altered assignments to make them work together and also discuss the new assignments that have been created for these courses. We will share some of the unexpected benefits and also some of the pitfalls. We will also share our methods for promoting the Learning Community to students and discuss what choices make this Learning Community popular with students.

071.05

An Upper-Division Astronomy Laboratory Course for Undergraduate Physics Majors

David M. Kuehn[1], B. L. Davis[1]
[1]*Pittsburg State University.*

While the Pittsburg State University Physics Department has taught general education astronomy lectures and labs as well as an astrophysics lecture course for upper-division physics majors for years, the department has not offered an astronomy laboratory course for advanced physics undergraduates. In spring 2006, such a lab course was implemented and centered on the availability of the department's research-grade observatory and associated equipment.

The course was divided into three sections: Asteroid Astrometry, Cluster Photometry, and Stellar Spectroscopy. Approximately five weeks were spent on each project beginning with data collection at the 0.6-m telescope, data reduction/modeling, and a report written as a scientific paper. The course was useful to the students in that it sparked further interest and increased their depth of understanding of the covered topics. They also discovered some of the difficulties of observational astronomy, which can sometimes provide a more challenging research environment than the typical upper-division physics laboratory. Three of the students plan to go to astronomy graduate school and one is pursuing further research in molecular spectroscopy.

071.06

A New Chart and Teaching Materials on Cosmology from CPEP

G Samuel Lightner[1], M. Cherney[2], G. Aubrecht[3], R. Reiland[4]
[1]*Westminster College,* [2]*Creighton University,* [3]*The Ohio State University,* [4]*Shady Side Academy.*

The Contemporary Physics Education Project (CPEP), a volunteer nonprofit corporation of educators and scientists that has been developing materials to support the introduction of contemporary physics topics into high school and college introductory physics for 20 years, recently introduced a teaching chart on cosmology: *The History and Fate of the Universe*. This new chart will be displayed and samples of the chart as well as examples of the activities and materials that are being developed to support the chart will be available. Featured also will be the Universe Adventure, an internet tutorial related to the chart coming on line through the efforts of collaborating scientists at Lawrence Berkeley National Laboratory. (www.CPEPweb.org)

071.07

Investigating Neglected Double Stars

R Kent Clark[1], J. M. Sanders[1], J. Guidry[1], J. Pearce[1]
[1]University of South Alabama.

The United States Naval Observatory maintains the Washington Double Star catalog (WDS) which contains over 100,000 entries. A significant fraction of these double stars have been classified as ″neglected″ and are in need of further measurements. Many of the neglected systems are easily visible in a small telescope, thus providing ample opportunity for undergraduate research.

In this poster we will describe the WDS, the research possibilities for students, and results of an undergraduate research project at the University of South Alabama in which it was determined that a double star was an optical pair and the proper motion of the secondary was measured. Finally, we will briefly describe a new electronic journal, the Journal of Double Star Observations, providing a publication outlet for double star research by students and amateur astronomers.

071.08

Simulating the Retention of an Atmosphere

Kevin M. Lee[1], C. M. Siedell[1], A. N. Davis[1]
[1]University of Nebraska.

This poster will describe new simulations exploring concepts related to the retention of an atmosphere. Users have will have the capability to investigate the distribution of speeds for common gases and how they vary with temperature. Another simulator will focus on escape velocity. These concepts will be linked together in simulating exactly which gases are retained by various solar system bodies over time.

The Nebraska Astronomy Applet Project consists of high quality astrophysics simulations surrounded by variety of supporting materials. The resources include complete background information, student guides, instructor guides, and embedded assessment. These materials are publicly available at http://astro.unl.edu and are funded by NSF grant #0231270.

071.09

Citizen-Scientists Monitor Light Pollution Worldwide via ″GLOBE at Night″

Constance E. Walker[1], S. M. Pompea[1], D. Isbell[1], D. Orellana[2], D. Ward[3], S. Henderson[3], K. Meymaris[3], S. Gallagher[3], D. Salisbury[4]
[1]National Optical Astronomy Observatory, [2]Centro de Apoyo a la DidÃ¡ctica de la AstronomÃa (CADIAS), Chile, [3]UCAR, [4]CSU.

More than 18,000 citizen-scientists in 96 countries submitted almost 4,600 observations of the darkness of their local night skies during the 10-day "GLOBE at Night" event at the end of March 2006. The GLOBE at Night program was designed to help students, families, and the general public observe and record how the constellation Orion looked from different locations, as a means of measuring the brightness of the sky at a variety of urban and rural sites. The program was conducted to aid teaching about the impact of artificial lighting on local environments, and the ongoing loss of a dark night sky as a natural resource for the world's population. Observers reported their results online by comparing the number of stars seen toward Orion with a set of template images on the program's Web site. These images showed the number of stars in the constellation for a range of visibilities from bright skies to very dark.

This session will describe the analysis from last year and our plans for this year to incorporate more technology into the GLOBE at Night program. Citizen-scientists will use sky quality meters (visible light photometers), calibrated digital photography, and GPS as a means to measure and map more accurately the brightness of the sky at selected urban and rural sites.

Given the widespread interest in the inaugural GLOBE at Night event, the GLOBE at Night team is eager to offer it again from March 8-21, 2007. For more information, see www.globe.gov/GaN or contact globeatnight@globe.gov.

071.10

Student-Scientists use Remote Sensing to Reach across the Equator

Constance E. Walker[1], R. Probst[1], C. Martin[2], B. Dorame[2], D. Isbell[1], S. M. Pompea[1], H. Ochoa[3], D. Orellana[4], A. Garcia[5]
[1]National Optical Astronomy Observatory, [2]Howenstine Magnet High School, [3]Cerro Tololo Inter-American Observatory, Chile, [4]Centro de Apoyo a la DidÃ¡ctica de la AstronomÃa (CADIAS), Chile, [5]Gemini Observatory, Chile.

A special student-to-student videoconference was held mid-May 2006 between students in Tucson, Arizona and La Serena, Chile, the headquarters for the north and south offices of the National Optical Astronomy Observatory (NOAO). Fifty participants at each location reported on a remote-sensing activity conducted by hundreds of students during February, March and April, 2006.

The students became acquainted with the geography and geology of their area using Landsat satellite remote sensing imaging. The Tucson students then analyzed images of La Serena and students from Chile analyzed images of Tucson. Since top-down satellite views may not provide complete information, students from one country emailed students from the other country and requested them to be human "rovers," taking local pictures of areas under question to establish ground-truth.

The success of this cross-cultural program has motivated NOAO outreach staff to broaden the project to schools in other countries, coordinated by students as their service-learning project. To facilitate this effort, a special, yet generic, worksheet is being developed. The worksheet can be by teachers to include local landmarks and geographical features. Once completed and tested, the worksheet will be placed on the NOAO website, along with Landsat7 satellite images for different areas around the world. In 2007, the program will be expanded to examine the surface of Mars using Google Mars and NASA images.

NOAO is operated by the Association of Universities for Research in Astronomy (AURA), Inc. under cooperative agreement with the National Science Foundation. For further information, email Connie Walker at cwalker@noao.edu.

071.11

NASA's Gravity Probe B Mission: Was Einstein Right?

Shannon K. Range[1]
[1]NASA's Gravity Probe B at Stanford University.

The most sophisticated and precise test of Einstein's theory of curved spacetime is finally complete after 46 years of development and study. What did we discover?

THE MISSION: In 1960, NASA began developing the most sophisticated and precise test of Einstein's theory of general relativity -the Gravity Probe B mission based at Stanford University. Was Einstein right about the shape of curved spacetime around the Earth? Did Earth's rotation actually ″twist″ spacetime around with it? After four decades of physics and engineering innovations, Gravity Probe B was ready to go. In 2004, NASA launched the Earth-orbiting satellite containing four near-perfect spinning spheres (gyroscopes) designed to reveal the shape of spacetime curvature near the Earth and the presence of ″frame-dragging.″ After 16 months of observations and a year-and-a-half of data analysis, we nearly have our answers. Stanford scientists and theorists are making the final verifications to our data and analysis in preparation for the release of the results.

IN YOUR CLASSROOM: We have translated the sophisticated science and technology of this unique mission into a teacher's guide, demonstration activities, and a mission DVD/CD. Each of these items is available to all and will help you engage your students in Einstein's ideas of spacetime, our work with gyroscopes and the exciting work of conducting research in space.

071.12

Using the Astronomy Diagnostic Test to Identify Students' Preconceptual Knowledge

Dennis M. Robbins[1], S. Tribiano[1], K. Ford[1], B. McKernan[1]
[1]*Borough of Manhattan Community College.*

The Astronomy Diagnostic Test (ADT 2.0) is a 33-item multiple-choice survey used to assess students' conceptual knowledge of fundamental astronomical ideas. This instrument allows different instructors to make common observations about the astronomy classroom. The results of ADT 2.0 might be used uncover students' pre-instructional knowledge, judge overall student preparedness, investigate the effectiveness of learning, evaluate teaching methods and develop new curriculum.(1) We report results of ADT 2.0 for two-year college students (N=170) enrolled in a general astronomy course. The present research establishes a database for making future curricular decisions and constitutes our initial attempt at Astronomy Education Research.

1. Hufnagel, B. (2002) Development of the Astronomy Diagnostic Test, *Astronomy Education Review*, 1(1): 47-51.

071.13

Interactive Lecture Experiments in Large Introductory Physics Classes

Marina M. Milner-Bolotin[1], A. Kotlicki[1], G. Rieger[1], F. Bates[1], R. Moll[1], K. McPhee[1], S. Nashon[1]
[1]*University of British Columbia, Canada.*

We describe Interactive Lecture Experiments (ILE), which build on Interactive Lecture Demonstrations proposed by Sokoloff and Thornton (2004) and extends it by providing students with the opportunity to analyze experiments demonstrated in the lecture outside of the classroom. Real time experimental data is collected, using Logger Pro combined with the digital video technology. This data is uploaded to the Internet and made available to the students for further analysis. Student learning is assessed in the following lecture using conceptual questions (clickers). The goal of this project is to use ILE to make large lectures more interactive and promote student interest in science, critical thinking and data analysis skills.

We report on the systematic study conducted using the Colorado Learning Attitudes about Science Survey, Force Concept Inventory, open-ended physics problems and focus group interviews to determine the impact of ILE on student academic achievement, motivation and attitudes towards physics. Three sections of students (750 students) experienced four ILE experiments. The surveys were administered twice and academic results for students who experienced the ILE for a particular topic were compared to the students, from a different section, who did not complete the ILE for that topic. Additional qualitative data on students' attitudes was collected using open ended survey questions and interviews. We will present preliminary conclusions about the role of ILEs as an effective pedagogy in large introductory physics courses.

Sokoloff, D.R. and R.K. Thornton (2004). Interactive Lecture Demonstrations: Active Learning in Introductory Physics, J.Wiley & Sons, INC.

Interactive Lecture Experiments: http://www.physics.ubc.ca/~year1lab/p100/LectureLabs/lectureLabs.html

071.14

Web administered pre/post assessment: reliability, compliance and security

Scott W. Bonham[1]
[1]*Western Kentucky University.*

Pre/post assessment measures learning by comparing assessment performance before and after instruction. Usually it is administered on paper during class, needing to be distributed, collected, graded and analyzed. Administration on the web outside class frees up class time and automates many steps. However, this switch to unproctored web administration raises questions. Will the results be as reliable? Will students take it? Will test questions leak to fraternity files? An experiment using two different assessments pre/post test was carried out in introductory astronomy classes. Each section took one assessment on line and one in class. Comparing performance on paper vs. web provides information on reliability. Numbers of students completing in each mode give information on compliance and factors influencing it. Browser events that could indicate copying, saving or printing of questions were recorded to identify possible loss of security.

071.15

Physics Applets for Drawing in the classroom

Scott W. Bonham[1]
[1]*Western Kentucky University.*

The Physics Applets for Drawing (PADs) are a suite of Java Applets that allow graphical responses to questions, with automatic grading and optional feedback. They can be used in class and within web-based homework. I have used them in my classroom for several years to reinforcing laboratory graph skills in, practice free body diagrams and energy bar charts, and practicing steps of a problem-solving strategy. PADs exercises are now more easily found and used in the classroom. Direct links to particular exercises can be found from the PADs website and from searches on comPADRE. WebAssign now offers a collection of PADs exercises as an additional resource (appearing as a supplemental textbook). Finally, we will soon have a Blackboard Building Block (plug-in) available that will support use of PADs. More information can be found at http://www.wku.edu/pads. This work was supported by NSF CCLI grant DUE-0231353.

071.16

Active Learning with Ubiquitous Presenter and Tablet PCs

Edward Price[1], B. Simon[2]
[1]*California State University, San Marcos,* [2]*University of California, San Diego.*

Ubiquitous Presenter (UP)* is a digital presentation system that facilitates spontaneity and interactivity in the classroom. Using the system, an instructor with a Tablet PC can spontaneously modify prepared slides. Furthermore, students with web-enabled devices can add digital 'ink' or text to the instructor's slides and submit them to the instructor during class. We have used this system to facilitate interactive engagement techniques in an introductory physics class where approximately one-third of the students had access to a Tablet PC during class. Class time was used for Interactive Lecture Demonstrations, Peer Instruction, and group problem solving. We describe the implementation of these active learning activities with UP and Tablet PCs, show examples of student contributions, and describe the impact on the classroom setting.

*http://up.ucsd.edu/about/

071.17

Simulation-Based e-Learning Tools for Science,Engineering, and Technology Education(SimBeLT)

Doyle V. Davis[1], Y. Cherner[2]
[1]*New Hampshire Community Technical College,* [2]*ATeL, LLC.*

The focus of *Project SimBeLT* is the research, development, testing, and dissemination of a new type of simulation-based integrated e-learning set of modules for two-year college technical and engineering curricula in the areas of **thermodynamics**, **fluid physics,** and **fiber optics** that can also be used in secondary schools and four-year colleges. A collection of sophisticated virtual labs is the core component of the *SimBeLT* modules. These labs will be designed to enhance the understanding of technical concepts and underlying fundamental principles of these topics, as well as to master certain performance based skills online. *SimBeLT* software will help educators to meet the National Science Education Standard that *"learning science and technology is something that students do, not something that is done to them*." **A major component of Project SimBeLT is the development of multi-layered technology-oriented virtual labs that realistically mimic workplace-like environments. Dynamic data exchange between simulations will be implemented and links with instant instructional messages**

and data handling tools will be realized. A second important goal of Project SimBeLT labs is to bridge technical skills and scientific knowledge by enhancing the teaching and learning of specific scientific or engineering subjects. *SimBeLT* builds upon research and outcomes of interactive teaching strategies and tools developed through prior NSF funding (http://webphysics.nhctc.edu/compact/index.html) (Project SimBeLT is partially supported by a grant from the National Science Foundation DUE-0603277)

071.18

Study of Interface Design for Engagement and Learning with Educational Simulations

Wendy K. Adams[1], S. Reid[1], R. LeMaster[1], S. McKagan[1], K. Perkins[1], C. E. Wieman[1]
[1]University of Colorado.

Interactive computer simulations with complex representations and sophisticated graphics are a relatively new addition to the classroom, and research in this area is limited. Here we present results from research on the design and use of such simulations conducted as part of the Physics Education Technology (PhET) project. PhET is an ongoing project that has developed over 60 simulations for use in teaching physics, chemistry, and physical science. The development of these simulations included over 165 individual student interviews during which the students described what they were thinking as they interacted with the simulations. These interviews are a rich source of information about how students interact with computer simulations and what makes an educationally effective simulation. We present a summary of findings from these interviews of what students are learning when playing with these simulations and the guidelines for developing simulations based on these findings. We have observed that simulations can be highly engaging and educationally effective. We will present the layout, tool use, help, representations, and effective features for engaging students in educationally productive interactions.

1. See http://phet.colorado.edu 2.Supported in part by funding from National Science Foundation, The Kavli Operating Institute, The William and Flora Hewlett Foundation and the University of Colorado at Boulder.

071.19

Advanced Modeling in Excel: from Water Jets to Big Bang

Olga Ignatova[1], D. Chyzhyk[2], C. Willis[3], A. Kazachkov[1]
[1]V.Karazin Kharkiv National University, Ukraine, [2]Kharkiv National University of Radio-Electronics, Ukraine, [3]University of Northern Colorado.

An international students' project is presented focused on application of Open Office and Excel spreadsheets for modeling of projectile-motion type dynamical systems. Variation of the parameters of plotted and animated families of jets flowing at different angles out of the holes in the wall of water-filled reservoir [1,2] revealed unexpected peculiarities of the envelopes, vertices, intersections and landing points of virtual trajectories. Comparison with real-life systems and rigorous calculations were performed to prove predictions of computer experiments. By same technique, the kinematics of fireworks was analyzed. On this basis two-dimensional 'firework' computer model of Big Bang was designed and studied, its relevance and limitations checked.

1.R.Ehrlich, *Turning the World Inside Out,* (Princeton University Press, Princeton, NJ, 1990), pp. 98-100.

2.A.Kazachkov, Yu.Bogdan, N.Makarovsky, N.Nedbailo. A Bucketful of Physics, in *R.Pinto, S.Surinach (eds), International Conference Physics Teacher Education Beyond 2000. Selected Contributions* (Elsevier Editions, Paris, 2001), pp.563-564.

Sponsored by Courtney Willis.

071.20

Develpoing computer program for calculating magnetic fields

Wook Hee Koh[1], A. Koh[2]
[1]Hanseo University, Republic of Korea, [2]Irvine Valley College.

A computer program that we developed to help students understand the magnetism under various conditions is presented. The program is coded by C++ language to make a window's program with GUI. The magnetic fields by circular permanent magnets as well as by circular current loops can be calculated in axisymmetric cylindrical coordinates. The code not only is able to calculate magnetic fields and equipotential lines but also is able to plot them as contours and vector by just inputing coil currents or magnetization.

071.21

Data Acquisition with Mathematica

Wesley W. Bliven[1], N. Fitch[2], P. Tam[1]
[1]Humboldt State Univ, [2]University of Colorado at Boulder.

This poster presents a project in which Mathematica is used to control a National Instruments data acquisition card to input or output electronic signals directly to and from a Mathematica notebook. The purpose is to supplement Mathematica's powerful theoretical and data analysis capabilities with data acquisition, creating an environment where the entire experimental process can be completed in a relatively simple and unified manner. A complete experiment that highlights the educational advantages of controlling the entire experimental process from within Mathematica is presented.

071.22

Teaching Computational Physics Using Spreadsheets

Jaebong Lee[1], K. Shin[1], S. Lee[1]
[1]Seoul National Univ., Republic of Korea.

In recent year, many research groups have been developing spreadsheet program for physics teaching. For example it used to solve Laplace equation[1], to visualize potential surface[2], and to animate physical contents[3]. Because Microsoft Excel program is easy to learn, it can apply to many physics problem. And Microsoft® Excel has a Visual Basics for Applications (VBA). ExcelVBA is user-friendly programming tool. Using Excel-VBA and operation with cells, we develop kinds of program about simple harmonic motion, pendulum, satellite orbit, diffraction and so on. We also taught undergraduate students how to program about physics contents using Excel-VBA. We will discuss its' effect and student's response.

1. T.T. Crow,"Solution to Laplace's equation using spreadsheets on personal computer", Am. J. Phy. 55, 817-823(Sept. 1987)

2. R. J. Beichner, "Visualizing potential surfaces with a spreadsheets", Phys. Teach. 35, 95-97(Feb. 1997)

3. O. A. Haugland," Spreadsheet Waves", Phys. Teach. 37, 14(Jan. 1999)

*Supported by the Brain Korea 21 project in 2006

071.23

Doing Physics with Spreadsheets: Old Tricks for New Dogs

A. John Mallinckrodt[1]
[1]Cal Poly Pomona.

Despite their decidedly "last year," low-tech status, spreadsheets remain singularly efficient and accessible tools for solving a wide variety of problems in physics, presenting examples in the classroom, and conducting preliminary or exploratory computational research projects. Moreover, newer features have enhanced these capabilities. Because of the shallow learning curve, spreadsheets should be a tool in the arsenal of all physics students and faculty. I will present a number of examples drawn from mechanics, thermodynamics, and electrostatics illustrating graphical analysis, combinatorics, animation, and solutions of ordinary and partial differential equations. I am soliciting examples from the physics teaching community for a new website devoted to the dissemination of instructional materials in spreadsheet physics.

071.24

Bouncing Ball Video Analysis: The Conservation of Mechanical Energy

Joel A. Bryan[1]
[1]*Texas A&M University.*

Video analysis software is one of the most recent technological innovations that is rapidly becoming an essential part of physics studies at the secondary and undergraduate levels. This poster graphically presents comparative analyses of the conservation of mechanical energy of a bouncing ball obtained using three inexpensive and/or free video analysis software programs VideoPoint, LoggerPro, and Tracker.

071.25

Changing Student Attitudes using Andes, An Intelligent Homework System

Brett van de Sande[1], K. VanLehn[1], D. Treacy[2], R. Shelby[2]
[1]*University of Pittsburgh,* [2]*US Naval Academy.*

The size of introductory physics lectures often inhibits personal homework assistance and timely corrective feedback. Andes, an intelligent homework system designed for two semesters of introductory physics, can fill this need by encouraging students to use sound problem solving techniques and providing immediate feedback on each step of a solution. On request, Andes provides principles-based hints based on previous student actions. A multiyear study at the U.S. Naval Academy demonstrate that students using Andes perform better than students working the same problems as graded pencil and paper homeworks. In addition, student attitude surveys show that Andes is preferred over other homework systems. These findings have implications for student attitudes toward, and mastery of, physics. See http://www.andes.pitt.edu for more information.

071.26

Using the Motion Visualizer Family of Programs to Enhance Classroom and On-Line Learning

James E. Trimble, Jr[1]
[1]*University of Tennessee.*

By utilizing the Motion Visualizer (MV) Family of Programs published by Alberti's Window, Inc., it is possible to enhance the learning experience of undergraduate level physics students. It is possible to build both on-line labs and demonstrations that can be viewed prior to class and during the classroom lecture period. By integrating the MV programs with Microsoft Excel, Video Playback software and Flash technology, first year physics students can be given the ability to see and interact with difficult concepts. Concepts such as position/velocity/acceleration relationships and conservation of momentum can be shown step by step as useful graphs and charts are created along with a video playback of the experiment. This allows the student to see how the data is taken and then interpret the data in a real time environment.

071.27

Choosing the Right Mixture of Techniques and Technologies

Todd K. Timberlake[1]
[1]*Berry College.*

Recent years have seen the development of a variety of teaching techniques specifically designed to improve student learning in physics. In addition, new technologies have been developed that help to increase interaction between students and instructors. Choosing which techniques and technologies to use, and then merging these techniques and technologies into a consistent whole, can pose a significant challenge for physics teachers. In this talk I will describe the various techniques and technologies I have used in teaching a two-semester algebra-based introductory physics sequence over the past five years. These courses have gradually evolved to incorporate a mixture of Peer Instruction and Just-In-Time-Teaching using online quizzes, Physlets, and an electronic response system.

072: AGNs, QSOs and Active Galaxies 1
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

072.01

Redshift Effects on the Spectroscopic Properties of Active Galaxies

Kelly Wallenstein[1], E. C. Moran[2]
[1]*Wellesley College,* [2]*Wesleyan University.*

Seyfert 2 galaxies provide an excellent spectral match to the X-ray background. However, optical observations of faint Chandra X-ray sources show that the population is dominated by apparently normal galaxies. One explanation is that that the distinguishing spectral features of distant Seyfert 2 nuclei are obscured by host-galaxy emission, which is significant in ground-based observations of high-redshift sources where spectral slits cover a large fraction of the host. Previous simulations using local Seyfert 2s revealed an apparent ″transformation″ of Seyfert 2s into normal galaxies when light was collected from the entire galaxy. In this paper we analyze spatially resolved spectra of nearby Seyfert 2s and their hosts to determine the fractional amount of extranuclear light necessary for these apparent transformations to occur or, equivalently, the redshifts at which distant Seyfert 2s might begin to appear as normal galaxies in integrated spectra.

We gratefully acknowledge support from NSF-REU grant AST-0353997 to the Keck Northeast Astronomy Consortium.

MONDAY

072.02

Applications Of Spectral Principle Component Analysis In AGN Research: Sample Selection and Beyond

Zhaohui Shang[1], M. Brotherton[1]
[1]*Univ. Of Wyoming.*

Spectral principal component analysis (SPCA) has great potentials in AGN spectral research. It has been shown that SPCA is very powerful and efficient in classification, correlation analyses, and spectral parameter measurements. We present here how SPCA can be used to select samples from large spectral surveys like SDSS, based on spectral properties

072.03

Quasar Metallicities and Host Galaxy Evolution

Simon E. Leah[1], F. W. Hamann[1]
[1]*University of Florida.*

From studies of galaxies in the local Universe we find the masses of the galactic spheroidal component corresponds with the mass of the central supermassive black hole (SMBH). This relation is known as the M(gal) M(BH) relation, and suggests a close relationship between the formation of the galaxy and the black hole. We study the metallicities near quasars at high redshift to observe this formation process in action. Associated absorption lines (AALs) provide us with a unique tool for this study, because these lines have a high probability of forming close to the quasar. Most of the work so far, using the emission lines, suggests that quasar environments are typically metal rich, with gas-phase metallicities near solar or higher at all observed redshifts. However, other independant abundance checks, such as AALs, are essential in order to confirm these results. We use very high resolution echelle spectra from VLT-UVES for 8 high redshift (z of 2 to z of 4.6) quasars, selected to contain candidate intrinsic absorbers, and ecompassing a typical rest-frame spectral range from approximately 900 Angstroms to 2500 Angstroms, designed to include at least Lyman alpha and C IV spectral features. We perform one of the first analyses of absorption line metallicities in high redshift quasars and present lower limits on column densities, as well as estimates for the absorber locations relative to the quasar. We place rough estimates on the abundances where possible. We find covering fractions which vary with velocity, and a significant fraction of absorption lines which exhibit variability, indicating their intrinsic nature. Saturated lines inhibit concrete abundance analysis, but present excellent opportunities for future research proposals.

072.04

Quasar Environments in the Sloan Digital Sky Survey

Amanda Haapala[1], J. Scott[1]
[1]Towson University.

We investigate the environments of low-redshift quasars using data from the Sloan Digital Sky Survey (SDSS), Data Release 5. A sample of about 2900 quasars with z <~0.2 will be compiled and cross correlated with the galaxies within a radius of 500 kpc. We will quantify the galaxy environments of the quasars in the sample by calculating the quasar-galaxy spatial covariance amplitude for each field. This will count galaxies brighter than a certain magnitude limit and within a certain volume of the quasar in order to classify the richness of the quasar environment. We will then compare the quasar fields with fields that contain no quasars to determine the relationship of a quasar with its environment. We will also be able to make correlations between the quasar environments and intrinsic properties of the quasar, for example radio loudness, luminosity, and black hole masses of the quasars.

072.05

Magnetorotational Instability in Strongly Magnetized Plasmas

Vladimir I. Pariev[1], V. V. Mirnov[1], S. C. Prager[1]
[1]Univ. Of Wisconsin-Madison.

Jets, either in AGNs, microquasars or gamma-ray bursts, may be flows of strongly magnetized, low beta (i.e.the ratio of sound speed c_s to Alfvén speed v_A is small), rotating plasmas. Effective excitation of MRI requires weak magnetic field because the tension of the strong, bent magnetic field would prevent MRI. Nevertheless, we embark on a study of MRI-like instabilities in strongly magnetized plasmas. A cylindrical jet with helical magnetic field and axial and rotational flows is considered. The perturbations do not bend magnetic field lines in the vicinity of resonant surfaces where $k_{||}=0$. We show that the shear flow localized to a resonant surface can drive localized unstable modes similar to the pressure driven Suydam modes in laboratory plasma devices (see Bondeson, Iacono, Bhattacharjee, 1987). Rotational flows with the angular velocity Ω can drive both the resonant compressible mode, when $r^2\, d\Omega/dr \sim= c_s$, and MRI-like resonant mode, when $r^2\, d\Omega/dr \sim= v_A$. Sheared axial flow *u* drives a compressible unstable mode when $r\, du/dr \sim c_s$. The interval of unstable values of du/dr is narrow. If the flow is ideally stable, slow resistive instabilities driven by sheared flow become important, although they are, probably, too slow to have time to develop in convective jets. This research was supported by the Center for Magnetic Self-Organization for Laboratory and Astrophysical Plasmas at the University of Wisconsin-Madison.

072.06

Discovery of Bright Quasars at Low Galactic Latitude

Induk Lee[1], M. Im[1]
[1]Seoul National University, Republic of Korea.

We report the discovery of 11 new bright quasars at low galactic latitude from the Seoul National University Quasar Survey in Optical (SNUQSO). Traditionally, quasars have been searched at high galactic latitude because of the severe stellar contamination at low galactic latitude.

As a part of SNUQSO, we are undertaking a survey of low galactic latitude quasars, in order to (i) provide a complete census of quasar population; (ii) to discover quasars with bright stars nearby for efficient adaptive optics study for their host galaxy properties; and (iii) to study the galactic matters using quasar spectra.

We have made an algorithm to find quasars at low galactic latitude using multi-wavelength data, and observed the candidates with the long-slit spectrograph on the 1.8m telescope and long-slit spectrograph at Mt. Bohyun Optical Astronomy Observatory (BOAO). We present newly discovered bright quasars at the zone-of-avoidance. Our result demonstrate that the new algorithm is highly efficient at selecting quasars at low galactic latitude.

072.07

Clustering of z=3 AGN in MUSYC-ECDFS

Harold Francke[1], E. Gawiser[2], P. Lira[1], S. Virani[2], E. Treister[3], C. M. Urry[2], MUSYC Collaboration
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The Multiwavelength Survey by Yale/Chile (MUSYC) covers 1.2 square degrees of sky to U,B,V,R = 26 and K = 22 (AB), and includes the Extended CDF-S field, home of the largest Chandra survey ever conducted at its depth (0.3 square degrees and 228 ks). The X-ray catalogs of this field (Virani et al. 2006, Lehmer et al. 2005) reveal more than 700 Active Galactic Nuclei (AGN). We used the deep optical catalogs to apply the Lyman-Break technique, which yielded a sample of 84 AGN at $2.7 < z < 3.7$. We performed a cross-correlation clustering analysis on these AGN and a sample of 1240 Lyman Break Galaxies at z~3. Here we present results on the clustering amplitude, estimates of the dark matter halo masses and number densities of z~3 AGN, and a measurement of the duty cycle for accretion by the SMBH hosted by these AGN.

072.08

Optical Variability of Infrared Power Law-Selected Galaxies & X-ray Sources in the GOODS South Field

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This study investigates the use of optical variability to identify AGN in the GOODS South field. Photometry was performed on a sample of 24 infrared power law-selected AGN candidates and 104 X-ray sources with optical counterparts. Each object is classified with a variability significance value, which is related to the standard deviation of its magnitude in five epochs separated by 45-day intervals. The variability significance is compared to IR and X-ray properties of the sources. We find that the majority of significant variables are consistent with IR spectral energy distributions typical of BLAGNs and are usually softer X-ray sources. However, 30% of the IR-selected AGN candidates without X-ray emission, generally thought to be highly obscured sources, display marginal optical variability, confirming their AGN nature.

072.09

Intrinsic Absorption in the HST Archive I: Search for Time Variable Systems

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We present a search for time-variable narrow absorption lines (NALs) in HST quasar spectra. NALs which appear in the spectra of quasars can be very powerful probes of physical conditions of a variety of structures. The primary signatures distinguishing intrinsic NALs from intervening NALs are partial coverage of the background source and time variability. Using low-dispersion, multi-epoch observations of quasars in the HST archive, we devised and implemented a method of selecting time-variable absorption lines. Using multi-epoch data for 72 quasars that span a large range of redshift and luminosity, we performed this selection and compiled a catalog of identified lines. We present 9 time-variable, and therefore intrinsic, systems detected in 8 of the quasars. We put forward several tests to investigate the cause of variability (ionization changes or motion of gas). This contribution is presented as a companion to another contribution in which intrinsic systems are identified using partial coverage.

This work was supported by the Space Telescope Summer Student Program, SURAP at the Wyoming Infrared Observatory, and NASA through grant numbers HST-AR-10296 and NAG5-10817.

072.10

Intrinsic Absorption in the HST Archive II: Partial Covering and Associated O VI Systems

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We present a search for quasar-intrinsic absorption-line systems in the rich archive of high-dispersion HST STIS echelle spectra. Our search consists of two parts: (1) systems with apparently diluted absorption troughs; and (2) systems appearing near the quasar redshift (''associated'' systems). In the former case, dilution of resolved troughs suggests that the background source is not fully covered by the absorbing gas, implying a vicinity near the quasar. This search is conducted in parallel with a recent similar search by Misawa et al. for intrinsic absorption at high redshift. Similar to that survey, we find strong NV absorption to be a reasonable indicator of gas with intrinsic origins. In addition, we complement the Misawa sample and previous FUSE studies with associated O VI absorption in low-redshift quasars. In spite of the close proximity of the OVI lines to the quasar redshift, we find: (1) no evidence for partial covering; and (2) little evidence that the absorption takes place near the central engine. Photoionization models of one OVI system toward HE0226-4110 suggest absorption in the host galaxy. In another OVI system toward PG1116+215, the absorption redshift matches that of galaxies in the field. This contribution is presented as a companion to another poster in which intrinsic systems are identified through time-variability. This work was supported by NASA through grant NAG5-10817.

072.11

Dust Lanes, Nuclear Dusty Disks, and Isophotal Properties as Observed by HST: What Do They Tell Us about the 3-D Structure of Elliptical Radio Galaxy Hosts?

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We investigate isophotal properties and dust morphology in the nuclear regions of 3CR radio galaxies, imaged in the optical and near-infrared as part of Hubble Space Telescope snapshot surveys. We present a sample-wide correlation between host galaxy isophotal structure and the inclination of dusty circumnuclear disks at the centers of these objects. We find that galaxies containing edge-on disks are invariably seen to possess boxy isophotes, while round, face-on disks are seen almost exclusively in objects with round or largely elliptical isophotes. Dust-rich sources with disky isophotes are observed only to possess dust in the form of lanes or clumpy patches, and not in settled distributions like disks. Such a correlation might allow us to not only interpolate the three-dimensional structure of the elliptical host, but also to draw a connection between the host and the post-merger activity of the dust within it. While host galaxy isophotal properties seem strongly coupled to dust distribution, there is no apparent connection to radio flux from the core.

072.12

Probing the Assembly of Massive Galaxies via Quasar Hosts at z=4

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We have undertaken a project to investigate the host galaxies and environments of quasars at z~4. These objects already contain supermassive black holes at early times and are destined to evolve into today's largest spheroids. They thus provide excellent leverage for tests of hierarchical models of galaxy formation. In this paper, we present deep, near-IR images of 34 such quasars observed with the Magellan I and Gemini North telescopes. We describe the search for host galaxies via 1and 2-D PSF fits, and we use the results to constrain the black hole/bulge relation at z=4.

We gratefully acknowledge support from NSF-REU grant AST-0353997 to the Keck Northeast Astronomy Consortium; the Wellesley College Science Center; and Theresa Mall Mullarkey.

072.13

Monitoring Microlensing Events In the Quasar RX J1131-1231

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[1]Penn State University, [2]The Ohio State University.

Resolving the emission regions of distant quasars is beyond the current capabilities of present-day telescopes. Direct imaging of accretion disks requires angular resolutions of the order of tens of nano-arcseconds at z ~ 1. Until the spacial resolution of telescopes reaches this limit we will have to rely on indirect methods of mapping the emission regions of quasars. We have initiated a multiwavelength monitoring campaign of several microlensing candidates with the main scientific goal of measuring the structure of AGN in the optical and X-ray bands in order to test disk models. Here we present the X-ray and optical observations of the z = 0.658 lensed quasar and microlensing candidate RX J1131-1231. Our analysis of the well sampled optical light curve of RX J1131-1231 allows us to constrain the microlensing model and use it to model the sparsely sampled X-ray light curve to constrain the size of the X-ray continuum source.

072.14

3D Simulations of Jet Interactions with Galaxy Cluster Environments

Sean M. O'Neill[1], T. W. Jones[1], D. Ryu[2]
[1]Univ. of Minnesota, [2]Chungnam National University, Republic of Korea.

We present the results of high-resolution 3D MHD simulations of light, supersonic AGN jets in realistic galaxy cluster environments. These simulations are designed to explore the viability of jets as a means of delivering energy to cluster environments to prevent the formation of cooling flows. Our simulated jets propagate in opposite directions from the cluster core, converting and depositing energy in their environments as they evolve. In some cases, the jet activity is varied to mimic real AGN duty cycles. The cluster environments feature full 3D gravity and realistic temperature and density profiles with mild density perturbations consistent with those observed in physical systems. Additionally, the cluster magnetic field is structured to provide physically reasonable field values and correlation lengths. Our study focuses on measuring in what amounts, forms, and locations this jet energy enters the ambient medium and whether it does so irreversibly to contribute to ICM heating. Furthermore, we explore the morphologies of jet, lobe, and bubble structures produced by both steady and intermittent flows.

This work was supported by NSF Grants 03-07600 and 06-07674, The Minnesota Supercomputing Institute, and a University of Minnesota Doctoral Dissertation Fellowship.

072.15

AGN near Weak Lensing Selected, X-ray Confirmed Galaxy Clusters

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A better understanding of AGN in cluster environments may provide clues to the reasons for their ignition and the subsidence throughout cosmic evolution. Furthermore, if this activity is related to the hierarchical growth of structure, as has been suggested, study of the distribution and nature of cluster AGN will allow us to test structure formation models.

The Deep Lens Survey (DLS) team has identified a unique sample of galaxy clusters through weak gravitational lensing shear mapping (Wittman et al. 2006). Chandra X-ray confirmation of several of these clusters has serendipitously uncovered large numbers of X-ray point sources, presumably AGN, in the fields of these clusters. We report here on our survey to characterize these AGN; determine their redshifts, optical and X-ray luminosities, and distribution relative to the hot gas, galaxies and dark matter mass of their cluster environment.

072.16

FeII(UV)/MgII Ratio versus Luminosity in QSOs

Ekaterina Verner[1], F. Bruhweiler[1], B. Peterson[2]
[1]Catholic University of America, [2]Siding Spring Observatory, Australia.

In our previous studies we examined the luminosity dependence of the Fe II(UV)/MgII ratio, and we found that beyond a threshold of FeII(UV)/MgII=5, and M_{2500} < -25mag, the Fe II(UV)/Mg II ratio increases with luminosity, as was predicted by our model.

We interpret our observed variation of the Fe II(UV)/MgII ratio with redshift as a result of the correlation of redshift with luminosity in a magnitude limited quasar SDSS sample. To check our funding further, we selected bright objects and carried observations using 2.3 m telescope at Siding Spring Observatory and 4m Anglo-Australian Telescope.

This presentation includes four bright objects for which we have collected data along with measurements. This work investigates how much the QSO continuum is affected by Fe II pseudo-continuum and physical conditions in these objects.

EV research and presentation at the AAS are supported by the National Science Foundation (NSF 0607465).

072.17

Are There Low Radiative Efficiency Accretion Disks in Low Luminosity AGN?

Marco Chiaberge[1], D. Macchetto[2]
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We have studied a carefully selected sample of local low luminosity AGN composed by LINERs, Seyferts and low luminosity radio galaxies, which have been imaged with the Hubble Space Telescope. We find faint unresolved nuclei in a significant fraction of the objects. The nuclear emission is as low as 10^{-8} times the Eddington luminosity, indicating extremely low radiative efficiency for the accretion process. The nuclei show a dichotomy as far as their radio loudness is concerned, and best separate in a plane in which the $L_{optical}/L_{Edd}$ is plotted against the nuclear radio loudness. This plane allow us to find objects that are the best candidates for hosting ADAF-like radiatively unefficient accretion, which can only be indentified using HST. Other planes showing an intriguing apparent unification of sources associated to black holes (from galactic BH to powerful QSOs) such as the so-called ″Fundamental plane of black hole activity″ are less useful for diagnostic purposes. The case of NGC4565 is promising: the object is a low-luminosity Seyfert galaxy which does not show significant nuclear absorption and its SED is peculiar. NGC4565 may thus represent the first case in which optical emission from an ADAF-like process is directly observed in an AGN.

072.18

Broad Line Regions in Low Luminosity Radio Galaxies: is the Distinction Between Broadand Narrow-Line Galaxies Real?

Jacob Noel-Storr[1], S. A. Baum[1], C. P. O'Dea[1]
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We present the results of a search, using HST/STIS, for broad line emission in the nuclei of a complete sample of nearby, low-luminosity radio galaxies. Our results show a flux limited detection of Broad Line Regions across the entire sample, suggesting that BLRs are present in the nuclei of all low luminosity radio galaxies. The detections are limited by flux alone, not by galaxy orientation, implying that an obscuring torus may not be a necessary component of the nuclei of these galaxies.

072.19

Optical Ensemble Variability of Low to Moderate Redshift Galaxies in the Sloan Digital Sky Survey

Tyler D. Desjardins[1], V. L. Sarajedini[1]
[1]Univ. Of Florida.

Using a large sample of 5,843 galaxies with a wide range of redshifts, we conduct statistical analyses correlating the ensemble variability with both rest frame time lag (the structure function) and the absolute magnitude of the galaxies. Since these objects have spectral features of quasars, but morphologically appear to be galaxies, they are likely to be a lower luminosity form of active galactic nuclei within visible hosts. We find that the structure function of lower-luminosity AGN follows the same general trend as that of quasars, which have been the focus of previous studies. Additionally, there is a correlation observed between ensemble variability and absolute magnitude.

072.20

Study of X-ray Spectral Parameters from Large Sample of RXTE Active Galaxies

Barbara Mattson[1], K. Weaver[1], C. Reynolds[2]
[1]NASA's GSFC, [2]University of Maryland.

We report preliminary results of an on-going systematic X-ray spectral variability study of bright Seyfert galaxies observed by the Rossi X-Ray Timing Explorer (RXTE). The RXTE public archive contains data for 40 Seyfert galaxies with suitable temporal coverage to perform variability studies covering short (days/weeks) to long (years) timescales. We have developed a data pipeline to automate the data reduction. The pipeline produces a series of spectra for each source divided temporally in such a way that each has at least 125,000 net photons to ensure a good spectral fit. To fit the spectra, we have assumed an intrinsic powerlaw X-ray spectrum produced close to the central black hole that is reprocessed and absorbed by material around the black hole. We fit each X-ray spectrum with a model of this reflected emission, including fluorescent Fe Kα emission, Compton reflection component and absorption. We have also performed Monte Carlo simulations of the spectral sample and fitted them to the same model to test the robustness of our results. The goal of this research is first to build a database of spectral parameters for a large sample of AGN, and then to seek correlations between spectral parameters and determine which correlations are specific to various classes of AGN (e.g. Seyfert type or radio-loudness). The results will constrain the geometry of the nuclear region, providing tests for current reflection and unification models of AGN. Our current results show a complex relationship between the photon index and iron line equivalent width. In addition, our Monte Carlo results confirm the strength of the systematic correlation between the photon index and reflection fraction.

072.21

An Archival HST Survey for Ultrafaint QSOs

Bernhard Beck-Winchatz[1], S. F. Anderson[2]
[1]DePaul University, [2]University of Washington.

Groundbased surveys for intermediate-redshift QSOs from the populous faint end of the quasar luminosity function often suffer from significant morphological contamination by compact galaxies. To address this problem, we have conducted an archival multicolor and morphological HST survey for faint QSOs to B<24.5, z<2.1 that takes advantage of the 0.1" spatial resolution of WFPC2 images. QSO candidates are selected based on UV-excess and either stellar or unresolved-nucleus plus resolved host galaxy morphology. Our survey includes 31 high-galactic latitude pure parallel fields that have been imaged deeply with WFPC2 in U, R, and I covering 0.04 deg^2 of the sky. We identify 19 new high-likelihood QSO candidates and derive a cumulative surface density of 511 deg^{-2} to B<24.5 and z<2.1, confirming our results from an earlier survey we conducted in the Groth-Westphal Strip. Our results are also in reasonable agreement with those from other faint quasar surveys that are based on very different candidate selection approaches.

072.22

The Broadband X-Ray Spectral Features of a Sample of Seyfert 1 Galaxies

Urmila Padmanabhan[1], K. A. Weaver[2], T. Yaqoob[1]
[1]Johns Hopkins University, [2]GSFC.

The archival BeppoSAX (MECS and PDS) data, for a sample of the fifteen brightest Seyfert 1 galaxies, are analyzed to examine the broad-band X-ray spectral features of Compton reflection and iron line flourescence, which arise from the inner regions around the supermassive black hole, such as the putative torus and/or the accretion disk. The results from the Chandra HETG observations for this sample (see Yaqoob & Padmanabhan 2004) are used to fix the line core parameters, with the intensity of the line free to vary as the two instruments are not cross normalized. We checked for the presence of a relativistically broadened iron line and tried to constrain the line parameters. We also looked for variability in the spectral features since many of the objects in our sample had been observed multiple times by BeppoSAX. Lastly we looked for evidence of a relation between the equivalent width W of the iron line and the reflection coefficient R and the equivalent width W and the slope of the power law.

072.23

Quantification of Quasar Environments via Absorption Spectra

Colleen M. McIntosh[1], J. Scott[1]
[1]Towson Univ..

We present a technique for systematically quantifying quasar environments by means of the absorption signatures of quasars. Using the substantial number of sample quasar spectra that can be found in the Hubble Space Telescope (HST) archives and literature measurements of the richness of quasar environments, we will determine whether the strength or the incidence of quasar-associated absorption in a quasar spectrum correlates with an excess of nearby galaxy neighbors.

072.24

Studies of Quasar Variability With the Sloan Digital Sky Survey

Brian C. Wilhite[1], R. J. Brunner[1], B. F. Lundgren[1], C. J. Grier[1]
[1]University of Illinois.

This poster summarizes the recent work within the Sloan Digital Sky Survey collaboration to study quasar physics through monitoring of their optical variability. SDSS repeat spectroscopic observations have resulted in multiepoch spectroscopy for ~2500 quasars observed more than 50 days apart. In the SDSS equatorial stripe, almost 10,000 spectroscopically confirmed quasars have been imaged at an average of 10 epochs with a baseline of 4 years. This marks the first time the precise wavelength dependence of quasar variability has been determined, allowing both the continuum and emission-line variability to be studied. We create an ensemble difference spectrum (bright phase minus faint phase) covering rest-frame wavelengths from 1000 to 6000 Angstroms. Also, we find a strong correlation between the change in the C IV line flux and the change in the line width. The relation between line flux change and line width change is consistent with a model in which a broad line base varies with greater amplitude than the line core. In addition, we find no evidence for variability of the well-known blueshift of the C IV line with respect to the low-ionization Mg II line in the highest flux objects, indicating that this blueshift might be useful as a measure of orientation. We have also studied the variability of broad absorption troughs for a subsample of these objects. For these objects, we observe that the strongest BAL variability occurs among the smallest equivalent width features, and at velocities exceeding 12,000 km/s, as predicted by recent disk-wind modeling. Most recently, using the repeat photometric scans of quasars in the SDSS equatorial stripe, we have found evidence that, for a given quasar luminosity, optical variability is directly related to the mass of the central black hole. This points towards Eddington ratio as one of the main drivers of quasar variability.

072.25

The Proximity Effect and the UV Background at z~4

Jennifer E. Scott[1], J. Bechtold[2]
[1]Towson Univ., [2]University of Arizona.

We present measurements of the mean UV background from the proximity effect in the spectra of 12 z~4 quasars observed with the Magellan telescope. We compare the measured background to models based on the contribution from quasars and star-forming galaxies to determine which sources dominate the background at this epoch.

072.26

A Search for the Earliest Luminous Quasars

Eilat Glikman[1], S. G. Djorgovski[1], A. A. Mahabal[1], M. J. Graham[1], D. Thompson[1], G. Meylan[2], A. Eigenbrod[2], F. Courbin[2]
[1]Caltech, [2]EPFL, Switzerland.

Luminous quasars at z > 6 are powerful probes of early structure formation and reionization. Optical panoramic surveys such as SDSS and PQ are limited to redshifts less than 6.5 by the CCD technology, and IR surveys are needed in order to push to higher redshifts. We conducted a search for z > 6.5 quasars using the early data release from UKIDSS matched to the SDSS and PQ. We selected candidates using multi-color selection in i,z,Y,J,H and K bands and further refined our candidate list with deeper imaging from P200+LFC. The surviving 18 candidates were followed up spectroscopically with Keck+NIRSPEC or LRIS. All turned out to be brown dwarfs, which was not surprising: the probability of finding such a quasar in the 27.3 square degrees of the EDR is < 10%. However the experience gained in this pilot project has allowed us to refine our technique for the extended search with the UKIDSS DR1 which is already underway.

MONDAY

072.27

Observation of the GZK Cutoff by the HiRes Experiment

Stefan Westerhoff[1], B. Connolly[1]
[1]Columbia University.

The High Resolution Fly's Eye Experiment (HiRes) in Utah is an air fluorescence telescope mapping the northern sky in cosmic rays at energies above 10^{18} eV. Since November 1999, HiRes has been operated in stereo mode, i.e. with two sites separated by 13 km to provide cosmic ray data of unprecedented quality of the northern sky. We focus on the latest results from the monocular and stereoscopic data concerning the primary chemical composition above 1018 eV, the search for small-scale anisotropies in the cosmic ray arrival distribution and the observation of the GZK cut-off.

073: Astronomers in Public Education
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

073.01

The Beyond Einstein Explorers' Program (BEEP) Getting Astronomers Involved in Afterschool Activities

Anita Krishnamurthi[1], B. Barbier[2], S. Mitchell[2], J. Lochner[3]
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[3]*NASA GSFC/USRA.*

There is tremendous potential for astronomers to engage afterschool programs in their local areas. Afterschool programs reach a diverse population of students and allow for learning experiences different from those in a classroom. We offer an astronomy afterschool program that scientists can easily adopt, adapt, and run in their local areas. BEEP is targeted at middle school students and introduces basic astronomical tools and the Universe beyond the solar system. The primary goal of the program is to spark curiosity and excitement about the Universe in both program leaders (who often don't have a science background) and students.

A promising model for training leaders and maintaining oversight of the programs is to have a team consisting of a scientist and 1-2 astronomy graduate students partnering with local afterschool program(s). BEEP's structure is flexible enough to be split into modules and run in a variety of settings, from "astronomy days" to summer camps to year-long afterschool programming. We also welcome the opportunity to work with astronomers running this program to add new modules.

This program was developed in close collaboration with afterschool programs in the Washington, DC area. The sessions were developed by adapting well-tested existing formal education materials and activities for the afterschool environment. The program was piloted in summer 2006 and evaluations showed that it was successful and met our primary goal of engaging the students (and preparing the leaders). We are currently refining this program to reflect feedback from the pilot, and it will be ready for wider dissemination by summer 2007.

074: Astronomy and Astrophysics with LISA
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

074.01

LISA: Probing the Universe with Gravitational Waves

Thomas A. Prince[1], P. Binetruy[2], J. Centrella[3], L. S. Finn[4], C. Hogan[5], G. Nelemans[6], E. S. Phinney[7], B. Schutz[8], LISA International Science Team
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LISA is a joint NASA/ESA space mission for detection and study of low-frequency gravitational waves in the band from 0.1 mHz to 0.1 Hz. The mission consists of three satellites separated by a nominal distance of 5 million kilometers, with precision metrology provided by laser ranging. LISA will detect many new sources of gravitational waves including: the inspiral and merger of supermassive black holes resulting from galaxy mergers anywhere in the observable universe, emission from thousands of individual ultra-compact binaries in our galaxy, and numerous cases of inspiral of small black holes, neutrons stars, and white dwarfs into the supermassive black holes that reside in the nuclei of most galaxies. These sources not only provide unique astrophysical information about the evolution of galaxies and stars, but the systems can also be used as "laboratories" for making precision measurements of physical phenomena that will lead to new insights into fundamental physics and cosmology. In addition to radiation from well-known astrophysical sources, some of the most exciting science may come from LISA searches for gravitational waves from the very early universe, such as waves from fundamental phase transitions or from the dynamics of cosmic superstrings. We survey the science goals of LISA and their impact on physics and astrophysics.

074.02

LISA Mission Architecture

Nicholas M. Jedrich[1], R. T. Stebbins[1], J. C. Livas[1], S. M. Merkowitz[1], R. G. Mink[1]
[1]*NASA.*

The Laser Interferometer Space Antenna (LISA) mission is unique from a mission design perspective in that three spacecraft and their associated operations form one distributed science instrument, unlike more conventional missions where an instrument(s) is a component of an individual spacecraft. The interferometer measurements between spacecraft that form the basis for the science measurements, i.e. strain, relies on all three of the spacecraft interacting as designed. The performance of one spacecraft in the LISA constellation is directly coupled to the performance of the two remaining spacecraft in order for the instrument to collect meaningful science data. This dependency on all three spacecraft to function as the instrument is the primary driver for unique design requirements that span all spacecraft subsystems and the overall mission design. A detailed discussion will be presented that describes the spacecraft and current mission architecture needed to meet the LISA science requirements.

074.03

The LISA Pathfinder Mission

Robin T. Stebbins[1], LISA Pathfinder Science Team
[1]*NASA Goddard Space Flight Center.*

LISA Pathfinder (formerly known as SMART-2) is an ESA mission designed to pave the way for the joint ESA/NASA Laser Interferometer Space Antenna (LISA) mission by testing in flight the critical technologies required for space-borne gravitational wave detection: it will put two test masses in a near-perfect gravitational free-fall and control and measure their motion with unprecedented accuracy.

LISA Pathfinder will carry two technology payloads, the European provided LISA Technology Package (LTP), and the NASA provided Disturbance Reduction System (DRS). The LTP comprises two inertial sensors, high precision laser metrology, drag-free control and an ultra-precise micro-Newton propulsion system. The DRS consists of a drag-free control system and a micro-Newton propulsion system. The DRS will use the LTP inertial sensors.

LISA Pathfinder is due to be launched in late 2009, with first results on the performance of the system being available approx 6 months later.

This poster gives an introduction to, and status of, the mission, followed by more details on the technologies to be tested in a space environment. It will also highlight the ways in which the LISA Pathfinder mission will be used for the preparation of LISA, *e.g.* ground segment development, on-orbit commissioning of the hardware, *etc*. as well as technology development.

074.04

System Validation and Verification Testing for the Laser Interferometry Space Antenna (LISA)

Jeffrey C. Livas[1], N. Jedrich[1], S. M. Merkowitz[1], R. T. Stebbins[1]
[1]*NASA's GSFC.*

The Laser Interferometry Space Antenna (LISA) mission is a set of 3 spacecraft that fly in a heliocentric orbit in an equilateral triangle formation to detect gravitational waves. Each side of the triangle is 5 million km long, and the formation detects passing waves by closely monitoring the distance between spacecraft.

The ideal for system-level testing of instruments and spacecraft is to "test as you fly". Given that the inter-spacecraft distance is approximately 13 times the distance between the earth and the moon, Ground testing for the LISA instrument will not be able to meet this ideal in a number of areas, so a combination of testing, simulation, and analysis will be needed instead. This paper will outline some of the areas where direct testing on the ground will not be possible, and discuss some of ideas, concepts and methods to meet that challenge.

The focus of the discussion will be on the optical and system-level aspects of the testing, as many of the issues associated with the proof masses and drag-free spacecraft are covered by the LISA Pathfinder mission.

074.05

Cancellation of the LISA Antenna Distortions due to the Earth

Peter L. Bender[1]
[1]*JILA, Univ. of Colorado and NIST.*

The 3 spacecraft of the ESA/NASA Laser Interferometer Space Antenna (LISA) gravitational wave mission will fly in a nearly equilateral triangular configuration with the antenna center on a 1 year period circular orbit around the Sun. For the nominal 5 million km triangle side lengths and no planetary perturbations, the variations in the side lengths and angles of the triangle would be plus and minus 24,000 km and 0.45 deg. However, with planetary perturbations and for 20 deg separation from the Earth, the variations would change by at least a factor 2 over roughly 8 years. T. H. Sweetser (2006) has shown that this is due to the different secular rates of change in the mean motions of the 3 spacecraft. Each spacecraft has an eccentricity of 0.00965, and the one that is closest to the Earth when the Earth is closest to triangle will have a larger secular rate of change in its mean motion.

Each spacecraft follows the motion of a pair of test masses inside it that are carefully isolated from non-gravitational forces. By applying accelerations of up to 2.1×10^{-9} m/s^2 to the test masses, the average differential effect of the Earth can be cancelled out. Forces can be applied by putting AC voltages on the capacitor plates around the test masses. However, the amplitudes of the voltages need to be very stable at frequencies down to 0.1 mHz in order to prevent introducing disturbances of the test masses. Thus a decision on whether to cancell the differential Earth effects has not yet been made.

074.06

Measurements of Forces Between Surfaces for LISA

Scott E. Pollack[1], S. Schlamminger[1], C. A. Hagedorn[1], J. H. Gundlach[1]
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The end mirrors of the LISA interferometer are housed within spacecraft which shield them from external disturbances. Couplings between the end mirrors and the spacecraft through electrostatic effects, such as time varying patch fields and cosmic ray charging, and thermal gradient related effects, such as the radiometer effect, radiation pressure, and outgassing, contribute heavily to the LISA noise budget at frequencies below 1 mHz.

We are measuring these forces using a highly sensitive torsion balance. Our apparatus consists of a suspended gold coated silicon pendulum and a movable gold coated split copper plate. Each half of our split copper plate can be individually electro-statically and thermally controlled. We present our current understanding of electrostatic surface potential fluctuations and forces due to thermal effects.

074.07

Modular Gravitational Reference Sensor for High Precision Astronomical Space Missions

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[1]*Stanford Univ..*

We review the progress in developing the Modular Gravitational Reference Sensor (modular GRS) [1], which was first proposed as a simplified core sensor for space gravitational wave detection missions. In a modular GRS, laser beam from the remote the sensor does not illuminate the proof mass directly. The internal measurement from housing to proof mass is separated from the external interferometry. A double side grating may further simplify the structure and may better preserve the measurement precision. We review the recent progress in developing modular GRS at Stanford. We have further studied optical sensing design that combines advantage of high precision interferometric measurement and robust optical shadow sensing scheme. We have made critical progress in optical measurement of the center of mass position of a spherical proof mass at a precision without costing the dynamic range while spinning. We have successfully demonstrated the feasibility of fabricating localized grating pattern onto the dielectric and gold materials. We have conducted an initial experiment of rf heterodyne of cavity reflection and thus lowered optical power than that in the direct detection. We have further studied UV LED that will be used for AC charge management experiment. The modular GRS will be an in-time, cost effective product for the advanced Laser Interferometric Space Antenna (LISA) and the Big Bang Observatory (BBO).

[1] K. Sun, G. Allen, S. Buchman, D. DeBra, and R. L. Byer, "Advanced Architecture for High Precision Space Laser Interferometers", 5th International LISA Symposium, ESTEC, Noordwijk, The Netherlands, 12-16 July 2004. Class. Quantum Grav. **22** (2005) S287-S296.

074.08

Tracking Cosmological Black Hole Mergers with LISA

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The coalescence of two massive black holes produces gravitational waves (GWs) that will be measurable by the space-based GW observatory LISA. Such binaries are formed by the merger of the holes' host galaxies; hierarchical structure formation predicts many tens of events per year, particularly at redshifts $z > 3$. Measuring the GWs from these events could thus allow us to track the growth of black holes and (indirectly) trace the assembly of galaxies. Most excitingly, these measurements can provide precision data on the black holes' masses and spins and on the luminosity distance to the source. With less precision, they also localize the source on the sky. We present results, based on maximum likelihood parameter estimation, for how well these parameters can be measured. Our code incorporates the effects of spin-induced precession on the gravitational waveform; these effects introduce modulations into the signal which break degeneracies among parameters. This improves (in some cases drastically) the estimated precision with which black hole parameters can be measured. We typically find masses can be measured at z ~ 1 with 0.05-1% accuracy. Low redshift systems can be localized at final merger to an ellipse which is roughly 10 a few x 10 arcminutes across in the long direction and a factor of 2 smaller in the short direction. Much of the pointing precision comes in the final week of observation; these ellipses are typically a factor of 2-4 (3-6) times larger 7 days (14 days) before the black holes merge. We find that the relative error in measured luminosity distance is 0.1-0.4% at z ~ 1. Finally, with the inclusion of precession, the magnitudes of the spins can be determined for the first time. For low redshift systems, these can be measured with 0.1-10% accuracy, depending on the spin value.

074.09

Modeling Binary Black Hole Mergers

John G. Baker[1]
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Gravitational radiation from binary black hole mergers is an important source for the Laser Interferometer Space Antenna (LISA) as well as for ground based-gravitational wave observatories. By numerical simulations of Einstein's equations, we derive predictions for the waveforms generated by the final, strongest dynamics of the merger. Our theoretical knowledge of these systems is dramatically increasing with rapidly improving simulation techniques which now allow accurate simulations covering several orbits. We present waveform results representing the last orbits, merger and black hole ringdown for a variety of black hole pairings. In typical combinations, asymmetric gravitational radiation produces a net kick leaving the final remnant black hole with significant velocity with respect to the original center of mass.

074.10

Observing Massive Black Hole Binaries with LISA

Sean McWilliams[1]
[1]*NASA GSFC.*

We present recently calculated waveforms from numerical relativity and their application to the search for binary black hole coalescences using LISA. Using representative inspiral-merger-ringdown waveforms and models of the cosmological BBH population distribution, we discuss some expectations for scientific investigation that LISA will be capable of facilitating.

074.11

Population Boundaries for Evolving White Dwarf Binaries on the LISA Sensitivity Curve

Kopparapu R. Kumar[1], V. Gokhale[1], J. Frank[1], J. E. Tohline[1]
[1]Louisiana State Univ..

Double White Dwarf (DWD) binaries are considered to be among the most promising sources for gravitational waves for LISA. Theoretical constraints on the properties of the white dwarf stars allow us to map out the evolutionary trajectories of these systems in the ′′absolute″ gravitational wave strain-frequency domain. We have identified population boundaries where inspiralling and/or mass transferring systems can be found. Further, we define sub-domains in which systems undergo stable/unstable, sub/super-Eddington mass transfer and the progenitors of Type Ia supernovae reside. We do this in the context of either direct impact or disk accretion, efficient or inefficient tidal coupling between the spins of the components and the orbit. We identify for what subset of these populations it should be possible to measure frequency shifts and determine binary system parameters like chirp mass and luminosity distance, given LISA's anticipated operational time. This work has been supported in part by NSF grants AST 04-07070 and PHY 03-26311 and in part through NASA's ATP program grant NAG5-13430.

074.12

Tidal Effects in Inspiraling Double White Dwarfs

Vicky Kalogera[1], B. Willems[1], B. Hansen[2]
[1]Northwestern University, [2]UCLA.

Despite the overwhelming abundance of double white dwarfs in the LISA gravitational wave frequency band, modeling of their waveforms has remained limited to the point-mass approximation in which gravitational radiation is the only source of systemic orbital angular momentum loss. As a significant fraction of these systems spirals in to periods as short as 5-10 minutes, tidal effects can, however, play an important role in modifying the gravitational wave frequency evolution. The strength of the tidal effects depends strongly on the energy dissipation mechanism damping the tides, which, for white dwarfs, is highly uncertain. In this poster, we present the first results of a systematic study of tidal dissipation in white dwarfs, and the impact of tides on the gravitational wave signal of close double white dwarfs.

074.13

Gravitational Waves from Cosmic Superstrings

Craig J. Hogan[1]
[1]Univ. of Washington.

The leading candidate theory unifying Standard Model quantum fields and the spacetime dynamics of General Relativity is based on fundamental quantized strings. Many versions of string theory now predict the formation of cosmic superstrings: quasi-stable strings that form that after inflation and are stretched to enormous length by the cosmic expansion.

In these theories, the primordial net of superstrings spawns isolated, oscillating loops that ultimately radiate almost all of their energy into gravitational waves. Backgrounds and bursts of gravitational waves are predicted to be the most conspicuous evidence of superstrings.

The background spectrum and burst statistics of gravitational waves produced by a cosmological population of cosmic string loops are estimated, and formulas are derived showing the dependence of observables on string parameters including the dimensionless tension Gμ. Predictions are compared with instrument noise from current and future experiments, and with confusion noise from known astrophysical gravitational wave sources such as stellar and massive black hole binaries. Limits on gravitational wave backgrounds from pulsar timing already indicate that if superstrings exist, they are so light that they have no observable effects except from their gravitational radiation: Gμ is less than about 10^{-10}, close to the minimum value where bursts might be detected by Advanced LIGO, and a typical value expected from superstrings in brane inflation models. Because of expected confusion noise expected from massive black hole binaries, pulsar techniques will not be able to go below about Gμ~ 10^{-11}. At this level, the stochastic background from strings dominates the LISA noise by a large factor, although burst events may also be detectable by LISA, allowing detailed study of loop behavior. LISA will be sensitive to stochastic backgrounds created by strings as light as Gμ~ 10^{-15}; however, for those lightest detectable strings, bursts are rarely detectable.

074.14

The Mock LISA Data Challenges: First Results and Future Prospects

Michele Vallisneri[1], Mock LISA Data Challenge Taskforce
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The Laser Interferometer Space Antenna (LISA) International Science Team Working Group on Data Analysis (LIST-WG1B) is sponsoring several rounds of mock data challenges, with the purpose of fostering development of LISA data-analysis capabilities, and of demonstrating technical readiness for the maximum science exploitation of the LISA data. The first round (MLDC1) was completed at the end of 2006, and the second round of challenges are currenlty in progress. Here we present a critical overview of the first results and discuss the future steps in this effort.

074.15

Listening to the Universe with the Laser Interferometer Space Antenna

Neil J. Cornish[1], J. Crowder[2], E. Porter[3]
[1]Montana State Univ., [2]Jet Propulsion Laboratory, [3]Albert Einstein Institutue, Germany.

Gravitational Wave observatories here on Earth are poised to end the ″silent era″ of Astronomy by measuring the vibrations in spacetime caused by colliding black holes and other energetic events. NASA and ESA are working together to open up the source-rich low frequency portion of the gravitational wave spectrum with the Laser Interferometer Space Antenna (LISA). A major challenge for this mission is how to deal with a data stream that is expected to contain the signals from tens of thousands of sources, including massive black hole binaries, stellar remant captures by galactic black holes, and a foreground of compact binaries in our own galaxy. Here we describe a fast and robust technique for simultaneously resolving tens of thousands of overlapping signals and recovering the source parameters. Our approach has been sucessfully tested on simulated LISA data, including the blind data sets of the Mock LISA Data Challenge.

074.16

Bayesian Inference and Observations of Massive Black-hole Binaries with LISA

Marc Van der Sluys[1], A. Stroeer[2], A. Vecchio[2], V. Kalogera[1]
[1]Northwestern University, [2]Northwestern University, University of Birmingham.

Massive black-hole binary systems are important sources for LISA as they shall be observable throughout the universe, providing new information about structure formation, black hole demographics and the behavior of gravity in the strong, non-linear regime.

Here we present results concerning the application of Markov Chain Monte Carlo methods to the analysis of LISA data in observations of gravitational waves generated during the inspiral phase of massive black-hole binaries.

074.17

An Application of the Hilbert-Huang Transform to the LISA Mock Data Challenge

John K. Cannizzo[1], J. Camp[2]
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We analyze time series generated for the LISA Mock Data Challenge utilizing the Hilbert-Huang Transform (HHT), an adaptive, two-step procedure in which a time series is first decomposed into orthonormal basis sets (intrinsic mode functions, IMFs) via ′′sifting′′ on the extrema in the data, and second each IMF is Hilbert-transformed so that a time series of instantaneous frequency f(t) is generated. By convolving f(t) with the instantaneous power versus time, one can select on time intervals of high signal strength, and thereby derive a much more finely graduated and high fidelity f(t) than is possbile through standard FFT techniques, even for cases where the signal consists of just a few oscillations. The difference in techniques is particularly noticeable for the case of BH-BH mergers with spin-orbit coupling included.

074.18

Coated Fused Silica Fibers for Enhanced Sensitivity Torsion Pendulum

Kenji Numata[1]
[1]Univ. of Maryland/NASA-GSFC.

To investigate the fundamental thermal noise limit of a torsion pendulum using a fused silica fiber, we systematically measured and modeled the mechanical losses of thin fused silica fibers, coated by thin metal film to obtain electrical conductivity. Our results indicate that it is possible to achieve a thermal noise limit lower by a factor of between 3 and 10, depending on the silica diameter, compared to the best tungsten fibers available. This will allow a corresponding increase in sensitivity of torsion pendulum used for weak force measurements, including the gravitational constant measurement and ground-based force noise testing for LISA mission.

075: Astronomy Research by Students of All Ages and the Public
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

075.01

The Use of a High School Observatory to Augment Our Understanding of the Metallicity Dependence of the Cepheid Period-Luminosity Relation

James Young[1], S. Scott[1], S. Kanbur[1], A. ominsky[2], C. Ngeow[3]
[1]SUNY Oswego, [2]SOuthern Cayuga High School Observatory, [3]University of Illinois.

The use of a high school observatory to augment our understanding of the metallicity dependence of the Cepheid Period-Luminosity relation. The metallicity dependence of the Cepheid Period-Luminosity relation is of crucial importance in Astrophysics. More data is needed to definitively answer this question. One aspect where existing databses could be improved is for Galactic Cepheids. Here we report on an attempt to use a high school observatory in upstate New York to augment multi-wavelength data on Galactic Cepheids. This project will have significant educational value for undergraduates and high school students.

075.02

The Arecibo Remote Command Center: Involving Students in Major Astronomical Research

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At the Center for Gravitational Wave Astronomy (CGWA) at the University of Texas-Brownsville (UTB), we are developing the first Arecibo Remote Command Center (ARCC). The ARCC will be a virtual control room where researchers and students will control the worldâ€™s largest single dish radio telescope at the Arecibo observatory. Web cams at Arecibo and digital projectors in the ARCC will provide students with a visually spectacular view of the instrument as they control it. Projections of instrument readouts and monitor screens will give controllers a virtual view of what is happening at Arecibo from the ARCC in Brownsville. Students and research scientists of all levels will be working together in teams to perform actual observations and data analysis. In this talk we describe the current implementation of the ARCC project, plans for student research, prototype projects conducted by students during summer of 2006, recent achievements and successes of student participants, and future plans for the establishment of the ARCC program as an ongoing enterprise.

075.03

Space Science Lab at PARI

Michael W. Castelaz[1], M. Blake[1], D. Clavier[1], C. Whitworth[1], J. D. Cline[1]
[1]Pisgah Astronomical Research Inst..

Native American, Hispanic, African American, and other underrepresented high school students in rural Western North Carolina have unprecedented opportunity as researchers in the Space Science Lab to conduct visible and radio observations of the Sun. The program involves 90 students over a three year period. The students conduct their own research and also interact with scientists around the world. The primary goal is to reach students who otherwise would not have this opportunity and motivate them to develop the critical thinking skills necessary for objective scientific inquiry. Students develop skills in electronics, computer sciences, astronomy, physics and earth sciences. Equally important is the hope that the students will become interested in pursuing careers in research or other science-related areas. The program objectives are aligned with the North Carolina Standard Course of Study for grades 9-12 in the areas of Earth/Environmental Science, Physical Science and Physics. The first group of 27 students spent a week in the Space Science Lab located on the campus of the Pisgah Astronomical Research Institute (PARI) during the Summer 2006. Students constructed their own JOVE radio telescopes that they took home to continue their observations. They share their results during four follow-up sessions throughout the school year. The students also have Internet access to radio telescopes and solar monitoring equipment at PARI. We expect their enthusiasm for science will increase by experiencing research investigations that are fun and relevant to their understanding of the world around them.

We gratefully acknowledge support from the Burroughs Wellcome Fund Student Science Enrichment Program.

075.04

The CUREA Program at Mount Wilson

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[1]Kenyon College, [2]Edinboro University of Pennsylvania, [3]Mount Wilson Observatory Association.

For fifteen years, Mount Wilson Observatory has been host to a unique educational program designed to introduce undergraduate students of physics and astronomy to elements of observational solar and stellar astrophysics. Founded by faculty members from four-year colleges who dubbed themselves the Consortium for Undergraduate Research and Education in Astronomy (CUREA), the CUREA program is an intensive two-week course in observational astronomy. It includes lectures by astronomers and physicists, observational exercises in both solar and stellar astrophysics, tours of various research facilities on the mountain and in the Los Angeles area, and an observational mini-project designed and executed by each student during the second week of the program. This paper will present the program's curriculum and goals, a brief history, and examples of observational projects undertaken by recent participants. CUREA is administered by the Mount Wilson Observatory Association, using facilities provided by the Mount Wilson Institute.

075.05

Astrophysical and Planetary Science Research at Four Minority Institutions

Donald K. Walter[1], L. P. Johnson[2], S. A. Austin[2], C. Salgado[3], P. A. Morris[4]
[1]South Carolina State Univ., [2]Medgar Evers College, [3]Norfolk State University, [4]University of Houston Downtown.

We describe a range of faculty and undergraduate student research programs at our four institutions. These include current studies or planned work in high energy astrophysics, gamma-ray bursts, AGNs, nearby galaxies, the ISM, transient phenomena and comparative analysis of terrestrial and Martian evaporate environments. We have nearly a decade of experience in preparing underrepresented students for research at majority institutions and government laboratories with our own pre-REU summer internships. We have partial or full ownership in robotic telescopes at observatories in Arizona and Virginia that will be fully operational in the near future. For the past three years we have had a balloon program flying student payloads. In addition to our research, we are heavily involved in education and public outreach in astronomy and related fields.

To further enhance our individual and collective programs, we have formed the Minority University Collaboration for Earth and Space Science (MUCESS). This collaboration includes South Carolina State University (SCSU), Medgar Evers College (MEC), the University of Houston Downtown (UHD) and Norfolk State University (NSU). We are interested in partnering with other institutions that have similar or complementary programs.

We acknowledge the support of all of our institutions through the NASA MUCERPI program; specifically, to NSU (NNG04GD93G, NAG5-10140), MEC (NNG04GD61G, NAG5-10142), SCSU (NNG04GD62G, NAG 5-10145) and UHD (NNG04GD68G, NAG5-10149).

075.06

Research-Infused STEM Reform at South Carolina State University

Daniel M. Smith, Jr.[1], J. A. Anderson[1], K. Adzievski[1]
[1]South Carolina State University.

South Carolina State University (SCSU) has embarked upon a mission to transform its science, technology, engineering, and mathematics (STEM) disciplines by offering more scholarships to students talented in the sciences, by introducing advanced topics in the introductory STEM courses, and by expanding research opportunities for STEM students. Specific examples will be provided from physics and astronomy. Program accomplishments after one year of operation will be highlighted, along with the difficulties of instituting such a broad-based reform.

NSF HBCU-UP Award #0506062

075.07

Education and Public Outreach for Stardust@home: An Interactive Internet-based Search for Interstellar Dust

Bryan J. Mendez[1], A. J. Westphal[1], A. L. Butterworth[1], N. Craig[1]
[1]UC Berkeley.

On January 15, 2006, NASA's Stardust mission returned to Earth after nearly seven years in interplanetary space. During its journey, Stardust encountered comet Wild 2, collecting dust particles from it in a special material called aerogel. At two other times in the mission, aerogel collectors were also opened to collect interstellar dust. The Stardust Interstellar Dust Collector is being scanned by an automated microscope at the Johnson Space Center. There are approximately 700,000 fields of view needed to cover the entire collector, but we expect only a few dozen total grains of interstellar dust were captured within it. Finding these particles is a daunting task. We have recruited many thousands of volunteers from the public to aid in the search for these precious pieces of space dust trapped in the collectors. We call the project Stardust@home. Through Stardust@home, volunteers from the public search fields of view from the Stardust aerogel collector using a web-based Virtual Microscope. Volunteers who discover interstellar dust particles have the privilege of naming them. The interest and response to this project has been extraordinary. Many people from all walks of life are very excited about space science and eager to volunteer their time to contribute to a real research project such as this. We will discuss the progress of the project and the education and outreach activities being carried out for it.

075.08

THEMIS Education and Outreach Program's Involvement in Authentic Science in the classroom.

Nahide G. Craig[1], L. M. Peticolas[1], V. Trautman[2]
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We will discuss how high school students are determining Earth's magnetic field strength during magnetically quiet and stormy times and predicting the appearance of dancing Auroras using THEMIS ground based magnetometer data.

The Education and Public Outreach program of the THEMIS Mission has deployed 10 ground-based observatories with science-grade magnetometers in schools in the Northern U.S. This network of schools, called Geomagnetic Event Observation Network by Students (GEONS), monitors local magnetic disturbances. The magnetometers are receiving local data; data are archived and available at the THEMIS Education and Outreach (E/PO) Website. The E/PO program conducts teacher professional development workshops for the teachers of these schools. During the third year of the project, teachers from Alaska and Wisconsin started a classroom research project trying to determine the strength of the local magnetic field and the 'local magnetic storminess index' using the magnetometers that are installed in their classrooms. We will describe how this project has inspired the teachers not only to learn how to conduct research with real data and usage of research tools, but they have also conducted workshops in their own states, influenced the science curricula in their districts, and also started student research in their classrooms. We will discuss the challenges, give the results of their research, and encourage other teachers who wish to use real data in their classrooms to participate in this exciting project.

076: Circumstellar Disk Models
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

076.01

Accretion of Terrestrial Planets from Oligarchs in a Turbulent Disk

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We have investigated the final accretion stage of terrestrial planets from Mars-mass protoplanets that formed through oligarchic growth in a disk comparable to the minimum mass solar nebula (MMSN), through N-body simulation including random torques exerted by disk turbulence due to Magneto-Rotational-Instability. For the torques, we used the semi-analytical formula developed by Laughlin et al. (2004). The damping of orbital eccentricities (in all runs) and type-I migration (in some runs) due to the tidal interactions with disk gas are also included.

Without any effect of disk gas, Earth-mass planets are formed in terrestrial planet regions in a disk comparable to MMSN but with too large orbital eccentricities to be consistent with the present eccentricities of Earth and Venus in our Solar system. With the eccentricity damping caused by the tidal interaction with a remnant gas disk, Earth-mass planets with eccentricities consistent with those of Earth and Venus are formed in a limited range of gas surface density. However, in this case, too many planets remain in terrestrial planet regions on average, because the damping leads to isolation between the planets.

We have carried out a series of N-body simulations including the random torques with different gas surface density and strength of turbulence. We found that the orbital eccentricities pumped up by the turbulent torques and associated random walks in semimajor axes tend to delay isolation of planets, resulting in more coagulation of planets. The eccentricities are still damped after planets become isolated. As a result, the number of final planets decreases with increase in strength of the turbulence, while Earth-mass planets with small eccentricities are still formed. In the case of relatively strong turbulence, the number of final planets are 4-5 at 0.5-2AU, which is more consistent with Solar system, for relatively wide range of gas surface density.

076.02

Disks in Transition Around Pre-Main Sequence Stars

Catherine Espaillat[1], N. Calvet[1], L. Hartmann[1]
[1]*University of Michigan.*

Circumstellar disks are essential in the evolution of stars and planets. It is believed that the formation of these disks is a natural outcome of the star formation process and that with time the disk becomes the principle supplier of the material that eventually makes up a star as well as the solids that eventually coalesce into planetary systems, much like our own solar system.

The finer details of how circumstellar disks evolve are still debated. The way in which the disk material dissipates is not well understood, specifically with regard to the physical processes which lead to the disappearance of the inner regions of a disk, a characteristic observed in transition disks. Transition disks have characteristics that fall between those objects that have clear evidence for disks and those objects with no disk material. Given that circumstellar disks are most easily detected in the infrared, the Spitzer Space Telescope has dramatically improved the ability to identify and study these objects by giving us detailed spectral energy distributions (SEDs) for pre-main sequence stars in the wavelength range 3.6-35 μm, corresponding to regions ~0.1-5 AU from the central star. With our disk modeling codes, we can model the SEDs of these objects, providing important constraints on disk evolution and here we will present our results.

076.03

Modification of Angular Velocity Distribution by Inhomogeneous Growth of MRI in Protoplanetary Disks

Mariko Kato[1], K. Nakamura[1], R. Tandokoro[1], M. Fujimoto[2], S. Ida[1]
[1]*Tokyo Institute of Technology, Japan,* [2]*JAXA/ISAS, Japan.*

We have performed two-dimensional CIP -MOCCT simulations of Magneto Rotational Instability (MRI) in accretion disks with nonzero ohmic resistivity. An accretion disk is formed as the gas around a protostar accretes to the central star. In the disk the formation of a planetary system proceeds. When the accretion disks have a weak magnetic field, it is well known that the Magneto Rotational Instability (MRI) is excited in the disks (Balbus & Hawley, 1991). Linear analyses by Sano & Miyama (1998) show that MRI growth rates are affected by various factors, such as weaker vertical magnetic field reducing growth rates in the presence of finite resistivity. A protoplanetary disk is considered to be weakly ionized. Then there can be a radial inhomogeneity of the MRI growth rate due to a spatial variation in the magnetic configuration. We have performed simulations of cases in which a MRI unstable and a MRI stable annulus are situated. Inhomogeneous MRI growth is observed and the angular momentum exchange proceeds vigorously only within the MRI unstable annulus. As a result, the radial profile of the angular velocity is modified such that, with the rigid rotation inside the unstable annulus as the extreme case, the angular velocity decline with distance from the central star is slower than the Kepler profile in and adjacent to the unstable annulus. As a result some parts of the accretion disk have the gas to rotate faster than the dust particles. The implication is that the process may lead to the prevention of dusts from falling to the central star and further to the formation of planetesimals. We also have performed three-dimensional simulations with test particles included and have examined the dust dynamic in detail.

076.04

The behaviors of Kelvin-Helmholtz Instability in protoplanetary disks

Yusuke Kobayashi[1], K. Nakamura[1], M. Fujimoto[1]
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We investigate the behaviors of the Kelvin-Helmholtz instability (hereafter KHI) in protolanetary discs by two dimensional simulations in a local box using CIP method. The excitation of KHI is expected at the inner-edge of the disk (Nakamura et al., this meeting). We find that the KH turbulence in a rotating frame develops differently from those of ordinary cases in a non-rotating frame. The gas in the rotating disc is under the balance between central gravity, centrifugal force and the pressure gradient. When a vortex is induced by the KHI, the modification to this pre-existing structure, which does not exist in an ordinary situation, leads to gas mixing over a much longer distance in the radial direction. This is due to the following two effects, (1) the Coriolis force acts as a buoyancy force so that a low density part of the vortex drifts radially outward. (2) Coriolis force is reduced such that it cannot balance against the gravity, making a dense part of the vortex to fall inward. These effects become stronger when the density contrast across the shear layer is large. Indeed a large density jump is expected at the disk-inner edge. The growth time scale of KHI is as fast as the orbital time implying that the local velocity shear layer dynamics at the inner-edge would develop quickly to have large-scale impacts over a substantial part of the disk.

076.05

Kelvin-Helmholtz vortices induced by MRI at the inner-edge of protoplanetary disks

Keita Nakamura[1], M. Kato[1], R. Tandokoro[2], M. Fujimoto[3], S. Ida[1], H. Yurimoto[4]
[1]*Tokyo Institute of Technology, Japan,* [2]*FUJITSU LABORATORIES LTD., Japan,* [3]*ISAS/JAXA, Japan,* [4]*Hokkaido University, Japan.*

When an accretion disk has a weak magnetic field, it is well known that the magneto-rotational instability (MRI) is excited in the disk (Balbus&Hawley 1991).

We study the effect of MRI in protoplanetary disks near the protostar using local three-dimensional resistive MHD simulations. We have done modeling of the near-star part of protoplanetary disks by including the magnetosphere of the protostar and the "dead zone" (low ionized region in protoplanetary disk). Both in the magnetosphere of a protostar and in the dead zone, MRI isn't excited because of the strong magnetic field and of the low ionization respectively. In this situation, MRI is excited only in the innermost part of the disk and large velocity shear is generated at the inner-edge (the boundary between the magnetosphere of a protostar and the disk). Then Kelvin-Helmholtz instability (KHI) is excited and grows into vortices there. The result suggests that the inner-edge of the disk is perturbed heavily by KH vortices. The chemical analysis results of meteorites suggest "Multiple pulse-like heating events at inner-disk edge" and/or "Oxygen isotopic variation due to fluctuating motion of the disk inner-edge" (Itoh&Yurimoto 2003). Our results suggest that KHI at the inner-edge is a candidate process responsible for this activity.

Furthermore, we have performed several simulations in which a variety of initial field configuration inside the disk is assumed, from a poloidal to a toroidal geometry. The results show that in the case of a nearly toroidal field, azimuthally asymmetric MRI is the dominant mode in the disk and azimuthal velocity changes more slowly than the case where azimuthally symmetric MRI is the dominant. Nevertheless we observe the generation of KH vortices at inner-edge in this case. The important conclusion is that vortices at the inner-edge are born regardless of the geometry of magnetic field in the disks.

076.06

A Test Suite for 3D Radiative Hydrodynamics Simulations of Protoplanetary Disks

Aaron C. Boley[1], R. H. Durisen[1], A. Nordlund[2], J. Lord[3]
[1]*Indiana University,* [2]*NBIfA, Denmark,* [3]*Whitman College.*

Radiative hydrodynamics simulations of protoplanetary disks with different treatments for radiative cooling demonstrate disparate evolutions (see Durisen et al. 2006, PPV chapter). Some of these differences include the effects of convection and metallicity on disk cooling and the susceptibility of the disk to fragmentation. Because a principal reason for these differences may be the treatment of radiative cooling, the accuracy of cooling algo-

MONDAY

rithms must be evaluated. In this paper we describe a radiative transport test suite, and we challenge all researchers who use radiative hydrodynamics to study protoplanetary disk evolution to evaluate their algorithms with these tests. The test suite can be used to demonstrate an algorithm's accuracy in transporting the correct flux through an atmosphere and in reaching the correct temperature structure, to test the algorithm's dependence on resolution, and to determine whether the algorithm permits of inhibits convection when expected. In addition, we use this test suite to demonstrate the accuracy of a newly developed radiative cooling algorithm that combines vertical rays with flux-limited diffusion.

This research was supported in part by a Graduate Student Researchers Program fellowship.

076.07

3D Radiative Hydrodynamics Simulations of Protoplanetary Disks: A Comparison Between Two Radiative Cooling Algorithms

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We present a comparison between two three-dimensional radiative hydrodynamics simulations of a gravitationally unstable 0.07 Msun protoplanetary disk around a 0.5 Msun star. The first simulation is the radiatively cooled disk described in Boley et al. (2006, ApJ, 651). This simulation employed an algorithm that uses 3D flux-limited diffusion wherever the vertical Rosseland optical depth is greater than 2/3, which defines the optically thick region. The optically thin atmosphere of the disk, which cools according to its emissivity, is coupled to the optically thick region through an Eddington-like boundary condition. The second simulation employed an algorithm that uses a combination of solving the radiative transfer equation along rays in the z direction and flux limited diffusion in the r and phi directions on a cylindrical grid. We compare the following characteristics of the disk simulations: the mass transport and torques induced by gravitational instabilities, the effective temperature profiles of the disks, the gravitational and Reynolds stresses measured in the disk and those expected in an alpha-disk, and the amplitudes of the Fourier modes. This work has been supported by the National Science Foundation through grant AST-0452975 (astronomy REU program to Indiana University).

076.08

Monte-Carlo SED Models Of Young Stars With Accretion Disks In Taurus-Auriga and Orion Region

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Current theory suggests that the accretion disks around T-Tauri stars regulate the angular momentum of these stars by way of the magnetic field lines. These field lines extend from the star into the disk, in effect "locking" the angular velocity of the star to that of the material at the inner edge of the disk (truncation radius). This disk shows up as an IR excess in the spectral energy distribution (SED) emitted by the star and disk. According to theory, the truncation radius is a key parameter in the regulation of the angular momentum evolution of the star.

We are currently using a Monte-Carlo simulation to model the SEDs of a sample of young stars in the Taurus-Auriga and Orion regions, and comparing these SEDs of these models with flux measurements available for these stars. Specifically, we are testing whether the truncation radii of these stars are consistent with those predicted by theory. We present the results of these stars and explore the implications of the results for theory.

076.09

Proto Planetary Disk Model Inversion Using Artificial Neural Networks

Gerald T. Ruch, Jr.[1], D. Wooden[2], C. E. Woodward[1]
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We explore the use of artificial neural networks (ANNs) both to increase the calculation speed of protoplanetary disk models and to rapidly recover model parameters from real observational data. The problem of recovering physical parameters from observational data is known as inversion. It is the inverse problem of modeling, which is the production of simulated observations from physical parameters. We use the two layer protoplanetary disk model of Dullemond et al. (2001) to create an ANN capable of quickly performing inversions. The model is used to calculate a grid of physical parameters versus the associated simulated spectra. The ANN is trained to mimic the grid, taking the simulated spectra on the input producing physical parameters on the output. From our point of view, the ANN can be viewed as multi-dimensional interpolation machine. It has the ability to generalize and interpolate between the grid points. In principle, real observational data can be presented to the ANN and it will quickly produce physical parameters at the output. We compare the speed of inversion and the recovered parameters by the ANN with the results of a common brute force method of performing inversions via least squares minimization.

076.10

Simulating Protoplanetary and Debris Disk's for ALMA

Robert L. Stone[1]
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Millimeter-wavelength interferometry offers a way to obtain high resolution information on the emission structures around nearby stars with debris disks such as Fomalhaut. ALMA will be able to attain a higher resolution than any other millimeter wavelength telescope to date. Observations of Fomalhaut's debris disk have already been made by single dish telescopes, as well as models, but the resolution of these can be fairly poor. I plan to discuss my model of Fomalhaut which simulates it's debris disk at several different frequencies to show the level of detail that ALMA will achieve. I will also discuss how ALMA will be the forefront tool in discovering other systems similar to Fomalhaut in the future.

077: Clusters & Cosmology
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

077.01

First Results from an HST/ACS Snapshot Survey of Intermediate Redshift, Intermediate X-ray Luminosity Clusters of Galaxies: Early Type Galaxies and Weak Lensing

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We present first results from our HST/ACS Snapshot survey of clusters randomly selected from a complete X-ray survey, the 160 Square Degree Survey (Vikhlinin et al. 1998; Mullis et al. 2003). We have catalogued and classified over 5,000 galaxies in 25 fields around X-ray clusters of low to moderate X-ray luminosities ($L_x = 10^{43}$-10^{44} erg s^{-1}) and spectroscopic redshifts between 0.3-0.6. We present the morphological properties of the early-type galaxies, with particular emphasis on the concentration index. We compare the concentration parameter of the early-type galaxies with those of early-type galaxies in the field at similar redshift, and with those of early-type galaxies in more massive and luminous clusters, also at similar redshifts. We find that early type galaxies in clusters may be more concentrated than early type galaxies in the field. We discuss preliminary results in our comparisons with broader samples, and we take a first look at ground-based color information obtained with the SOAR Optical Imager. We also present the first estimates of shear-based mass estimates for these clusters, derived entirely from the ACS images. This work was supported by STScI/HST GO Cycle 13 and 14 grants.

077.02

Populations of Lyman Break Galaxies in Two Large Quasar Groups at 0.8<z<1.2

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The nature of galaxy structures on large scales is a key observational prediction for current models of galaxy formation. The SDSS and 2dF galaxy surveys have revealed a number of structures on 30-50 Mpc scales at low redshifts, and some even larger ones. To constrain galaxy number densities, luminosities and stellar populations in large structures at higher redshift, we have discovered and investigated two sheet-like structures of galaxies at z=0.8 and 1.2 spanning a 30x30 arcmin field, spanning at least 30 comoving Mpc (Lambda CDM cosmology, h=0.7) embedded in large quasar groups extending over at least 100 Mpc.

We present first results of analysis of these sheet--like structures using two

1 deg Galex fields (FUV and NUV) cross-correlated with optical data from the Sloan Digital Sky Survey (SDSS) and deep VI images from the CTIO 4m Blanco telescope. We derive a sample of about 590 Lyman Break Galaxy (LBG) candidates tracing the sheets. Using the GALEX and SDSS data, we show that the overall average spectral energy distribution of a LBG galaxy at z~1 is flat from u to z in the observed frame. This implies that there are evolved populations of stars in the LBGs.

Funded by HST grant GO9877 and NASA GALEX grant NN G05GC15G.

077.03

Simulation of the Magnetothermal Instability in 3D and Application to Clusters of Galaxies

Ian J. Parrish[1], J. M. Stone[1]
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In dilute astrophysical plasmas, thermal conduction is primarily along magnetic field lines, and therefore highly anisotropic. As a result, the usual convective stability criterion is modified such that atmospheres in which the temperature increases with height are unstable to convection. We present fully three-dimensional magnetohydrodynamic simulations with anisotropic thermal conduction of the resultant instability, which we call the magnetothermal instability (MTI). We discuss different saturation mechanisms of the instability, which can include a rearrangement of the atmosphere to an isothermal vertical profile. In addition, we show that the saturated steady state turbulence efficiently transports heat and generates a magnetic dynamo to amplify the magnetic field until it is in equipartition with the subsonic convective velocities.

The intracluster medium (ICM) of clusters of galaxies is in the long mean free path regime where thermal conduction is purely anisotropic. We show that for a typical galaxy cluster, the ICM is unstable to the MTI on scales of several kiloparsecs. We present initial simulations of the MTI in a model galaxy cluster and extract computed temperature and density profiles to compare to observations.

077.04

Discovery of Distant Galaxy Clusters in the ROX Survey

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Distant galaxy clusters are key to the study of galaxy evolution in dense environments and to the independent measurement of cosmological parameters. The number of known clusters at redshifts around unity and higher is small but increasing rapidly -at present there are not enough clusters to measure good statistics at each redshift, nor to study how evolution depends on cluster mass, x-ray temperature, etc. The ROSAT Optical X-ray Survey (Donahue et al. 2002 ApJ 569, 689) searched for galaxy clusters using both optical and x-ray detection methods. Of 57 diffuse x-ray sources found, 10 were not detected in I-band, suggesting either high redshift or a spurious x-ray detection. We imaged the 10 fields in the near infrared J and K bands, and in several cases confirmed the existence of the cluster by detecting the red sequence of the member galaxies. We report the clusters discovered and what is known of their properties.

077.05

THE EVOLUTION OF WEAK MgII ABSORBERS FROM 0 < z < 2.4.

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We present results from a VLT/UVES survey of weak absorbers in the redshift interval $0.4 < z < 2.4$. Using 81 quasar spectra extracted from the ESO archive, we were able to identify 112 weak systems in a survey that is 84% complete down to a rest-frame equivalent width limit of Wr(2796) = 0.02 Angstrom. Based on this identified sample, we present results on the statistical properties of weak MgII absorbers, the redshift number density (dN/dz) for single and multiple cloud weak systems and the equivalent width distribution. Synthesizing results from previous weak and strong MgII surveys, we also demonstrate an evolution in the incidence of weak systems from redshift 2.4 to the present. Based on these results, we discuss the physical nature of weak systems and the potential processes that could be responsible for the observed evolution.

077.06

First Results from the XMM/IMACS Groups Project

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We present the first results of the XI (XMM/IMACS) Groups Project, a study targeting a redshift-selected, statistically unbiased sample of galaxy groups with the goal of understanding how the properties and dynamics of group galaxies relate to global group properties. Here, we present X-ray and optical data for the first nine groups observed. We detect a diffuse intragroup medium in three of the nine groups. In two of these groups, the luminosity of the diffuse gas is among the lowest found for any X-ray group thus far. Compared to typical X-ray selected groups of similar velocity dispersion, the XI groups tend to be X-ray faint. The lack of significant X-ray emission in these groups is consistent with the idea that they are collapsing for the first time. The XMM and IMACS data have also been used to study the AGN population. We find that unlike rich clusters, optically-selected groups do not contain a large population of X-ray bright, optically-dull AGN. We suggest that the differences in the AGN populations of groups and clusters can be understood in terms of differences in the accretion rates for supermassive blackholes in these two environments.

077.07

Mapping the Intergalactic Medium in Chandra Deep Fields

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The warm/hot intergalactic medium (WHIM) in the cosmic web may help solve the missing baryon problem. Recent observations of the cosmic X-ray background (CXB) in the Chandra Deep Fields North and South by Hickox and Markevitch (2005) compel us to revisit earlier theoretical predictions for the WHIM integrated spectrum and flux distribution. We use a new higher resolution large scale simulation which includes the effects of galactic superwind feedback to create maps which reproduce the spatial and energy resolution, and pixel selection criteria of the Chandra fields. We compare these statistically with the CXB they obtain and to predict the signature of this important baryon reservoir in the CCF of the CXB with the galaxy distribution.

077.08

Chandra Observations of Abell 222 & Abell 223

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We present the analysis of Chandra observations of two rich clusters in a binary pair, Abell 222 & Abell 223. The clusters were observed with the ACIS-I detector for a total of 45 ksecs in ″VERY FAINT'' mode. After screening the data we fit the surface brightness of both clusters we find that both exhibit signs of a past merger. Fitting the surface brightness of the clusters reveal significant changes in the ellipticity and position angle of the fitted ellipses, which are signs that the clusters have not fully relaxed. Neither cluster shows evidence of shocks in the temperature maps. The temperature of each cluster is very similar, 4.89+/-0.31 keV for A 222 and 4.72+/-0.33 keV for A 223. The temperature of the bridge region between the two clusters does not show any temperature enhancement and therefore the two clusters have not yet begun to interact strongly.

077.09

Evidence for Evolution in Weak MgII Absorbers at z < 1.5

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We present a survey of 92 weak MgII absorbers [those with $W_r(2796) < 0.3$~Å] in 132 HIRES and UVES quasar spectra. The spectra are 97% complete to $W_r(2796) = 0.02$~Å over the redshift range 0.15--1.45 and have a cumulative redshift path of ~ 76. We find pronounced evidence for evolution in the redshift path density, dN/dz, which monotonically decreases toward higher redshift. Assuming $dN/dz \propto (1+z)^{\gamma}$, we estimate $\gamma = -1.0 \pm 0.5$, where $0.5 < \gamma < 1.0$ would represent no evolution in the population of absorbers. Similarly, assuming $dN/dz \propto (1+z)^{2+\varepsilon}$ $\backslash\Omega_m(1+z)^3+\Omega_\Lambda$ $^{-1/2}$, we estimate $\varepsilon = -2.0 \pm 1.0$, where $\varepsilon = 0$ would represent no evolution. We also discovered eight MgII absorbing systems with $W_r(2796) < 0.02$~Å and three with $W_r(2796) < 0.01$~Å, allowing us to explore the equivalent width, column density, and Doppler b parameter distributions down to very small values of $W_r(2796)$.

077.10

The NOAO-XCS Survey Program

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The XCS (Romer et al. 2001) is an ambitious program to mine the entire XMM archive for galaxy clusters. It will produce a catalog of several thousand serendipitously-detected clusters in over 500 square degrees and to beyond z=1. A key feature will be X-ray temperatures (T_X to within 20%) for any cluster with >500 counts. T_X is one of the best observational proxies for cluster mass. The XCS Survey will provide the cluster targets used to calibrate the cluster mass function from redshift 0 to 1. Such a calibration will be vital for the next generation of large-area galaxy cluster surveys.

The NOAO-XCS (NXS) Survey is a homogeneous multi-band optical imaging survey of more than 500 XCS clusters in the northern and southern hemispheres (via KPNO and CTIO). Upon completion in 2008, it will constitute the largest and deepest multiwavelength survey of galaxy clusters. The cluster photometric redshifts will drive the derivation of cosmological parameters as well as the first ever self-consistent measurement of the cluster X-ray luminosity-temperature relationship to z>1. The XCS-NOAO galaxy catalog will probe the evolution of cluster galaxies as a function of cluster mass. The legacy will be a unique dataset for the community to exploit until the next great X-ray observatory.

077.11

Chandra Studies of Dark Matter and Galaxy Formation: Signatures from the Intracluster Medium

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We present two on-going Chandra studies of X-ray clusters of galaxies. Our first study is a deep, 200 ksec observation of the nearby cluster Abell 1650. Abell 1650 has a very faint radio source and no obvious cavities, yet early observations by Chandra revealed an elevated entropy level in the gas in the core. Follow-up observations of this cluster have allowed us to extract a detailed temperature, mass, and entropy profile, as well as a map of metallicity variations in the core. Our second study is an archival review of the entropy profiles of nearly all of the clusters in the current Chandra archive, significantly extending our work from Donahue et al. (2006). We find that the cores of clusters have a range of central entropies (not bi-modal), including clusters with extremely low central entropy (~2 keV cm^{-2}) and isothermal clusters with high central entropy. We discuss the radio and emission-line properties of the central galaxies in context with the central entropy levels of the host cluster. This work has been supported by a NASA Long Term Space Astrophysics grant and by the SAO/Chandra Science Center.

077.12

The Stellar Populations of Ultra-Compact Dwarf Galaxies

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We have discovered an intracluster population of ultra-luminous compact stellar systems in the Fornax cluster. Originally coined ″ultra-compact dwarf galaxies″ (UCDs), these objects were thought to be remnant nuclei of tidally stripped dE,Ns. Subsequent searches in Fornax (2dF+VLT) have revealed many fainter UCDs; making them the most numerous galaxy type in the cluster and fueling controversy over their origin. UCDs may be the bright tail of the globular cluster (GCs) population associated with NGC1399. Alternatively they may be real intracluster GCs, resulting from hierarchical cluster formation and merging in intracluster space. Determining the stellar populations of these enigmatic objects is challenging. UCDs are unresolved from the ground but our HST/STIS+ACS imaging reveals faint halos around the brightest UCDs. Here we present deep u'g'r'i'z' images of the cluster core using the CTIO 4m Mosaic. Combined with GALEX/UV imaging and using SSP isochrones, UCDs appear to be old, red and unlike cluster dEs. In contrast, our recent IMACS and Keck/LRIS+ESI spectroscopy shows that UCDs are unlike GCs and have intermediate stellar populations with significant variations in their Mg and H$\boldsymbol{\beta}$ line strength indices.

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077.13

Spatial Probing of MgII Absorption in ''Halo'' Gas through Adaptive Mesh Refinement Simulations of Galaxies

Christopher W. Churchill[1], G. Kacprzak[1], D. Ceverino[1], J. Evans[1], A. Widhalm[1]
[1]New Mexico State Univ..

We present a mock quasar absorption line survey through a simulation of an evolving Milky Way--like galaxy from z=1 to z=0.5 that undergoes a merging at z~= 0.6. The synthesized absorption lines are presented as HIRES/UVES quality spectra of the MgII λ 2796 transition. We probe the region surrounding the galaxy in a 30 × 30 kpc grid with separations of 10 kpc. The simulations were performed using the Eulerian gasdynamics plus N--body Adaptive Refinement Tree (ART) code (Kravtsov 2003, ApJ, 590, L1). The code implements metallicity dependent cooling, star formation, and thermal feedback. The simulated box size is 10 Mpc h^{-1} with a force resolution between 60--200 pc.

We examine the spatial variations and temporal evolution of the MgII absorbing gas kinematics. We also explore various orientations of the galaxy, including face--on and edge--on inclinations. We find that gas kinematics are confined to velocity spreads of ~ 300 km s^{-1} with respect to the galaxy systemic velocity. We examine the covering factor of the MgII absorbing gas as a function of equivalent width and compare with our observations of ~ 40 MgII absorption selected galaxies studied via *HST/V* imaging and HIRES/UVES absorption line data (Kacprzak et al.\ 2006, ApJ, submitted). We find that the simulations underpredict the covering factor of strong absorbers, which may indicate either some problems with overcooling or angular momentum loss, or bias in the observational data.

077.14

Cosmic Ray Scattering in Compressible Turbulence

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We show that compressible turbulent motions on scales smaller than CR mean free path induce gyroresonance instability in CRs. This CR-Alfven wave instability provides efficient scattering of CRs much like streaming instability, but without streaming. The amplitude of the new slab-type Alfven waves generated by instability is restricted by steepening, while on large scales it is damped by turbulent shearing. The energy transfer from compressive turbulence to the slab waves provides a new mechanism of damping of compressive motions that is efficient in a media with relatively large CR pressure. For the typical parameters of turbulence in the ICM or ISM the instability provides scattering frequencies that are much higher that those given by quasilinear theory from the direct resonance with MHD turbulence modes.

077.15

Chandra Spectral Analysis of the Intergalactic Gas in the Unusual Cluster RXJ 0419+0225

Kristina Nyland[1], R. Dupke[1]
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We performed a spatially resolved, spectroscopic analysis of the intracluster medium of the bright, nearby (z~0.012) galaxy cluster RXJ 0419+0225, along with two deep Chandra observations taken with the ACIS-S3 chip. The cluster is unusual since it is very cold yet still appears to be a dynamic system, as was previously observed in an ASCA study. We conducted a detailed analysis of temperature, velocity, and elemental abundance distributions in order to better understand the evolutionary stage of this system. RXJ 0419+0225 has a cold core with temperature variations from 1.1+-0.04 keV in the center to 1.6+-0.04 keV in the outer regions. We find significant (>90% confidence level) radial abundance gradients of Si, S, Fe, Mg and Ne. Also, the radial distributions of temperatures and

abundances is asymmetric, thus indicating the presence of substructuring. We explore the nature of the temperature and metal abundance substructure by building adaptively binned maps of the interesting parameters.

077.16

Sunyaev-Zel'dovich Effect Signals in Cluster Models

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The upcoming generation of Sunyaev-Zel'dovich effect (SZE) surveys will shed fresh light onto the study of clusters. What will this new observational window reveal about cluster properties? What can we learn from combining X-ray, SZE, and optical observations? How do variations in the gas entropy profile, dark matter concentration, accretion pressure, and intracluster medium (ICM) mass fraction affect SZE observables? We investigate the signature of these important cluster parameters with an analytic model of the ICM. Given the current uncertainties in ICM physics, our approach is to span the range of plausible models motivated by observations and a small set of assumptions. We find a tight relation between the central Compton parameter and the X-ray luminosity outside the cluster core, suggesting that these observables carry the same information about the ICM. The total SZE luminosity is proportional to the thermal energy of the gas, and is a surprisingly robust indicator of cluster mass: L_{SZ} α f_{ICM} $M^{5/3}$. We show that a combination of L_{SZ} and the half-luminosity radius r_{SZ} provides a measure of the potential energy of the cluster gas, and thus we can deduce the total energy content of the ICM. We caution that any systematic variation of the ICM mass fraction will distort the expected L_{SZ} M calibration to be used to study the evolution of cluster number density, and propose a technique using kSZ to constrain f_{ICM}(M,z).

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077.17

The Beta Problem: The Incompatibility of X-ray and Sunyaev-Zeldovich Model Fitting

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We describe an analysis of a large sample of numerically simulated clusters which demonstrates the effects of using X-ray fitted beta-model parameters with Sunyaev-Zeldovich effect (SZE) data. There is a fundamental incompatibility between beta-model fits to X-ray surface brightness profiles and those done with SZE profiles. Since observational SZE radial profiles are in short supply, the X-ray parameters are often used in SZE analysis. We show that this leads to biased estimates of the integrated Compton y-parameter inside r500 and the value of the Hubble constant calculated from clusters. We suggest a simple scaling of the X-ray beta-model parameters which brings these calculated quantities into close agreement with the true values.

077.18

OVI and HI Around Nearby Galaxies

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We present the results of a survey of 73 extragalactic sightlines observed by FUSE and/or HST, which pass within 1 Mpc of a nearby galaxy (v(Gal) =400 to 5000 km/s). Most of these galaxies are found in the RC3, with additional ones coming from NED. We then search for Lya, Lyb and OVI absorption at a velocity within about 200 km/s of that of the galaxy, noting detections and non-detections. We find 282 coincidences that allow a search for Lya and/or Lyb, 251 for OVI. For Lya/Lyb and OVI the detection rate decreases regularly with impact parameter, b. We find HI in 86% (6 of 7) coincidences with b<100 kpc, 60% (27 of 52) for b=100-300 kpc, 44% (35 of 79) for b=300-560 kpc, 17% (25 of 144) for b=560 to 1000 kpc. In addition, we find 28 HI detections without a galaxy within 1 Mpc. OVI is found in 50% (3 of 6) of coincidences with b560 kpc. Assuming that the OVI occurs in collisionally ionized gas with 1/10th solar metallicity, and ionization fraction <20%, the OVI column densities correspond to H columns $>10^{18.5}$ cm^{-2}. The distribution of impact parameters then implies a mass of ~$3x10^5$ K gas that is $>10^{11}$ solar masses per OzVI absorber associated with galaxies.

077.19

Chandra Observation of the Cluster Environment of a WAT Radio Source in Abell 1446

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Wide-angle tail (WAT) radio sources are typically associated with dominant central galaxies in clusters. Various models have been proposed to explain the bending of these sources, including cluster-cluster mergers. We present a recent observation with the Chandra X-ray Observatory which suggests that the galaxy cluster Abell 1446 (z = 0.1035), host to the WAT 1159+583, may be the site of an on-going merger with a sub-cluster. The presence of temperature and pressure substructure along the line that bisects the WAT as well as what may be a wake of stripped interstellar material to the southeast of the host galaxy support the merger scenario. A filament to the north may represent cool, infalling gas that further contributes to the WAT bending. The X-ray emission is approximately circularly symmetric about the core with an isothermal (kT = 4.0 keV) radial temperature profile out to a distance of 400 kpc from the center. Additionally, we investigate the model of fast and light radio tails where slow galactic motion through the ICM is revisited as a WAT bending mechanism.

077.20

A Possible Mass-Density and Star Formation Density relation at z=5.7

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Using a narrow band filter centered at 815 Angstroms on Subaru/Suprime-Cam we find 110 galaxies at z=5.7 in a volume of 175 x 175 x 50 Mpc. These objects have a significant clustering signal, and several large structures are visible. Furthermore, the objects with the brightest UV continuum tend to be in dense regions. We derive ages of 0.1 Gyr, and masses of 10^9 M_{sun} for the brightest objects detected with IRAC. A stacking analysis of the fainter objects yields a constant z-3.6um color down to z<28 indicating all objects are of a similar age. Assuming this constant age, the z band magnitude can be used as a proxy for both mass and star formation rate. This implies a mass-density and star formation density relation at z=5.7.

077.21

Group Analysis Reveals Previously Unrecognized Patterns in Stellar and Galactic Distributions

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As a novel approach to discover groups in the distribution of nearby stars and galaxies, group analysis, a monothetic divisive clustering method, was applied to stars from the NStars database and the Gliese 3 Star Catalogue, and to galaxies from the Tully Collection. Groups were identified based on position, type, and proper motion. The group coefficient, a measure of significance, was calculated for each group. The groups identified all have a high group coefficient showing that the distribution is not homogenous or random. It was discovered that the cool M type star tends to associate with warmer stars. It was also found that the majority of the stars travel clockwise around the galaxy's center while the rest do not follow the pattern. Prominent groups in the distribution of galaxies were identified as well: elliptical galaxies were found to associate with spiral galaxies with little star formation. However when elliptical galaxies are absent, groups tended to associate with irregular and spiral galaxies with middle-level star formation. This work has demonstrated that group analysis is a useful new tool for understanding patterns in distributions. It has provided a more detailed description of the structure of nearby space and its underlying correlations.

077.22

New Statistical Methods to Analyze the SDSS DR5 Galaxy Distribution

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The large-scale distribution of the galaxies can be characterized by various statistical and topological methods, but commonly used ones often have large uncertainties. Our new method is a combination of The Metric Space Technique and Rhombic Dodecahedron cell method, we call it MSRD method. It allows multiple measures to be simultaneously applied for quantitative analysis of any type of structure distribution. All such distributions are considered to be elements of many-parameter space, and the analysis is based on considering a sample's output functions, which characterize the distributions in multi-parameter space. We use several slices of a volume of space containing many newly measured galaxies from SDSS DR5. By systematically studying hundreds of thousands of galaxies, we construct a comprehensive map of the local Universe, which allows us to measure some of the fundamental parameters that define the large-scale structure in the cosmos. We compare results with that of mock samples of galaxies from large-scale structure model simulations.

077.23

Exploring Galaxy Environments with Characteristic Field Mapping

Shannon A. Snider[1]
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The connection between characteristic properties of galaxies and their local environments is an important tool in understanding the life history of galaxies, their formation, and their effects on the large-scale structure of the universe. However, while there has been significant progress in understanding galaxy properties with relation to local densities and nearby cluster distances, fundamental questions still remain unanswered.

Three-dimensional field mapping techniques are explored as a means of investigating the environmental dependence of characteristic properties of galaxies in large data sets. Field maps are applied to the Millenium Run semi-analytic galaxy catalog to create a baseline of methodology against a simulated data set. The field maps are then extended for application to the Data Release 5 of the Sloan Digital Sky Survey.

An open architecture is presented as a framework for further studies of the correlational dependence of arbitrary characteristics. In particular, the techniques are being applied in current investigation towards an understanding of the relationships of metallicity, densities, star formation, mass, and luminosities in local environments in the DR5 of the SDSS.

077.24

A Weak Lensing Study of the Coma Cluster in SDSS

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[1]Fermi Nat'l. Accelerator Lab., [2]Brown University.

We present a weak lensing study of the Coma Cluster in the Sloan Digital Sky Survey (SDSS). The large area covered by the SDSS allows us to study for the first time the weak lensing signal due this low redshift cluster. The wealth of external information that exists for Coma can be combined with our weak lensing analysis to study this cluster using methods that are not possible for higher redshift clusters. Here we present our method of detecting the lensing signal due to Coma as well as preliminary results.

077.25

Quantifying Galaxy Cluster Substructure

David A. Ventimiglia[1], G. M. Voit[1], M. Donahue[1], S. Borgani[2], S. Ameglio[2]
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We examine the influence of mergers and substructure on the mass-temperature relationship for a sample of galaxy clusters simulated using radiative cooling and supernova feedback. We conduct a critical analysis of three measures of substructure, Centroid Variation, Axial Ratio, and Power Ratio, and of their correlations with a cluster's offset from the mass-temperature relationship. Our analysis shows that Power Ratio is the most promising measure of substructure to use as an additional parameter in tightening this relationship.

077.26

Iron Abundance and Temperature Gradients in High Redshift Galaxy Clusters

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Galaxy clusters are the largest gravitationally bound objects in the universe, and full of a high temperature, metal rich plasma known as the Intra-Cluster Medium (ICM). In order to better understand the orgin and evolution of the ICM and of galaxy clusters, it is helpful to understand the presence or absence of gradients in the temperature as well as the iron abundance within the cluster. Here I have used over twenty galaxy clusters from Chandra and XMM to see if there are any discernable trends in iron abundance or temperature with core radius. The results show that, on average, there is evidence of some sort of evolution of these properties of the ICM with time.

077.27

A Detection of Large-scale Intrinsic Alignments and Implications for Cosmic Shear

Rachel Mandelbaum[1], C. M. Hirata[1], M. Ishak[2], U. Seljak[3]
[1]Institute for Advanced Study, [2]University of Texas (Dallas), [3]Princeton University.

Cosmic shear, or weak lensing by large-scale structure, has been used to constrain the matter power spectrum normalization around $z \sim 1$, and future surveys are being planned to allow high signal-to-noise measurements of cosmic shear to constrain the equation of state of dark energy. One potential systematic error is the correlation between the intrinsic ellipticities of galaxies and the density field that causes gravitational lensing (GI correlation). We describe the original detection of GI correlations to 60/h Mpc scales using galaxies from the Main spectroscopic sample of the Sloan Digital Sky Survey (SDSS) around $z \sim 0.1$, followed by a measurement of the scaling with luminosity and redshift for the red galaxies in the SDSS Luminous Red Galaxy sample around $z \sim 0.25$. This highly statistically significant detection of GI correlations for galaxies brighter than L* has a sign predicted by theoretical models. The GI correlation could cause the existing lensing surveys at $z \sim 1$ to underestimate the linear amplitude of fluctuations by as much as 20% depending on the source sample used. The GI contamination is dominated by the brightest galaxies, possibly due to anisotropic infall along filaments, although other sources of contamination cannot be excluded at this point. Unlike autocorrelations between galaxy intrinsic ellipticities (II correlations), the GI correlations cannot be eliminated by cross-correlating galaxy samples at different redshifts, and in fact are enhanced by this procedure. We discuss methods for eliminating GI contamination in current and future weak lensing surveys, particularly those with data in multiple passbands that allow for the exclusion of the brightest red galaxies, and show what fraction of a typical survey would need to be excluded to reduce the contamination to the sub-percent levels needed for precision cosmology.

077.28

Constraining Lambda CDM and Brane-based Cosmologies using Gamma Ray Bursts

Razieh Behkam[1], J. Rhoads[1]
[1]Arizona State Univ..

It has recently become possible to use gamma ray bursts as cosmological tracers, exploiting correlations between their spectral peak, light curve break time, and apparent isotropic energy (the Ghirlanda and Amati relations). We are using these correlations to compare a standard Lambda CDM cosmology to a cosmology motivated by brane models, where the cosmic acceleration is a purely geometric effect and not a consequence of dark energy. Deffayet et al (2002) have examined this comparison using supernova Ia data, which are compatible with both models. The larger redshift range spanned by GRBs provides additional leverage, allowing us to constrain either model better and potentially also to distinguish between them. We discuss both the results from the currently available sample of 15 GRBs and the prospects for improved constraints from much larger samples in future.

077.29

Understanding a Cosmic Yardstick Simulating Neutral Hydrogen in Disk Galaxies

Alok Singhal[1], R. Fisher[2], K. O'Neil[2], E. Murphy[3]
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I am developing a 3-dimensional model of neutral hydrogen (HI) in disk galaxies to study galaxy kinematics and its effects on the Tully-Fisher (TF) relation. Many factors can introduce bias in the TF relation. The study of these factors is important because, if not corrected, these factors would result in a bias in distances determined from the TF relation. One of the important sources of bias lies in the estimation and correction of turbulent motions. The current practices result in over-correcting for turbulent velocities. This correction is larger for smaller galaxies, and thus turbulent motion corrections introduce errors as well as bias in the distances.

We simulated HI in UGC7321 and compared the simulated line profile and channel maps with the observations of the galaxy. Both show good agreement with the published results, with the caveat that the best-fit rotation curve and turbulent velocity are slightly different from the ones published in literature. One of the reasons for this discrepancy could be because of the lack of flaring/warping of HI in our model, while UGC7321 clearly shows signs of warping and flaring.

077.31

The Opposite of Dark Energy: Limits on Ultralight Energy in the Early Universe

Robert J. Nemiroff[1]
[1]Michigan Technological University.

Might energy species "lighter" than radiation, with $w > 1/3$, exist? A dimensional expansion of the cosmological Friedmann Equation of energy has a clear place for them. Such energies would affect the universe much differently than dark energies, and so are here dubbed "ultralight." As the universe expands, ultralight dilutes even faster than light. Ultralight is not considered a candidate to make a significant contribution to the energy budget of the universe today, although ultralight might have affected the universe in the distant past. In particular, the $w=2/3$ ultralight energy specie appears to have relatively mundane physical attributes. A discussion of properties and falsifiable attributes of ultralight is given. Limits on the possible cosmological density of ultralight in the early universe are determined from existing microwave background and primordial nucleosynthesis data.

077.32

Cosmology with the Cluster Mass Function

Kenneth J. Rines[1]
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Galaxy clusters probe the amplitude of density fluctuations in the early universe and the growth of large-scale structure. I will discuss our recent efforts to constrain Ω_m and σ_8 using the mass function of X-ray selected galaxy clusters in the Sloan Digital Sky Survey. Our results agree well with Third-Year WMAP results and have statistical uncertainties competitive with cosmic shear estimates. Alternatively, these measurements can be used to estimate the velocity segregation of cluster galaxies. Taking the Third-Year WMAP results as a prior, we estimate that cluster galaxies have a velocity dispersion 1.3 times larger than the dark matter. I will discuss future efforts to improve these constraints and to use the evolution of the mass function to probe dark energy.

078: Computation, Data Handling, and Image Analysis AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

078.01

Theory SkyNode

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A working example of a Basic SkyNode serving theoretical data will be presented. The data is taken from the Simulated Cluster Archive (a set of simulated galaxy clusters, where each cluster was computed using four different physics models). The Theory SkyNode tables contain columns of both computational and observational interest. Examples will be shown of using this theoretical data for comparison to data taken from observational SkyNodes, and vice versa.

The relative ease of setting up the Theory SkyNode is of import, as it represents a clear way to present tabular theory data to the Virtual Observatory. Also, the Theory SkyNode provides a prototype for additional ″theory catalogs″, which wil be created from other simulations.

This work is supported by the University of California Office of the President via UCDRD-LLNL award ″Scientific Data Management″. Travel funding was provided by the US NVO Summer School.

078.02

Datamining the NOAO NVO Portal: Automated Image Classification

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Image metadata describes the properties of an image and can be used for classification, e.g., galactic, extra-galactic, solar system, standard star, among others. We are developing a data mining application to automate such a classification process based on supervised learning using decision trees. We are applying this application to the NOAO NVO Portal (www.nvo.noao.edu). The core concepts of Quinlan's C4.5 decision tree induction algorithm are used to train, build a decision tree, and generate classification rules. These rules are then used to classify previously unseen image metadata. We utilize a collection of decision trees instead of a single classifier and average the classification probabilities. The concept of ′′Bagging′′ was used to create the collection of classifiers. The classification algorithm also facilitates the addition of weights to the probability estimate of the classes when prior knowledge of the class distribution is known.

078.03

A New Telescope Control System Interface for the HET

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The Hobby-Eberly Telescope (HET), located on Mt. Fowlkes at the McDonald Observatory near Ft. Davis, Texas, is unique in that unlike a classical equatorial or Alt-Azimuth telescope, it has a fixed elevation/zenith angle and moves only in azimuth. The Telescope operator is responsible for general telescope movement and tracking, but also for maintaining focus and image quality. Although the operator is relieved by computers for many of the complex operations and adjustments on the optical system, the interface in which the operator communicates to the telescope computer systems is largely irrelevant and non-intuitive.

A new Graphical User Interface has been proposed to replace the current Telescope Control System interface. The proposal centers on a purely graphical interface to succeed the current interface for use in controlling the telescope and related equipment, as well as providing an integrated display for several sources of crucial data for the telescope operator. In this endeavor, we analyze the possibilities of a graphical interface and the advantages it will provide in reducing engineering and operating time while providing a greater window for scientific operations. The observations of the telescope operator are described to elucidate some of he decisions made about the interface, as are some of the considerations that must be made when developing a new interface for a complicated telescope control scheme. We also discuss the decisions on the integration of other control GUI's into the control system interface.

Research Experience for Undergraduates program funded by the National Science Foundation.

078.04

VOEventNet: Event Messaging for Astronomy

Andrew J. Drake[1], G. Djorgovski[1], M. Graham[1], R. Williams[1], A. Mahabal[1], C. Donalek[1], E. Glikman[1], J. Bloom[2], T. Vastrand[3], R. White[3], D. Rabinowitz[4], C. Baltay[4]
[1]*Caltech,* [2]*UCB,* [3]*LANL,* [4]*Yale.*

The time domain remains one of the the least explored areas in modern astronomy. In the near future the next generation of large synoptic sky surveys (Pan-STARRs, Skymapper, LSST) will probe the time dependent nature of the sky by detecting hundreds of thousands of astronomical transients (variable stars, asteroids, GRBs, lensing events). A global event distribution and follow-up network is required to characterize the nature of these transients.

For over a year the VOEventNet project has been in the process of implementing a transient event follow-up network which distributes crafted structured data packets called VOEvents. These packets have been designed to be general enough to contain metadata for transients seen at all wavelengths, yet interpretable by robotic telescope systems (which are already automatically responding with follow-up observations). The VOEventNet project currently has transient event follow-up with the Palomar 60 and 200in (Caltech), RAPTOR (LANL), PARITEL and KAIT (UCB) as well as UK telescopes.

VOEventNet transient event streams are publicly available. The subscription, publication and reception of VOEvents is implimented with a number of open source software clients. The software and details of how to receive streams of events are available from http://www.voeventnet.org. Current event streams include OGLE microlensing events, SDSS Supernovae, GCN GRBs, Raptor and Palomar-Quest optical transients. In the near future, many additional streams of VOEvents will be available, including optical transients from the ESSENCE, Planet and MOA projects, as well as those from UKIRT and JCMT telescopes. We also expect that transient event alerts will be available from Solar, X-ray and Radio telescopes.

078.05

Real-time Transients from Palomar-QUEST Synoptic Sky Survey

Ashish A. Mahabal[1], A. Drake[1], S. G. Djorgovski[1], C. Donalek[1], E. Glikman[1], M. J. Graham[1], R. Williams[1], C. Baltay[2], D. Rabinowitz[2], A. Bauer[2], N. Ellman[2], R. Lauer[2], PQ team (Caltech, Yale, NCSA, Indiana, ...)
[1]*Caltech,* [2]*Yale University.*

The data from the driftscans of the Palomar-QUEST synoptic sky survey is now routinely processed in real-time. We describe here the various components of the pipeline. We search for both variable and transient objects, including supernovae, variable AGN, GRB orphan afterglows, cataclysmic variables, interesting stellar flares, novae, other types of variable stars, and do not exclude the possibility of even entirely new types of objects or phenomena.

In order to flag as many asteroids as possible we have been doing two 4-hour scans of the same area covering ~250 sq. deg and detect over a million sources. Flagging a source as a candidate transient requires detection in at least two filters besides its absence in fiducial sky constructed from past images. We use various software filters to eliminate instrument artifacts, and false alarms due to the proximity of bright, saturated stars which dominate the initial detection rate. This leaves up to a couple of hundred asteroids and genuine transients. Previously known asteroids are flagged through an automated comparison with a databases of known asteroids, and new ones through apparent motion. In the end, we have typically ~ 10 20 astrophysical transients remaining per night, and we are currently working on their automated classification, and spectroscopic follow-up.

We present preliminary results from real-time follow-up of a few candidates carried out with the Palomar 200-inch telescope as part of a pilot project. Finally we outline the plans for the much harder problem of classifying the transients more accurately for distribution through VOEventNet to astronomers interested only in specific types of transients, more details and overall setting of which is covered in our VOEventNet poster (Drake et al.)

078.06

SEDBuilder: A Federating Tool for the Virtual Observatory

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Tools are needed to federate the many data resources found in the Virtual Observatory (VO), allowing for increased productivity for VO users. We present our tool, SEDBuilder, which is a basic spectral energy distribution (SED) creation and fitting application. SEDBuilder performs an instantaneous search of VO resources, including SkyNodes (e.g. SDSS, 2MASS, FIRST/NVSS) and web-based catalogs such as Vizier as well as extracting photometry from image cutouts, federates the resulting positional matches into a broad band SED, and return a bolometric luminosity and fit parameters. Various functional forms are implemented to allow users to model stars, galaxies or AGN. Redshifts or distances can be passed, in which case a luminosity is returned. In the absence of distance information integrated fluxes are returned. In all cases the user is returned a table of fluxes as well as the necessary curation metadata.

078.07

Status of the CDS Services, SIMBAD, VizieR and Aladin

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[1]Obs. de Strasbourg, France, [2]LSIIT, France, [3]LAT, France, [4]GRAAL, France.

Major evolutions have been implemented in the three main CDS databases in 2006.

SIMBAD 4, a new version of SIMBAD developed with Java and PostgreSQL, has been released. Il is much more flexible than the previous version and offers in particular full search capabilities on all parameters. Wild card can also be used in object names, which should ease searching for a given object in the frequent case of 'fuzzy' nomenclature. New information is progressively added, in particular a set of multiwavelength magnitudes (in progress), and other information from the Dictionnary of Nomenclature such as the list of object types

attached to each object name (available), or hierarchy and associations (in progress).

A new version of VizieR, also in the open source PostgreSQL DBMS, has been completed, in order to simplify mirroring. The master database at CDS currently remains in the present Sybase implementation. A new simplified interface will be demonstrated, providing a more user-friendly navigation while retaining the multiple browsing capabilities.

A new release of the Aladin Sky Atlas offers new capabilities, like the management of multipart FITS files and of data cubes, construction and execution of macros for processing a list of targets, and improved navigation within an image plane. This new version also allows easy and efficient manipulation of very large ($>10^8$ pixels) images, support for solar images display, and direct access to SExtractor to perform source extraction on displayed images.

078.08

An Implementation of the VO Spectrum Model

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The CfA Virtual Observatory SED Library is a set of Java classes that are intended to be a common and general way for the VO community to store spectral energy distributions, spectra, and time series data with their associated metadata. The library is an implementation of the IVOA Spectrum Data Model Recommendation. Functionality includes serializing and deserializing the supported file formats into and out of the Spectrum Data Model classes. These file formats include FITS, VOTable, and XML. This common way to store and deliver spectrum data allows various archives to interoperate with each other. Additionally, basic plotting of Flux versus Spectral Coordinate is provided. The library is open source and available for download from http;//vo.cfa.harvard.edu. This work is supported by the NSF under the NVO project.

078.09

How to Find More Supernovae with Less Work: Object Classification Techniques for Difference Imaging

Stephen J. Bailey[1], G. Aldering[1], C. Aragon[1], S. Bongard[1], M. Childress[1], S. Loken[1], P. Nugent[1], S. Perlmutter[1], K. Runge[1], R. Scalzo[1], R. Romano[1], R. Thomas[1], B. Weaver[1], C. Baltay[2], A. Bauer[2], D. Herrera[2], D. Rabinowitz[2], E. Pecontal[3], G. Rigaudier[3], P. Antilogus[4], S. Gilles[4], R. Pain[4], R. Pereira[4], C. Buton[5], Y. Copin[5]
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We present the results of applying new object classification techniques to difference images in the context of the SNfactory supernova search. Most current supernova searches subtract reference images from new images, identify leftover objects, and apply simple threshold cuts on parameters such as statistical significance, shape, and motion to reject backgrounds such as cosmic rays, asteroids, and subtraction artifacts. This leaves a large number of non-supernova candidates which must be verified by human inspection before triggering additional followup.

In comparison to simple threshold cuts, more sophisticated methods such as boosted decision trees, random forests, and support vector machines provide dramatically better signal/background discrimination. At the SNfactory, we reduced the number of background candidates by a factor of 10 while increasing our supernova identification efficiency. Methods such as these will be crucial for handling the large data volumes produced by upcoming projects such as PanSTARRS and LSST.

078.10

Arecibo Observatory and the National Virtual Observatory

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The United States Virtual Observatoryw as established in 2001 to provide worldwide access to data acquired by U.S. observatories, including Arecibo Observatory at the National Astronomy and Ionosphere Center in Puerto Rico. Arecibo's 7-element L-band Feed Array (ALFA) is being used to survey line and continuum radiation over large areas of the 21cm-wavelength sky. Two surveys were the focus of this project: the Galactic interstellar medium HI 21cm line survey (GALFA) and the Arecibo Galaxy Environment HI Survey (AGES). Both surveys are producing large volumes of data in ''cubes'' of intensity as a function of right ascension, declination, and line-of-sight doppler velocity. An essential objective of both GALFA and AGES is to make the data available over the World Wide Web. This will require a user interface that returns the appropriate cube for a given set of coordinates, or computes a new cube on the fly covering a desired coordinate range. To implement this service, computationally efficient processing

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and serving methods are required. This presentation will discuss the current methods used for remote data access as well as new methods that can be used to analyze data cubes online with web tools.

This work has been supported by the Research Experiences for Undergraduates program of the National Science Foundation and by the National Astronomy and Ionosphere Center operated by Cornell University under Cooperative Agreement with the NSF.

078.11

Moletai Meeting on CCD Strömvil Photometry

A. G. D. Philip[1], R. P. Boyle[2], R. Janusz[2]
[1]ISO and Union College, [2]Vatican Observatory.

In August/September 2006, after the IAU meetings in Prague, a group of us met for two weeks at the Moletai Observatory, in Lithuania. Attending the meeting were the three authors, Olga Pintado from Argentina and the Lithuanian group, headed by Vytas Straižys. We started the meeting with a series of papers given by each member of the group. The first papers dealt with the creation of the Strömvil System, the next papers concerned the reduction of data and the calibration of the system. The final paper session reviewed the CommandLog, written by Janusz and Boyle. The CommandLog allows one to paint IRAF commands into the IRAF window and this ensures that all members of our group will reduce the photometric data in exactly the same way. For the rest of the meeting the group used the CommandLog to reduce photometric data. The Lithuanian group had not used this method up to now so Janusz and Boyle instructed them on the use of the CommandLog. CCD data from the Maksutov telescope at Moletai was reduced and gave good results. Janusz, Philip and Pintado worked on CCD data obtained on the 2.15 M telescope at Casleo in July. They confirmed earlier reductions made at Castel Gandolfo last year that the white spot on the dome gave flat frames that needed no corrections.

078.12

Bayesian Source Separation for PAH Spectra

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[1]NASA/Ames Research Center, [2]University of Albany (SUNY), [3]University at Albany (SUNY).

The Aromatic Infrared Bands (AIBs) are prominent features of many galactic spectra in the infrared and are strongly associated with star-forming regions. Polycyclic Aromatic Hydrocarbons (PAHs) are a leading contender as the source for this emission. Unequivocally establishing this identification has been difficult since the AIBs do not appear to be the result of emission from a small, tractable number of PAHs. Rather the observed emission bands appear to be composed of the contributions from possibly hundreds of different PAHs, neutral and ionized, each with its own distinctive spectrum. A major step toward verifying the PAH hypothesis would be to quantitatively establish how well the observed AIBs can be explained, or not explained, as the combination of known PAH spectra. To date this problem has been attacked by either manually superimposing individual PAH spectra or by using non-negative least squares. We explain how both of these approaches have serious deficiencies.

We then describe our progress in applying Bayesian source separation techniques to this difficult problem. In this phase of our investigation, we have worked with theoretically generated PAH spectra at a single temperature composed of combinations of arbitrarily selected PAHs with added Gaussian noise. First, we show how the non-negative least squares approach fares as a function of PAH composition, noise level, and spectral resolution. Next, we outline our Bayesian approach, which relies on Skilling's nested sampling algorithm. This approach allows us to find highly probable solutions and evaluate the uncertainties in our estimates by sampling the posterior. Moreover, this algorithm also enables us to compute the evidence provided by the data as well as visualize the posterior probability in the high-dimensional hypothesis space generated by the numerous combinations of possible PAH contributions.

This research is supported by NASA Applied Information Systems Research Grant 05-AISR05-0143.

079: Cool dwarfs
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

079.01

Spitzer Observations of Substellar Companions

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Since the discovery of the first brown dwarf, hundreds of such substellar objects have been identified. Although their existence has been confirmed, the determination of many fundamental properties of brown dwarfs is still an ongoing process. Luminosity and mass are two parameters that are difficult to determine without a known distance and age, yet are critical to our fundamental understanding of substellar evolution. We present a study of a small sample of known brown dwarf companions of main sequence stars using the Spitzer Space Telescope. The brown dwarfs in our study range from early to late L with a wide age range and are companions of primary stars having known distances and ages. Using the measured fluxes from 2MASS to mid-infrared wavelengths (1 24 microns) along with the known quantities of the primary stars (age and distance), we will present SEDs and bolometric luminosities that can be compared to theoretical model predictions.

This work is part of the Visiting Graduate Student Fellowship Program at the Spitzer Science Center, California Institute of Technology.

079.02

Activity and Kinematics of Ultracool Dwarfs Including Flare Observations

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We present an analysis of the activity and kinematics of a volume-limited (20 pc) sample of over 150 M and L dwarfs photometrically selected from the Two Micron All Sky Survey (2MASS). We calculate tangential velocities from new proper motion measurements and spectrophotometric distance estimates. These kinematic data are combined with spectroscopic observations of H_alpha emission to investigate possible age/activity relations for low-mass stars and brown dwarfs. We also use our sample to investigate the variability of ultracool dwarfs. Eleven dwarfs out of 153 show evidence of variability, ranging from small fluctuations to large flare events. We estimate a flare cycle of 5% for late-M dwarfs and 2% for L dwarfs, assuming all dwarfs in each spectral type are equally likely to flare. Data for two flare observations are presented an amazing flare event on the the M7 dwarf 2MASS J1028404-143843 and strong, variable activity on the L1 dwarf 2MASS J10224821+5825453.

079.03

Discovery of a Nearby, Very Young L Dwarf

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We present the discovery of an unusual late-type L dwarf that, at a suspected distance of 6.0 pc, may be the second closest L dwarf to the Sun. We display a nearly complete 0.8-4.1 um spectrum of this object and compare it to the spectra of normal late-L dwarfs. The comparison demonstrates its many peculiarities -a triangular-shaped H-band peak, an extremely red J-Ks color, and excess flux at L-band -which we attribute to low gravity. The low gravity implies a young age of between a few Myr and a few tens of Myr. At such a young age and with such a late spectral type, its mass may lie below the deuterium burning limit, M<13M_Jup. We also present kinematic data in an attempt to associate this object with one of the young, nearby stellar associations such as beta Pic, TW Hya, AB Dor, and Tucana-Horologium. This object's proximity to earth, late spectral type, and solitary nature make it an excellent benchmark in the study of low-temperature, young brown dwarfs.

079.04

A Custom Near-IR Filter for Finding Young Brown Dwarfs

Katelyn N. Allers[1], M. Liu[1]
[1]*Univ. Of Hawaii.*

We present design analysis of a custom near-IR filter for use with ULBCAM on the UH 2.2-m telescope, which in combination with broad-band J and H band photometry, can be used to determine the spectral type of M and L type objects. Our filter is centered on the 1.45 micron steam absorption feature seen prominently in the spectra of M and L type objects, and is predicted to determine spectral type, independent of gravity and reddening, to within one subtype. For identifying young brown dwarfs in star-forming regions, our filter will greatly reduce the number of contaminant field dwarfs, giants, and extragalactic objects, thereby increasing the efficiency of spectroscopic followup by a factor of 2 to 8 over existing photometric selected samples. Unlike existing photometric surveys for young brown dwarfs, the number of contaminant objects for a sample of candidates selected with our filter should not increase for fainter magnitudes. This will allow us to accurately determine the low-mass IMF in star-forming regions.

079.05

Recent Results of the NIRSPEC Brown Dwarf Spectroscopic Survey

Emily L. Rice[1], I. S. McLean[1], L. Prato[2], M. R. McGovern[3], A. J. Burgasser[4], J. Kirkpatrick[5], S. S. Kim[6]
[1]*UCLA,* [2]*Lowell Observatory,* [3]*Antelope Valley College,* [4]*MIT,* [5]*IPAC/Caltech,* [6]*Kyung Hee University, Republic of Korea.*

The NIRSPEC Brown Dwarf Spectroscopic Survey (BDSS) began in 1999 with the commissioning of NIRSPEC on Keck II. In the first phase of the survey, J-band spectra of 53 objects covering all spectral types from M6 to T8 were obtained at a resolving power of R~2000 (McLean et al. 2003). This poster presents results from the second phase of the survey, which focused on high-resolution (R~20,000) J-band observations for a sample of 16 very low mass stars and brown dwarfs from M2.5 to T6 (McLean et al. 2006, submitted). By comparing opacity plots and line lists to the high-resolution spectra we identify hundreds of FeH, H2O, and atomic features and analyze how these features change with spectral type. We also begin to explore the apparently complex dependence of spectral features on the metallicity and surface gravity of brown dwarf atmospheres, which is the topic of the current phase of the BDSS. Data presented herein were obtained at the W.M. Keck Observatory, which is operated as a scientific partnership among the California Institute of Technology, the University of California and the National Aeronautics and Space Administration. The Observatory was made possible by the generous financial support of the W.M. Keck Foundation.

080: COSMOS
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

080.01

The Luminosity Function of COSMOS Radio Sources

Timothy Paglione[1], V. Smolcic[2], E. Schinnerer[2], K. Salvador[3], P. Ciliegi[4], M. Bondi[4], S. Tribiano[5]
[1]*CUNY-York College,* [2]*MPIA, Germany,* [3]*AMNH,* [4]*INAF, Italy,* [5]*CUNY-BMCC.*

The luminosity function (LF) is a powerful tool for studying galaxy populations and evolution. We present the LF of the radio sources from the VLA-COSMOS catalog. The sensitivity limit of VLA-COSMOS only 0.04 mJy allows us to probe the fainter, presumably star-forming galaxies often undetected by large area surveys. The accompanying COSMOS optical catalog, which provides photometric redshifts and galaxy spectral types, allows us to estimate the luminosities of a large sample (2,647) of radio sources and to compare their radio properties with galaxy type. We examine a very broad range of luminosities, $18 < \log P < 25.5$, where P is the total 1.4 GHz luminosity in W/Hz/sr. We have photometric redshifts up to $z = 2.97$ and spectroscopic redshifts up to 1.87. The COSMOS radio LF is consistent with the 2dFGRS radio LF, and shows contributions from both AGN and star-forming spirals. The available spectroscopic redshifts are mostly for sources selected for their likely AGN activity (X-ray and radio emission), but our LF derived using them is consistent with that of the photometric sample given a higher fraction of active galaxies rather than spirals. The 1/Vmax method we use to calculate the LF is known to show bias for clustered fields, so we also measure the correlation function to measure this effect. Though not as strongly clustered as early type galaxies, the amplitude of the VLA-COSMOS correlation function is higher than that of the NVSS and FIRST sources. This result is consistent with those of the optical clustering in the COSMOS field. We have studied the effects of the radio spectral index (the K-correction) on the LF as well, and investigate the possible evolution of the population. We are examining methods to distinguish between the star-forming galaxies and the AGN to track their evolution separately.

080.02

The Faint End Slope Of Starburst Galaxy Luminosity Functions In The COSMOS 2-Square Degree Field

Charles Liu[1], P. Capak[2], B. Mobasher[3], T. A. Paglione[4], R. M. Rich[5], N. Z. Scoville[2], S. M. Tribiano[6], N. Tyson[7], COSMOS Collaboration
[1]*CUNY College of Staten Island,* [2]*Caltech,* [3]*STScI,* [4]*CUNY York College,* [5]*UCLA,* [6]*CUNY BMCC,* [7]*AMNH.*

We examine the faint-end slope of the V-band luminosity function, to $M < -14$, of strongly star-forming galaxies of galaxy spectral type Scd and bluer with redshift $z < 0.5$, using a sample of 20,620 galaxies in the Cosmic Evolution Survey (COSMOS) field. The steepness of the faint-end slope for the redshift range $0.02 < z < 0.1$ for these galaxies is $\alpha \sim -1.05$; it is sharply steeper, however ($\alpha \sim -1.46$), for galaxies of only the bluest starburst types. For the redshift range $0.1 < z < 0.5$, the faint-end slope is consistent with, or slightly shallower than, these values. These results are consistent with previous studies of the luminosity function of strongly star-forming galaxies.

080.03

The COSMOS Survey: New Data Releases

Patrick L. Shopbell[1], P. Capak[1], N. Scoville[1], COSMOS Team
[1]*Caltech.*

The Cosmic Evolution Survey (COSMOS) is a survey designed to probe the formation and evolution of galaxies as a function of redshift and large scale structure environment. The survey covers a 2 square degree equatorial field with imaging by most of the major space-based telescopes (Hubble, Spitzer, GALEX, XMM, Chandra) and a number of large ground-based telescopes (Subaru, VLA, ESO-VLT, UKIRT, NOAO, CFHT, and others). These data and the associated catalogs are made publicly available per a comprehensive data release schedule. This poster provides an overview of the data currently available from the COSMOS Archive (maintained at IRSA), and presents a number of new data products being released at this meeting. These new data include submillimeter imaging, newly revised HST ACS and NICMOS imaging, updated GALEX cycle 2 data, and deeper XMM imaging from cycle AO4. New to the COSMOS archive are a number of catalogs as well, including an object catalog produced from the core HST ACS imaging and our primary photometry catalog, produced from deep multiband ground-based observations. All of these data are available through the COSMOS public archive at http://irsa.ipac.caltech.edu/data/COSMOS/.

080.04

A Multiwavelength Study of Millimeter Galaxies in the Bolocam-COSMOS Survey

James E. Aguirre[1], Bolocam-COSMOS Collaboration
[1]NRAO Jansky Fellow at the University of Colorado, Boulder.

We present a multiwavelength study of galaxies detected in a 1.1 mm Bolocam survey of the center 940 square arcminutes of the COSMOS HST Treasury field. The Bolocam survey reached an RMS noise level (filtered for point sources) of 1.9 mJy/beam. We compare the detections with overlapping AzTEC and MAMBO surveys, and examine the radio to X-ray properties of these galaxies using the rich datasets available in the field. Particular attention is given to Spitzer IRAC and MIPS counterparts from the S-COSMOS survey.

080.05

The VLA-COSMOS 1.4 GHz Survey: The Properties of the Faint Radio Population and Star Formation Rates

Vernesa Smolcic[1], E. Schinnerer[1], C. Carilli[2], M. Scodeggio[3], P. Franzetti[3], K. Jahnke[1], A. Martinez-Sansigre[1], M. Salvato[4], G. Zamorani[5]
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Radio observations have important advantages in determining the star formation history of the universe, in particular there is no need for uncertain dust-extinction corrections. Radio (synchrotron) emission at 1.4 GHz (20 cm) is dominated by the emission from active-galactic nuclei (AGN) and star-forming (SF) galaxies, hence a reliable SF/AGN separation is one of the main pre-requisites for a robust determination of star-formation rates utilizing radio-data. Although there have been suggestions that the faint end (below fluxes of 1 mJy) of the 1.4 GHz source counts may be dominated by SF galaxies, the exact composition of the faint radio population is still controversial. The VLA-COSMOS survey with ~3,600 detected radio sources at 1.4 GHz, with 1.5″ resolution and high sensitivity (rms = 10 micro Jy), provides enough targets to allow for a robust systematic characterization of the 'cosmological mix' of faint radio sources. Utilizing the entire COSMOS multi-wavelength (X-ray to radio) data set, we present a method that separates the radio population into SF galaxies and AGN. Our results indicate that SF galaxies are not the dominant radio population at faint flux densities ($<$1 mJy), but rather have a fairly constant contribution with decreasing fluxes. Selecting the SF galaxies within the VLA-COSMOS population, we derive their star formation rates and present the cosmic star-formation history out to z=1, for the first time based on radio observations of a large, contiguous field with unprecedented sensitivity.

080.06

The Chandra COSMOS Survey

Martin Elvis[1], C-COSMOS Team
[1]Harvard-Smithsonian CfA.

The 1.8 Msec Chandra COSMOS Survey is the largest Chandra GO program awarded to date. COSMOS is a pan-chromatic survey of the extragalactic sky designed to be both large and deep enough to study galaxy and quasar evolution in typical environments with minimal 'cosmic bias'. The location of COSMOS near the equator (10h +02deg) allows all major and future facilities (esp. EVLA, ALMA) to target this 2 sq. deg.region. Both space HST, Spitzer, GALEX, XMM and ground-based VLA, Subaru, CTIO, KPNO, CFHT, Magellan, VLT have already surveyed the area to faint limits. The central region of the COSMOS field is now the target of deeper surveys by the VLA and VLT, and proposed for GALEX and VISTA.

The Chandra COSMOS Survey (C-COSMOS) to be carried out 2006/2007 will cover the central area of the COSMOS field to ~2e-16 cgs (0.5-2keV) with a series of 36 heavily overlapped ACIS-I 50 ksec pointings, giving a total exposure of 200 ksec over ~0.8 sq. deg. This overlap gives uniform exposure over the whole area.

By going for area over extreme depth, C-COSMOS sources will typically be bright enough to be also detected in the rest of the COSMOS data set, allowing ready follow-up of their multi-wavelength their properties. The depth of C-COSMOS was chosen to 'break through' the flux level where the AGN creating the bulk of the X-ray background dominate, and so detect significant numbers of starburst galaxies, up to redshifts ~0.9, comparable with the depth of the COSMOS galaxy surveys. The ~20,000 galaxies with VLT redshifts can be studied by 'stacking'.

We will show the early data from C-COSMOS, the data analysis approach, and discuss the main science objectives.

This work is supported in part by a NASA Grant, number TBD.

081: Disks Later in Life
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

081.01

Mid-infrared Spectra of PAH Emission in Herbig AeBe Stars

Luke D. Keller[1], G. C. Sloan[2], S. Shah[1], N. Chitrakar[1], W. J. Forrest[3], B. Sargent[3], D. M. Watson[3], A. Li[4], J. Najita[5], C. H. Chen[5], J. D. Green[3], T. F. Herter[2], P. D'Alessio[6], N. Calvet[7], L. Hartman[7], J. R. Houck[2]
[1]Ithaca College, [2]Cornell University, [3]University of Rochester, [4]University of Missouri, [5]NOAO, [6]UNAM, Mexico, [7]University of Michigan.

We present spectra for 20 Herbig Ae and Be stars obtained with the Infrared Spectrograph (IRS) on the Spitzer Space Telescope. All objects show emission from polycyclic aromatic hydrocarbons (PAHs), most very strong. Five of the spectra show strong PAH emission but no silicate emission at 10 microns. The PAH ionization fraction is higher for systems in our sample with hotter, brighter central stars. Our sample includes both flared and flattened/settled disk systems, but the overall PAH emission is not negatively correlated with independent indicators of dust settling or disk flattening. Our objects show a remarkable variety of PAH luminosities and ionization fractions, but very similar PAH spectral classifications based on positions of major PAH feature centroids. This may indicate that the PAH molecules are altered by the same physical processes in Ae/Be disks but to varying degrees. It may be that the PAH spectra indicate very little processing of the PAH molecules implying that the PAH are relatively new to the scene in Ae/Be disks. Finally, we see no strong correlations of PAH luminosity with stellar evolutionary stage from system to system.

081.02

Spectroscopy of the Post-AGB Disk around HR 4049

Kenneth H. Hinkle[1], S. D. Brittain[2], D. L. Lambert[3]
[1]NOAO, [2]Clemson University, [3]University of Texas.

High-resolution infrared spectroscopy in the 2.3-4.6 μm region is reported for the peculiar star HR 4049. HR 4049 has severe depletion of refractory elements but solar abundances of volatile elements suggesting a winnowing process. Lines from the CO fundamental and first overtone, OH fundamental, and several H_2O vibration-rotation transitions have been observed in the near-infrared spectrum. The spectrum of HR 4049 appears in emission through the 3 and 4.6 μm region and in absorption in the 2 μm region. The 4.6 μm spectrum shows a rich 'forest' of emission lines. All the spectral lines observed in the 2.3-4.6 μm spectrum are shown to be circumstellar in origin. The presence of OH and H_2O lines confirm the oxygen-rich nature of the circumstellar gas. HR 4049 has an oxygen-rich circumbinary disk surrounded by a carbon-rich circumstellar shell. The emission and absorption line profiles show that the gas is located in a thin, rotating layer near the circumbinary dust ring. In addition to rotation, gas in the ring is also flowing outward with a velocity of at least 1 km s^{-1}. A model is described where the gas is driven from the grains in a winnowing process producing the observed surface abundances. Contrary to prior reports, the HR 4049 carbon and oxygen isotopic abundances are typical for an AGB or post-AGB star. $^{12}C/^{13}C=9\pm6$ and $^{16}O/^{17}O>200$. Assuming that the binary orbit is coplaner with the disk, the mass of the post-AGB star is 0.58 solar mass and the mass of the unseen companion is 0.34 solar mass.

081.03

Periodic Variations in the Emission Lines of Zeta Tauri

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[1]Univ. of Missouri-Rolla, [2]Univ. of Toledo.

The emission lines of Be stars are usually double peaked due to the rotation of the circumstellar disk. Zeta Tauri exhibits this feature in both the Hα and Fe II lines, with the V/R ratio of the peaks varying periodically due to different density regions in the disk. At certain times the Hα emission becomes triple peaked, a phenomenon yet to be completely explained. A spiral shaped disk has been proposed as a model that can explain the triple peak in the Hα emission. To attain a better picture of the disk structure, we investigate the behavior of the Hα, Fe II, and He I lines of Zeta Tau. The observations span from 1997 to 2006, and were taken at the Ritter Observatory at the University of Toledo.

This research was supported by the REU program at the University of Toledo, with funding provided by the NSF.

081.04

Be Star Spectra: Disk Variability and Radial Velocity Variations

Erika Grundstrom[1], D. R. Gies[1], T. S. Boyajian[1], S. J. Williams[1], D. W. Wingert[1]
[1]Georgia State Univ..

Using a sample of 135 Be stars, we present an analysis of spectra taken at the Kitt Peak National Observatory 0.9m Coude Feed telescope in 2004, 2005 and 2006. First we show examples of disk variability over the course of our observations through changes in emission line strength and shape. Second, we describe our analysis of radial velocity variations for evidence of binarity.

081.05

Probing the Circumstellar Disks of Be Stars with Contemporaneous Optical and IR Spectroscopy

Karen S. Bjorkman[1], E. N. Hesselbach[1], J. P. Wisniewski[2], J. E. Bjorkman[1]
[1]Univ. of Toledo, [2]NASA GSFC.

Asymmetric double-peaked hydrogen emission line profiles in classical Be stars have been interpreted as evidence of one-armed density waves in the circumstellar disks. Contemporaneous optical and IR spectroscopy can aid in mapping the density structure of these one-armed waves as a function of radius. Furthermore, variability has been detected in these stars over both short (days to weeks) and longer (months) time-scales. We present preliminary results from contemporaneous Ritter Observatory (Hα) and IRTF SpeX (0.8-5.4 μm) spectroscopy of 16 classical Be stars observed in September 2005 and January 2006. The data illustrate a range of line profiles common in Be stars and show significant variability. These observations are the first of a larger project to utilize combined optical and IR data to investigate the physical details of these circumstellar disks.

This research has been supported in part by a NASA GSRP fellowship to JPW, a NASA LTSA grant to KSB, and an NSF grant to JEB. We thank the NASA IRTF for observing time allocations and support. We thank the Ritter observing team, and especially Nancy Morrison, for crucial assistance with the supporting optical observations.

081.06

Mid-Infrared Spectra of Circumsteller Dust Debris around Main-sequence A and Late B Type Stars

Farisa Morales[1], M. Werner[1], G. Bryden[1], C. Beichman[1], K. Su[2], G. Rieke[2]
[1]JPL/Caltech, [2]U of A.

We report spectra obtained with the IRS on board Spitzer Space Telescope in the 5-35 micron range of 15 nearby main-sequence A and late B type stars which have photometric excesses at 24 and 70 microns as measured by Spitzer's MIPS instrument. Prominent spectral features are rare, suggesting that the bulk of the emitting particles have diameters larger than 10 microns. The principal results are: (1) In many cases, the excesses extend below 10 microns, thus overlapping the terrestrial planet zone around these stars. (2) For several stars, the entire excess out to 70 microns can be well-fit by a single power law F(nu)~lambda^n, with n in the range 0.8 to 1.25; in several others, by a single black body continuum with T~200 K. (3) The other stars show composite spectral energy distributions.

This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

082: Formation and Detection of Habitable Planets
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

082.01

Is the Binary-Planetary System of Gamma Cephei Dynamically Full?

Joseph Castro[1], N. Haghighipour[1]
[1]Institute for Astronomy, University of Hawaii.

Gamma Cephei is a spectroscopic binary consisting of a 1.59 solar-mass K1 IV subgiant primary star and a 0.34-0.92 solar-mass red giant secondary star. The primary of this system is host to a 1.7 Jupiter-mass planet at approximately 2.1 AU and with an eccentricity of 0.12. Numerical simulations were carried out on the dynamical stability of additional hypothetical planets located 3 to 5 AU from the primary star. To ensure a comprehensive search, various values for the mass, eccentricity, and inclination of the additional Jupiter-like planets were used. Similar simulations were also carried out for possible Saturnand Neptune-like planets within the same range. Results indicate that Gamma Cephei appears to be dynamically full and no stable orbits of any additional planets were found.

This work was conducted by an NSF funded Research Experience for Undergraduates (REU) position for J.C. at the University of Hawaii's Institute for Astronomy. Support for N.H. by the NASA Astrobiology Institute under Cooperative Agreement NNA04CC08A at the Institute for Astronomy at the University of Hawaii-Manoa, is also acknowledged.

082.02

Habitable Planetary Systems (un)like our own: Which of the Known Extra-Solar Systems Could Harbor Earth-like Planets?

Sean Raymond[1], A. Mandell[2], S. Sigurdsson[2]
[1]Univ. of Colorado, [2]Pennsylvania State University.

Gas giant planets are far easier than terrestrial planets to detect around other stars, and are thought to form much more quickly than terrestrial planets. Thus, in systems with giant planets, the final stages of terrestrial planet formation are strongly affected by the giant planets' dynamical presence. Observations of giant planet orbits may therefore constrain the systems that can harbor potentially habitable, Earth-like planets. We combine two recent studies (1,2) and establish rough inner and outer limits for the giant planet orbits that allow terrestrial planets of at least 0.3 Earth masses to form in the habitable zone (HZ). For a star like the Sun, potentially habitable planets can form in systems with relatively low-eccentricity giant planets inside 0.5 Astronomical Units (AU) or outside 2.5 AU. More than one third of the currently known giant planet systems could have formed and now harbor a habitable planet.

We thank NASA Astrobiology Institute for funding, through the Penn State, NASA Goddard, Virtual Planetary Laboratory, and University of Colorado lead teams.

(1. Raymond, S.N., 2006, ApJ, 643, L131.; 2. Raymond, S.N., Mandell, A.M., Sigurdsson, S. 2006, Science, 313, 1413).

082.03

Laboratory demonstration of coronagraph imaging for the detection of Earth-like planets

John T. Trauger[1], W. A. Traub[1]
[1]JPL.

The detection and characterization of exoplanets around nearby stars is the main objective of several proposed space missions. The development of viable concepts will require the laboratory demonstration of optical wavefront correction and diffracted light suppression to the levels needed to detect Solar-System-like planets at visible wavelengths. Our laboratory setup captures the essential optical features of a space coronagraph. A band-limited coronagraph configuration was used, actively corrected with a single deformable mirror (DM) and a speckle nulling algorithm at the final image plane. The entire optical system is enclosed in a space-like vacuum environment.

We report the suppression of background speckles to contrast levels of 6×10^{-10} compared to the occulted central star, over a field of view extending in angle from 4 to 10 λ/D from the star, and with wavefront correction stable to the required levels over periods of hours. We illustrate the use of multiple images from the laboratory to push the detection levels to below 10^{-10}. These demonstrations were carried out in narrowband light, representing a big step in the right direction, but more work remains. Ongoing laboratory work is focused on broadening the spectral bandwidth, suppressing speckles simultaneously on both sides of the star with a pair of DMs, and increasing the radial field of view, both inward and outward. The present work lays the groundwork for the development of future missions that will, for the first time, explore nearby exoplanet systems by direct imaging and spectroscopy.

083: Galactic and Extragalactic Surveys Using AzTEC AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

083.01

AzTEC: A New Millimeter-Wave Camera

Jason Austermann[1], P. A. Ade[2], J. J. Bock[3], J. Glenn[4], S. R. Golwala[5], S. Kim[6], P. D. Mauskopf[2], T. A. Perera[1], C. R. Predmore[7], C. Roberts[1], K. S. Scott[1], G. W. Wilson[1]
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AzTEC is a large-format bolometer array camera developed at the University of Massachusetts, Amherst, and will serve as one of the first facility instruments of the Large Millimeter Telescope (LMT). AzTEC's detector array is comprised of 144 silicon nitride micromesh bolometers with a band-pass defined through a series of changeable filters and coupling optics. AzTEC was recently commissioned at 1.1 millimeters on the James Clerk Maxwell Telescope (JCMT) and successfully completed its first science-grade observing run in the winter 2005/2006. We experienced excellent performance throughout the run, with a median raw per-pixel sensitivity to point-like sources of 14 mJy $\sqrt{s}$. We present the instrument design and achieved specifications, as well as the nature of AzTEC data and its format. We also discuss calibration and observing strategies for using the AzTEC instrument.

083.02

Optimizing AzTEC Data Reduction for Extracting Point-like Objects

Thushara Perera[1], J. Austermann[1], C. Battersby[1], C. Roberts[1], K. S. Scott[1], G. W. Wilson[1], M. S. Yun[1]
[1]Univ. Of Massachusetts Amherst.

Because of its 1.1-mm observing band and ~18 arcsecond FWHM angular resolution, the AzTEC instrument is well suited for conducting untargeted surveys of high-redshift sub-mm galaxies. For such surveys, which comprise the majority of 2005/2006 observations, data reduction methods as well as observing strategies were tailored to maximize sensitivity to point sources. We describe first the choice of aggressive observing strategies that allowed us to map large areas of sky at high sensitivity (about 1 square degree overall with ~1 mJy flux limit). Then we briefly outline the method used for removal/mitigation of atmospheric and instrumental drifts from time-stream data as well as a time and memory efficient pipeline for eventually combining the results of several observations into one map. Finally, we describe a quick filtering technique for reliably extracting point-source fluxes and their uncertainties.

083.03

AzTEC Observations of the SHADES Fields

Kimberly S. Scott[1], AzTEC/SHADES group
[1]Univ. Of Massachusetts.

We report the results of our 1.1 mm imaging of the SCUBA HAlf Degree Extragalactic Survey (SHADES) with AzTEC. The goal of the SHADES project was to map 0.5 square degrees to an 850 micron rms of ~2 mJy with SCUBA, dividing the survey equally between two regions of sky: the Lockman Hole East (LH) and the Subaru/XMM-Newton Deep Field (SXDF). Nearly 50% of the survey area had been imaged when SCUBA was decommissioned in late 2005. We surveyed the full SHADES field using AzTEC at the James Clerk Maxwell Telescope to a 1.1 mm depth of ~1.1 mJy and ~1.4 mJy for the LH and the SXDF fields, respectively. We present the AzTEC/SHADES maps and discuss the overlap between the 1.1 mm and 850 micron source catalogues.

083.04

The Star Formation History of SHADES Sources

Itziar Aretxaga[1], SHADES consortium and AzTEC team
[1]INAOE, Mexico.

We present the redshift distribution of the SHADES 850um selected galaxy population based on the rest-frame radio-mm-FIR colours of 120 robustly detected sources in the Lockman Hole East (LH) and Subaru XMM-Newton Deep Field (SXDF). The redshift of sources constrained with at least two photometric bands peaks at z ~ 2.4 and has a near-Gaussian distribution. The inclusion of sources detected only at 850um, for which only very weak redshift constraints are available, leads to the possibility of a high-redshit tail. We find a small difference between the redshift distributions in the two fields; the SXDF peaking at a slightly lower redshift than the LH, which we mainly attribute to the noise properties of the photometry used. We discuss the impact of the AzTEC data on the further precission of these results. Finally we present a brief comparison with sub-mm galaxy formation models and their predicted and assumed redshift distributions and derive the contribution of these sources to the star formation rate density at different epochs.

083.05

Milli-Jansky Sources in GOODS-N Detected with JCMT/AzTEC

James D. Lowenthal[1], I. Aretxaga[2], J. Austermann[3], E. Chapin[4], K. Coppin[4], M. Crowe[4], L. Frey[4], A. Gibb[4], M. Halpern[4], D. H. Hughes[2], T. Perera[3], A. Pope[4], D. Scott[4], K. Scott[3], G. Wilson[3], M. S. Yun[3]
[1]Smith College, [2]INAOE, Mexico, [3]University of Massachusetts, [4]University of British Columbia, Canada.

We have recently obtained with JCMT/AzTEC a 10x15 arcmin map of the GOODS-N field at 1.1 mm to a sensitivity of about 1 mJy (1 sigma) -the deepest mm-wave ″blank sky″ map yet made. We have extensively tested and analyzed the signal and noise properties of the map. We detect more than 30 sources (to 3.5 sigma), many of them previously undetected. Like sub-millimeter galaxies studied with SCUBA, these sources are likely dominated by dusty starburst galaxies and/or AGN at high redshift (z>2). We present initial results from analysis of the source number counts and case-by-case correlation of our sources with those observed at other wavebands by SCUBA, Spitzer, Chandra, HST, VLA, and Keck. We briefly summarize the implications for our understanding of (sub-)millimeter galaxies at high redshift.

083.06

Nature of the 1100 Micron AzTEC-COSMOS Sources

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The Cosmic Evolution Survey (COSMOS) is a 2 square degree HST/ACS survey specifically designed to probe galaxy evolution as a function of time and environment (PI: N. Scoville). To take advantage of the extensive complementary databases already available through the COSMOS collaboration, we have undertaken a 1100 micron imaging survey of a 30' x 30' field centered just north of the earlier mm/submm surveys by the Bolocam on CSO and MAMBO on the IRAM 30-m telescope. In this poster paper, we will compare the results of the AzTEC and Bolocam surveys and discuss the nature of the AzTEC sources based on the existing multi-wavelength data in hand.

083.07

A 1.1mm AzTEC Survey Tracing Accelerated Galaxy Formation Towards a Protocluster at z~3.8

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Aztec has recently conducted a sensitive, wide-area (300 sq. Armin's) continuum survey at 1.1mm using the 15-m James Clerk Maxwell Telescope towards 4C41.17, a powerful high-redshift (z ~ 3.8) radio galaxy. These Aztec data, which cover an area >40 times larger than our previous SCUBA survey, reveal a significant over-density of luminous, massive dust-enshrouded galaxies, compared to the results from lower-redshift blank-field sub-mm surveys. One natural interpretation of these new AzTEC data is that the over-density is tracing a large (5 x 5 Mpc) ″proto-cluster″ structure at z~3.8 associated with the environment of 4C41.17, within which the formation of ultra-luminous starburst galaxies (with rest-frame FIR luminosities $>5 \times 10^{12}$ Lsun or SFRs > 500 Msun/yr) is taking place at an accelerated rate. Proving the physical association of these massive optically-faint starbursts with the environment of this high-z AGN, and not with the blank-field sub-mm population, for which 50% of the population lies at $1.9 < z < 2.9$, remains an outstanding problem. In this presentation we will describe the AzTEC survey, the empirical evidence for this protocluster structure in the early universe, and the planned multi-wavelength follow-up observations of the brightest AzTEC sources towards 4C41.17 that may demonstrate that we are witnessing accelerated galaxy formation, via an increased rate of merging gas-rich galaxies within a rapidly-developing gravitational potential. AzTEC is one of the suite of instruments destined for the 50-m Large Millimeter Telescope (LMT). We will conclude this presentation with a summary of future LMT observations that will trace the evolution of obscured star-formation in the dynamic environments towards a significant sample of intermediate and high-z powerful AGN with greater sensitivity and spatial resolution.

083.08

Joint Analysis of the Full AzTEC Sub-Millimeter Galaxy Data Set

Grant Wilson[1], P. Ade[2], I. Aretxaga[3], J. Austermann[1], J. Bock[4], D. Hughes[3], Y. Kang[5], S. Kim[5], J. Lowenthal[6], P. Mauskopf[2], T. Perera[1], K. Scott[1], M. Yun[1]
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Using the new AzTEC millimeter-wave camera on the James Clerk Maxwell Telescope (JCMT) in winter 2005/06, we conducted several surveys of the submm galaxy (SMG) population. The AzTEC 1.1 millimeter surveys include both blank-fields (no significant bias or foreground contamination) and regions of known over-densities, and are both large (100-1000 sq. arcmin.) and sensitive (~1 mJy rms). The unique power of the AzTEC data set lies not only in the size and depth of the individual fields, but in the combined surveyed area that totals over 1 square degree. Hundreds of new sub-millimeter sources have been detected. A joint analysis of all AzTEC surveys will provide important new constraints on many characteristics of the SMG population, including number counts, clustering, and variance. In particular, the large area of the full AzTEC data set provides the first significant measurement of the brightest and most rare of the SMG population. Herein we present the initial combined results and explore the future potential of a complete joint analysis of the full AzTEC SMG data set.

083.09

AzTEC Observations of 1.1 mm Emission from the Orion Nebula

Sungeun Kim[1], I. Aretxaga[2], J. Austermann[3], J. Bock[4], D. Hughes[2], J. Lowenthal[5], P. Mauskopf[6], T. Perera[3], K. Scott[3], G. Wilson[3], I. Yoon[3], S. Youn[1], M. Yun[3]
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We present a map of the OMC-1 region in the 1.1 mm emission observed with the AzTEC, a new large-format array composed of 144 silicon-nitride micromesh bolometers currently in use at the James Clerk Maxwell Telescope (JCMT). The Orion A molecular cloud is known to be the most important high-mass star-forming region in the Milky Way, and the OMC-1, located in the middle of the Orion A cloud, is especially important to structure the environment. The AzTEC observations of the OMC-1 at 1.1 mm reveal dozens of cloud cores and a tail of filaments in a manner almost identical to the submillimeter continuum emission at 450 and 850 mum of the entire OMC-1 region and coincide with the filaments of ammonia gas. The implication is that the direction of flow is likely to be away from the core of OMC-1 and the dust-clump structures correspond to Jean's length, i.e. thermal fragmentation of the dense filamentary material. With physical properties of the cores in the clumped structures in conjunction with the Spitzer images of the OMC-1, we will discuss new young core candidates which could harbor embedded young stellar objects. This research was supported in part by Korea Science & Engineering Foundation (KOSEF) under a cooperative agreement with the Astrophysical Research Center of the Structure and Evolution of the Cosmos (ARCSEC).

083.10

Constraints on the Star-forming Content of Extreme Molecular Cloud Environments using AzTEC

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We present the results of surveys in the mm continuum, using AzTEC at the JCMT, of two Galactic molecular clouds. These two regions have extreme and contrasting internal and external environments and the data place constraints on the efficiency with which the clouds are producing dense, potential star-forming structures.

084: Galactic ISM II
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

084.01

An Upper Limit on Anomalous Dust Emission at 31~GHz in the Diffuse Cloud [LPH96]201.663+1.643

Clive Dickinson[1]
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[LPH96]201.663+1.643, a diffuse HII region, has been reported to be a candidate for emission from rapidly spinning dust grains. Here we present Cosmic Background Imager (CBI) observations at 26-36 GHz that show no evidence for significant anomalous emission. The spectral index within the CBI band, and between CBI and Effelsberg data at 1.4/2.7 GHz, is consistent with optically thin free-free emission. The best-fitting temperature spectral index from 2.7 to 31 GHz, Beta=-2.06 +/0.03, is close to the theoretical value, Beta=-2.12 for Te=9100K. We place an upper limit of 24% (2sigma) for excess emission at 31 GHz as seen in a 6arcmin FWHM beam. Current spinning dust models are not a good fit to the spectrum of LPH96. No polarized emission is detected in the CBI data with an upper limit of 2% on the polarization fraction.

084.02

A Study of the ρ Oph Cloud: Mapping the Stars and the Distribution and Motions of the Interstellar Gas

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We have used Guest Investigator results from the Hipparcos astrometric satellite combined with high-resolution optical spectra obtained at the Anglo-Australian Telescope to create a three-dimensional map of the stars in the ρ Oph cloud, and where the stars are in relation to the several interstellar gas components that are seen in the spectra. At least three principal gas components (and several more that are not so extensive) are interspersed among the bright stars, which can subdivided into three main groupings on the basis of RA and Dec. These main gas components are found to persist over several tens of parsecs, both laterally and radially, and there is evidence for an overall rotation of the gas, as determined by the observed radial velocities.

This research been supported by the ESA Guest Investigator program for Hipparcos, and by NASA grants to the University of Colorado and the University of Chicago.

084.03

Laboratory Analysis of Carbon Dioxide Ice Mixtures in Support of Observations from the Spitzer Space Telescope

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A comprehensive database of infrared absorption spectra of ice mixtures containing solid CO_2 is being collected in the laboratory. These data will add to the current knowledge of interstellar solid CO_2 by documenting the thermal history and temperature effects of the ice mixtures. Specifically, analyses of the 15μm bending mode peak of CO_2 will provide a more in-depth knowledge of the chemical behavior of the ices at different temperatures. The results will then be used in comparison to infrared spectroscopic data from the Spitzer Space Telescope and subsequently made available to the scientific community. This research was supported by NASA award NNG05GE44G.

084.04

The Halo's Hot Gas, as Revealed by a Shadowing Observation of its O VI Resonance Line Emission

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We report the OVI resonance line (1032, 1038 Angstroms) intensity of the Milky Way's halo. The intensity was deduced from a pair of *FUSE* shadowing observations. An observation toward a nearby cloud recorded the Local Bubble's intensity while an observation toward a neighboring, relatively unobscured direction recorded the combined Local Bubble and halo intensity. We attribute the difference in intensity, IOVI = 4680(+570,-660) photons cm^{-2} s^{-1} sr^{-1}, to the halo. Given the slight extinction along the second path, the intrinsic intensity may be as much as twice this value. We used the standard method to estimate the electron density, thermal pressure, and pathlength for the OVI-rich gas in the halo, 0.01-0.02 cm^{-3}, 7000-10,000 cm^{-3} K, and 50-70 pc, respectively. The pathlength is much less than the OVI scale height, suggesting a small filling factor of OVI-rich gas. We compared our *FUSE* OVI observations with *ROSAT* soft X-ray observations of the same directions. Depending on the assumed line-of-sight extinction, the halo's OVI doublet emission is 1.1 to 4.7 times more powerful than its 1/4 keV emission. Simulated supernova remnants evolving in low density gas have similar OVI to X-ray ratios when the remnant plasma is approaching collisional ionizational equilibrium and the physical structures are approaching dynamical "middle age". Alternatively, the plasma can be described by a temperature power-law. Assuming the material is approximately isobaric and the length (or volume fraction) scales according to $T^{beta}d(\ln T)$, we find beta = 1.5±0.6 and an upper temperature cutoff of $10^{6.6(+0.3,-0.2)}$ K. The radiative cooling rate for all of the gas, including that which is too hot to hold OVI, is 6x10^{38} erg s^{-1} kpc^{-2}. This rate implies that ~70% of the energy produced in the disk and halo by SN and pre-SN winds is radiated by the hot gas in the halo.

084.05

Distances of Four High-Galactic Latitude Molecular Clouds

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The Sun is embedded within a large, irregularly-shaped region of plasma called the Local Bubble that formed when relatively nearby stars exploded as supernovae several million years ago. Lallement et al. (2003) have traced its convoluted boundary by using the equivalent widths of NaD lines in 1005 distant stars. To avoid directional bias, however, they intentionally avoided targeting stars that shared lines-of-sight with clouds visible on IR, X-ray, or radio maps. Thus, to complement their study, we have determined the distances and radial velocities of four molecular clouds that were also classified as soft X-ray shadows by Snowden et al. (2000). We targeted these objects since X-ray shadows are expected to lie at or near the bubble's boundary. Thus, their distances and radial velocities provide information about the bubble's edge. In addition, a small fraction of the clouds that are also shadows may prove to lie well within the bubble. The number and nature of such interlopers places constraints on the bubble's history.

The clouds' distances and radial velocities were determined using moderately high-resolution spectra of 88 bright, early-type stars lying near the clouds. The spectra were obtained using the Sandiford Cassegrain-Echelle spectrograph of the 2.1m Otto Struve Telescope. We then searched the stars' spectra for interstellar Na-D lines and used their known distances to bracket the distances to the clouds. We use the derived distances to calculate the density and pressure of the Local Bubble in the direction of these clouds.

084.06

New Maps of the 3-D Distribution of Cold and Warm Interstellar Gas within 500pc

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We present preliminary maps of the 3-D spatial distribution of cold (T <1000K) neutral and warm (T ~ 5000K) partially ionized interstellar gas as traced by the NaI and CaII absorption lines observed towards stars with distances < 500pc from the Sun. These maps have been constructed from high-resolution (R ~ 80,000) spectral data collected towards ~ 1600 sight-lines, with the 3-D local gas density distribution being calculated from an inversion of the derived column density values. Our new maps, which trace the gas density within a 1kpc 3-D data cube surrounding the Sun, clearly show the neutral boundaries to several interstellar cavities that surround our own Local Bubble region (e.g. Loop I) and also reveal several adjacent interstellar tunnels and chimneys. Our final goal is to obtain maps based on ~ 2000 interstellar sight-line measurements, and these data will be a valuable tool in solving several anomalies linked to the distribution of local gas such as the puzzling distribution of D-to-H values as measured within 1kpc by the NASA FUSE satellite.

084.07

Radio and Recombination Lines from a Thermal Spur associated with the HII Region S54 : A Model to explain the Observational Results

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I report H159 alpha observations of a long narrow, thermal spur, supposed to be emerging from the large HII region S54. The spur has been previously detected at 1420, 2695 and 4750 MHz radio continuum and the H110 alpha recombination line by Muller et al (1987). Physical Parameters are derived from the H159 alpha observations. A model for the radio continuum and radio recombination line emission suggests that the gas should be ionized by about 40 B1 stars with a mean stellar mass of 10 Solar Mass and an stellar density of 1 Solar Mass for cubic parsec into the region.

084.08

Observational Evidence for X-ray Induced Plasma Damping of Grain Alignment

Bengt-Goran Andersson[1]
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Standard theory predicts that the damping of interstellar grain rotation, and hence the dealignment of the grains, in neutral gas should be dominated by gas-grain collisions. I will present evidence that, in addition to the collisional damping, X-ray induced ″plasma damping″ (Draine and Lazarian 1998) plays a non-negliable part in the grain rotation dynamics.

084.09

The Dynamical Structure of the Local Interstellar Medium

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We present a dynamical analysis of the largest collection of local interstellar medium (LISM) absorption velocity component measurements. High resolution ultraviolet observations with the Hubble Space Telescope of stars within 100 pc provide 183 interstellar components and ground-based CaII spectra provide an additional 87 components. We fit these data with 15 rigid velocity vectors and determine the shapes of the associated clouds located within 15 pc of the Sun. Assignment of cloud membership is not solely derived from projected velocity agreement, but also includes comparison of physical parameters (e.g., temperature, nonthermal velocity, and depletions) with nearby cloud members. The Local Interstellar Cloud, the collection of gas that directly surrounds our solar system is easily identified in more than 75 sightlines. The remaining clouds are identified with 4 to 21 sightlines. 20% of observed components are not satisfactorily characterized by the 15 velocity vectors, and possibly include more distant clouds that subtend much smaller solid angles or are caused by absorption of circumstellar gas. Several clouds have a filamentary structure, which may be indicative of shocked or interacting material. We examine cloud dynamics at boundary regions and search for evidence of shear flows or cloud-cloud interactions. We find that several nearby radio scintillation scattering screens are coincident with the intersections of the LIC, and other nearby clouds.

Support for this work was provided by NASA through Hubble Fellowship grant HST-HF-01190.01, AR-09525.01A and GO-10236.02 awarded by the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., for NASA, under contract NAS 5-26555.

084.10

OH Study of the Massive Star-Forming Region IRAS 19111+1048

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The 18 cm (1665, 1667, 1612, and 1720 MHz), 6 cm (4765, 4751, and 4660 MHz) and 5 cm (6031, 6035, 6049, and 6017 MHz) OH lines, as well as the 4830 MHz H_2CO and the 6668 MHz CH_3OH lines, were detected toward the massive star-forming region IRAS 19111+1048. All lines were observed on July 4-5, 2005 using the Arecibo Telescope L-band, C-band and C-high receivers. The analysis was completed using Arecibo routines for reducing correlator data. Maser emission was confirmed in the 1665, 1667, 6031, and 6035 MHz OH lines, and each maser line was accompanied by an absorption feature. By comparison with previous studies, all but the 6031 MHz line appear to be highly variable. The 6 cm OH lines, the 18 cm and 5 cm OH satellite lines, and the absorption features were found to exhibit weak and broad spectral profiles, indicating that their appearance may be due to a form of quasi-thermal excitation rather than the masing process. Currently there is no evidence for either H_2O or CH_3OH masers, but massive CO outflows have been detected through previous studies. Along with the detection of OH masers, these properties place IRAS 19111+1048 in a late stage of protostellar evolution in which the H II region has expanded and developed enough to allow for conditions that are unable to generate H_2O or CH_3OH masers.

084.11

Dissipation and Heating in Supersonic MHD Turbulence

M. Nicole Lemaster[1], J. M. Stone[1]
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We have begun a project to study energy dissipation in driven and decaying supersonic compressible MHD turbulence and its implications for star formation by modeling the conditions in molecular clouds using three-dimensional magnetohydrodynamic simulations. We begin by reproducing the work of Stone, Ostriker, & Gammie (1998) with Athena, a new higher-order Godunov scheme for ideal MHD which exactly conserves energy, momementum, and magnetic flux. We study the convergence of the energy in fluctuations in saturated turbulence with numerical resolution, for various initial magnetic field strengths, and compare to previous results. We also describe our algorithms to treat non-ideal MHD effects with more realistic thermodynamics which we plan to use to model the heating by decaying turbulence in molecular clouds.

084.12

***Spitzer* Observations of HD 34078 and IC 405: Bow Shock and Mid-IR Emission Variations**

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We present new infrared observations of the emission/reflection nebula IC 405 obtained with the *Spitzer Space Telescope*. Infrared images in the four IRAC bands and two MIPS bands (24 and 70 microns) are complemented by IRS spectroscopy (6-20 microns) of two nebular filaments. The IRAC (8.0 micron) and MIPS imaging shows evidence of a bow shock associated with the runaway O9.5V star, HD 34078. The ratio of emission at 24 to 70 microns is higher in the immediate vicinity of HD 34078 than in the outer filaments, providing evidence for elevated dust temperatures ($T_d > 90$ K) in the shock region. The nebular imaging reveals that the morphology is band dependent, with varying contributions from aromatic emission features, H_2, and dust emission. Nebular spectroscopy is used to quantify these contributions, showing several aromatic emission bands between 6-14 microns, the S(5), S(3), S(2), and S(1) pure rotational emission lines of H_2, and atomic fine structure lines. The low-dispersion spectra provide constraints on the ionization state of the large molecules responsible for the aromatic infrared features. An average $T(H_2)=\sim 400$ K is inferred, with evidence for additional non-uniform excitation by UV photons in the intense radiation field of HD 34078. The photoexcitation hypothesis is supported by direct measurement of the far-UV H_2 fluorescence spectrum, obtained with *FUSE*.

084.13

Intrinsic Stellar Color and Reddening with the Sloan Digital Sky Survey

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Surveys of stellar reddening (or color excess) often use data gleaned from various heterogeneous sets of photometry and spectral type and are therefore subject to large sources of unpredictable uncertainty. We have taken advantage of the Sloan Digital Sky Survey, which will eventually provide spectra and photometry for several hundred thousand stars distributed over more than a quarter of the sky, to calculate reddening. We find a correlation between intrinsic colors and the strength of hydrogen spectral lines for stars in the low extinction regions, as given by the SFD maps, and use it to independently estimate reddening for stars in the high extinction regions. Intrinsic color and therefore reddening is estimated to within about 0.05 mag or better for over 20,000 stars. This method of calculating reddening is more accurate over a larger set of stars than previous studies have accomplished. In future work, we will use this method to map interstellar extinction over the SDSS survey area and test current understanding of the normalized extinction curve.

084.14

Analyzing the X-Ray Dust Halo and Extinction Toward X Per

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An improved understanding of interstellar dust will lead to robust models that can more accurately recover intrinsic spectral energy distributions and probe the grains' environment. Current grain models meet the requirements placed on them by the UV-IR observations and elemental abundances; we must look to other wavelength regimes to futher constrain them and thus discriminate amongst models. X-ray dust halos are an excellent grain characteristic diagnostic and can provide badly needed constraints on grain models. We have obtained UV-NIR extinction curves and X-ray halo data along the sightline to X Per. This broad wavelength coverage will allow us to challenge grain models and distinguish amongst them.

084.15

High Resolution Observations of the Interstellar Medium Along the Future Solar Trajectory

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We present a high spectral resolution absorption line survey of 43 nearby stars in the direction of the future solar trajectory in order to map the structure of our future Local Interstellar Medium (LISM). The LISM may be a contributing factor in Earth's atmospheric chemistry, climate, lightning production, and biologic mutation. A comparative study of the future LISM with our current interstellar environment will provide empirical estimates of the frequency and properties of the various LISM structures the Sun may experience. The sources are between 44 and 380 pc away, and have an angular separation <10º from the solar trajectory direction, with a median value of 4.9º. The spectra were taken with either the McDonald Observatory H.J. Smith Telescope (2.7m) or the Anglo-Australian Telescope (3.9m) with a spectral resolution between 60,000 and 1,000,000. The spectra include the CaII H and K lines and the NaI D doublet resonance lines, and have been flux normalized and telluric absorption features removed from the NaI spectra. Absorption from several interstellar structures are detected, including nearby clouds (<50 pc) and the Local Bubble shell (~90 pc). The absorption lines in these spectra are currently being used in a calculation of column density as a function of velocity and distance, along these near-solar-trajectory sightlines, ultimately giving us an understanding of the morphology of the LISM which we will be passing through over the next 30 million years.

This work was carried out at the McDonald Observatory REU program supported under NSF AST-0243745. Support for this work was provided by NASA through Hubble Fellowship grant HST-HF-01190.01 awarded by the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., for NASA, under contract NAS 5-26555.

084.16

H_2/PAH emissions in the shocks and UV dominated regions of the embedded young cluster NGC2316

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Observations of embedded young star clusters, still contained within their parent molecular clouds are important to understand how the UV flux and shocks caused by young stars influence the evolution of the cloud, its dispersal and subsequent termination or triggering of star formation. NGC 2316 is a young embedded star cluster containing a central HII region powered by a B3 star. The UV flux and shocks caused by this young star affect the physical conditions and the chemical composition of the surrounding cloud. We present Spitzer IRS maps of the PAH features and H_2 lines in the 9 -14 μm (SL1) and 15 -18μm (LL2) bands obtained using multiple slit positions. We show the distribution and the relative variations between the various PAH features at 11.2, 12.0, 12.7, 13.5, 16.4, and 17.4 μm with distance from UV source, and with respect to the shocks. We have also mapped the line intensities at three H2 transitions: S (1) Ortho 17.0 μm, S(2) Para 12.3μm, and S(3) Ortho 9.7μm. The H2 line emission is dominant over the outer shock regions while PAH features are prominent inside. The H2 line intensities are used as diagnostics of the temperature structure and the PAH features to trace the UV field and the chemical composition of the gas and dust. We interpret the observed differences between the distributions of the PAH features in terms of the excitation, destruction and molecular structure of PAHs.

This work was performed by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration

084.17

Correlations between Tracers of Dense Molecular Gas and Star Formation Rate in GMCs

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We present observations of the dense molecular gas tracers HCN(1-0), CS(2-1), HNC(1-0) and HCO+(1-0) with the FCRAO 14m towards 10 high-mass star-forming dense cores that have been observed by Spitzer. In each of the cores, we sample them in the step of 25″ with the FCRAO 14m and convolve the infrared images to the same as the FCRAO beamsize (~60″). Then we compare the fluxes of the dense gas tracers of HCN(1-0), CS(2-1), HNC(1-0) and HCO+(1-0) with the fluxes of 24 micron (M1) and 8 micron (I4) at the same positions. We fit the correlations of the fluxes between the dense gas tracers and that of the infrared emission. The most important result is the correlation between the dense gas tracers and the infrared emission is non-linear in each of the sources with a wide range of

the slope from 0.2 to 1.7. So the linear correlation derived from galaxies and dense cores globally is not applicable in the local star formation region inside the GMC dense cores. With our maps of the star forming cores with HCN(1-0), CS(2-1), HNC(1-0) and HCO+(1-0), we find that in most of the cores the emission regions of HCN(1-0) and CS(2-1) are more compact than that of HCO+(1-0), which confirm that HCN and CS are the better dense molecular gas tracers than HCO+.

084.18

Probing the Dust Structure in the LMC with Light Echoes

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The SuperMACHO collaboration has discovered light echoes from four ancient supernovae (SNe) in the Large Magellanic Cloud using difference image analysis (Rest et. al, 2005). These light echoes offer one of the most effective means to probe the 3-D structure of the dust in the interstellar medium in the LMC, as they illuminate sheets and bands of the dust at different distances from the SN. As the light echos ″move″, they continuously map out different structures, providing the opportunity to map out large structures over time. We find that the light echoes cross-correlate very well with dust structures detected in the infrared in images from the Spitzer space telescope. We also cross-correlated these with structures found in the ATCA HI velocity maps.

084.19

The Non-Linear Relationship between Silicate Absorption Depth and IR Extinction in Dense Clouds

Jean E. Chiar[1], Y. Pendleton[2], K. Ennico[2], A. Boogert[3], T. Greene[2], C. Lada[4], T. Roellig[2], A. Tielens[2], M. Werner[5], D. Whittet[6]
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Interstellar silicates are likely to be a part of all grains responsible for extinction in the diffuse interstellar medium (ISM) and dense clouds. A correlation between visual extinction (Av) and the depth of the 9.7 mu silicate feature (measured as optical depth, tau(9.7)) is expected if the dust species are well mixed. In the diffuse ISM, such a correlation is observed for lines of sight in the solar neighborhood. A previous study of the silicate absorption feature in the Taurus dark cloud showed a tendency for the correlation to break down at high Av (Whittet et al. 1988, MNRAS, 233, 321), but the scatter was large.

We have acquired Spitzer Infrared Spectrograph data of several lines of sight in the IC 5146, Barnard 68, Chameleon I and Serpens dense clouds. To eliminate any uncertainties associated with adopting a specific extinction law, we investigated the relationship between tau(9.7) and E(J-K). Our data set spans E(J-K) between 0.3 and 8 mag (Av=between ~2-35 mag.). All lines of sight show the 9.7 mu silicate feature. For E(J-K) greater than about 2 mag, tau(9.7) levels off, much like the trend observed in the Taurus data. There are two exceptions: one line of sight in Serpens, with E(J-K)~4 mag lies on the diffuse ISM line. Another line of sight with E(J-K)~8 mag, also in Serpens, lies well below the diffuse ISM line, but well above the "flat" trend of the other dense cloud sources. This particular line of sight also has a high ice column relative to the amount of visual/infrared extinction. The cause of the "flat" trend exhibited by most of the dense cloud points is undetermined. However, in general, it is unlikely that ice mantles would have any effect on the measured silicate feature since ices are transparent in the 10 mu region.

084.20

The Photo-Dissociation Region Surrounding HR 5171AB

Michael T. Schuster[1], M. Marengo[1], J. L. Hora[1], R. D. Gehrz[2], R. M. Humphreys[2], G. Fazio[1]
[1]Harvard-Smithsonian, CfA, [2]University of Minnesota.

HR 5171AB is an example of how an extremely massive star, a hypergiant, and its hot companion play the dominant role in their local environment. Their effects are demonstrated by first creating and then shaping what is likely a large Photo-Dissociation Region (PDR, Radius ~8 pc) out of the molecular cloud in which they formed. We present extremely sensitive Spitzer Space Telescope IRAC images, as well as MSX and IRAS/IRIS data, that show this region in the mid-IR with previously unseen detail. The PDR surrounding HR 5171 lies at the outermost limits of the RCW 80 HII region, and is spatially well correlated with a molecular cloud at the same kinematic distance. The mid-IR colors of the dust and gas surrounding HR 5171 show a definite lack of shocked material. When combined with the expected colors for dust in a uniform UV radiation field, the data make a strong case for a quiescent PDR. The origins of the PDR likely date to when HR 5171A was a main sequence O-type star (~50 Mo), and the current sustaining ionization source is its companion HR 5171B (B0 Ibp).

This work is based in part on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA.

084.21

The effects of Geometry, Dust and Magnetic Fields upon Strong-line Abundance Indicators in HII Regions

Humeshkar B. Nemala[1], G. J. Ferland[1]
[1]University of Kentucky.

HII regions form a complex matrix of gas and dust with the physical conditions being governed by the equation of state. Two fundamental issues in astrophysical research are the determination of physical conditions and chemical abundances in HII regions. Knowledge of chemical abundances is vital to the understanding of star formation, chemical evolution and nucleosynthesis. Collisionally excited strong line ratios address these two issues. For example, [SII] λ6716/ λ6731 is used to determine the electron density while R_{23} = (O[II] λ3727+ [OIII] $\lambda\lambda$4959,5007)/Hβ is used to determine the oxygen abundance. Strong line ratios have traditionally been studied as functions of ionization parameter and used as chemical abundance diagnostics. This simplistic approach cannot account for the diversity of observed strong line ratios. Recent authors, for example, have suggested that magnetic fields play an important role in the gas equation of state. We have developed a set of photoionization models in an attempt to provide a more complete picture by determining the effect of various physical conditions and geometry on the strong line ratios. In addition to magnetic field effects, we also consider the effects of dust by the inclusion of grains and PAHS which regulate the temperature and chemistry in the HII region complexes. Finally, we explore the effects of turbulence and the possible enhancement of local cosmic ray density due to compressed magnetic fields. We thank the National Science Foundation for its support through Ast 0607028.

084.22

Numerical Simulations of Interstellar Gas with a Variable Continuum Source

Gary J. Ferland[1], W. J. Henney[2], R. J. Williams[3]
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The observed spectra of astronomical objects often include numerous emission and absorption lines, produced as a result of the interaction of ionizing radiation with interstellar matter. These line spectra are an import diagnostic of conditions in these nebulae. The plasma simulation code Cloudy has long been used to model these environments under the assumption of ionization equilibrium. However, in many cases the continuum

source may vary on time scales that are short compared with the times needed for atomic processes in the gas to reach a steady state. Examples range from the envelopes of planetary nebulae to the interstellar medium in the host galaxy of a gamma-ray burst. We have expanded the treatment of dynamical flows described by Henney, Arthur, Williams & Ferland (ApJ 621, 328) to include the effects of a time-variable continuum source. We present calculations of several representative geometries in which these effects are important.

084.23

Recent FUSE Observations of Diffuse O VI Emission in the Galactic Interstellar Medium

William V. Dixon[1], R. Sankrit[2]
[1]*Johns Hopkins University,* [2]*University of California, Berkeley.*

We present new results from our on-going survey of diffuse O VI (λ1032) emission in the interstellar medium with the *Far Ultraviolet Spectroscopic Explorer (FUSE)*. Background observations obtained during 2005 and 2006 have yielded five new O VI detections of 3σ significance, and archival searches have revealed a sixth. Our sight lines probe the Magellanic Stream as well as low-velocity gas associated with the Galactic disk.

O VI emission centered at $V_{LSR} = 19 \pm 13$ km s^{-1} is seen in one spectrum that probes a line of sight ~ 1' from the Seyfert 1 galaxy Fairall 9, which shows strong O VI absorption at low velocities (Wakker et al. 2003). From the ratio of our emission-line intensity to the O VI column density in the low-velocity gas, we derive an electron density of 0.01 cm^{-3} and a path length through the emitting gas of about 50 pc. The observed emission-line velocity and these derived properties suggest that the emitting gas is part of the corotating thick disk/halo of our Galaxy.

This work is supported by NASA contract NAS5-32985.

084.24

A Comparative Study of Velocity Statistics of Hydrodynamic and Magnetohydrodynamic Turbulence

Nicholas Hall[1], G. Kowal[1], A. Lazarian[1], J. Cho[2]
[1]*University of Wisconsin Madison,* [2]*Chungnam National University, Republic of Korea.*

Turbulence is extremely important for many astrophysical processes including star formation, transport of heat, and cosmic ray propagation. For astrophysical media that are both magnetized and compressible, it is important to address the differences that magnetic fields and compressibility make in turbulence. A comparative study is performed of changes that arise in the velocity statistics, or turbulent motions, as a result of individually including an external magnetic field and compressibility. The following three models of turbulence are used: incompressible hydrodynamic, incompressible magnetohydrodynamic (MHD), and compressible MHD. The compatibility of the spectra of all three models with the Kolmogorov spectrum is confirmed, suggesting that the energy transfer process is consistent for all three models. For the MHD models the probability distribution functions of the velocity components in the plane perpendicular to the external magnetic field are like the incompressible hydrodynamic model while those parallel are not. It is found that high order longitudinal statistics in both the global reference frame and in the frame perpendicular to the local mean magnetic field are extremely similar for all three models, while those in the frame parallel to the local mean field are not. We therefore conclude that turbulent motions in the plane perpendicular to the local mean field are affected very little by the inclusion of an external magnetic field and compressibility, while those parallel are affected significantly. The statistics are then decomposed into Alfvenic, fast, and slow modes. It is found that the Alfven mode is mostly responsible for the above-mentioned results in both frames. It is also shown that high order longitudinal statistics in the plane perpendicular to the local mean field for the Alfvenic mode are similar for both MHD models. Our study clarifies the extent to which magnetic fields are important for different astrophysical processes.

085: Ground-Based Instrumentation II
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

085.01

The 21-Meter Space Tracking Antenna and Radio Telescope at Morehead State University

Thomas Pannuti[1], B. K. Malphrus[1], M. Combs[1], J. Kruth[1], J. W. Atwood[1]
[1]*Morehead State Univ..*

The Space Science Center at Morehead State University has developed a full-motion 21-meter class antenna system: this instrument is known as the Morehead State University Space Tracking Antenna and Radio Telescope. The antenna system is engaged in rigorous research programs in radio astronomy and will also serve as a ground station with capability of tracking low earth orbiting satellites. Currently, the telescope features receivers sensitive to radiation in the K_u band (11.2 to 12.7 GHz, including a well-known methanol line), S band (2 to 4 GHz) and L band (1.4 to 1.7 GHz, including lines of atomic hydrogen and hydroxyl).

A description of the antenna, its capabilities and research projects planned for or currently being conducted by the antenna (such as monitoring active galactic nuclei and surveying the Galactic supernova remnant population) will be presented and discussed.

085.02

Atacama Large Millimeter Array Low Noise Analysis

Manasseh O. Obi[1]
[1]*Idaho State University.*

The Atacama Large Millimeter Array (ALMA) is a millimeter wavelength telescope. It comprises about fifty 12meter antennas located in Chile, South America. ALMA is an international astronomy facility. ALMA construction and operations are led on behalf of North America by the National Radio Astronomy Observatory (NRAO), operated by Associated Universities, Inc. (AUI). ALMA is scheduled to be completed and become fully operational by 2012.

In the summer of 2006, the prototype of the front end cartridge bias board of the ALMA telescope was simulated and measured to ensure that the bias box met the required specification before it was mass produced, assembled and finally shipped off to Chile for installation.

It is critical that the ALMA amplifiers meet their required performance specifications under normal operating conditions.

The Allan Variance stability, voltage and current noise densities are specified in the ALMA Front End Cartridge Bias Module Technical Specifications document number FEND-40.04.02.00-005-A-SPE. In order for the front-end cartridge to meet the required specifications, the bias voltage provided by the circuitry must be extremely stable and relatively free of noise. These specifications allow the given antenna resolution, imaging, array configuration, spatial resolution and sensitivity as stated in the ALMA scientific agreement to be met.

With my poster presentation, I intend to:

•

Present the results of the observations and analysis I made at the NRAO site located in Green Bank, West Virginia and explain its relevance to the on-going ALMA project.

•

Correlate the critical role of good engineering lay out and pre-design simulation of astronomical telescopes to their relative high performance based on my experience at Green Bank.

•

Discuss the applications of intrinsic low noise amplifiers, filters, and miniature electrical components to Radio Astronomy.

Sponsors: The NRAO and NSF

085.03

MUSTANG: A 90 GHz Bolometer Array for the Green Bank Telescope

Brian S. Mason[1], S. Dicker[2], P. Korngut[1], D. Benford[3], M. Devlin[2], K. Irwin[4], H. Moseley[3], MUSTANG collaboration
[1]NRAO, [2]UPenn, [3]NASA GSFC, [4]NIST.

In Fall of 2006 first light was achieved at 3mm on the Robert C. Byrd Green Bank Telescope (GBT) using a SQUID-multiplexed, TES bolometer array. This instrument --the Multiplexed Squid/Tes Array for Ninety Gigahertz, or MUSTANG --was designed and built by the University of Pennsylvania, NASA/GSFC, NIST, and NRAO. We describe the instrument, results from first light observations on the GBT, plans for further development, and future scientific observations.

085.04

Research Experience for Teachers at Green Bank: High-Precision Calibration, Baselines and Nonlinearities with the GBT

Shelly Hynes[1], R. J. Maddalena[2], C. Figura[3]
[1]Louisiana School for Math, Science and the Arts, [2]National Radio Astronomy Observatory, [3]Wartburg College.

The traditional methods for calibrating single-dish radio telescopes assume that the system gain is linear: detected power is taken to be proportional to the power incident on the antenna. The assumption is wrong at some low level and noticeably breaks down when observing an object that has a large dynamic range. The high sensitivity, clean beam, and very stable electronics of the Green Bank Telescope (GBT) allow us to detect nonlinearities that would be masked in most other radio telescopes. In particular, the signal processing components of the GBT produce an output power that exhibits at least a quadratic dependence on incident power. Our study indicates that measuring and compensating for the nonlinearity is rather trivial and improves calibration when observing objects with a high dynamic range. Once measured, the nonlinearity is shown to be stable over a typical observing run (~6-8 hours) with evidence of stability for up to several weeks.

We also investigated ways to improve spectral-line calibration and baseline shape when observing over a band that is many GHz wide, as is typical with many high frequency GBT projects. We have found that baselines are seriously degraded when using the traditional methods of calibration via scalar values for the system temperature and calibration noise diode that are averaged over the entire bandwidth of the observations. System calibration and baselines are shown to be substantially improved when we use noise diode and system temperature values that have a frequency resolution of a few MHz.

Incorporating this research and the general topic of radio astronomy into the high school science classroom will also be discussed.

This work was funded in part by the NSF-RET program.

085.05

Potential Astronomy Applications of Large Deep Space Network Arrays

Dayton L. Jones[1], T. B. Kuiper[1], W. A. Majid[1]
[1]Jet Propulsion Laboratory.

NASA and the Jet Propulsion Laboratory are considering future upgrades to the Deep Space Network (DSN) to increase sensitivity and reduce operating costs. Among the most promising options are large arrays of small-diameter antennas, which can reduce the cost per unit of collecting area and are very robust against individual antenna or receiver failures. If large DSN arrays are built, they will be potentially valuable assets for radio and radar astronomy in addition to their primary role of spacecraft tracking. We have recently completed a study of the scientific uses of DSN arrays, assuming that they are built according to the current design that considers only spacecraft tracking requirements. We then examined a number of possible upgrades to the current array design to increase the scientific potential, and estimated the incremental cost (in dollars and performance loss) of each upgrade. We conclude that a significant increase in bandwidth, by a factor of 2-8, is the most cost-effective upgrade for the arrays. Other upgrade options considered include enhanced tuning range (wider feed, polarizer, and amplifier frequency coverage), increased correlator capacity, additional frequency bands, and the addition of a small number of antenna clusters located a few hundred km from each main DSN array site. This study was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

085.06

Ionospheric Phase Errors and Corrections at 1 m Wavelength

William D. Cotton, Jr.[1], J. Uson[1]
[1]NRAO.

High resolution observations at long wavelengths are adversely affected by ionospheric irregularities causing a screen of variable index of refraction. A correction technique developed for VLA observations at 4 m wavelength is shown to be both necessary and beneficial for wide-field, high resolution imaging at 1 m wavelength using the VLA. A time and celestial position dependent refraction is determined from observations of known strong sources and used to correct the derived image. Due to the spatially dependent nature of the ionospheric refraction, application of the corrections must be implemented as part of the imaging and deconvolution process. The National Radio Astronomy Observatory (NRAO) is operated by Associated Universities Inc., under cooperative agreement with the National Science Foundation.

085.07

A Web-based Portable RFI Monitor for LWA Site Selection

Robert L. Mutel[1], T. Jaeger[1], G. Taylor[2]
[1]Univ. of Iowa, [2]Univ. of New Mexico.

We describe a portable system for monitoring radio frequency interference in the 10-100 MHz range. The system consists of a discone antenna, GPS module, low-noise pre-amplifier, and commercial spectrum analyzer controlled by Labview VI (virtual instrument) modules running on a notebook PC. Dynamic (frequency-time) spectra are recorded at user-specified intervals and recorded as FITS-format binary tables. The system is controllable either on-site or remotely using a web-based interface. We will use this portable system to conduct a brief RFI survey of several potential sites for Long Wavelength Array (LWA) array elements in southwestern New Mexico during Fall 2006. The results of this survey will be summarized.

085.08

The Mileura Widefield Array

Colin J. Lonsdale[1], International MWA partnership
[1]MIT.

The Mileura Widefield Array, Low Frequency Demonstrator project (MWA-LFD) is an international effort to build a highly innovative telescope operating in the 80-300 MHz spectral range. The project is a collaboration between MIT, CfA, several Austalian universities including U. Melbourne, ANU, Curtin and others, and CSIRO. Scientific goals of the project include the Epoch of Reionization, solar and heliospheric research, and surveying the transient radio sky.

The telescope will be an interferometric array comprising 500 phased array antennas, and will be built at a superbly radio-quiet location in outback western Australia. All project partners are funded, and work is progressing toward initial operations on a 2-year timescale. The array design, and the current status of the project will be presented.

085.09

Construction of a Novel Interferometric Array of Small Radio Telescopes

Dalit Engelhardt[1], P. Timbie[2]
[1]Boston University, [2]University of Wisconsin-Madison.

Interferometric arrays of large numbers of antennas are under study for a variety of programs, such as the Square Kilometer Array and instruments optimized for observing the cosmic microwave background radiation. The Wisconsin Small Telescope Array for Radio-waves (WSTAR) will serve as a test of a simple and inexpensive method for building an adding interferometer with a large number of antennas. The approach creates a simple analog correlator from an ordinary receiver. Signals from each radio antenna are phase-modulated between 0 and 180 degrees at unique frequencies. The signals are added together and then enter a receiver/spectrometer. The visibilities from each baseline are decoded by phase-sensitive detection of the receiver output at the appropriate modulation frequencies. The scheme can be extended to an arbitrary number of antennas and has minimal computational requirements.

WSTAR will consist of three small radio telescopes of 2.5 meter diameter which closely follow the Small Radio Telescope (SRT) design developed at the MIT Haystack Observatory. WSTAR will operate as a three-dish adding interferometer of variable spacing. The initial configuration is an equilateral triangle with 10 m spacing. At this stage, one telescope has been successfully constructed and is undergoing initial testing. Completion of the array is expected in 2007. This poster will present the adding algorithm and its significance as well as the construction details of WSTAR.

This work was supported by the National Science Foundation's REU program and the Department of Defense's ASSURE program through NSF Award AST-0453442.

085.10

Effectiveness of the Correlator Field of View Weighting Technique in Source Attenuation

Dylan R. Nelson[1], S. S. Doeleman[2], C. J. Lonsdale[2], D. Oberoi[2], R. Cappallo[2]
[1]University of California Berkeley, [2]Massachusetts Institute of Technology, Haystack Observatory.

The science requirements of next-generation radio telescope arrays present a new set of challenges to traditional imaging and data processing techniques. Instruments such as the MWA and SKA implementing large numbers of small diameter (LNSD) elements have a naturally large field-of-view. In order to achieve high image fidelity and dynamic range, signal contributions from off-center sources must be reduced a task traditionally requiring imaging of the full field-of-view. However, implementing this process under proposed designs requires unreasonable computational speeds while also generating unmanageable volumes of data. One approach to this problem involves dynamic control over the field-of-view, implemented in software as a weighting algorithm within the integration routine of an advanced correlator. Using this technique we can effectively reduce the contribution from sources outside the region of interest, and in some cases dramatically reduce the volume of data exiting the correlator. Herein we focus on verifying the effectiveness of this technique, implemented through the MIT Array Performance Simulator (MAPS). The limitations and design requirements of this approach are also evaluated, including the impact of variable levels of radio frequency interference (RFI) excision on image fidelity and off-center source signal rejection.

085.11

First Astronomical Imaging Spectroscopy Obtained with a Multiplexed Superconducting Bolometer Array

Dominic J. Benford[1], J. G. Staguhn[1], T. J. Ames[1], C. A. Allen[1], J. A. Chervenak[1], C. R. Kennedy[2], S. Lefranc[3], S. F. Maher[1], S. H. Moseley[1], F. Pajot[3], C. Rioux[3], R. A. Shafer[1], G. M. Voellmer[1]
[1]NASA / GSFC, [2]Notre Dame, [3]IAS, France.

We present spectral images taken with the first deployed astronomical instrument to use multiplexed superconducting bolometers. The Fabry-Perot Interferometer Bolometer Research Experiment (FIBRE), a broadband submillimeter spectrometer, took these images as a detector investigation at the Caltech Submillimeter Observatory (CSO). FIBRE's detectors are superconducting bilayer transition edge sensor (TES) bolometers read out by multiplexed SQUID amplifiers. An order-sorted Fabry-Perot provides illumination of a 16-element linear bolometer array, resulting in five orders at a spectral resolution of around 1200 covering the 350 micron atmospheric band. We present multiwavelength images of Jupiter, Venus and the high-mass star-forming region G34.3+0.2 taken with this instrument at several wavelengths in the 350 micron band, separated by approximately 8 microns. These images have validated the use of multiplexed superconducting bolometers in an astronomical application and have helped inform the design of our future instruments.

085.12

An Innovative Multicolor Submillimeter Camera Using Microwave Kinetic Inductance Detectors

James A. Schlaerth[1], P. K. Day[2], J. Gao[3], J. Glenn[1], S. Golwala[3], S. Kumar[3], H. G. LeDuc[2], B. A. Mazin[2], H. T. Nguyen[2], J. E. Vaillancourt[3], A. Vayonakis[3], J. Zmuidzinas[3]
[1]University of Colorado, [2]Jet Propulsion Laboratory, [3]California Institute of Technology.

Submillimeter Galaxies are dust enshrouded, high redshift galaxies

with extreme luminosities greater than 10^{12} L_{solar} powered by star formation. In order to fully understand the star formation history of the universe, we must know the dust temperatures, bolometric luminoities and redshifts of these galaxies by measuring the full spectral energy distribution (SED) in the submillimeter and millimeter bands. To quickly acquire the long-wavelength component of the SED, we are constructing a camera for the Caltech Submillimeter Observatory (CSO) using antenna-coupled Microwave Kinetic Inductance Detectors (MKIDs). MKIDs are highly sensitive superconducting pair-breaking detectors which, when coupled to lithographed phased-array antennas, can read out multiple bands simultaneously. The MKID camera will have 600 pixels, each viewing bands centered at 750 μm, 850 μm, 1.1 mm and 1.3 mm. We are verifying the performance of the detectors using a demonstration camera, a 16-pixel, 2-color (850 μm and 1.3mm) array, at the CSO.

085.13

Development of A Protype Infrared Exoplanet Tracker for All Sky Extrasolar Planet Survey

Pengcheng Guo[1], J. Ge[1], S. Mahadevan[1], L. Ramsey[2]
[1]Univ. of Florida, [2]The Pennsylvania State University.

We present a design of a prototype infrared version of the Exoplanet Tracker (ET). This instrument is a combination of a fixed-delay interferometer with a medium resolution near infrared spectrograph (R~10,000). It inherits the design of the single object optical ET instrument at the Kitt Peak 2.1m telescope, which has been used for high precision radial velocity observations since 2004, including a discovery of ET-1(HD102195b) planet. This IR ET is optimized for high throughput and Doppler precision in 0.9-1.8 microns. An existing medium resolution spectrograph available at Penn State will be used for initial lab testing and telescope demonstration. We will also present instrument performance simulation results.

Once the capability is demonstrated, we will develop a multiple object version for the Sloan 2.5m telescope for surveying nearby tens of thousands of M dwarfs for new planets during All Sky Extrasolar Planet Survey.

085.14

Exploring Precision Radial Velocities in the NIR: PRVS Pathfinder

Lawrence W. Ramsey[1], S. Bongiorno[1], L. Engel[1], S. Redman[1], A. Wolszczan[1], H. R. Jones[2], J. Barnes[2]
[1]Penn State Univ., [2]University of Hertfordshire, United Kingdom.

In summer of 2005 we began a program at Penn State to build a test instrument to explore issues involved with attaining ~1 meter/sec Precision Radial Velocities (PRV) in the near infrared where M and L stars emit most of their flux. These low mass stars are the most likely place where PRV techniques will allow detection of earth mass planets in the "Habitable Zone". Key issues studied are calibration techniques, effects of telluric absorption and modal noise in fibers. The instrument is a standard in-plane echelle spectrograph with a LN2 cooled Hawaii 1K array. It can be set to cover selected regions between 1.0 and 1.7 microns. More recently our experiments were aimed more directly toward addressing key issues in the design approach to the Gemini Precision Radial Velocity Spectrometer (PRVS) taken by the UK ATC/Penn State/U Hawaii/U Hertfordshire team. Tests to date have focused on measuring the earth's rotation signature in the integrated sunlight spectrum. We present results showing 10 meter/sec or better precision and compare the observed errors with what is expected from the information content of the solar spectrum in this region.

085.15

The Tunable Spatial Heterodyne Spectrometer (TSHS): A High-Resolution Spectral Sensor for Broadband Studies of Diffuse Targets in the UV-Visible.

Walter M. Harris[1], O. Dawson[1], L. Giersch[1]
[1]Univ. of Washington.

All-reflective spatial heterodyne spectrometers (SHS) are a form of common-path interferometer that combine large étendue and high spectral resolution in a compact package that can be easily incorporated into variety of ground and space based optical systems. SHS works by splitting incoming light, introducing an anti-symmetric wavelength dependent rotation in the wavefronts of each of the two beams, and then recombining them at an output where interference produces a 2 dimensional pattern of fringes with a power-spectrum set by the distribution of frequencies in the source. These instruments recover the full theoretical resolving power of the illuminated grating-width, which gives them very high spectral resolution without the limitations on field of view imposed by aperture re-imaging in grating spectrographs. This wide input acceptance angle makes them ideal for the study of extended, low surface brightness targets. The primary limitation of SHS technology is that the bandpass available for sampling is limited by the spectral resolution and the number of frequencies the detector system can resolve. For typical applications this restriction limits the bandpass for a single tune to a range of ~1-10 nm, which has limited them previously to applications calling for observations of single, targeted spectral features. We report here on our progress in developing a Tunable SHS that can dynamically realign its tuning wavelength, thereby translating its 1-10 nm bandpass across a range in wavelength from 300-700nm.

086: LSST
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

086.01

The LSST System

Donald Sweeney[1], J. A. Tyson[2], LSST Collaboration
[1]LSST Corporation, [2]University of California, Davis.

The proposed 319 m^2Deg^2 etendue Large Synoptic Survey Telescope (LSST) is only one component of an end-to-end astronomical survey facility to acquire, process, analyze, catalog, and maintain the world's largest database of optical astronomical data. The sky coverage will be full hemisphere from the site on Cerro Pachon in northern Chile. From its 2000 exposures in six bands from 320-1050 nm per 10 square degree field, LSST will also open the time domain for studies of transient and moving objects. This poster will present the integrating system concepts for the LSST Observatory from the telescope to the Data Centers that support the key science deliverables and individual users. The strategy and timelines for bringing this system to fruition will be reviewed. The ability to support many science missions from a single database has lead to broad support from the community.

086.02

LSST Survey Strategy

Zeljko Ivezic[1], A. J. Tyson[2], M. A. Strauss[3], S. Kahn[4], C. Stubbs[5], P. Pinto[6], K. Cook[7], LSST Collaboration
[1]Univ. of Washington, [2]Univ. of California, Davis, [3]Princeton University, [4]Stanford University, [5]Harvard University, [6]Univ. of Arizona, [7]Lawrence Livermore National Laboratory.

The LSST is envisioned to be a large, wide-field ground based telescope designed to obtain sequential images covering the entire visible sky every few nights. The current baseline design with an 8.4m primary mirror and a 10 sq.deg. field of view will allow to do so in two photometric bands every three nights. The system is designed and engineered to yield exquisite astrometric and photometric accuracy, and image quality. The survey area will include 30,000 sq.deg. of sky with Dec<34.5, and will be imaged multiple times in six bands covering the wavelength range 320--1050 nm. The vast majority (about 90%) of the observing time will be spent in a deep-wide-fast survey mode which will observe a 20,000 sq.deg. large region about 1000 times during the 10-year long survey. The deep-wide-fast survey data will serve the majority of science programs. The remaining 10% of observing time will be allocated to special programs such as Very Deep and Very Fast time domain surveys. We will illustrate how LSST science drivers led to these choices of system design parameters.

086.03

Science Opportunities with the LSST

Michael A. Strauss[1], LSST Collaboration
[1]Princeton Univ..

The Large Synoptic Survey Telescope (LSST) will have a scientific impact on fields ranging from studies of asteroids in the Solar System to the nature of dark energy. The LSST has defined a series of Science Collaborations, semi-autonomous groups of scientists drawn from the astronomy and high-energy physics communities, which will lay the detailed groundwork to carry out scientific investigations once the LSST data begin to flow in 2013. These collaborations, which will be formed over the next year, will be working with the LSST team on various aspects of survey design, cadence and depth, software pipelines, and database design. They will take the lead in carrying out science investigations with early data from the LSST, to commission the system and ferret out subtle problems in the data. They will develop code and other analysis techniques to allow them to take full advantage of the data once it starts to flow, and will plan precursor or follow-up observations using other facilities needed to meet their scientific goals. The ten science collaborations are: Solar System Objects, Stellar Populations, Milky Way Structure, Transient Objects, Galaxy Studies, AGN, Large Scale Distribution of Galaxies/Baryon Oscillations, Supernovae, Weak Lensing, and Strong Lensing.

086.04

LSST Survey Strategy: Cadence Design and Simulation

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The LSST will allow a wide variety of science to be done using data from a single survey. A large part of ensuring this claim is designing a smart and adaptive algorithm for scheduling observations, one which can effectively merge multiple requirements into a single program of observations while maximizing time on the sky and coping effectively with changing conditions in real time.

Diverse requirements include multiband imaging of 30,000 square degrees of sky, achieving a uniform depth of exposure across 20,000 square degrees in each of six filters, allowing effective search strategies for NEO's and shortand long-period variables, and providing frequent, deep exposures to characterize faint transients and moving objects.

The LSST operations simulator includes a detailed model of seeing and sky transparency derived from data obtained at its site on Cerro Pachon, Chile. It also includes a detailed model of the delays incurred by readout of the camera, filter changes, active optics acquisition, and movements of the dome and telescope.

We describe current progress in the LSST scheduler design and present simulations of a prototype ten-year LSST mission which demonstrate that all of the science requirements and constraints can be accomodated successfully into a single survey.

086.05

Calibration of LSST Instruments and Data

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Science studies made by the Large Synoptic Survey Telescope will reach systematic limits in nearly all cases. Requirements for photometric measurements accurate to 1% are particularly challenging. Advantage will be taken of the rapid cadence and pace of the LSST survey to use secondary standard stars to monitor stability and uniformity of astrometric and photometric data. A new technique using a tunable laser is being developed to calibrate the wavelength dependence of the total telescope and camera system throughput. Spectroscopic measurements of atmospheric extinction and emission will be made continuously to allow the broad-band optical flux observed in the instrument to be corrected to flux at the top of the atmosphere. Calibrations with standard stars will be compared to instrumental and atmospheric calibration.

086.06

Calibrating Photometric Redshifts for LSST

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Many of the cosmological tests to be performed with LSST will require extremely well-characterized photometric redshift measurements. The true mean redshift of the objects in each photo-z bin must be known to better than ~0.002(1+z) if errors in cosmological measurements are not to be degraded. We are addressing this issue in many ways, both observational and theoretical, to ensure that the power of LSST is not limited by redshift calibration errors. We have applied recent photometric redshift algorithms to weak lensing measurements using Deep Lens Survey data, and are obtaining further wide-field photometry in LSST passbands using Subaru/Suprime-Cam to forecast LSST precision. We are also investigating new techniques: **(1)** One approach relies on extremely deep, multiwavelength photometry over a small fraction of the LSST area. In these regions, photometric redshifts may be calibrated using relatively bright galaxies with spectroscopy, and then applied to fainter galaxies using the many-band photometry. The accurate multiwavelength photometric redshifts obtained for these fainter galaxies can then be used to calibrate the LSST photometric redshift system. **(2)** A powerful alternative approach is to exploit the clustering of galaxies to test or perform photometric redshift calibrations. The angular cross-correlation between separate photometric redshift bins provides a measure of the degree to which those bins overlap in redshift, allowing photometric redshift outlier fractions to be measured. High precision results may be obtained by measuring the angular cross-correlation between objects in some photometric redshift bin and objects with known spectroscopic redshift, as a function of the spectroscopic z. This allows the true redshift distribution of the photometric sample to be reconstructed in detail, even if it includes objects too faint for spectroscopy or if spectroscopic samples are highly incomplete (like existing samples at high z). With currently planned spectroscopic samples this method can reach LSST calibration goals.

086.07

The LSST Data Products

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The LSST produces data products at two cadences. The nightly data products consist of raw images, low-latency alerts, and updates to the object, source, and orbit catalogs, all of which are archived and publicly available. Some additional data produced by the nightly pipelines, such as calibrated and subtracted images, are not necessarily archived but can be recreated on demand. At longer intervals, approximately twice a year, data releases are produced. A data release is the result of processing the survey images accumulated to date through the deep detection and classification pipelines, as well as the image processing pipeline. Once produced and validated, a data release is frozen and archived as an entity that can be readily accessed in the future. This will facilitate publishing papers that refer to specific LSST data releases. The principal data products in a release are the object catalog and stacked images. The object catalog includes a full range of object properties as co-measured from all images in all bands which contain the object, light curves over the duration of the survey, and object classifications. The photometry and astrometry in this catalog will be calibrated to a more precise level than available from the nightly data products, and in general the intent is that most science done with LSST will use this catalog directly. The stacked images are used internally for production of template images, as well as for producing RGB images useful for visual understanding of objects and for EPO.

086.08

Four LSST probes of Dark Energy

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The physics that produces the observed accelerating cosmic expansion is unknown. The half-sky LSST multi-band survey will address the underlying dark energy physics by exploiting a diversity of precision cosmic probes:Weak lensing (WL) of galaxies vs. redshift, which probes both distances and the evolution of structure vs. redshift, thereby setting multiple independent strong constraints on the dark energy equation of state (EOS).Spatial correlations of galaxies vs. redshift (Baryon Acoustic Oscillations, BAO) utilizes the "standard ruler" of the peak in the correlation of dark matter revealed in the temperature anisotropies in the cosmic microwave background (CMB).The redshift distribution of shear peaks due to large structures of dark matter (via WL combined with the optical data) are an exponentially sensitive probe of the dark energy EOS.A million supernovae are complementary for probing the recent cosmic era when dark energy becomes dominant.When combined with the CMB data these tests form interlocking checks on cosmological models and the physics of dark energy. The combination of BAO with WL is especially powerful. By simultaneously measuring the distance-redshift and growth-redshift relations, LSST data can tell us whether the recent acceleration is due to dark energy or modified gravity. Astrophysical observations are susceptible to systematics, so the LSST is being specifically designed and engineered to minimize and control systematics at a level ten times below the smallest signal of interest. The diverse techniques above are complementary, removing degeneracies. Much of the power of the LSST comes from the fact that the measurements will be obtained from the same set of observations with a powerful facility optimized for this purpose. Using realistic estimates of systematics from

LSST-like observing on the Subaru telescope, we will show projected precision of the LSST survey constraints on the nature of dark energy.

086.09

Cosmology with Photometric Baryon Acoustic Oscillation Measurements

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LSST will obtain photometric redshifts for more than 3 billion galaxies with the distribution peaking around $z = 1$ and approximately 10% of the galaxies at $z > 2.5$. It will achieve sub-percent level precision on the angular diameter distance to 7 redshift bins from $z = 0.2$ to 3 with a CMB-calibrated standard ruler baryon acoustic oscillations (BAO) in the galaxy/matter power spectrum. By themselves, LSST BAO will provide weaker constraints on the dark energy equation of state parameters, w_0 and w_a*, than LSST weak lensing (WL). However, because one can calibrate the error distribution of photometric redshifts with galaxy power spectra and determine the galaxy bias with galaxy and WL shear power spectra, a joint analysis of LSST BAO and WL will reduce the error ellipse area in the* w_0-w_a *plane to one sixth of that by LSST WL alone.*

086.10

Weak Lensing with LSST

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Constraining dark energy parameters with weak lensing is one of the primary science goals of the LSST. The LSST Weak Lensing Science Collaboration has been formed with the goal of optimizing the weak lensing science by optimizing the survey cadence; working with Data Management to insure high-quality pipeline processing which will meet our needs; developing the necessary analysis tools well before the onset of data-taking; participating in high-fidelity simulations to test the system end-to-end; and analyzing the real dataset as it becomes available.

We review the major weak lensing probes, the twoand three-point shear correlations, and how they constrain dark energy parameters. We also review the possibility of going beyond dark energy models and testing gravity with the LSST data. To realize the promise of the awesome LSST statistical precision, we must ensure that systematic errors are kept under control. We review the major sources of systematics and our plans for mitigation. We present data that demonstrate that these sources of systematics can be kept to a level smaller than the statistical error.

086.11

Supernova Science and Cosmology with the LSST

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The LSST will open up new opportunities for supernovae and supernova cosmology. In addition to repeated coverage of much of the visible sky, which will result in tens of thousands of Type Ia supernovae at redshifts less than 0.2 and one million Type Ia supernovae out to a redshift of 1, a special deep-drilling survey will focus on finding tens of thousands of Type Ia supernova out to redshifts of 1.2. This redshift span will provide a very good range for investigations of the dark energy equation-of-state parameter with the precision of a self-consistently calibrated system. The concern for future supernova cosmology experiments is generally with the systematics rather than the statistics; we observe that the unprecedented number of supernovae that will be found by the precisely-calibrated LSST system will provide a means to detect and calibrate many of these important systematic effects. Supernovae of all types will be discovered by LSST and we anticipate that the wealth of data provided will allow many questions of supernova progenitor and late-stage stellar evolution to be addressed by a combination of the supernovae found by the LSST extra-galactic survey and the survey of the billions of stars in our own galaxy. We present here the expected numbers, distribution, and coverage of supernovae based on the nominal LSST cadence program and discuss the opportunities for supernova and cosmological science from the resulting rich supernova dataset.

086.12

Gravitationally Lensed Quasars Lessons from SDSS and Predictions for LSST

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The SDSS survey is uncovering many gravitationally lensed quasars and demonstrating the usefulness of large-scale optical surveys for lens statistics. In the SDSS, lensed quasars are surveyed by searching ''extended'' quasars for small-splitting lenses, or by comparing colors of stellar objects nearby quasars if lensed images are well resolved. Although LSST data have no spectroscopic information, its multi-epoch multiwavelength imaging observation makes it possible to conduct an efficient search of lensed quasars by making use of their colors and time variability. We will discuss the propsect for finding lensed quasars from LSST and for determining cosmological parameters.

086.13

Transients and Variables

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The first half of the twentieth century was dominated by the discovery of explosions (supernovae), erruptions (novae) and variable stars (Cepheid variables).

As we go into this century, LSST, thanks to its large etendue, can be expected to contribute tremendously to the area of transients and variables. Are there events between novae and supernovae? Are there new types of (rare) supernovae? What do coalescence of stars (combination of main sequence, planets, white dwarfs, neutron stars, black holes) result? Are these connected to short hard gamma-ray bursts and LIGO events? LSST is in a position to address these questions.

086.14

AGN Science with the LSST

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The LSST will provide great advances in our understanding of the demography and physics of AGNs, owing to its unprecedented combination of solid-angle coverage, photometric and astrometric accuracy, sensitivity, broad wavelength coverage, and time sampling. Well-defined, large ($> 10^7$ objects) samples of AGNs at $0 < z < 7$ can be constructed via four approaches: location in color-color space, variability, lack of proper motion, and matching to multiwavelength data. The samples will allow studies of the AGN luminosity function and AGN clustering down to Seyfert luminosities out to z ~ 6-7. The time baseline (hours to years), coupled with the large sample size, will produce a data set that can be used to address the physics of the AGN accretion process, allowing insights into the fueling of AGNs by stellar tidal disruptions and the lifetime of AGNs. Comparison of LSST data with archival X-ray and infrared fields will be the first stage of follow-up for hundreds of thousands of AGNs, many of which will be heavily obscured.

086.15

Mapping the Milky Way with LSST

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The Milky Way and its environment provide a unique, powerful laboratory for testing theories of galaxy formation and small-scale predictions of CDM cosmology. Recent results from large-area surveys have drastically altered our view of the Galaxy and made it clear that it is a complex, dynamical structure that is still being shaped by the infall of smaller systems. The multicolor, multi-epoch photometric map created by the LSST will provide an unprecedented means to explore the Galaxy's structure, star formation, chemical enrichment, and accretion history on a panoramic scale. Strategic time and space sampling of each field over ten years will allow variability, proper motion and parallax measurements for objects brighter than V~24, and the final map will cover half the sky to V~26.5. This combination of area, depth and time resolution will enable Galactic science from the solar neighborhood to the edge of the Milky Way's halo and well into the Local Group. RR Lyrae stars detected in the time-series data will reach to 400 kpc, tracing the halo structure and substructure beyond the Milky Way's virial radius. Parallax measurements will create a census of all stars within 500pc down to the hydrogen-burning limit. Accurate multi-band colors will permit both photometric parallaxes and chemical abundance estimates for over a billion main sequence stars to 100 kpc. Proper motions and 3D structural maps will provide a powerful statistical sample for Galactic studies. The LSST photometry will reach M(V)~+8 in the Magellanic Clouds, allowing their main sequence stars to be used for tracing the detailed interaction of the Clouds with the Galaxy halo. New dwarf galaxies in the Local Group and other nearby groups will be revealed via over-densities in resolved stars. Novae discovered by LSST time sampling will trace intergalactic stars out to the Virgo and Fornax clusters.

086.16

Stellar Populations with the LSST

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The LSST will produce a multi-color map and photometric object catalog of half the sky to g~27.5(5σ). Strategically cadenced time-space sampling of each field spanning ten years will allow variability, proper motion and parallax measurements for objects brighter than g~25. As part of providing an unprecedented map of the Galaxy, the accurate multi-band photometry will permit photometric parallaxes, chemical abundances and a handle on ages via colors at turn-off for main-sequence stars at all distances within the Galaxy, permitting a comprehensive study of star formation histories (SFH) and chemical evolution for field stars. With a geometric parallax accuracy of 1mas, LSST will produce a robust complete sample of the solar neighborhood stars. While delivering parallax accuracy comparable to HIPPARCOS, LSST will extend the catalog to more than a 10 magnitudes fainter limit, and will be complete to M_V~15. In the Magellanic Clouds too, the photometry will reach M_V~+8, allowing the SFH and chemical signatures in the expansive outer extremities to be gleaned from their main sequence stars. This in turn will trace the detailed interaction of the Clouds with the Galaxy halo. The LSST time sampling will identify and characterize variable stars of all types, from time scales of ~1hr to several years, a feast for variable star astrophysics. Cepheids and LPVs in all galaxies in the Sculptor, M83 and Cen-A groups are obvious data products: comparative studies will reveal systematic differences with galaxy properties, and help to fine tune the rungs of the distance ladder. Dwarf galaxies within ~10Mpc that are too faint to find from surface brightness enhancements will be revealed via overdensities of their red giants: this systematic census will extend the luminosity function of galaxies to the faint limit. Novae discovered by LSST time sampling will trace intergalactic stars out to the Virgo and Fornax clusters.

086.17

LSST: Taking Inventory of the Solar System

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LSST is a wide-field survey instrument that addresses key scientific priorities, including planetary science objectives, of a number of committees commissioned by the National Academy of Sciences. The baseline LSST design is an 8.4m aperture telescope with a 3.2 giga-pixel focal plane array that will allow detections of point sources as faint as magnitude 24.8 by co-adding back-to-back 15-second images comprising 9.6 square degrees each. By visiting each field twice in a night and revisiting on 3-5 well-spaced nights per lunation, the survey will accumulate a massive catalog of solar system objects. This will include upwards of 70-80% of the potentially hazardous asteroids larger than 140m diameter within 10 years, making a significant contribution towards addressing a recent Congressional directive to NASA to catalog 90% of such objects. LSST will catalog millions of main-belt asteroids and perhaps 20,000 trans-neptunian objects, providing ancillary information about color and photometric variability for many of these. Pluto-like objects will be detectable at heliocentric distances beyond 300 AU. Long-period comets will generally be discovered far earlier than previously possible, enabling photometric studies uncontaminated by nucleus activity and the testing of Oort cloud population models.

086.18

An Overview of the LSST Telescope and Site

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The LSST uses a modified Paul-Baker 3-mirror optical design with 8.4-m primary, 3.4-m secondary and 5-m tertiary mirrors. The 3mirror telescope feeds a 3 element refractive corrector to produce a 3.5-degree diameter field of view over a 64-cm flat focal surface. This design provides excellent image quality with 80% encircled energy diameters of <0.3" in u and g; <0.25" in Y; and <0.2" in r and i spectral bands over the full field of view. The etendue (collecting area times field of view), a measure of survey capability, for the LSST is 319m^2deg^2, many times that of any other existing or proposed facility.

The primary and tertiary mirrors are arranged so that their surfaces form a cusp at their intersection, allowing them to be fabricated from a single substrate. This is a unique feature of the LSST and is called the M1M3 monolith. The M1M3 monolith will be fabricated the Steward Observatory Mirror Lab using their structured borosilicate spin casting technology. Fabrication is scheduled to start in mid 2007.

The optical design has been analyzed for correctability and is shown to be remarkably tolerant to anticipated fabrication errors with a limited number of compensators. The active optical compensation and figure control of the three mirrors and camera is done by tomographic analysis of four wavefront sensors at the edge of the field of view. Stray and scattered light analysis shows the LSST will achieve its signal to noise requirements.

The summit facility on Cerro Peñón in Northern Chile consists of a 30-m cylindrical dome and support building. The cylindrical dome design utilizes extensive natural ventilation to maintain thermal equilibrium. Numerical fluid models of this desig indicate more than 50 dome air changes per hour in median wind conditions.

086.19

The Baseline Design of the LSST Camera

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The Large Synoptic Survey Telescope will be a large aperture, wide-field ground-based telescope designed to survey half the sky every few nights. The LSST camera will be the largest digital camera ever built. As such, its design presents a number of challenges. The field of view will be 3.5 degrees in diameter and will be sampled by a 3.2 billion pixel array of sensors. The entire array must be read out in under 2 seconds, which leads to demanding constraints on the sensor architecture and the readout electronics. In addition, given the fast optical beam (f 1.2), the build tolerances on the assembly and alignment of the focal plane are tight. The camera incorporates three very large refractive lenses, an array of five large filters mounted on a carrousel, and a mechanical shutter.

We will present an overview of the baseline camera design, with an emphasis on key aspects of our development program. Parallel posters will discuss the details of the sensor development and of the electronics.

086.20

The LSST Sensor Development Program

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The LSST focal plane array (FPA) will consist of an order of magnitude more pixels than any imaging array realized so far. The sensors must produce low read noise, high QE at 1 micron, and a very tight PSF. This will all be necessary to do the science at the LSST. For an FPA involving about 200 large format (4k x 4k) sensors, an industrial approach has to be developed and adopted. In this initial phase of sensor development, we have targeted specific technology experiments at selected vendors, with the goal of establishing both the technical characteristics of actual sensors, based on our projected requirements, and the industrial feasibility of their production. We have chosen to fund three projects in this initial development phase, two involving CCD technology and one utilizing hybridized PIN-CMOS architecture. Initial test results from the first devices in a smaller format resulting from this study program will be presented. Design concepts for assembly of the large format sensors into larger modules (rafts) containing 3 x 3 sensors each, with their readout electronics, will also be presented.

086.21

LSST Camera Electronics

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The requirements for reading out the focal plane of the Large Synoptic Survey Telescope are driven by the scientific goals of simultaneously achieving exceptionally high throughput and faint limiting magnitude (i.e., 10 square degrees imaged to 24.5 AB magnitude every 15 s). This results in a large pixel count (3.2 Gpix) and very high segmentation (3,200 readout channels) operating at modest pixel rates (250 kHz 500 kHz). Using this massively parallel readout, about six gigabytes of data are generated per exposure. Present plans call for installing front end electronics inside the cryostat adjacent to the sensors at a temperature of -100C. Digitizing and multiplexing electronics will be in a separate thermal zone within the main cryostat, and data will exit the cryostat over a small number of optical fiber links. Strict attention to contamination control will be required to prevent volatile materials from the electronic hardware from condensing on the sensor surfaces. Two critical ASIC developments are underway for the Front End Electronics; an Analog Signal Processing ASIC containing multiple channels of dual slope integrators, and a Clock Driver ASIC to handle conversion of logic levels to CCD clock levels. These developments are crucial to achieve the high density, low power, and low noise levels required.

086.22

Maximizing Observations in the Large Synoptic Survey Telescope Cadence Simulator (OpSim) and Uncovering Its Abilities: Evaluating The Search for Variable Stars

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The Large Synoptic Survey Telescope (LSST) is a proposed 8.4 meter ground-based survey telescope to be built in Cerro Pachon, Chile and is scheduled for completion in late 2012. It will perform a ten year survey of the night sky, utilizing its wide ten square degree field of view to dynamically survey the sky using frequent 30 second exposures. The LSST cadence simulator (OpSim) is a computer simulation model that has been developed to mimic the cadence scheme of the LSST. Using the LSST cadence simulator, we examined the dates of observation of several fields of the sky, and using this data and several methods of period analysis attempted to determine the feasibility of using the LSST as a search tool for types of variable stars with known periods.

This research was supported by the NOAO/KPNO Research Experiences for Undergraduates (REU) Program which is funded by the National Science Foundation through Scientific Program Order No. 3 (AST-0243875) of the Cooperative Agreement No. AST-0132798 between the Association of Universities for Research in Astronomy (AURA) and the NSF.

087: M33: Our Other Neighbor
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

087.01

Chandra ACIS Survey of M33 (ChASeM33): A Deep X-ray Survey of theNearest Face-on Spiral

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The Chandra ACIS Survey of M33 (ChASeM33) is a Very Large Project with the Chandra X-ray Observatory to observe the inner regions of M33, the nearest roughly face-on spiral galaxy. The ChASeM33 survey, which covers the majority of the area inside the D25 isophote, provides an unprecedented view in X-rays of the hot phase of the Interstellar Medium (ISM), the Supernova Remnant (SNR) population, and the point source population of M33. Chandra provides the highest angular resolution yet achieved in X-ray astronomy (~1 arcsecond), resulting in a limiting luminosity for point sources in this survey of ~1e35 ergs/s in the 0.5-7.0 keV bandpass. The survey consists of 14 pointings of 100 ks each at seven fields in the galaxy, such that each field is observed twice roughly one year apart. We briefly discuss the technical challenges of combining a large dataset with multiple, overlapping Chandra observations. We present mosaic images of the survey data in three bands, ''total'' (0.5-8.0 keV), ''soft'' (0.5-2.0 keV), and ''hard'' (2.0-8.0 keV), and an X-ray ''true-color'' image. These mosaic images are compared to the optical, UV, and radio images of M33 to identify large features in the ISM such as evolved SNRs, large HII regions, and superbubbles. For two of the largest HII regions in the galaxy, NGC 604 and IC 131, the Chandra data resolve structure within the HII regions and identify significant spectral variations within the regions. Adjacent posters in this session will present more details on the point source population, the SNR population, and the brightest SNR in M33.

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087.02

Chandra ACIS Survey of M33 (ChASeM33): The X-ray Point Source Population of M33

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With most of the 1.4 Ms of Chandra ACIS M33 data already available, we have begun measuring the properties of the hundreds of sources present in the data. To date nearly 600 discrete sources have been cataloged, over 90% of these objects are point sources closely matching the Chandra point spread function. The high spatial resolution (about 1 arcsecond) has made separating point and extended sources more straightforward over a larger region of M33 than ever before. Spectral and timing analyses of the current source catalog have provided hardness ratios and variability information to aid in initial source classification. The full catalog of X-ray binaries will provide an X-ray Luminosity Function (XLF) down to luminosities of around 10^35 erg/s (at the 3-sigma level). Such an XLF will allow detailed studies of the interplay between star formation and X-ray source formation, providing a new level of detail in the understanding of galaxy evolution from one end of the stellar life cycle to the other. Finally, the data set is a treasure trove of exotic X-ray sources, such as new transient X-ray sources, the first eclipsing black hole binary, and a new eclipsing high mass X-ray binary.

This work was supported by NASA Chandra award number G06-7073A.

087.03

Chandra ACIS Survey of M33 (ChASeM33): Supernova Remnants

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We are obtaining deep 200 ksec X-ray images of seven fields covering the central regions of M33, using the ACIS-I instrument on the Chandra X-ray Observatory. The survey region includes most of the nearly one hundred supernova remnants (SNRs) that have been identified previously by a combination of optical and radio imaging and spectroscopy. A substantial fraction of these SNRs have been detected as X-ray sources for the first time. Here we discuss the identification of SNRs in the X-ray survey. We compare characteristics of the X-ray spectra of previously-identified SNRs to all of the X-ray objects that have been detected in the survey. We use these characteristics (along with the existing optical and radio data) to identify new SNRs and SNR candidates. Finally, we use both SNRs in the M33 survey and integrated spectra of LMC and Galactic SNRs to estimate the total number of SNRs that are likely to be contained in the X-ray sample and to calibrate the M33 SNR survey in terms of detectability as a function of remnant type.

087.04

Chandra ACIS Survey of M33 (ChASeM33): X-ray Imaging and Spectroscopy of M33SNR21, the Brightest X-ray Supernova Remnant in M33

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We present and interpret new X-ray data for M33SNR21, the brightest X-ray supernova remnant (SNR) in M33, obtained as part of the ChASeM33 project. M33SNR21 (SNR #21 in Gordon et al. 1998, ApJS 117, 89) is an optical SNR which was confirmed by nonthermal radio emission and X-ray (ROSAT) emission. It is seen in projection against (and is probably interacting with) the giant HII region NGC592. We have obtained 200 ks of high resolution X-ray imagery resolving the SNR into a slightly elliptical shell 5 arcsec (20 pc) in diameter. The eastern rim is nearly five times brighter than the western rim, which suggests the SNR is interacting with a large scale density gradient, consistent with its position in a complex environment. We fitted an elliptical shell model to determine accurately the SNR dimensions and also the X-ray center. The high spatial resolution data from near on-axis pointings, plus additional lower resolution data from pointings where the source is farther off-axis, together provide ~10000 X-ray counts. An absorbed Xspec sedov model fit to spectra extracted from these data imply a shock temperature kT = 0.46 keV, an ionization timescale of ~2e12 cm^-3 s, and an SNR age of ~5000-10000 yr. The SNR X-ray luminosity (0.245-4.0 keV) is 1.2e37 erg/s (absorbed), compared to 1.1e36 erg/s (0.1-4.0 keV) for the Cygnus Loop (Ku et al. 1984, ApJ 278, 615) and 6.3e36 erg/s (0.5-5.0 keV) for the Large Magellanic Cloud remnant N49 (Hughes et al. 1998, ApJ 505, 732). A search for harder emission results in an upper limit of 1.2e35 erg/s for any central compact source or plerion.

This work was supported by NASA Chandra award number G06-7073A and by NASA contract NAS8-03060.

087.05

Stellar Populations of the Disk of M33

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We present multiband photometry obtained with the Advanced Camera for Surveys on board the Hubble Space Telescope of four fields in the disk of M33. By studying the positions in the color magnitude diagrams of the most massive main sequence stars and examining the colors of the red giant branches we derive the maximum ages for the youngest stars in each field and make an initial estimate the metallicity gradient across the four fields. We also combine near UV photometry of individual stars in each field obtained with the Wide Field Planetary Camera 2 to make reddening maps of the four fields. We examine whether there is any correlation between the observed reddening and HI maps of the fields.

087.06

A Spectroscopic Study of M31 dSphs -Kinematics, Chemical Abundances, and Radial Distributions in And I, II, and III

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We present Keck/DEIMOS spectroscopic observations of hundreds of individual red giant branch (RGB) stars in three of Andromeda's dwarf spheroidal galaxies (dSphs) -And I, II, and III. Accurate radial velocities with uncertainties of a few km/s are derived for a subset of these data allowing us to resolve the intrinsic velocity dispersion of each galaxy and place constraints on the mass-to-light ratio of And I, II, and III. Both the photometric and spectroscopic metallicity of each confirmed dSph member is measured independently. We investigate the mean abundance, abundance spread, and radial variation in abundance and velocity and find strong differences between the three galaxies. These differences likely point to unique evolutionary histories for these dSphs.

This research was funded by grants from NSF and NASA/STScI.

088: MIPSGAL
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

088.01

MIPSGAL I & II: A Survey of the Inner Galactic Plane at 24 and 70 Microns, The Mosaics

Sean J. Carey[1], A. Noriega-Crespo[1], D. R. Mizuno[2], S. Shenoy[1], R. Paladini[1], K. E. Kraemer[3], T. A. Kuchar[2], F. R. Marleau[1], S. D. Price[3], D. L. Padgett[1], R. Indebetouw[4], J. G. Ingalls[1], B. Ali[5], G. B. Berriman[5], F. Boulanger[6], R. M. Cutri[5], W. B. Latter[5], P. Martin[7], M. Miville-Deschenes[6], S. Molinari[8], L. M. Rebull[1], R. F. Shipman[9], L. Testi[10]
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We present mosaics of the Galactic plane at 24 and 70 microns taken with the MIPS instrument aboard the Spitzer Space Telescope. The region surveyed is -63 < l < 63, |b| < 1 excluding an sixteen square degree region about the Galactic center. The resolutions of the mosaics are 6 and 18 arcseconds FWHM at 24 and 70 microns, respectively. Substantial image processing has been applied to the SSC supplied basic calibrated data to produce the final mosaics. The data are useful for studies of massive star formation, the distribution and energetics of interstellar dust, evolved stars such as luminous blue variables, and supernova remnants. These mosaics will be publically available by mid-January 2007 and are going to be hosted by the NASA/IPAC Infrared Science Archive.

This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

088.02

Data processing of MIPSGAL 24 micron images

Donald R. Mizuno[1], A. Noriega-Crespo[2], D. L. Padgett[2], S. J. Carey[2], R. Paladini[2], S. Shenoy[2], K. Kraemer[3], T. Kuchar[1], F. Marleau[2], S. Price[3]
[1]Boston College, [2]Spitzer Science Center, [3]Air Force Research Laboratory.

We describe the modifications and corrections that we have made to the standard SSC pipeline-produced, 24 micron basic calibrated data (BCDs) for the MIPSGAL survey. The 24 micron data suffers from numerous artifacts, many of which are caused by scanning across bright point sources and compact extended emission. Generally these can be classified into two types: latency effects, in which there are short timescale elevations and long timescale depressions in pixels that have experienced high flux levels; and global effects wherein entire columns or rows of pixels have level offsets due to the presence of a bright source on or adjacent to the array. We also account for a residual bias pattern in the array which is similar in nature to the ″first-frame″ effect noted in IRAC data. Most of our corrections are additive in nature as multiplicative corrections cause noticeable irregularities over the large dynamic range observed in our survey mosaics. In most cases our approach is to characterize the artifact and determine a correction, although in some cases the artifacts are simply masked from the images.

This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

088.03

The MIPSGAL 24 Micron Point Source Catalog: Preliminary Results

Sachindev S. Shenoy[1], F. Marleau[1], D. Mizuno[2], S. J. Carey[1], A. Noriega-Crespo[1], K. E. Kraemer[3], S. D. Price[3], T. A. Kuchar[2], D. L. Padgett[1], R. Paladini[1]
[1]SSC Caltech, [2]Boston College, [3]Air Force Research Laboratory.

″MIPSGAL'' is a survey of the Galactic plane at 24 and 70 microns using the Multiband Imaging Photometer for Spitzer (MIPS) onboard the Spitzer Space Telescope. The survey covers 220 square degrees of the inner Galactic plane spanning, -63 < l < 63 with a latitude range of |b| < 1 (excluding a region around the Galactic center). We describe the details of the 24 micron point source extraction method, including modifications to the default parameters in the MOsaicking and Point source EXtraction (MOPEX) package and the quality assurance tests we employ. Test runs show that we can reliably extract sources with fluxes in the range 1-1000 mJy with signal-to-noise ratios above 3. The results of the point source extraction are being compiled into a catalog that will be available to the general astronomical community. We present preliminary results on the content for selected MIPSGAL subfields such as source density, confusion limits, background complexity, and comparisons with other infrared plane surveys.

This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

088.04

Data Processing of MIPSGAL 70 Micron Images

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We describe the modifications and enhancements that we have made to the standard SSC pipeline produced, 70 micron basic calibrated data (BCDs) for the MIPSGAL survey. The high background levels and large number of saturating sources in the observed portion of the Galactic plane create large variations in the responsivity of the Ge:Ga detectors used in the MIPS instrument. We detail how we reprocess the stimulator solutions using the GeRT software provided by the MIPS instrument team. The stim-corrected data have then a delta flat field applied to correct for short term responsivity variations. We explore several methods of destriping the data on a scan to scan level. A globally derived gain correction appears to be the best solution although a wavelet based destriper also retrieves good results. The photometry is checked by comparing the resulting mosaic images to IRIS reprocessed 60 micron data (Miville-Deschenes & Lagache 2005; ApJSS, 157, 302). Over most of the dynamic range of the data, the color-corrected MIPSGAL data agrees to 10% with IRIS. For the brightest regions, the values can be descrepant by 30% with a substantial fraction of the discrepancy due to the uncertainty in the color correction applied.

This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

088.05

Dusty Sculptures in the MIPSGAL Survey

Nicolas Flagey[1], A. Noriega-Crespo[2], S. Carey[2], MIPSGAL Team
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The active star-forming region M16, also known as the Eagle Nebula, has become famous for its pillars that the Hubble Space Telescope has imaged more than ten years ago. The interaction between the radiation field of young stars and the inhomogeneous molecular cloud where they were born results in these structures and triggers the formation of a new generation of stars. The dust, mixed with the gas, is highly processed and its properties significantly change across the entire region. The analysis of the dust emission in M16 may thus help to improve our understanding of the dust evolution cycle and properties.

I combine data from the MIPSGAL and GLIMPSE surveys of the Spitzer Space Telescope, as well as ancillary images and spectra from ISOCAM, IRAS and MSX, in order to probe the Near to Far Infrared emission of the smallest to biggest dust grains, respectively. Using an updated version of the

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model of Desert et al. (1990), I aim at constraining the smallest dust grains (PAH) properties in terms of size and ionization state, as well as the dust size distribution, in agreement with these observations.

I will present some preliminary results of this work, which is my current research project as a Visiting Graduate Student at the Spitzer Science Center, California Institute of Technology.

088.06

The Astronomical Zoo in MIPSGAL I and II

Thomas A. Kuchar[1], D. Mizuno[1], S. Shenoy[2], R. Paladini[2], K. Kraemer[3], S. Price[3], F. Marleau[2], D. Padgett[2], R. Indebetouw[4], J. Ingalls[2], B. Ali[2], B. Berriman[2], F. Boulanger[5], R. Cutri[2], W. Latter[2], M. Miville-Deschenes[5], S. Molinari[6], L. Rebull[2], L. Testi[7], R. Shipman[8], P. Martin[9], S. Carey[2], A. Noriega-Crespo[2]
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The view of the Galactic Plane at 24 μm is breathtaking. A great part of this beauty arises from the complexity of the Interstellar Medium shaped by endless energetic events driven by HII regions, supernova explosions, Wolf-Rayets, Luminous Blue Variables, and evolved and new born massive stars. A sample of these objects is presented in this poster, gathered from the Multiband Imaging Photometer for Spitzer (MIPS) Survey of the Galactic Plane I and II (MIPSGAL; see Carey et al. 2006, this meeting). The global color properties of these objects are derived by combining the data at 24 and 70um with that from the Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE), and following similar schemes as those used in the Spitzer Surveys of the Magellanic Clouds (Bolatto et al. 2006, astroph-0608561; Meixner et al. 2006, astroph-0606356).

This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA in part through an award issued by JPL/Caltech.

089: Stellar Populations III
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

089.01

***FUSE* Observations of the Unprecedentedly Deep ″Quiescent″ Magnetic Activity State of alpha Centauri A**

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[1]Villanova U..

Since 1990 we have been engaged in the “Sun-in-Time” project -a program of coordinated multiwavelength observations of solar-type stars. These stars, which all have similar physical properties (mass, radius, temperature, and depth of convection zone), have been selected as proxies for the Sun at stages throughout its main-sequence lifetime, differing only in age, or equivalently, rotation period. An important component of this program is the investigation of magnetic activity cycles that occur within these solar proxies, and the changes in high energy X-ray coronal and FUV transition region emissions.

Recently, X-ray emission fluxes for one of our program stars, the approximately solar-aged α Cen A, was observed to diminish by a factor of ~25 in only two years’ time, a phenomenon never before observed for any solar-type star. The *XMM* observations imply that the chromospheric through coronal regions of α Cen A can be highly variable, with changes in both mean temperatures and the emission measures necessary to address these recent observations. Presented here are *FUSE* Cycle 7 observations obtained during this unprecedented, very deep magnetic inactivity state of this solar proxy. These new observations are compared to the previously existing Cycle 2 spectra, secured before this dramatic magnetic recession began. We find that in this short span of five years α Cen A has exhibited a significant decrease of approximately 2.5-3× in the key FUV emissions, which may indicate an activity cycle. Examination of other high energy measures, such as X-ray (coronal; *Einstein*, *ROSAT*, and *XMM*), UV (transition region; *IUE*), and NUV (chromospheric; *IUE*) emissions of α Cen A, along with comparisons to the Sun (*Solar EUV Experiment*) are presented.

We gratefully acknowledge support by NASA Grant NNX06AC45G and the Villanova University Research for Undergraduates Award Program.

089.02

Results from the Nearby Stars (NStars) Program: Candidate Solar Twinsand Chromospheric Diversity in G and K dwarfs

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Since the year 2000, our institutions have been engaged in a study of the nearby dwarf and giant stars earlier than spectral type M0 in the Hipparcos catalog and within 40 parsecs of the Sun. This study has used classification-resolution spectra to provide new, precise spectral types and basic physical parameters (effective temperature, surface gravity and metallicity) for these stars. In addition, we are providing measures of the chromospheric activity for these stars. Results so far have been published in Gray et al. (2003, 2006). In this poster, we discuss the solar-twin/solar analogue candidates we have found in our sample, and comment on the interesting diversity we have found in the expression of chromospheric activity in active G and K dwarfs.

089.03

Global Simulations of the Magnetorotational Instability in a Spherical Geometry

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We explore the action of the magnetorotational instability (MRI) in a spherical geometry. Though often discussed in relation to accretion disks, the MRI, which occurs in the presence of a weak magnetic field in a differentially rotating plasma, is relevant to numerous phenomena in magnetized rotating stars. Here we use global MHD simulations to examine the non-linear development of this instability in differentially rotating polytropes. We conduct our simulations with an Eulerian grid code that includes self-gravity. Our results are most applicable to the radiative zones of solar-type stars; implications for degenerate stars are also discussed.

089.04

Time Variation in the Magnetic Activity of Cool Stars

Andrew A. West[1], J. T. Wright[1], G. W. Marcy[1], M. Agueros[2], L. M. Walkowicz[3], E. J. Hilton[3], S. L. Hawley[3], J. J. Bochanski[3], K. R. Covey[4]
[1]UC, Berkeley, [2]Columbia University, [3]University of Washington, [4]CfA.

We present results from the analysis of multi-epoch, spectral observations of magnetically active M-dwarfs. Using data from the California and Carnegie Planet Search Program, the Sloan Digital Sky Survey, and follow-up observations at Apache Point Observatory, we examine the time variation of chromospheric magnetic activity (as traced by the H-alpha, H-beta and Calcium K emission lines). We investigate the amplitude of activity variation in individual stars and compare this to the spread in activity seen in large SDSS samples of M-dwarfs. The data suggest that the activity variation of individual stars cannot explain the range of activity seen in the SDSS sample, indicating there is an intrinsic spread of activity strength in the M-dwarf population. In addition, we examine differences in the observed activity variation between the measured emission lines. Our analysis puts important constraints on the range of chromospheric temperatures predicted from models of M-dwarf dynamos.

089.05

The Old Feeble Coronae of Solar-like Dwarf Stars in the Arcturus Moving Group

Alexander Brown[1], E. Hodges-Kluck[1], T. R. Ayres[1], G. M. Harper[1]
[1]*Univ. of Colorado.*

The Arcturus Moving Group (AMG) is very likely a remnant of the merger of a dwarf galaxy with the Milky Way Galaxy in the distant past. This kinematically distinct group has members located very close to the Sun, allowing study of coronal activity on very old stars that would typically not be possible. We are investigating a sample of nearby AGM dwarfs to study the properties of stellar magnetic activity on old (7-8 Gyr), low metallicity stars. Our sample has metallicities between 0.4 and 0.04 solar, spectral types F9 K0, and distances less than 35 pc from the Sun. We have detected X-ray emission from two AMG dwarfs with the Chandra ACIS-S S3 BI detector during Cycle 7 and two further stars have been approved for observation in Cycle 8. The detected stars are HD199288 (G0 V, V=6.6, d = 21.6 pc, [Fe/H] = -0.68) and HD65583 (G8 V, V=6.9, d = 16.8 pc, [Fe/H] = -0.68) and their derived X-ray luminosities are 4.4 and 1.9 10^{26} erg s^{-1} respectively. These X-ray luminosities are somewhat less than the minimum solar L_x (range 6 -20 10^{26} erg s^{-1}) but are comparable with that of the inactive, more metal rich ([Fe/H] = -0.42] G8 dwarf Tau Cet. All the detected source X-rays are very soft with energies of 0.2-0.3 keV, indicating very cool ($\sim$ 1 MK) coronal temperatures.

These results were obtained and funded by CXO project 7200977.

089.06

The Age-Activity Relation for M dwarfs Using 25,000 SDSS Spectra

Suzanne L. Hawley[1], A. A. West[2], J. J. Bochanski[1], K. R. Covey[3]
[1]*Univ. of Washington,* [2]*Univ. of California,* [3]*CfA.*

The age at which strong surface magnetic activity ceases in M dwarfs has been inferred to have a strong dependence on mass (spectral type, surface temperature) to explain previous results showing a large increase in the fraction of active stars at later spectral types. Using spectral observations of 25,000 M dwarfs in the SDSS, we show that the fraction of active stars decreases as a function of vertical distance from the Galactic plane, and that the magnitude of this decrease changes significantly for different M spectral types. Adopting a simple dynamical model for thin disk vertical heating, we assign an age for the activity decline at each spectral type, and thus determine an activity-age relation for M dwarfs. These results provide constraints for dynamo models that seek to describe the production of surface magnetic fields in low mass stars.

089.07

Flare Rate Analysis of M-Dwarf Lightcurves

Adam F. Kowalski[1], E. J. Hilton[1], A. C. Becker[1], S. L. Hawley[1]
[1]*University of Washington.*

We present a preliminary variability index analysis of lightcurves of several thousand M-dwarfs extracted from the Sloan Digital Sky Survey Equatorial Stripe. These objects have been subclassed by magnetic activity and spectral type. This analysis will provide the rates of flaring activity as a function of the above parameters as well as characterizing the colors of these stars while active. M-dwarf flare rates will be applicable to next-generation time domain surveys such as the Large Synoptic Survey Telescope by predicting the fraction of observed variable objects that are flaring M-dwarfs and not other cosmological transients.

089.08

Simulations of Convection and Magnetism in Fully Convective Stars

Matthew K. Browning[1], G. Basri[1]
[1]*UC Berkeley.*

We present three-dimensional simulations of convection and magnetism within fully convective low-mass stars. Our spherical computational domain encompasses the bulk of the convective interior of a 0.3 solar mass M-dwarf, rotating at the solar angular velocity. We use the Anelastic Spherical Harmonic (ASH) code to examine highly nonlinear flows that extend over multiple scale heights and admit magnetic dynamo action. We find that small seed magnetic fields are amplified by many orders of magnitude and sustained against Ohmic decay. We assess the strength and morphology of the resulting magnetism, the character of the convective flows, and the nature of the differential rotation established within the interior.

090: More Supernovae
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

090.01

Targeting Supernovae in Very High Redshift Galaxy Clusters with HST: Preliminary Results

Kyle Barbary[1], S. Perlmutter[2], G. Aldering[1], K. S. Dawson[1], G. Goldhaber[1], N. Kuznetsova[1], J. Meyers[1], D. Rubin[1], D. J. Schlegel[1], A. L. Spadafora[1], N. Suzuki[1], R. Amanullah[3], E. Linder[3], C. Lidman[4], M. Kowalski[5], T. Hattori[6], N. Kashikawa[6], A. Fruchter[7], V. Fadeyev[8], M. Doi[9], Y. Ihara[9], K. Konishi[9], T. Morokuma[9], N. Takanashi[9], N. Yasuda[9]
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We demonstrate a novel approach to obtaining Type Ia supernovae (SNe Ia) at very high redshifts (z>~1) in dust-free environments. In a 219 orbit program (Perlmutter, PI), we have used the Advanced Camera for Surveys (ACS) and NICMOS on the Hubble Space Telescope (HST) to repeatedly observe a sample of 25 massive galaxy clusters at z>~1 to find and follow SNe. Clusters of galaxies are known to be dominated by nearly dust-free early type galaxies. SNe discovered in these galaxies are expected to have negligible dust extinction, the largest source of both statistical and systematic uncertainty in SNe derived distances. In addition, galaxy clusters contain a population of early type galaxies at a density much larger than that in the high redshift field, leading to a significantly higher rate of detection of SNe Ia in this well-understood host environment. The rolling nature of the search means we automatically follow field SNe, leading to a higher overall rate of SN discoveries compared to ″blank field″ surveys. The discovery rate we find is consistent with these expectations. Using pre-scheduled time on the Subaru, Keck, and VLT telescopes we have obtained either spectroscopic confirmations or host galaxy redshifts for most newly discovered candidates. This data set will significantly improve supernova constraints of dark energy both in terms of statistical uncertainty, and perhaps more importantly, of systematic uncertainty.

This work has been supported by the Office of Science, U.S. Department of Energy, through contract DE-AC02-05CH11231 and in part by NASA through grants associated with HST-GO-10496.

090.02

A Probabilistic Approach to Classifying Supernovae Using Photometric Information

Brian Connolly[1], N. Kuznetsova[2]
[1]*Columbia University,* [2]*Lawrence Berkeley National Lab.*

We present a novel method for determining the probability that a supernova candidate belongs to a known supernova type (such as Ia, Ibc, IIL, etc.), using its photometric information alone. It is validated with Monte Carlo, and both spaceand groundbased data. We examine the application of the method to well-sampled as well as poorly sampled supernova light curves. Central to the method is the assumption that a supernova candidate belongs to a group of objects that can be modeled; we therefore discuss possible ways of removing anomalous or less well understood events from the sample. This method is particularly advantageous for analyses where the purity of the supernova sample is of the essence, or for those where it is important to know the number of the supernova candidates of a certain type.

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090.03

Combining Supernova Datasets for Cosmological Measurements

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We present a new approach to analyzing compilations of Type Ia supernovae (SNe Ia), employing new analysis procedures to work with these heterogeneous datasets. A "union" compilation comprising currently available datasets from ground and space-based observations is formed. In addition to previously published SNe, data from a set of low-redshift nearby-Hubble-flow SNe Ia is included. A single, consistent analysis procedure is used for the various SN Ia subsamples and a new procedure is presented for consistently rejecting outliers. The very-high redshift data collected with the Hubble Space Telescope NICMOS instrument have all been reanalyzed to correct for the recently found non-linearity. The full set of refitted light-curves from this union compilation is used for cosmological parameter estimation, following a blind analysis protocol. Finally, we discuss a new method to include systematic errors in the constraints obtained from the combination of supernova data with the latest WMAP and BAO data.

090.04

The Carnegie Supernova Project: First Results From the High-Redshift Campaign

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The Carnegie Supernova Project (CSP) is aimed at providing an independent estimate of the dark energy contribution to the total energy content of the universe. Using Type Ia supernovae (SNIa), the CSP differs from other projects undertaken to date in its goal of providing an I-band restframe Hubble diagram. The CSP is focused on testing for and reducing systematic uncertainties, by obtaining multi-wavelength observations of approximately 200 supernovae falling in the redshift range $0 < z < 0.7$. The high-redshift campaign is focused on obtaining NIR photometry for SNIa in the redshift range $0.2 < z < 0.7$ using Persson's Auxilliary Nasmyth Infrared Camera (PANIC) on the Magellan telescopes. In this poster, we present the first results from our 2004-2005 campaign.

090.05

CfA Nearby Supernova Ia Light Curves and Exploring Correlations Between Light Curve Shape And Host Galaxy Type

Malcolm Hicken[1], P. Berlind[1], S. Blondin[1], M. Calkins[1], P. Challis[1], G. Esquerdo[1], C. Hergenrother[1], R. Kirshner[1], D. Latham[1], M. Modjaz[1], M. Wood-Vasey[1], A. Rest[2], T. Matheson[3]
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Type Ia supernovae (SN Ia) are central in measuring the accelerated expansion

of the Universe and the properties of the underlying dark energy.

Nearby SN Ia are compared with distant ones to establish the history of cosmic

expansion. In fact, current efforts in SN Ia cosmology are constrained by the

limited number of well-observed nearby SN Ia. A significantly improved sample

of nearby SN Ia, fully covering the space of Ia properties, is needed to

maximize the utility of high-redshift SN Ia. Our ongoing project at the CfA

has collected such a set of 150 CCD-based SN Ia, with some in UBVRI and some in UBVri, using the FLWO 1.2m telescope on Mt. Hopkins. We have now reduced this sample and present light curves of these SN Ia along with an analysis of their properties. In particular, we use our large nearby sample to explore the possible correlations of nearby SN Ia light-curve shape with host galaxy type.

The CfA Supernova program is supported in part by the National Science Foundation through grant AST-0606772 to Harvard University.

090.06

First Two Years: Infrared Light Curves of Type Ia Supernovae with the Peters Automated Infrared Imaging Telescope (PAIRITEL)

Andrew S. Friedman[1], W. M. Wood-Vasey[1], M. Modjaz[1], R. Kirshner[1], J. S. Bloom[2], C. H. Blake[1], A. H. Szentgyorgyi[1], E. E. Falco[1], D. Starr[2], M. Skrutskie[3]
[1]Harvard-CfA, [2]University of California, Berkeley, [3]University of Virginia.

We present JHK band light curves of Type Ia supernovae for the first two observing seasons with the fully robotic Peters Automated Infrared Imaging Telescope (PAIRITEL) on Mount Hopkins. We outline the performance of PAIRITEL's Type Ia supernova follow-up program to date, and discuss the cosmological applications of a homogenous sample of well-observed nearby Type Ia light curves in the near infrared. The CfA Supernova program is supported in part by the National Science Foundation through grant AST-0606772 to Harvard University.

090.07

Effects of Gravitational Lensing on SNe Discovered Behind Massive Galaxy Clusters

Mark Wagner[1], T. Pritchard[1], K. Dawson[1], X. Huang[1], S. Perlmutter[1], G. Smoot, III[1], N. Suzuki[1], Supernova Cosmology Project
[1]LBNL.

In a 219 orbit Hubble Space Telescope program (Perlmutter, PI), we have used the Advanced Camera for Surveys (ACS) to search for SNe in high redshift galaxy clusters (See poster by Barbary et al). We present a preliminary analysis of the effects of gravitational lensing on three supernovae (SNe) discovered in the background of these clusters. Assuming hydrostatic equilibrium, we calculate the line of sight velocity dispersion of the lensing cluster in order to determine a virialized mass and radius. Using this data, we construct a dark matter halo model using the Navaro, Frenk, & White (NFW) profile. We then compute the magnification factor of the supernovae due to gravitational lensing by the cluster halo, with an emphasis on reducing systematic errors attributed to these SNe in a future cosmology analysis.

This work has been supported by the Office of Science, U.S. Department of Energy, through contract DE-AC02-05CH11231 and in part by NASA through grants associated with HST-GO-10496.

090.08

SALT2: Using Distant Supernovae to Improve the Use of Type Ia Supernovae as Distance Indicators

Julien Guy[1], SNLS Collaboration
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We present an empirical model of the Type Ia supernovae spectrophotometric evolution with time built using a large data set including light-curves and spectra of both nearby and distant supernovae, the latter being observed by the SNLS collaboration.

We derive the average spectral sequence of Type Ia supernovae and their principal variability components including a color variation law.

The model allows us to measure distance moduli in the spectral range 200-920 nm with calculable uncertainties, including those arising from variations in the spectral features.

Thanks to the use of high-redshift SNe to model the rest-frame UV spectral energy distribution, the model leads to improved distance estimates for SNe~Ia at redshifts larger than 0.8. The model can also be used to improve spectroscopic identification and possibly perform photometric identification and derive photometric redshifts of distant supernovae.

090.09

Photometric Calibration of the Supernova Legacy Survey Fields

Nicolas Regnault[1], SNLS Collaboration
[1]LPNHE IN2P3 CNRS, France.

We present the photometric calibration of the Supernova Legacy Survey (SNLS). The primary goal of the SNLS is to measure the dark energy equation of state with a statistical precision of 0.05. The calibration uncertainties are currently the dominant contribution to the systematic error budget. The photometric calibration of the SNLS dataset is challenging in several aspects. First, Megacam is a wide-field imager, and only a handful of its 36 CCDs can be directly calibrated using standard star observations. Second, measuring the restframe B-band luminosity of SNe~Ia over the $0.3<z<1.0$ redshift range requires an excellent flux intercalibration of the Megacam bands. Finally, the SN~Ia SED differs significantly from that of stars and transfering the stellar calibration to the SNLS data requires a precise knowledge of the SN~Ia spectra and the instrument transmissions. We present and discuss the SNLS calibration strategy.

090.10

Resolving Supernovae, H_0, and the Equation of State with HST

Louis-Gregory Strolger[1], A. C. Rohde[1], M. J. Gorski[1], A. G. Riess[2], H. Lampeitl[2], H. C. Ferguson[2], A. R. Martel[2]
[1]Western Kentucky Univ., [2]Space Telescope Science Institute.

There is little understood about the nature of the dark energy component of the universe. Presently, inconsistency in the value of the Hubble constant and the limited sample of Type Ia supernovae (SNeIa) at $z>1$ provide the largest sources of uncertainty in the evolutionary nature of dark energy. There is also growing suspicion that SNeIa may be the result of at least two physical mechanisms, which may produce unnoticed effects in cosmological parameters. The preferred bulk mechanism for SN Ia progenitors, and more importantly the accuracy of the same empirical corrections over all redshifts, can be ascertained by studying the rate of SNeIa in the early universe. The notably few SNeIa found at $z>1.4$ in the deep HST surveys have suggested that most SNeIa take 3-4 Gyr to develop from a single burst of star formation. Simple tests of this conclusion would be to gather a more statistically significant sample of SNeIa in the desired redshift range, or just a few events at $z>2$.

We present our new investigations with HST into these critical issues. Our Cycle 15 program, SHOES, continues the search for SNeIa at $z>1$ with ACS, but has an added component of simultaneous observations with NICMOS of Cepheids in galaxies that have hosted well studied SNeIa. These observations are expected to greatly reduce the uncertainty in H_0 (likewise reducing uncertainty in Omega_M), which along with the increased overall $z>1$ sample, will likely reduce dark energy constraints by approximately 40%.

With the addition of the SHOES sample to those from PANS and GOODS, we will have nearly 4 times as many $z>1$ SNeIa to test the bulk delay of SNeIa from the cosmic star formation rate history. And by performing creative combinations of the data, we will ultimately produce an ultra deep survey for possible $z>2$ SNeIa.

090.11

Constraints on Dark Energy from the ESSENCE Supernova Survey

Gajus A. Miknaitis[1], W. Wood-Vasey[2], ESSENCE team
[1]Fermi National Accelerator Lab., [2]CfA/Harvard.

The nature of dark energy is a key question in modern cosmology, with current efforts focused on measuring its equation of state parameter, w, as a means to discriminate between the cosmological constant and other possible models for dark energy. The ESSENCE survey is an ongoing six year effort to use high-redshift ($0.2 < z < 0.8$) supernovae to probe the expansion rate of the universe and constrain w to 10%. We present here constraints from analysis of 65 supernovae from the first four years of ESSENCE data, which, combined with constraints from baryonic acoustic oscillations, show good agreement with the current concordance cosmology. We also present a detailed systematic error budget. While the current constraints are dominated by statistical error, as the sample grows, our ability to constrain dark energy will depend on mastering systematic uncertainties, such as the treatment of extinction in supernova host galaxies. We describe progress towards reducing systematic uncertainties, including novel improvements to the art of calibration.

091: Neutron Stars
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

091.01

Measurement of Orbital Decay in the Double Neutron Star Binary PSR B2127+11C

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We report the direct measurement of orbital period decay in the double neutron star pulsar system PSR B2127+11C in the globular cluster M15 at the rate of $(-3.95\pm0.13)\text{x}10^{-12}$, consistent with the prediction of general relativity at the ~3% level. We find the pulsar mass to be $m_p=1.358\pm0.010$ M_{solar} and the companion mass $m_c=1.354\pm0.010$ M_{solar}. We also report long-term pulse timing results for the pulsars PSR B2127+11A and PSR B2127+11B, including confirmation of the cluster proper motion.

091.02

Isolated Neutron Stars: Magnetic Fields, Distances, and Spectra

David L. Kaplan[1], M. H. van Kerkwijk[2]
[1]MIT, [2]University of Toronto, Canada.

We present timing measurements, astrometry, and high-resolution spectra of a number of nearby, thermally emitting, isolated neutron stars. We use these to infer magnetic fields strengths and distances, but also encounter a number of puzzles. We will discuss a number of these puzzles relating to the multi-wavelength spectra of these objects, and try to make progress in unraveling the natures of these enigmatic objects.

091.03

Properties of Rotating Neutron Stars Using Density Dependent Relativistic Hadron Field Theory

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[1]San Diego State Univ., [2]Institut fur Theoretische Physik, Universitat Giessen, Germany.

We present properties of rotating, fully relativistic neutron stars for equations of state computed in the framework of the density dependent relativistic Brueckner-Hartree-Fock hadron field theory. Particular emphasis is put on the hyperon composition of neutron stars, which changes dramatically with rotational frequency. This may have important consequences for rotational instability modes in rapidly spinning neutron stars, as will be pointed out.

MONDAY

091.04

New Insights into Atoll X-Ray Binaries: Fourier Resolved Spectroscopy of 4U 1728-34

Chris R. Shrader[1], D. Kazanas[1], P. Reig[2], I. Papidakis[2]
[1]NASA's GSFC, [2]University of Crete, Greece.

Rapid variability and the spectral energy distribution are both powerful probes of the accretion-flow physics of neutron star X-ray binaries. Significant progress has been made over the last decade with the wealth of data provided by the current suite of orbiting high-energy observatories. Notably, in the temporal domain the power density spectra (PDS) exhibit a variety of features ranging from narrow quasi-periodic oscillations (QPOs) to broad noise components. Progress in the spectral domain has also been significant leading to refined understanding of the separate physical components of the binary systems; in particular, an accretion disk and boundary layer and line-emitting regions. However, more powerful methods of study though are ones which can simultaneously probe temporal and spectral characteristics. In this context, we describe the method of Fourier-resolved spectroscopy, and its application to the Atoll source 4U 1728-34. We identify the variability characteristics of the sources in its island and banana states, as well as over a range of about a factor of 20 in the (low-frequency) QPO frequency. Some notable results are: (i) The rms variability of the X-ray signal above ~8 Hz is not large enough to get good S/N in the upper banana state, despite overall count rates of >~1600 cts/s. (ii) In the island state a hard spectral component consistent with Compton reflection, which is not discernable in the frequency averaged spectra appears in the Fourier-resolved spectra. (iii) Thermal Comptonization models generally provide reasonable fits to the data, except for the upper banana state. We offer interpretation of our results and comment on the prospects for future applications of our method.

092: Planetary and Pre-Planetary Nebulae
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

092.01

Probing Nucleosynthesis in Intermediate Mass Stars via Planetary Nebulae Abundances

Jackie Milingo[1], J. K. Teske[2], R. B. Henry[3], K. B. Kwitter[4], S. P. Souza[4]
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With data for >120 Galactic PNe, we present compilations of Ne, O, S, Cl, and Ar abundances. The impetus for this project is to probe the abundance patterns in our sample for enhancements and depletions of key elements that flag nucleosynthesis in intermediate mass stars. We point specifically to deviants from the well-established linear relationship between Ne and O as possible indicators of neon enrichment. These data are unique in that they are based upon spectrophotometry covering an extended range in wavelength λ3600-9600 Å. Utilizing ELSA, a 5-level atom abundance routine, we've carefully determined T_e, N_e, ICFs, and total element abundances working toward a uniformly processed set of data. We gratefully acknowledge support from the AAS Small Research Grants program, NSF grant AST-0354056, and the Maria Mitchell Association.

092.02

The Radio Evolution of NGC7027

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NGC 7027 is the planetary nebula with the highest flux density in the radio spectrum, and is widely used as a flux density calibrator. We present the results of 23 years of precise monitoring of its flux density, using the VLA, at seven frequency bands between 1.4 and 43 GHz.

At 1.4 GHz, we find the flux density is uniformly increasing at a rate of 0.24 percent/year. This directly measures the expansion of the nebula. The expansion parallax gives a distance of 800 pc. The optically thin flux density is decreasing at a rate of 0.15 percent/year. This is attributed to a decreasing number of ionizing photons as the star increases in temperature. Based on Rauch models, the temperature increase is found to be 280 +/25 K/year, assuming constant luminosity. This increase is very sensitive to stellar mass -we determine a value of 0.675 +/.002 solar masses. This is the first measurement of the remnant mass of a carbon star.

092.03

Far-UV Temperature Diagnostics for Hot Central Stars of Planetary Nebulae

George Sonneborn[1], R. Iping[2], J. Herald[3]
[1]NASA's GSFC, [2]NASA's GSFC & CUA, [3]Johns Hopkins University.

The effective temperatures of central stars of planetary nebulae are usually determined from the ratios of optical He II lines. However, far-ultraviolet spectra from the FUSE satellite of several hot ($T_{eff} > 70{,}000$ K) hydrogen-rich central stars have stellar features that imply a significantly hotter effective temperature than that determined from He II. There are many stellar features in the long wavelength portion of the FUSE spectrum. These include O VI 1146-47, F VI 1039.5, Fe VII 1118.6, 1141.4, Fe VI 1120.9, 1131.5, and Ni VI 1124.2, 1148.2. The strong F VI 1139.5 line is of interest because of the large overabundance (over 100X solar) of F in some PG1159 stars reported recently by Werner et al. (2005). Modeling these spectral features may provide an method for measuring the effective temperature of these stars independent of the He II lines. An example of HD 200516, the central star of NGC 7009 ($T_{eff} = 82000$ K from He II vs 95000 K from Far-UV metal lines) is presented. The FUSE observations were obtained under GI program C176. This work has been supported in part by NASA grant NAG5-12347 to Catholic University of America.

092.04

The Hubble Catalog of Planetary and protoPlanetary Nebulae

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We have downloaded, processed, and coadded every image of a planetary nebula (PN) and protoPN obtained with Hubble WFPC2 and ACS and available in the HST archives as of May 2006 (≈3700 images). Our immediate aim is to construct a high-resolution multi-filter catalogue of PNe and protoPNe to be posted on the web, along with image coordinates and primary references.

The next step in our work is to look anew at the range of PN and pPN morphologies. We will define new morphological classes and sequences separately for PNe and protoPNe, examine the frequencies of defining characteristics in the sample, and relate the observed symmetries to various types of theories for AGB mass ejection and subsequent mass shaping processes such as fast stellar winds. Already it is clear that the shapes of protoPNe are more various and complex than those of most PNe, showing that the structures initially imposed by AGB mass ejections are blurred by the momenta of ionization fronts and fast stellar winds that come later.

The final step will be to relate the morphologies of protoPNe to the evolutionary stages of their central stars.

This research is based on observations made with the NASA/ESA Hubble Space Telescope, obtained from the data archive at the Space Telescope Science Institute. STScI is operated by the Association of Universities for Research in Astronomy, Inc. under NASA contract NAS 5-26555. Support for this work was provided by NASA through grant number AR-10933 from the Space Telescope Science Institute, which is operated by AURA, Inc., under NASA contract NAS 5-26555.

092.05

Spitzer IRS Spectral Observations of the 21 and 30 Micron Emission Features in Several Galactic Proto-Planetary Nebulae

Bruce J. Hrivnak[1], K. Volk[2], S. Kwok[3]
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A very broad emission feature (or features) around 30 microns has been observed in the mid-infrared spectra of carbon-rich evolved objects (AGB stars, planetary nebulae, proto-planetary nebulae (PPNe)) and has been generally attributed to MgS. A broad emission feature around 20 microns and particular to PPNe was first discovered in the IRAS LRS spectra and has subsequently been seen in a dozen carbon-rich PPNe. Its identification is uncertain although several suggestions have been published. We have used Spitzer to observe several PPNe with IRS in the high-resolution mode, resulting in the discovery of a new 21 micron source (IRAS 06530-0213) and the confirmation at much higher S/N of another 21 micron source (IRAS 05113+1347). These spectra are examined to investigate (a) if the 30 micron feature consists of two components, as has been reported, and (b) if the 21 micron features in the new sources have the same shape and central wavelength as in the half-dozen previously observed at high S/N. This research is supported in part by NASA through a grant from JPL.

092.06

Chandra X-ray Detection of a Shocked Polar Jet in the Symbiotic Mira System Hen 2-104

Rodolfo Montez, Jr.[1], J. H. Kastner[1], R. Sahai[2]
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We report the detection by Chandra's Advanced CCD Imaging Spectrometer (ACIS) of X-ray emission from Hen 2-104, a D-type symbiotic Mira system that sits at the core of an hourglass-shaped bipolar nebula (the ″Southern Crab″). The X-ray source is marginally resolved and is displaced ~2 arcsec SE of the central symbiotic system, very near the position of an isolated, high-velocity feature detected in visual-wavelength echelle spectroscopy of Hen 2-104. Spectral modeling indicates a temperature in the range 3-9 MK for the X-ray-emitting plasma. These results indicate that the X-ray source arises in shocks along a polar jet (or system of bullets) with a large velocity gradient. Along with R Aqr, Menzel 3, and CH Cyg, Hen 2-104 is the fourth symbiotic Mira system observed by Chandra to show X-ray emission from strong shocks associated with (bi)polar jet or bullet systems.

092.07

Deuterium Astration in the Planetary Nebula Sh 2-216?

Cristina M. Oliveira[1], P. Chayer[1], H. Warren Moos[1], J. W. Kruk[1], T. Rauch[2]
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Sh 2-216 is a large and old low surface brightness planetary nebula at a distance of ~130 pc. Its central star, WD0439+466, has been observed by FUSE and STIS allowing us to derive abundances of several elements along the sightline: D/H = (0.76 + 0.12 -0.11)E-5, O/H = (0.89 + 0.13 0.11)E-4, and N/H = (3.24 + 0.61 0.53)E-5.

This fairly short sightline contains a large amount of hydrogen, most of which is in molecular form (J=0 through J=9), leading to an average volume density of 0.54 cm^(-3), higher than that of similar sightlines. In addition, we detect also absorption by HD J=0,1 and CO.

We argue that most of the gas along this sightline is associated with the planetary nebula and that the low D/H ratio is likely the result of this gas being recently astrated. This would be the first time that the D/H ratio has been directly measured in astrated gas. The O/H and N/H ratios derived here are lower than typical values measured in other PN; however there is a large scatter in PN abundances. For these two species, ionization corrections not taken into account here might be important.

Financial support to U. S. participants has been provided in part by NASA contract NAS5-32985 to Johns Hopkins University.

092.08

The Ejection of Jets and Tori in Proto-Planetary Nebulae

Patrick J. Huggins[1]
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We investigate the time sequence for the appearance of high velocity jets and equatorial tori during the transition of stars from the Asymptotic Giant Branch to the proto-planetary nebula (PN) phase. The tori represent the sudden, final ejection of the stellar envelope, and the jets are common features of proto-PNe and young PNe, but their origin is uncertain. Based on the expansion times of well observed examples, we find that jets and tori develop in a characteristic sequence. They are nearly simultaneous which provides evidence that they are physically related but the jets tend to appear after the onset of the intense equatorial mass loss, with a time delay (jet-lag) of up to ~1,000 yr. We discuss the implications of this sequence for models of jet formation. For models where binary accretion plays a role, the jet-lag sets limits on the disk accretion time and the parameters of the disk.

093: Properties of Cool Giant Stars
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

093.01

The Wilson-Bappu Effect Fifty Years Later

Rachel A. Matson[1], R. E. Stencel[1]
[1]University of Denver.

Wilson and Bappu (1957 ApJ 125) published an empirical correlation between the FHWM of the emission core of the CaII K-Line at 393nm and the intrinsic luminosity among late-type dwarf, giant, and supergiant stars. Later on, Stencel (1977 ApJ 215) extended this luminosity calibrator by using so-called wing emission lines found in the wings of the H and K lines. Efforts to extend these techniques to the brightest supergiants in local group galaxies were frustrated by the limits of photographic coude spectra at the time, even on 4-meter telescopes. With the advent of CCD spectroscopy and S/N possible with 8-meter telescopes, we here explore the potential for extragalactic hypergiant star distance calibration.

Using the Paranal Observatory library of high-resolution spectra (http://www.sc.eso.org/santiago/uvespop/) obtained from the UVES instrument at an ESO Very Large Telescope, we measure the line widths of the CaII H and K lines and the wing emission lines in late type stars. By plotting the measured FWHM and absolute magnitude, we re-evaluate the Wilson-Bappu-Stencel line-width-to-luminosity correlation for the K core emission and H-K core wing emission lines. Because the H-K wing emission lines remain visible in very luminous stars cooler than F1, whereas circumstellar absorption obliterates the core emission, the wing line-width-to-luminosity correlation may be useful in estimating intrinsic luminosity for these stars.

We are grateful to Dainis Dravins for bringing our attention to the UVES altas, and for partial support from the Geise Foundation and the estate of William Herschel Womble for astronomy at the University of Denver.

093.02

Abundances of Extremely Metal-Poor Stars, aNnew HIRES Sample

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We present the results of an abundance analysis for a sample of stars with -2>[Fe/H]> -4. The set includes 29 stars, with effective temperature ranging from 4800 K to 6300 K. The data were obtained with the HIRES spectrograph at Keck Observatory. For most objects our wavelength range reaches from about 3100 angstroms to 5800 angstroms. Our spectra allow us to further constrain the abundance scatter at low metallicities for the light elements including carbon and nitrogen, up through the iron group, and for many neutron-capture elements. Most of our objects have come from the Beers et al. HK survey (1992, AJ, 103, 1987) for metal-poor stars, and for many of them this is the first high-resolution study.

This research is based on work supported by the National Science Foundation under the grant AST-0607770.

093.03

The Abundances of Na, Mg, & Al in the Hyades: Giants, Dwarfs, and Mixing

Simon C. Schuler[1], J. R. King[2], L. The[2]
[1]NOAO/CTIO, Chile, [2]Clemson University.

The abundances of Na, Mg, and Al in three giants and four dwarfs in the Hyades open cluster have been derived from high-resolution, McDonald 2.7-m echelle spectra. These data are compared to the expected changes in surface composition of the giants as predicted by a stellar model generated with the Clemson-American University of Beirut stellar evolution code in order to investigate if the Hyades giants have undergone non-standard mixing. The preliminary results of our analysis are presented.

This work is supported by the NOAO Leo Goldberg Fellowship to S.C.S.; NOAO is operated by AURA under cooperative agreement with the NSF. Additional support was provided by the NSF through grants AST 00-86576 and AST 02-39518 to J.R.K. and by the Charles Curry Foundation through a generous grant to Clemson University.

093.04

Heavy Element Abundances in the Photospheres of Cool Supergiants

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[1]CUA/NASA-GSFC, [2]Lund Observatory, Sweden, [3]NASA-GSFC.

We report on a program to determine the chemical composition of massive, cool supergiant photospheres. We concentrate on elements heavier than the iron group, addressing the question of whether nuclear by-products from the weak s-process have been brought to the surface by convective processes. For massive stars, atoms with mass up to approximately A = 100 are thought to be formed by neutron capture via the weak s-process. The abundances of these elements have been calculated by other researchers to be a function of stellar mass.

Our initial work has concentrated on the identification of useful atomic spectral lines at infrared wavelengths, where absorption from molecular species is reduced relative to that at optical wavelengths for M-type stars. Abundances are determined by synthetic spectrum fitting to line profiles in high-resolution spectra.

We present results for the cool, supergiant Betelgeuse (M2 Iab). Abundances are determined for a number of heavy elements, and despite large uncertainties attributed to the available atomic data (oscillator strengths), a distinct enhancement of Sr is determined after correcting for non-LTE effects. Such an enhancement is predicted by models of interior nucleosynthesis via neutron capture. Our results illuminate the problems that must be overcome before being able to derive abundances with the accuracy required for rigorous comparison with theoretical calculations. We also present our approach to applying the results for Betelgeuse to additional cool supergiants.

093.05

Brighter Still! A Summary of Photometric Data from the HST Eta Carinae Treasury Project

John C. Martin[1], K. Davidson[2], M. D. Koppelman[2], R. M. Humphreys[2]
[1]University of Illinois Springfield, [2]University of Minnesota.

During the past decade Eta Carinae has brightened markedly, indicating a possible change of state. Here we summarize the photometry of just the central star including STIS/CCD and ACS/HRC data gathered for the HST Eta Carinae Treasury project. The current eight-year brightening trend is reminiscent of 1938--1953 when the 5.5 year spectroscopic cycle first appeared. Already the brightness of the central star has begun to overwhelm the bright inner ejecta. Our results indicate that its mass loss rate is probably decreasing. Over the coming decades this should cause the ionization of the Little Homunculus and other envelopes of ejecta, dramatically altering the appearance of Eta Car.

093.06

Late-Type Red Supergiants: Too Cool for the Clouds?

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It has long been known that the median spectral types of red supergiants change from M2 I in the Milky Way to M1 I in the Large Magellanic Cloud (LMC) and to K5-7 I in the Small Magellanic Cloud (SMC) (Elias et al 1985, Massey & Olsen 2002). This is now understood in terms of the shifting of the evolutionary tracks to warmer temperatures with decreasing metallicity. Stars falling below the temperatures of these tracks would no longer be in hydrostatic equilibrium. This region of the H-R diagram is known as the Hayashi ″forbidden zone″. Early work identified supergiants no later than M2 I in the SMC, while in the Milky Way supergiants of spectral class M4 I and later abound.

However, our work has identified seven red supergiants in the LMC and four red supergiants in the SMC, all of which have spectral types that are considerably later than the average type observed in their parent galaxy. We find that these stars have radial velocities which are consistent with membership in the Clouds. By fitting our moderate-resolution spectrophotometry of these stars with MARCS stellar atmosphere models of the appropriate metallicities, we also determine their physical parameters and place them on the H-R diagram for comparison with the predictions of current stellar evolutionary tracks. We find that these stars are colder and more luminous than allowed by the predictions of stellar evolutionary theory at these low metallicities. Unsurprisingly, these stars also exhibit unusual variability in V. We then suggest that these stars have such unusual properties because they are in an unstable (and short-lived) phase of their evolutionary lives. This work was supported by the National Science Foundation through AST-0604569 to PM.

093.07

A Search for Companions to AGB Stars

Krzysztof Findeisen[1], R. Sahai[2], A. Gil de Paz[3], C. Sanchez Contreras[4]
[1]Cornell University, [2]Jet Propulsion Laboratory, Caltech, [3]Universidad Complutense de Madrid, Spain, [4]Instituto de Estructura de la Materia, CSIC, Spain.

Most current theories to explain the observed shapes of planetary nebulae require that the nebula be created by a binary star system rather than an isolated asymptotic giant branch (AGB) star. Detection of binary companions to AGB stars, however, is hampered by the extreme luminosity of the primaries. We have used observations taken in ultraviolet light, where the AGB star is relatively faint, to search for systems that have flux in excess of AGB star models. Of the systems for which we obtained data, nearly all have an ultraviolet excess, which we interpret as emission from a companion star. The high detection rate demonstrates the feasibility of ultraviolet observations as a search technique for hot companions of AGB stars.

093.09

A Spitzer Survey of Mass Losing Stars in the Galactic Bulge

Raghvendra Sahai[1], M. Stute[1], M. Morris[2], I. Glass[3], J. Blommaert[4], M. Groenewegen[4], M. Schultheis[5], A. Omont[6], K. Kraemer[7]
[1]JPL, [2]UCLA, [3]SAAO, South Africa, [4]K.U.Leuven, Belgium, [5]Observatoire de Besancon, France, [6]IAP, France, [7]AFRL.

Determining the dependence of mass-loss as a function of stellar parameters (temperature, luminosity, metallicity) during late stellar evolution is of profound importance in astrophysics. The Galactic Bulge (GB) is an ideal laboratory for determining this dependence, providing a very large sample of stars all essentially at the same distance, in contrast to nearby stars which form a much more inhomogeneous population. The GB is also an important dynamical and morphological component of our Galaxy, offering an environment distinct from the Galactic disk, for the study of stellar populations, stellar evolution and the mass-loss processes which accompany and in the end, control late stellar evolution.

Here we present results from a small Spitzer program in which we observed 7 small (~0.1 deg^2) selected fields within, and in the vicinity of, the Nuclear Bulge (central ~1 degree of the GB) with Spitzer's IRAC & MIPS (at 24 micron) instruments, predominantly along a radial vector inclined by 15 degrees to the minor axis of the Bulge, extending to a distace of 4 degrees from the Galactic Center. Our preliminary results dramatically demonstrate Spitzer's ability to quickly probe large populations of Bulge stars (>~20,000) down to unprecedentedly low mass-loss rates (<~few x 10^{-10} M_{sun} yr^{-1} -roughly a factor 20 lower than that achieved by an earlier study with ISO (ISOGAL: Omont et al. 2003, A&A, 403, 975). The increased sensitivity of Spitzer allows us to probe mass-loss on the red giant branch down to luminosities of ~100 L_{sun}, and determine mass-loss rates much more accurately at the lower end of the range. Our study will ultimately result in a significantly more reliable and precise dependence of the mass-loss rate on fundamental stellar parameters.

094: Putting Education into Outreach
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

094.01

Collaboration for Education with the Apple Learning Interchange

Patrick A. Young[1], T. Zimmerman[2], K. A. Knierman[3]
[1]Los Alamos National Laboratory, [2]Apple Computer, [3]Steward Observatory.

We present a progressive effort to deliver online education and outreach resources in collaboration with the Apple Learning Interchange, a free community for educators. We have created a resource site with astronomy activities, video training for the activities, and the possibility of interactive training through video chat services. Also in development is an online textbook for graduate and advanced undergraduate courses in stellar evolution, featuring an updatable and annotated text with multimedia content, online lectures, podcasts, and a framework for interactive simulation activities. Both sites will be highly interactive, combining online discussions, the opportunity for live video interaction, and a growing library of student work samples. This effort promises to provide a compelling model for collaboration between science educators and corporations. As scientists, we provide content knowledge and a compelling reason to communicate, while Apple provides technical expertise, a deep knowledge of online education, and a way for us to reach a wide audience of higher education, community outreach, and K-12 educators.

094.02

Astronomy in the Digital Universe

Bernard M. Haisch[1], J. Lindblom[1], Y. Terzian[2]
[1]Digital Universe Foundation, [2]Cornell University.

The Digital Universe is an Internet project whose mission is to provide free, accurate, unbiased information covering all aspects of human knowledge, and to inspire humans to learn, make use of, and expand this knowledge. It is planned to be a decades long effort, inspired by the Encyclopedia Galactica concept popularized by Carl Sagan, and is being developed by the non-profit Digital Universe Foundation. A worldwide network of experts is responsible for selecting content featured within the Digital Universe. The first publicly available content is the Encyclopedia of Earth, a Boston University project headed by Prof. Cutler Cleveland, which will be part of the Earth Portal. The second major content area will be an analogous Encyclopedia of the Cosmos to be part of the Cosmos Portal. It is anticipated that this will evolve into a major resource for astronomy education. Authors and topic editors are now being recruited for the Encyclopedia of the Cosmos.

094.03

Opportunitites for Scientist Participation in Chandra Education and Public Outreach

Kathleen Lestition[1], P. Edmonds[1], K. Kowal-Arcand[1], M. Watzke[1]
[1]SAO.

This poster will present a full range of opportunities available to scientists to engage in education and public outreach (E/PO) activities through the Chandra E/PO program at the Chandra X-ray Center. We will present a selection of successful past examples covering activities and products such as NASA Science Updates and Media telecons, podcasts, multi-media and printed products, web content, presentations, and other activities. We will offer specific current opportuntites for scientist involvement. We invite product and activity suggestions, and ideas for collaborations that leverage the resources of the CXC, NASA, and the scientist's home institution or other resources in the geographical area.

094.04

Astro-Science Workshop: Education and Public Outreach at the Adler Planetarium

Lauren R. Grodnicki[1], M. Hammergren[2], A. Puckett[1]
[1]Univ. of Chicago, [2]Adler Planetarium.

Astro-Science Workshop, a 43-year-old program, is a unique opportunity for research astronomers at the Adler Planetarium in Chicago to work with gifted area high school students on project-based learning. In its current form, ASW is funded by a fellowship from the NSF and run by a graduate student from the University of Chicago. The immersion program is as much a learning experience for the graduate student as for the high school students who attend the 3-4 week course. Because the graduate student tailors the program to his/her interests, the program varies greatly from year to year. Recent topics include impacts in the solar system and solar astronomy. Last year the course included an extended weekend at the Yerkes Observatory. The students took images of asteroids with the telescopes on site, analyzed the data themselves, and submitted their measurements of the asteroids' positions to the Minor Planet Center, some of which have already been published on the ADS. The plan for Summer 2007 is a 3-week course on the formation of the Solar System, in which students will explore the near-space environment with high-altitude balloon-born instruments that they build themselves. ASW provides a unique opportunity for an informal learning instituion to connect high school students with astronomers and institutions of higher learning. It has provided over a thousand students with college-level instruction and exposure to the cutting edge of astronomical research.

094.05

Solar Education and Outreach at Columbus State University's Mead Observatory

Michael Johnson[1], J. Hood[1], S. T. Cruzen[1]
[1]Columbus State University.

Since Columbus State University's Mead Observatory opened its doors in 1996, the primary goals have been public outreach and education using its main 16-inch telescope and an army of smaller 8and 10inch telescopes that travel to many locations giving adults and children a new view on the night sky. In 2001, Mead Observatory's main instrument, the 16-inch Meade LX200, was converted to a full-time solar telescope with a generous grant from a private foundation.

Since 2001, the Solar Observatory has grown to include an online accessibility that allows schools from around the world to log on and experience the Sun from their own classroom. At the beginning of 2006, the decision was made to upgrade some of the hardware and software used for online access. The upgrades were intended to make the online experience easier for teachers and allow for better imaging over the internet. This poster highlights how these changes enhance the online experience and allow the Mead Observatory to achieve is educational outreach goals.

094.06

The SNAP Education and Public Outreach Program

Lynn R. Cominsky[1], P. Plait[1], S. Silva[1], SNAP Collaboration
[1]Sonoma State Univ..

The Joint Dark Energy Mission concept SuperNova Acceleration Probe *(SNAP)* presents a challenge for Education and Public Outreach (E/PO). Advances in cosmology have dramatically changed the way scientists think about the Universe, but have left much of the public behind. For a robust E/PO program to be created, the first critical step is to perform a "needs assessment," a survey to determine what conceptions and misconceptions-_people have about cosmology. We have a three-pronged approach to this: surveying people in museums (informal), giving short quizzes to students through teachers who have attended our workshops (formal), and creating a "Cosmology Diagnostic Test (CDT)" derived from the venerable Astronomy Diagnostic Test. The CDT will be used to assess the needs for content and pedagogy for college students, and preand in-service teachers (education). The results of these assessments will not only be able to guide the E/PO program for *SNAP*, but will also be published in the Astronomy Education Review so that other E/PO programs can benefit from it. Our poster will give details on the planned needs assessment and present preliminary E/PO plans for *SNAP* including the website, and other possible elements including museum and planetarium partnerships, an on-line cosmology course and blog.

094.07

The Sky is the Limit: Benefits from Partnering with the Project ASTRO National Network!

Constance E. Walker[1], D. Zevin[2], W. van der Veen[3], A. Fraknoi[4], R. Wilson[1], S. Gurton[2], V. White[2], C. Clemens[5], J. Harvey[6]
[1]National Optial Astronomy Observatory, [2]Astronomical Society of the Pacific, [3]New Jersey Astronomy Center for Education, [4]Foothill College & ASP, [5]Harvard-Smithsonian Center for Astrophysics, [6]Gemini Observatory.

As a partner for EPO programs, the Project ASTRO National Network offers access to hundreds of trained educators and astronomer-educator partnerships across the country. This makes the Network extremely suitable for dissemination and/or testing of new science education products, in particular those that benefit from support by scientists and/or (through Family ASTRO) those that target families/communities. For example, the Network is currently being leveraged (through NASA funding) to create and disseminate nationally new hands-on classroom activities on solar physics.

Project ASTRO is a national program that partners professional and amateur astronomers with local educators at regional sites around the country. Developed by the Astronomical Society of the Pacific, Project ASTRO provides training for astronomer-educator partnerships in hands-on, inquiry-based science activities while emphasizing the importance of student preconceptions as a starting point for learning. During an intensive two-day training workshop, a partnership is forged that blends the teacher's knowledge of instructional methods and classroom management with the astronomer's knowledge of and passion for science and astronomy. Nationwide, over 500 active astronomer-educator partnerships bring the excitement of astronomy to over 20,000 students annually.

All Project ASTRO sites follow the same model for partnership training and support and meet annually to discuss common strategies and share new ideas. Many sites also target families/communities through the Family ASTRO sister program. Each site (there are 15 total in the Network) is managed by a Lead Institution supported by a Local Coalition of scientific and educational organizations who help with recruiting of new participants, programming, and fund-raising.

This poster will detail why the Project ASTRO National Network is an ideal partner for EPO programs.

For more information on various ways your organization can partner with the Project ASTRO National Network, please contact Dan Zevin at dzevin@astrosociety.org.

094.08

Space Science Outreach in the Virtual World of Second Life

Anthony W. Crider[1], International Spaceflight Museum
[1]Elon University.

The on-line ″game″ of Second Life allows users to construct a highly detailed and customized environment. Users often pool talents and resources to construct virtual islands that focus on their common interest. One such group has built the International Spaceflight Museum, committed to constructing and displaying accurate models of rockets, spacecraft, telescopes, and planetariums. Current exhibits include a Saturn V rocket, a Viking lander on Mars, Spaceship One, the New Horizons mission to the Kuiper Belt, and a prototype of the Orion crew exploration vehicle. This museum also hosts public lectures, shuttle launch viewings, and university astronomy class projects. In this presentation, I will focus on how space science researchers and educators may take advantage of this new resource as a means to engage the public.

094.09

The Sunnel: Engaging Visitors in Solar Research via a Tunnel Through the Sun

Nora H. DeMuth[1], C. E. Walker[2]
[1]El Camino College, [2]National Optical Astronomy Observatory.

The publicly accessible hallway space inside the McMath-Pierce Solar Telescope building on Kitt Peak has great untapped potential to house a display that would be relevant and understandable to KPNO visitors without the need for mediation or further explanation. An effective display would unite background content on solar physics and astronomy, and information on current solar research techniques and results in an accessible way that would excite and engage visitors. Considering these requirements, we created a concept currently dubbed the Sunnel (for "Sun-tunnel"). The Sunnel consists of two 95by 13-foot murals of the layers of the Sun stretching down the visitor hallway in the McMath-Pierce Solar Telescope. Temperatures of the layers are represented by the colors of the peak in the corresponding black-body curves, and solar features such as sunspots and pressure waves are represented by abstract designs flowing along the walls. A photon path will be laid on the floor using tiles, and several posters highlighting current solar research and background science content relevant to solar research will be displayed on one wall. An audio tour featuring interviews with solar researchers guides visitors along the Sunnel, engaging them and supporting deeper appreciation of the solar research. Installation of the murals is scheduled for early 2007, just in time to celebrate the International Heliophysical Year. DeMuth's research was supported by the NOAO/KPNO Research Experiences for Undergraduates (REU) Program which is funded by the National Science Foundation through Scientific Program Order No. 3 (AST-0243875) of the Cooperative Agreement No. AST-0132798 between the Association of Universities for Research in Astronomy (AURA) and the NSF.

094.10

Slackerpedia Galactica

Aaron Price[1], M. Koppelman[2], M. Robinson[3], D. L. Welch[4], T. Searle[5], R. Turner[5]
[1]AAVSO/Tufts University, [2]University of Minnesota, [3]Swinburne University of Technology, Australia, [4]McMaster University, Canada, [5]AAVSO.

Slackerpedia Galactia (SG) is a wiki dedicated to the lighter side of astronomy. Using the same Wikimedia software, SG has a similar look to Wikipedia but a decidely different feel. Articles are factually correct and can go into considerable depth, but opinions, jokes, silliness and a sense of fun are also characteristic of its content. Since its launch in September of 2006, SG has around 500 articles from 52 registered users. Anyone can contribute and material is released under a Creative Commons license. SG is part of a larger project involving astronomy audio and video podcasts, blogs, webcomics and more. Info at www.slackerpedia.org.

094.11

″It's Our Universe″: Astronomy Outreach in Appalachian Ohio

Mangala Sharma[1], G. Eberts[1], M. Hartwick[2], L. Miller[3]
[1]Ohio Univ, [2]Southeast Ohio Astronomical Society, [3]Athens Public Library.

We present highlights from an on-going astronomy outreach program for all ages, being conducted by a collaboration of astronomers both professional and amateur with the local public library in Athens county in Appalachian Ohio. The elements of our program include a two-part series of exhibits, a public lecture series highlighting women or minority astronomers or astronauts, and five ′Space Days' with hands-on astronomy activities for grades 4-6. Complementing these are the extremely popular telescopic observations of the Sun or the night sky. We are making a special effort to reach homeschooled children.

We gratefully acknowledge funding from a NASA/STScI IDEAS grant.

094.12

Arecibo Observatory for All

Gloria M. Isidro[1], C. A. Pantoja[1], P. Bartus[1], C. La Rosa[1]
[1]University of Puerto Rico.

We describe new materials available at Arecibo Observatory for visitors with visual impairments. These materials include a guide in Braille that describes the telescope, some basic terms used in radio astronomy and frequently asked questions. We have also designed a tactile model of the telescope. We are interested that blind visitors can participate of the excitement of the visit to the worlds largest radio telescope.

We would like to thank the ″Fundacion Comunitaria de Puerto Rico″ for the scholarship that allowed GMI to work on this project. We would like to express our gratitude to the Arecibo Observatory/NAIC for their support.

094.13

Effectively Engaging Family Groups in Learning Astronomy

Jacob Noel-Storr[1]
[1]Rochester Inst. of Technology.

Can family astronomy programs be designed that engage entire family groups in learning and not just support the learning of one or two children in the family group? Can parents be trained 'on the fly' to engage in leading their children's science learning? Can children and their parents find roles that allow them to learn together as a group? ¼ I will present results from a two new sets of family astronomy programs that work towards getting a "YES!" in reply to all three questions.

095: Radio Galaxy Surveys
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

095.01

The Arecibo Legacy Fast ALFA Survey: HI Sources in the Northern Virgo Cluster Region

Rebecca A. Koopmann[1], ALFALFA Consortium
[1]Union College.

The Arecibo Legacy Fast ALFA (ALFALFA) survey is in its second year of mapping 7000 square degrees of the high galactic latitude sky visible from Arecibo, providing an extragalactic HI line spectral database covering the redshift range between -1600 km/s and 18,000 km/s. Exploiting Arecibo's large collecting area and small beam size, ALFALFA is specifically designed to probe the faint end of the HI mass function in the local universe and will provide a census of HI in the surveyed sky area to faint flux limits, making it especially useful in synergy with wide area surveys conducted at other wavelengths.

This poster presents a summary of detections in the first 132 square degrees (2%) of the survey area. ~715 HI detections are cataloged within the solid angle spanning right ascensions of 11h 44m to 14h 00m and declinations of 12 to 16 degrees. Optical counterparts are identified via examination of the digital optical imaging databases. Although this region of the sky has been heavily surveyed by previous targeted observations based on optical fluxor size-limited samples, 70% of the extracted sources are newly reported HI detections. The median redshift is ~7000 km/s and the redshift distribution reflects the known local large-scale structure including the Virgo cluster and the void behind it, the A1367-Coma supercluster at cz ~ 7000 km/s and a third more distant overdensity at cz ~ 13000 km/s. A small percentage of HI detections have no identifiable optical counterpart and do not appear connected to or associated with any known galaxy. Several extended HI features are found in the vicinity of the Virgo cluster.

This work has been partially supported by NSF grants AST-0307661, AST-040711, and AST-0607007, by a grant from the Brinson Foundation, and by NAIC.

095.02

The Arecibo Legacy Fast ALFA HI Survey: The Rich Galaxy Group Zwicky 1400+0949

Thomas J. Balonek[1], B. M. Walsh[1], ALFALFA Consortium
[1]Colgate Univ..

The Zwicky Cluster 1400+0949 (also known as the NGC 5416 group, one of the richest nearby galaxy groups) has been mapped as part of the Arecibo Legacy Fast ALFA (ALFALFA) extragalactic HI survey. This blind survey will map 7000 square degrees of the high galactic latitude sky visible from Arecibo, generating a HI line spectral database covering the redshift range -1600 to 18,000 km/s with about 5 km/s resolution. We present a catalog and atlas of ALFALFA HI detections in the region surrounding Zw 1400+0949, cz ~6000 km/s. Using the observed HI velocities, and optical redshifts from the NASA Extragalactic Database (NED) for non-detected galaxies, we determine group membership and study the relationship of this group to surrounding structures. This work has been partially supported by NSF grants AST-0307661 and AST-0607007, by a grant from the Brinson Foundation, by Colgate University (the Faculty Research Council and the Division of Natural Sciences and Mathematics), and by the National Astronomy and Ionosphere Center (NAIC).

MONDAY

095.03

A Neutral Hydrogen Survey of the NGC 7332 Region with the Arecibo L-band Feed Array

Robert F. Minchin[1], E. Momjian[1], L. Cortese[2], K. L. O'Neil[3], P. A. Henning[4], J. I. Davies[2], AGES Team
[1]Arecibo Obs., [2]Cardiff University, United Kingdom, [3]National Radio Astronomy Observatory, [4]University of New Mexico.

As part of the Arecibo Galaxy Environment Survey, we have mapped a 2.5 degree by 2 degree region around the NGC 7332 / NGC 7339 galaxy pair. Three sources were detected around the redshift of the pair: NGC 7339 itself and two galaxies not listed in NED. NGC 7332, which is an S0 galaxy, was not detected. Behind the group a further 20 definite sources were found in the cube, out to a redshift of around 17000 km/s, along with 31 marginal detections. We also searched the cube using the Duchamp autofinder (Whiting 2006); this turned up 21 of the 23 definite sources and none of the marginal detections when run with its default settings.

The Arecibo Observatory is part of the National Astronomy and Ionosphere Center, which is operated by Cornell University under a cooperative agreement with the National Science Foundation

095.04

The ALFA Zone of Avoidance Survey: Results from the Precursor Observations

Chris M. Springob[1], P. A. Henning[2], B. Catinella[3], F. Day[2], R. Minchin[3], E. Momjian[3], B. Koribalski[4], K. L. Masters[5], E. Muller[4], C. Pantoja[6], M. Putman[7], J. L. Rosenberg[8], S. Schneider[9], L. Staveley-Smith[10]
[1]Naval Research Laboratory, [2]Univ. of New Mexico, [3]National Astronomy and Ionosphere Center, [4]Australia Telescope National Facility, Australia, [5]Harvard-Smithsonian, CfA, [6]Univ. of Puerto Rico, [7]Univ. of Michigan, [8]George Mason Univ., [9]Univ. of Massachusetts, [10]Univ. of Western Australia, Australia.

We present new extragalactic 21 cm observations in the Galactic Plane region. These observations are a precursor to a large scale, extragalactic, zone of avoidance survey with the Arecibo L-band Feed Array (ALFA). The data for this survey are being taken concurrently with a Galactic survey and a pulsar survey. Full survey observations, which will begin in 2007, will reveal local large scale structure in a part of the extragalactic sky that is relatively unexplored due to the obscuration of optical light by dust in our Galaxy. One of these surveys will have an integration time of 268 seconds per point in the inner Galaxy and 134 seconds in the outer Galaxy, covering $|b|<5$ degrees, while the other will have an integration time of only 5 seconds per point, covering $|b|<10$ degrees with an rms of roughly 6 mJy. No other extragalactic ALFA survey will cover these latitudes. Precursor observations have been taken using the latter observational setup on two patches of sky totaling 140 square degrees (one near $l=40$ degrees, and the other near $l=192$ degrees). We have measured HI parameters for detections from these observations, and cross-correlated with the NASA/IPAC Extragalactic Database. A significant fraction of the objects are new, having never been detected at any wavelength. For those galaxies that have been previously detected, the majority have no previously known redshift, and and no previous HI detection. This research was performed while C.M.S. held a National Research Council Research Associateship Award at the Naval Research Laboratory. Basic research in astronomy at the Naval Research Laboratory is funded by the Office of Naval Research. P.A.H. acknowledges support from NSF grant AST-0506676. The Arecibo Observatory is part of the National Astronomy and Ionosphere Center, which is operated by Cornell University under a cooperative agreement with the National Science Foundation.

096: Research in K-12 Astronomy Education for Students, Their Teachers, and Their Families both in and out of the Classroom
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

096.01

The Search: for Life Beyond Earth

Neal E. Hurlburt[1], J. Blair[2], S. Lubbs[2], D. Miller[2]
[1]Lockheed Martin Corp., [2]Evergreen Valley High School.

Are we alone in the universe? This educational unit approaches this question through scientific observations outlined by the Drake Equation. The Drake Equation, named after Frank Drake of SETI, can be used to calculate the number of advanced civilizations that are willing to communicate with us. Through this unit students determine values for each term of the equation and site evidence for their values. This unit provides a holistic view of science by combining chemistry, physics, astronomy, biology, and sociology.

096.02

Stones from the Sky: Introducing Middle School Students to Meteorites

Angela R. Sarrazine[1], E. Albin[1]
[1]Fernbank Science Center.

We present findings for a piloted outreach program about meteorites. Meteorites are important because they provide a first hand look at material from the early history of our Solar System. Observations suggest that middle school-aged children are naturally interested in meteors and meteorites. Such interest may be tied to the luminous nature of fireballs and bolides that drop stones from space onto the surface of our planet. To this end, a travel or outreach program was designed to further student knowledge concerning these celestial samples. A set of specimens was gathered that introduces students not only to meteorites but to stones often confused for meteorites ("meteor-wrongs"). Materials associated with impact craters were also included in these sets. Individual sample cases include the following fourteen specimens: four meteorites (iron, stony, stony-iron, carbonaceous chondrite), five "meteor-wrongs" (slag, ironstone, diabase, magnetite, illmenite), and five impact crater materials (shattercone, breccia, impactite, impact melt, tektite). After a brief introduction, which includes a look at larger hand samples of meteorites and a Power-Point style presentation, students are separated into groups and encouraged to examine / characterize the suite of specimens. In addition to acquiring an appreciation for meteorites and the craters they can form, students become aware of how to distinguish meteorites from ordinary terrestrial rocks.

096.03

Education and Public Outreach using Venus Express

Rosalyn A. Pertzborn[1], S. S. Limaye[1], H. Y. Pi[1]
[1]University of Wisconsin.

Nearly two decades after NASA's Magellan radar mission to Venus, its atmosphere and surface is being investigated with new instruments by the Venus Express spacecraft from orbit. It was launched by the European Space Agency (ESA) on 11 November 2005, and has been orbiting Venus since April 2006. This mission provides an opportunity to focus on comparative planetary meteorology for education and public outreach efforts. We present an inquiry-based approach for informal and formal learning audiences by comparing atmospheric states of Venus and Earth using data available from Earth weather satellites and Venus Express.

In the context of a middle or a high school curriculum, the science themes of Venus Express mission provide many connections to the themes of the National Science Education Standards. For the general audiences, Venus presents many of its mysteries such as its super rotation in the form of a giant hemispheric vortex akin to a hurricane, its deep atmosphere with sulfuric acid clouds, and the huge greenhouse effect concepts that are familiar to many.

More than a dozen US scientists are participating in the Venus Express mission with support from NASA.

096.04

The eXtreme Universe: A Portable Planetarium Program

Philip Plait[1], S. Silva[1], T. Graves[1], J. Reed[1], L. Cominsky[1]
[1]Sonoma State Univ..

Portable planetaria are a popular medium through which to teach young students astronomy. Students and teachers alike love them, and they are very useful for teaching astronomy fundamentals such as the appearance of the night sky, cultural myths, and planetary motion. However, until now no planetarium shows existed to teach concepts about the high-energy end of the electromagnetic spectrum. To remedy this, the NASA E/PO Group at Sonoma State University, sponsored by the XMM-Newton observatory mission, has created an interactive planetarium program called "The eXtreme Universe". This program teaches basic concepts in X-ray astronomy for older elementary and middle school students an age level where the EM spectrum is a national science standard.

Many different small planetaria formats exist, but digital formats using non-proprietary hardware are becoming increasingly popular due to their ease of use and availability of laptops and digital projectors. Using the freely available (and open-source) software Stellarium as an engine, "The eXtreme Universe" displays the optical night sky as well as bright X-ray sources from the ROSAT point source catalog. The teacher can display them simultaneously, or toggle each to compare the distribution of sources. Images of

the brightest and most interesting X-ray sources (such as Sirius B, the Crab Nebula, and Cas A) can also be displayed next to their optical counterparts. An accompanying Educators Guide was also written with fun and engaging activities that teach students about X-ray astronomy and how objects look and behave differently when viewed in X-rays.

This poster will outline the show (including required equipment), the Educators Guide, the history and development of the show (hurdles and opportunities), and how to obtain a copy.

096.05

Demystifying Scientific Data

Esther A. Santos[1], P. Nassiff[2], P. Pratap[3]
[1]Nashua High School South, [2]Burlington High School, [3]MIT Haystack Observatory.

The importance of data in modern scientific research was the focus of the 2006 Research Experience for Teachers (RET) program at MIT's Haystack Observatory. *Demystifying Scientific Data* is a project aimed at introducing high school students to two of the essential components of research efforts at MIT's Haystack Observatory the processes of collecting of large quantities of data and their subsequent analyses. A recent report on Goals for Astronomy 101, created by astronomers, calls for students to be introduced to methods of analyzing evidence and critically evaluating the results, including the role of uncertainty and error in science. To do this, the RET participants Esther Santos and Peter Nassiff created a unit that will introduce high school science students to the essential skills of data analysis and interpretation. The lesson plans and activities were mainly based on astronomy, atmospheric science and geodetic research being done at Haystack Observatory.

Several topics were included in the lesson plans: using a small radio telescope (SRT) to measure the emission from the Hydrogen atom and use the data to measure the rotation curve of the Galaxy; looking at emission from water masers; the Sun-Earth connection observing the Sun with the SRT and monitoring for solar activity; observing the effects of solar activity on the Earth; and plate tectonic theory. In particular, the SRT measurements allow students to collect and analyze their own data and learn about instrumental effects on data and the effect of large number statistics.

This unit introduces students to several techniques in data analysis, giving them useful experience performing authentic scientific tasks. It gives them a first hand view of the process of science, as raw data is transformed into explanatory theories.

The RET program at MIT Haystack Observatory is funded by a grant from the National Science Foundation.

096.06

The Impact of Science Graduate Students in Urban Science Classrooms: The SFOS Program at Cal State Los Angeles

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The SFOS program at Cal State Los Angeles places science graduate students in minority serving high schools and middle schools in the Los Angeles region. Graduate fellows pursue Master's degrees in biology, chemistry, geology, or physics while working with partner teachers to provide science demonstrations and activities that are based on California science content standards. Fellows in the classroom are not apprentice teachers, but rather, their role is science communication. Now in its fourth year, we discuss the impacts of the SFOS program on graduate fellows, teachers, and high school curricula.

096.07

How Astronomers Can Help Prepare Future Teachers

Christine Shupla[1], L. Ruberg[2], T. F. Slater[3], G. Schultz[4]
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Classroom teachers are expected to teach a variety of astronomical topics, yet research indicates that most undergraduates do not have a scientific understanding of these topics, and there is widespread misunderstanding as to the nature of science. **How can astronomers help to prepare the next generation of teachers in space science?**

Our group has met with teacher educators from both science and education departments, and conducted a survey to better understand the role and needs for astronomy in teacher pre-service. We will share the current research and the results of our own survey of teacher educators, and some of the models and suggestions that the members of the *NASA Science Mission Directorate's Pre-Service Education Working Group* (http://www.lpi.usra.edu/education/score/pre_service.shtml) have discovered.

Research has shown that effective teaching practices need to be modeled--future teachers need to be taught a subject the way they will be teaching it in their classrooms. Our survey of teacher educators (from science and education departments at a variety of colleges across the US) suggests educators are concerned that today's future teachers are not taught science in college as inquiry-based, with activities that model the nature of investigation. The survey also indicated that future elementary teachers often have a fear or dislike of science, and do not understand the nature of science, and that students do not have enough breadth in science subjects.

Our group's meetings and discussions have discerned a variety of opportunities for astronomers to effect change in the future classroom teacher. These include changing the way that classes are taught, increasing opportunities for future teachers (in addition to future scientists) to have true scientific research experiences, creating scientist-education partnerships to improve science pre-service education, and establishing programs with scientists as mentors to future teachers.

097: Sloan Digital Sky Survey
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

097.01

Environments of Low-Redshift Merging Galaxies

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Merging galaxies are believed to be an integral component of galaxy evolution. Gaining insight about their environments may lead to a better understanding of their role. We identify a sample of over 350 low-redshift ($z \le .05$) mergers collected from SDSS by visually inspecting close pairs of galaxies for tidal features or other signs of interaction. To analyze the environment of the mergers, we determine the distance to the nearest large group of galaxies and the number of galaxies in that group. We find that mergers are more likely to occur closer to the center of a group, but have not detected a dependence on the size of the group. We are comparing our data with theoretical CDM simulations of structure formation.

097.02

A Search for Low Surface Brightness Galaxies in the Ultraviolet with GALEX

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Low surface brightness (LSB) galaxies have traditionally been difficult to detect at visible wavelengths due to their low contrast with the night sky and their low numbers per deg^2. We describe a new search for LSB galaxies using UV images from the Galaxy Evolution Explorer (GALEX) satellite. The images are from the GALEX Medium Imaging Survey targeting mainly areas of the sky within the Sloan Digital Sky Survey (SDSS) footprint. Due to the UV sky background at high Galactic latitudes reaching levels of only approximately 28 mag arcsec^{-2} as well as the relatively large sky coverage from GALEX, we can potentially search for LSB galaxies that would be difficult to detect optically.After first convolving the images with a suitable kernel, we select a diameter limited set of objects which we then inspect manually in order to remove image artifacts and other spurious detections. Red galaxies that have high optical surface brightness can be identified using either the ratio of far-UV to near-UV flux or via comparison to SDSS images. We quantify our selection limits using a set of artificial galaxy tests. Our goal is to find blue, ultra-LSB galaxies that would be virtually undetectable in large optical imaging surveys.

GALEX is a NASA Small Explorer, launched in April 2003. We gratefully acknowledge NASA's support for construction, operation, and science analysis for the GALEX mission.

097.03

Active Galaxies in Redshift Surveys

Pietro Reviglio[1], D. Helfand[1]
[1]Columbia Univ..

Analysis of the frequency and physical properties of galaxies with star-formation and AGN activity in different environments in the local universe is a cornerstone for understanding structure formation and galaxy evolution. We have undertaken a study of active galaxies in different galaxies surveys (15R, 2DF, SDSS) to explore the properties of these systems in different environments. We built new multi-wavelength catalogs gathering information on H-alpha, R-band, radio,far-infrared, and X-ray emission, as well as radio and optical morphologies, and have developed a classification scheme to compare different selection methods and to select accurately samples of radio emitting galaxies with AGN and star-forming activity. While alternative classification schemes do not lead to major differences for star-forming galaxies, we show that spectroscopic and photometric classifications of AGN lead to incomplete samples. In particular, a large population of AGN-containing galaxies with absorption-line spectra, and in many cases extended radio structures (jets, lobes), is missed in the standard Baldwin-Phillips-Terlevich emission-line classification of active galaxies. This class of objects accounts for roughly half of the radio AGN population. Similarly, for X-ray selected AGN in our sample, we find that absorption-line AGN account for half of the sample. Spectroscopically unremarkable, passive galaxies with AGN activity are not an exception, but the norm, and we show that although they exist in all environments, these systems preferentially reside in higher density regions. Because of the existence of this population, the fractional abundance of AGN strongly increases with increasing density, in contrast to the results based on emission-line AGN extracted from the 15R, Sloan and 2DF redshift surveys. Since emission-line radio AGN are mostly associated with late-type galaxies and absorption-line radio AGN with early-type galaxies, the trends found are connected to the well-known but poorly understood density-morphology relation.

097.04

Constraints on the Stellar Initial Mass Function from the Integrated Light Properties of Galaxies in the Sloan Digital Sky Survey

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The stellar initial mass function (IMF) is widely treated as universal-independent of factors such as galaxy type, radiation environment, chemical composition and time. While this conclusion seems physically unlikely considering the great diversity of star forming environments across the universe systematic IMF variations are as yet trumped by measurement errors. Systematic IMF variations would impact a wide range of astrophysical disciplines, from theories of star formation to measurements of star formation rates and mass-to-light ratios. We present the results of our study of the IMF in a sample of 130,000 actively star forming galaxies in the Sloan Digital Sky Survey (SDSS). H alpha equivalent widths (EW) are compared to broadband colors to constrain the IMF within the 3″ SDSS apertures which contain on average 25% of the total light from the galaxies. The H alpha EW is effectively the ratio of massive O and B stars, via UV photons reprocessed into H alpha flux, to post main sequence stars of around a solar mass, which dominate the light of the red continuum. As a result our method is sensitive to the IMF slope above a solar mass. In this parameter space the effects of the age of the stellar population are largely orthogonal to those of the IMF and the effects of metallicity are small compared to IMF variations. Monte Carlo simulations reveal that for our large data set the random errors in the measured IMF slope are negligible compared to the systematic errors which are dominated by star formation history. We find that for luminous galaxies the agreement with a universal IMF is good. However, low luminosity galaxies appear to exhibit IMF variations above what can be attributed to systematics.

097.05

The Clustering Properties of UV-selected Galaxies at Low Redshift from GALEX-SDSS Data

Sebastien Heinis[1], T. Budavari[1], A. Szalay[1], M. Neyrinck[2], I. Szapudi[2], B. Milliard[3], S. Arnouts[3], GALEX Team
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We present angular correlation function measurements of UV-selected galaxies from GALEX-SDSS data, based on a sample of ~150,000 objects. These measurements are fitted by HOD model predictions, to derive parameters describing the dark matter haloes hosting star forming galaxies at low redshift. These results are compared to previous similar studies at high and low redshift.

097.06

Arecibo Survey of HI Emission from Disk Galaxies at Intermediate Redshift

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[1]NAIC-Arecibo Obs., [2]Center for Radiophysics and Space Research and NAIC, Cornell Univ., [3]Pittsburgh Univ..

We present the results of a targeted survey undertaken with the 305m Arecibo radiotelescope to detect HI-line emission from disk galaxies at redshift $z>0.16$. The targets for the observations were extracted from the Sloan Digital Sky Survey database according to their redshift, optical emission line strength, inclination, disk morphology, and relative isolation (to minimize confusion within the beam). We obtained HI profiles of adequate quality for velocity width measurement for 20 galaxies in the redshift range 0.17-0.25. In particular, this sample includes the highest redshift detections of HI emission from individual, normal galaxies to date. The average total integration time varied between 2 and 6 hours, primarily depending on the redshift of the target. The HI mass of these galaxies is of the order of a few 10^{10} solar masses. We are using this sample to study the evolution of the zero point of the Tully-Fisher relation (TFR) for galaxies at intermediate redshifts. Compared to optical widths, HI measurements sample a larger fraction of the disks, where the rotation curves are typically flat, and are not affected by slit smearing and misalignment or by aperture effects. Thus, in contrast to studies based on optical spectroscopy, this data set allows us to perform a direct comparison with the local TFR that is technique independent. Preliminary results of this analysis will be presented.

The Arecibo Observatory is part of the National Astronomy and Ionosphere Center, which is operated by Cornell University under a cooperative agreement with the National Science Foundation.

097.07

The Star Formation History of Early-Type Galaxies

Vaishali Bhardwaj[1], M. Blanton[2]
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The formation and evolution of elliptical galaxies is an unsolved problem in galaxy astrophysics. One fundamental constraint on any theoretical model is the star-formation history of elliptical galaxies. We analyze SDSS optical spectra in conjunction with GALEX UV photometry. Using constraints on color, Sersic index, minor to major axis ratio and surface brightness, we target red, elliptical galaxies in the SDSS. We visually verify that this leads to a contamination by S0 and disk galaxies of $< 5\%$.

Then, we match this sample to the GALEX catalog to utilize information from both wavelength ranges.

Before comparing our galaxies to Bruzual-Charlot (BC03) models, we average spectra in different luminosity bins to increase our signal to noise ratio. We then use BC03 models to test several possible star formation histories, including those with and without current star formation, and find the star formation history that best fits the data and the optical spectroscopy and UV photometry together.

Our results show that the UV data highly constrain the possible star formation histories. The UV fluxes put very strong upper bounds on on-going star formation rates.

097.08

Dust Lanes as Markers of the Mass Transition in Edge-on Galaxies

Mirela Obric[1], A. A. West[2], J. Dalcanton[1]
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We present results from a study of the presence of dust lanes in edge-on galaxies. Our sample consists of 281 edge-on galaxies selected from the Sloan Digital Sky Survey (SDSS), all of which have single dish HI data. We combined the SDSS optical data with NIR images from the 2 Micron All Sky Survey (2MASS) to produce false color optical-NIR images for 168 galaxies. We visually inspect the resulting images for the presence of dust lanes. We show that the presence of dust lanes is a strong function of rotation speed, confirming previous results, which found that dust lanes are absent in low mass galaxies. For our larger, more diverse sample, the transition occurs at rotation speeds of 140 km/s, slightly higher than the original 120 km/s seen in the bulge-less undisturbed sample studied previously. Only 25 galaxies (9%) do not follow the transition. We discuss the outliers and the possible causes for the differences in the dust lane presence as well as their morphology.

097.09

A Multi-Wavelength Catalog of Radio Objects Detected by NVSS and FIRST, and (some by) WENSS, GB6, and SDSS

Amy E. Kimball[1], Z. Ivezic[1]
[1]Univ. of Washington.

We present a multi-wavelength catalog of radio objects created by positionally matching the FIRST, NVSS, WENSS, GB6, and SDSS photometric and spectroscopic surveys. The complete catalog contains over 2 million objects detected by at least FIRST or NVSS with over 400,000 detected by both, and about 20,000 detected by all four radio surveys. We examine the distribution of optically classified galaxies and quasars in radio color-color, magnitude, and morphology space to investigate the radio galaxy/quasar unification paradigm. Further applications include statistical analysis of the impact of radio sources on their environment as a function of morphology, examination of the accuracy radio galaxy evolution models, and detailed studies of the properties of quasars with jets or lobes. This catalog will also be a significant source of certain rare objects such as radio stars and very high-redshift quasars.

097.10

Reconstruction of SDSS Nearby Galaxies

Laura K. Kushner[1], M. Obric[1], A. A. West[2], J. Dalcanton[1]
[1]University of Washington, [2]University of California, Berkeley.

We present The SDSS Multiple Offspring Recombination Engine (SMORE), a newly developed code that automatically and interactively recombines galaxies fragmented by the Sloan Digital Sky Survey (SDSS) Photo pipeline. The SDSS software was optimized for the faint-end of the brightness limit and tends to over-deblend galaxies with angular sizes over 2 arcmin, sometimes separating spiral arms and HII regions from their parent galaxies. This process can remove a large percentage of the flux from the galaxy and bias datasets due to incorrect photometry. SMORE automatically builds galaxies from the fragments (″children″). Decisions on which child to include are made on the basis of its g-r and r-i color (relative to the mean colors of the largest galaxy children), size, distance to the center of the galaxy, type (as assigned by SDSS Photo) and the position angle. If there are pieces for which a decision cannot be made and their relative flux is more than 5% of the total flux of the galaxy, the interactive SMORE gives a user option to manually choose which of those children should be included. Recombined galaxies are built on a clean background without foreground and background objects and new photometry is performed.

097.11

Correlation of Galaxy Types in the 2MASS Redshift Survey with 2MASS/SDSS Colors and HI Content

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We selected 1449 galaxies brighter than 11.25 magnitudes from the 2MASS redshift survey which match with galaxies which are also detections in the SDSS DR5 survey. We computed NIR/Optical colors and correlate them with galaxy type. As expected, there is variation of average NIR or optical color with galaxy type: later type spirals are bluer. A subset of 461 of these galaxies also have 21 cm line data available in the literature: for these, NIR/Optical color was correlated with HI content. Also as expected, HI content correlates with galaxy type such that later type spirals have greater HI/L. Since a galaxy's 2 micron luminosity is very well correlated with its baryonic mass in stars this confirms the higher efficiency of star formation in early type spirals. A sample of 2MASS galaxies with no prior HI detections has been observed at the Green Bank Radio Telescope. For this sample, it is shown that optical and IR properties do not conclusively correlate with HI detectability: there is no statistical difference between HI detections and non-detections with any other galaxy property we measured.

This work was supported by NSF grant AST0406906 and made use of the GBT, operated by AUI for the NSF.

097.12

Improvement in the SDSS Photometric Calibration for Red Stars

James R. Davenport[1], J. Bochanski[1], K. Covey[2], S. Hawley[1]
[1]Univ. Of Washington, [2]Harvard.

The SDSS has been an extremely fruitful survey for the study of late-type stars and other inherently red objects. Because of the breadth of the survey, it is important that all of the photometric data be calibrated on the standard SDSS 2.5m ugriz system. However, for stars redder than r-i $>$ 0.6, the stellar locus measured with the SDSS 2.5m telescope begins to diverge from the SDSS photometric telescope calibration measurements using the presently derived color transformations. We use photometry of hundreds of late type stars that have been measured with both the SDSS 2.5m and the SDSS photometric telescope to obtain improved color transformations between the two telescopes for stars with red colors. These data will be particularly useful for calibrating an improved photometric parallax relation for low mass stars.

097.13

Minor Galaxy Interactions in the SDSS

Deborah Freedman Woods[1], M. J. Geller[2]
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We study star formation in a sample of 635 minor pairs of galaxies, where the z magnitude difference $>$ 2, selected from the Sloan Digital Sky Survey photometric and spectroscopic databases. The galaxy pairs are coincident both in apparent physical separation (Delta D $<$ 50 kpc/h) and in redshift space (Delta cz $<$ 500 km/s). The large data set allows us to examine the effects of the interaction on the major and minor companions separately, and to segregate the galaxies by color and by absolute magnitude. We study the relationship between specific star formation and apparent physical separation, and between specific star formation and the relative magnitude of the pair.

098: SNAP Mission
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

098.01

SNAP Telescope Performance for Weak Lensing Surveys

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The SuperNova Acceleration Probe is a prospective space mission that incorporates two cosmological probes of dark energy: a redshift magnitude diagram of ~2000 SNe ranging to z=1.7, and a weak gravitational lensing survey spanning ~ 1000 square degrees (4000 sq deg in an extended mission). Reliable weak lensing shear determination places stringent requirements on the telescope point spread function (PSF) and its time stability. We present estimates of the PSF and its time variations for a nominal mission environment. These estimates show that expected instrumental shear errors are ten to 1000 times smaller than the statistical errors in shear determination.

098.02

Characterization of LBNL SNAP CCD's: Quantum efficiency, reflectivity, and point-spread function

Donald E. Groom[1], C. J. Bebek[1], M. Fabricius[1], J. A. Fairfield[1], A. Karcher[1], W. F. Kolbe[1], N. A. Roe[1], J. Steckert[1]
[1]*Lawrence Berkeley Nat'l Lab..*

A Quantum Efficiency Machine has been developed at Lawrence Berkeley Lab to measure the quantum efficiency (QE) of the novel thick CCD's planned for use in the Supernova/Acceleration Probe (SNAP) mission. It is conventional, but with significant innovations. The most important of these is that the reference photodiode (PD) is coplanar with the cold CCD inside the dewar. The PD is on a separate heat sink regulated to the PD calibration temperature. The effects of geometry and reflections from the dewar window are eliminated, and since the PD and the CCD are observed simultaneously, light intensity regulation is not an issue. A ''dark box'' provides space between the exit port of the integrating sphere and the CCD dewar, ensuring nearly uniform illumination. It also provides a home for a reflectometer and spot projector, both of which are fed by the alternate beam of the monochromator.

The measurement of reflectivity (R) is essential for corroborating the QE measurements, since QE < 1-R everywhere, and QE = 1-R over much of the spectral region. In our reflectometer the light monitor and the CCD carriage are both moved so that no extra mirrors are introduced. The intrinsic point-spread function (PSF) of a CCD is limited by transverse diffusion of the charge carriers as they drift to the potential wells, driven by the electric field produced by the substrate bias potential---hence a bias voltage that is normally several times that needed for total depletion. A precision spot projector is installed in the dark box for the measurements. A PSF rms width of 3.7 pm 0.2 um is obtained for the 200 um thick SNAP CCD's biased at 115 V, thus meeting the SNAP design goals. The result agrees with simple theory once the electric field dependence of carrier mobility is taken into account.

098.03

Current-Integrating Amplifier and Computer Interface for SNAP Photodiode Readout

Stephen J. Battazzo[1], B. Adams[2], M. Gebhard[2], N. Mostek[2], S. Mufson[2]
[1]*Indiana University (REU)/University of Oregon,* [2]*Indiana University.*

SNAP plans to use photodiodes for calibration in low light level applications. A current-integrating amplifier and computer interface was designed to acquire data from a photodiode detector. A simple device was prototyped using separate charge integrator and ADC ICs. A microcontroller was programmed to receive instructions from a PC to determine integration time, and then act as an intermediate step in the transfer of result data from the ADC to the PC.

This work has been supported by the National Science Foundation through grant AST-0452975 (astronomy REU program to Indiana University).

098.04

SNAP Focal Plane Development

Chris Bebek[1], SNAP Collaboration
[1]*LBNL.*

The SNAP mission concept is being developed to measure properties of dark energy. The science program requires photometric discovery and detailed follow-up observations of at least 2000 Type Ia supernovae with redshifts ranging from 0.3 to 1.7 and a weak lensing survey of 2000 sq. deg. The instrument, which sits at the focus of a 2-m class three mirror anastigmat telescope with a 1.4 square degree FOV, consists of a photometer that instruments 0.7 square degree of the FOV, and a low resolution spectrograph. Both the photometer and spectrograph use visible and NIR detectors to span the wavelength range 400 nm to 1700 nm. A 2D-symmetric array of fixed filters is deployed over the photometer sensors and the focal plane is operated in a step-and-stare mode to perform broadband photometry over fixed regions of the sky. The multi-object spectrograph is based on an image slicer.

098.05

Auxiliary Science with SNAP Surveys

Timothy McKay[1], SNAP collaboration
[1]*Univ. of Michigan.*

The SNAP mission will generate the first truly wide field optical/NIR surveys from space. Primary mission observations will include both a ″narrow″ deep survey covering about 15 square degrees to an AB magnitude fainter than 31 and a wide ″shallow″ survey covering about 1000 square degrees to an AB magnitude of 28. Both surveys will be conducted in six optical and three NIR filters, and will feature the high resolution and photometric stability made possible by a space platform. These imaging surveys will impact all areas of astronomy, including cosmology, galaxy formation and evolution, galaxy clusters, high redshift quasars, gravitational lensing, resolved stellar populations of near-by galaxies, cool stars in the Milky Way halo, and various transients. This poster presents an overview of some key SNAP auxiliary science prospects, with an emphasis on those topics which will be most advanced by use of a space platform.

098.06

SNAPsim: A Software Package for Simulating of Astronomical Observations

Alex G. Kim[1], SNAP Collaboration
[1]*LBNL.*

SNAPsim is a software package used to simulate optical-telescope data. The software allows user control over properties of the observatory, telescope, and camera; the universe and the astronomical sources within; and the taken exposures. SNAPsim includes supernova-cosmology analysis tools. SNAPsim is used to compare the dark-energy-parameter precision and accuracy of various strawman supernova surveys, and to provide requirements and optimize the Supernova / Acceleration Probe (SNAP) experiment. This poster describes the structure, usage, and flexibility of SNAPsim. Results from example simulation studies are also presented.

098.07

SNAP: The Power of Supernovae, Weak Lensing, and Space

Eric Linder[1], SNAP Collaboration
[1]Berkeley Lab/UC Berkeley.

Space provides unique capabilities for highly accurate data sets that enable robust tests of the nature of dark energy. Supernovae can be tightly characterized over the full optimal leverage redshift range of z=0.1-1.7 with a homogeneous, well calibrated sample. Weak gravitational lensing measurements enjoy depth, high resolution, stable point spread functions, and shear calibrations each with improvements of 3-10 times over ground based levels. Morover, full optical and near infrared coverage produces highly accurate galaxy photometric redshifts for lensing tomography and galaxy studies. SNAP's tight systematics control, plus its complementarity of supernovae and weak lensing, provide a clear path to understanding dark energy, while generating some one million Hubble Deep Field quality images, in nine bands.

098.08

Computation and Data Product Model for the SNAP Mission

William Carithers[1], G. E. Kushner[1]
[1]LBNL.

SNAP is a concept for a dark energy mission featuring Type Ia supernovae and weak lensing surveys leading to a precise measurement of the dark energy equation of state. The mission concept includes a wide-angle imager in nine filters and an integral field spectrograph estimated to generate approximately 250 Gigabytes of raw data per day. This poster will describe the Science Operations pipeline and the anticipated data products. The products will include time-domain and co-added catalogues for a deep 7.5 square degree field and catalogues for a wider, but shallower (roughly equivalent to the Hubble Deep Field for point sources), field of 1000 square degrees. An extended mission would expand the wide survey to 4000 square degrees. All catalogues will include all nine filters and will be accessible on the Virtual Observatory.

098.09

The SNAP Mission Overview

Patrick Jelinsky[1], SNAP Collaboration
[1]UC, Berkeley.

The Supernova / Acceleration Probe (SNAP) is a proposed mission designed to reveal the nature of dark energy by measuring both the expansion history and the growth of structure in the universe, through two complementary probes_a supernova Ia survey and a weak-lensing survey. We present an overview of the design of the SNAP mission. The choice of orbit, mission timeline, data flow, instrument schematic, and other key mission parameters are discussed.

098.10

Near Infrared Detectors for SNAP: Towards Precision Photometry

Michael Schubnell[1], SNAP Collaboration
[1]Univ. of Michigan.

A number of large format (1k $\times$ 1k and 2k $\times$ 2k) near-IR detectors manufactured by Teledyne Scientific & Imaging (formerly Rockwell Scientific) and Raytheon Vision Systems have been characterized as part of the near infrared R&D effort for SNAP (the SuperNova / Acceleration Probe). The majority of these detectors are hybridized HgCdTe focal plane arrays with a sharp high-wavelength cutoff at 1.7 μm. This particular cutoff wavelength provides a sufficiently deep reach in redshift, z, while it allows at the same time low dark current operation of the passively cooled detectors at about 140 K. Precision photometry is essential to the science goals of SNAP and will require low noise, high QE detectors with a high degree of sub-pixel uniformity. In this poster presentation the science driven requirements for the near infrared detectors are summarized and several key findings obtained during the SNAP R&D program will be discussed. In particular, high QE (>95%) has been measured in substrate removed AR coated engineering grade SNAP devices and it was shown that intra-pixel variations in high QE devices are small ($\approx$1%). This ensures that SNAP can meet the photometric S/N goals.

098.11

A Monochromatic Illumination and Cryogenic Calibration System for SNAP Calibration Studies

Stuart Mufson[1], N. Mostek[1], C. R. Bower[1], S. S. Allam[2], C. J. Bebek[3], R. C. Bohlin[4], S. Deustua[5], S. M. Kent[2], M. L. Lampton[6], M. Richmond[7], D. T. Tucker[2], B. E. Woodgate[8], SNAP Collaboration
[1]Indiana Univ., [2]FNAL, [3]LBNL, [4]STScI, [5]AAS, [6]UC Berkeley, [7]RIT, [8]GSFC.

To understand the calibration requirements of measuring dark energy parameters with SNAP, we have built the Monochromatic Illumination and Cryogenic Calibration System (MICCS) at Indiana University. The MICCS system is designed to deliver constant, monochromatic irradiance to a dewar system operated at 140K. The system will transfer irradiance calibration from a NIST calibrated photodiode to cold transfer photodiodes. These transfer photodiodes will be used by collaborators to measure the quantum efficiency of SNAP detectors. In addition, the system will use a miniature rotation stage to test prototype interference filters at SNAP temperature under a range of angles relevant to the SNAP design.

098.12

Effects of Zero Points Calibration Uncertainties in Dark Energy Supernova Surveys

Lorenzo Faccioli[1], A. G. Kim[1], R. Miquel[2]
[1]Lawrence Berkeley National Laboratory, [2]ICREA / IFAE, Spain.

We investigate the effects of zero point calibration uncertainties in supernova surveys by simulating an SNLS-like mission and a SNAP-like mission. We show that a significant reduction in the uncertainties of the cosmological parameters Ω_M, w_0 and w_a and can be achieved by fitting all the supernovae distance moduli simultaneously rather than independently.

This work uses the SNAP simulation software SNAPsim.

098.13

Observational Cadence vs. Exposure Time Trade-off for Supernova Surveys

Natalia Kuznetsova[1], SNAP Simulation Team
[1]Lawrence Berkeley National Lab.

To extract the maximum cosmological information from type Ia supernovae, magnitude measurement errors should not exceed the intrinsic dispersion of ~0.15 magnitudes. This requirement has a direct impact on any supernova cosmology mission design. We explore the observational cadence (how frequently the supernova flux is sampled -the light curve), the exposure time per sampling, and trade-offs between these two parameters and the obtainable number of supernovae given a limited survey time. Taking into account realistic experimental constraints, we propagate measurement errors throughto light curve fit parameters and ultimately distance measurement precision.

098.14

Packaging for SNAP CCDs

Charles Baltay[1], A. Bauer[1], W. Emmet[1], T. Hurteau[1], D. Rabinowitz[1], A. Szymkowiak[1], C. Bebek[2], K. Dawson[2], J. Emes[2], D. Groom[2], S. Holland[2], A. Karcher[2], B. Kolbe[2], N. Roe[2], T. Diehl[3], M. Demarteau[3], P. Derwent[3], B. Bigelow[4]
[1]Yale University, [2]Lawrence Berkeley National Lab, [3]Fermi National Lab,

MONDAY

[4]University of Michigan.

The Supernova Acceleration Probe (SNAP) mission proposes to use 36 charged coupled devices (CCDs) for the optical imaging. Each device is now envisioned to have 3512 x 3512 pixels 10.5 microns square each, with each CCD being approximately 40mm x 40mm x 200 um in size. The CCDs will have to be packaged to be suitable for mounting on the SNAP Silicon Carbide focal plane. The packages will have to be four side buttable and be stable over a temperature range of +50 degrees C to -150 degrees C, maintaining a flatness and thickness tolerance of 10 microns or less over this temperature range. The packages will be mounted on silicon carbide pedestals to match the coefficient of thermal expansion of the pedestals to both the silicon CCDs and the silicon carbide focal plane. The current design and progress on prototype packages will be described.

098.15

Radiation Tolerance of SNAP CCDs

Koki Takasaki[1], SNAP collaboration
[1]UC, Berkeley.

The Supernova Acceleration Probe (SNAP) mission will employ a unique charge-coupled device (CCD) for imaging at wavelengths from 350 1000 nm. These thick, fully-depleted p-channel CCDs developed at LBNL have three advantages over traditional thin n-channel CCDs. They have much higher quantum efficiency in the near-infrared, they are much more radiation tolerant, and the point spread function (PSF) can be controlled through application of the bias voltage and made very small. Recent results obtained on the irradiation of CCDs designed for SNAP will be presented showing the charge transfer efficiency (CTE), the dark current and its decay with time, and the observed number of ″hot pixels,″ all as a function of the delivered proton fluence. Results on SNAP CCDs irradiated in a dewar at 140K while fully powered will also be presented. Comparisons will be made to the CTE degradation of n-channel CCDs used in previous space missions.

098.16

Calibration of Interference Filter Transmission using Light Emitting Diodes

Nick J. Mostek[1], S. L. Mufson[1], C. R. Bower[1], S. S. Allam[2], C. J. Bebek[3], R. C. Bohlin[4], S. Deustua[5], S. M. Kent[2], M. L. Lampton[6], M. Richmond[7], D. L. Tucker[2], B. E. Woodgate[8], SNAP Collaboration
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Accurate calibration of SNAP filter throughput is essential to eliminating systematic error in the dark energy parameters determined by SNIa light-curve measurements. The calibration of filter transmission in a space-based mission is hampered by the lack of precision color reference sources under space conditions. We propose to use the semi-monochromatic emission of solid state light emitting diodes (LEDs) to provide precise spectral power for broadband filter calibration applications. We describe a method to track global changes in filter transmission using LEDs and detail the throughput differences between bare LEDs and an LED-fed monochromator.

098.17

Critical Parameters for Supernova Cosmology

Lifan Wang[1], K. Kannan[1], A. Kim[2]
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We investigate the values of some critical parameters for next generation supernova cosmology studies. These include: (1) the intrinsic magnitude dispersion after light curve width and color correction; (2) the parameters that quantifies spectral features of Type Ia supernovae; (3) the parameters that describe the light curve and color curve shapes of Type Ia supernovae. We present results of a principle component and independent component analysis (PCA and ICA) of supernova properties based on our newly developed error weighted PCA and ICA algorithms. We present various scenarios that these studies may help in controlling systematic errors of future supernova cosmology experiment such as SNAP.

098.18

Development of Spectrophotometric Standards to Support the SNAP

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The SNAP mission will study Type Ia supernovae (SNe) to probe the dark energy content of the Universe. Photometric calibration is critical to the success of the mission. Kim & Miquel (2006) computed the impact of various levels of band-to-band photometric zero-point offsets on the derived cosmological constraints and determine the Type Ia method constraints reach full effect when the relative band photometry is accurate to 1% or better. Poorer photometry leads to larger scatter in the derived redshift-magnitude diagram for SNe and weakens the constraints on dark energy models. We outline the photometric calibration program designed to provide sensitivity calibrations with systematic errors no greater than 1-2% for both the SNAP spectrograph and imager.

Currently, the best absolute flux standards covering the 0.4-1.7μm range are the HST hot (T$_{eff}$=30,000-60,000K) pure hydrogen WDs. NLTE models of these WDs determine the shape of their SEDs, while precise Landolt V band photometry sets the overall absolute flux level. Models of A stars and K giants along with solar analog stars are also commonly used for flux standards; but these alternative approaches are not as precise as the models for pure hydrogen hot WDs. SNAP must observe the WDs in both the spectrograph and the imaging modes with an exposure time uncertainty of <<1%.

The achievement of <<1% errors in the transfer of the flux calibrations from the fundamental standard stars to the SNAP instrumentation will be demonstrated by the repeatability level of multiple observations of the SNAP fundamental standards. We discuss the uncertainties in the fundamental standards, in transferring the calibration to the SNAP instrumentation, variations over the FOV, scaling (linearity) factors, and instrument/spacecraft factors (shutter timing, filter bandpasses, etc.). We include a discussion of the impacts to the calibration program if the systematic error requirements are increased from 1% to 0.5%.

098.19

Dark Energy Science Constraints on Calibration: Design of the SNAP Calibration System

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SNAP's primary science goal is investigating dark energy properties, and thereby distinguishing amongst the families of theoretical models. This places requirements on the precision of the determination of dark energy equation of state parameters ($w(z) = w_0 + w_a(1+ z)$, where $w = -\rho/p$ (density/pressure)), corresponding to uncertainties on w_0 to 0.05 and w_a to 0.3 or better. In this paper we concentrate on the calibration constraints set by the need to obtain multicolor light curves and peak magnitudes of SNe Ia at redshifts between z=0.3 and z=1.7. The key factor in using the SNe Ia magnitude-redshift relation for determining cosmological parameters is the B-band peak magnitude. Thus, to standardize SNe Ia brightnesses, we take the ratios of the observed rest frame B-band magnitudes m(z) to that of a SNe Ia at z=0, e.g. $B-J = -2.5 \log f_B/f_J$. Therefore the calibration requirement is on the need for accurate and precise colors and hence on accurate knowledge of the slope of spectral energy distribution of calibrating sources -corresponding to an uncertainty of ~1% per filter, and 2% in color.

The problem we must solve is how to precisely and accurately measure colors of faint objects in the visible and in the near-infrared, and maintain the reliability or scale of the calibration during the lifetime of the mission. Some of the challenges we need to overcome are the large (ten or more) magnitude difference between current, faint spectrophotometric standards

(V ~ 13 mag) and the science targets with magnitudes as faint as 27 mag, the difference is SEDs between stars and supernovae, and the calibration of a half-billion silicon and MgCdTe pixels.

This paper briefy describes the calibration methodology needed to ensure that the desired calibration requirements can be met and the calibration scale maintained throughout the SNAP mission.

098.20

The SNAP Integral Field Spectrograph

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A well-optimised spectrograph concept has been developed for the SNAP (SuperNova/Acceleration Probe) experiment. The goal is to ensure proper identification of Type Ia supernovae and to standardize the magnitude of each candidate by determining explosion parameters. The spectrograph is also a key element for the calibration of the science mission. An instrument based on an integral field method with the powerful concept of imager slicing has been designed and is presented. A prototype of the full concept is under development in France (CNRS/INSU/IN2P3), with a CNES and UC Berkeley support to provide the verification of the optical performances at the requirement level. A complete simulation of the instrument is also developed at pixel level and will be validated. This permits a detailed strategy for the future ground and in orbit calibration scenario.

099: Source Surveys, Catalogs and Astrometry
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

099.01

Time-Series Data and the Virtual Observatory

Mark Huber[1], A. Drake[2], K. Vivas[3], D. Gasson[4], K. Cook[1], S. Nikolaev[1]
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Astronomy is entering a time of massive, time-domain surveys with the Palomar-Quest survey, Pan-STARRS, and ongoing development for the LSST. There already exist, however, significantly large time-domain surveys, legacy or in progress (i.e., MACHO, SuperMACHO, LONEOS, NSVS, FSVS, Quest1, to name a few), that can provide a wealth of secondary science as well as precursor information for future programs. Data mining across these datasets proves to be a challenge given the variety of formats, interfaces, and availability. We have investigated VO-enabled access of an assortment of datasets with a science goal of extracting tracers, such as RR Lyrae, to study Galactic Halo structure. Presented will be a current description of the datasets used, tools developed, and preliminary results.

099.02

Basic Stellar Parameters for SIM Planet Quest Reference Grid Stars

Dmitry Bizyaev[1], V. V. Smith[1], K. Cunha[1]
[1]NOAO.

We continue to monitor the radial velocities of about 1400 candidates to the SIM Planet Quest reference grid stars in the Northern hemisphere. Spectra of some 800 red giants, not contaminated by reference iodine lines are available for analysis. We present a preliminary version of a code for deriving Teff, log g, [Fe/H], and v sini for selected stars. The code fits artificial spectra (made with the MOOG package and Kurucz model stellar atmosphere) to the observed ones. Analysis of one hundred stars selected randomly from the main sample indicates that most of the pre-selected stars are K-giants with somewhat subsolar metallicity. The project is supported by NASA grant NRA-99-04-OSS-058.

099.03

Milliarcsecond Accurate Astrometry for Extension of the ICRF in the Southern Hemisphere

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We report new milliarcsecond accurate radio positions in the International Celestial Reference Frame for 74 Southern Hemisphere radio sources obtained by a continuing VLBI research program in Southern Hemisphere astrometry and imaging which is a collaboration between the U.S. Naval Observatory, the Australia Telescope National Facility and associated facilities. These results are part of an effort to increase the sky density of Southern Hemisphere sources with accurate positions in order to better define the ICRF and to provide additional phase-reference sources for use in astrophysical observations. The positions for all these sources are south of declination -20 degrees and they represent the largest group of new milliarcsecond accurate astrometric positions for sources in this declination range since the initial definition of the ICRF. The impact of these new sources on the improvement of the ICRF in the Southern Hemisphere will be discussed.

099.04

Atmospheric Gravity Waves as a Source of Anomalous Refraction Observed in High Precision Astrometry

Suzanne Taylor[1], J. McGraw[1], J. Pier[2], P. Zimmer[1]
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A century ago, astronomers using transit telescopes to determine precise stellar positions were hampered by an unexplained periodic shifting of the stars they were observing. With the advent of CCD transit telescopes in the past two decades, this unexplained motion, now known as 'anomalous refraction', is again being observed.

Anomalous refraction is described as a low frequency, large angular scale motion of the entire image plane with respect to the celestial coordinate system as observed and defined by previous astrometric catalogs. These motions of typically several tenths of an arcsecond with timescales on the order of 10 minutes have been attributed to the effect of atmospheric gravity waves. A comprehensive research campaign to systematically investigate the effect of atmospheric gravity waves on high-precision astrometry through anomalous refraction is proposed. This includes theoretical modeling of atmospheric gravity waves to predict their refractive effects, analysis of preexisting astrometric data from several sources, including the original CCD/Transit Instrument (CTI) and the Sloan digital Sky Survey (SDSS), and simultaneous astrometric and atmospheric measurements to observe the direct atmospheric wave anomalous refraction correlation. Preliminary research shows that atmospheric gravity waves are a plausible cause of anomalous refraction with the largest effects resulting from waves in the lowest levels of the atmosphere.

099.05

ALPACA: An Inexpensive but Uniquely Powerful Imaging Survey Telescope

Arlin P. Crotts[1], ALPACA Consortium
[1]Columbia Univ..

ALPACA (Advanced Liquid-mirror Probe of Astrophysics, Cosmology and Asteroids) is an 8-meter optical telescope destined for Cerro Tololo and designed to scan a strip of sky passing overhead and extending over ~1000 square degrees. The imaging survey will be conducted in five photometric bands covering the optical waveband and allow for photometric descrimination of many source types, including supernova types and asteroid categories, and allow photometric redshift determination for both galaxies and supernovae. The ALPACA is intended to extend over at least a three years and reach a cumulative point-source detection of about 28th magnitude AB at ~10-sigma. ALPACA will deliver nightly photometry for many classes of

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variable and moving objects. Most crucial, perhaps, will be the exquisitely deep, numerous and well-sampled multiband lightcurve sample for supernova, particularly SNe Ia to redshifts z ~ 0.8. This is an excellent redshift range for dark energy model descrimination, but also can be used for unprecedentedly sensitive tests and improvements of the SN Ia standard candle relation. There are many other superlative projects that will be conducted with ALPACA data, including studies of high redshift galaxies, quasars and AGN, large scale structure, novae, variable stars, Galactic Bulge microlensing, Galactic structure, stellar populations, extrasolar planets, Kuiper Belt objects, Near-Earth objects and many other classes of targets.

ALPACA is based on the 6-meter LZT (Large Zenith Telescope), which is currently operating in British Columbia and producing largely seeing-limited imaging. ALPACA has undergone conceptual design review and is now under design. Seeing tests are underway at sites on Cerro Tololo. We hope to achieve first light on ALPACA by late 2009. Proto-ALPACA is a stage of the project with the full-sized telescope with a smaller field of view, and will be first operational. ALPACA might eventually add instrumentation; a multiobject spectrograph is under study.

099.06

OT060420 and the Systematic Automated All-sky Search for Bright Optical Transients

Lior Shamir[1], R. Nemiroff[1]
[1]Michigan Tech.

Real-time detection of bright optical transients has an important role in modern astronomy, and many robotic telescopes have been built and operated for this purpose. However, since traditional narrow-angle telescopes cover only a very small portion of the sky at a given time, one can reasonably assume that some bright short-timescale transients may not be recorded by the available narrow-angle sky surveys.

In this study we applied a systematic all-sky automated search for bright short-timescale optical transients. The search used two panoramic all-sky cameras located in the northern and southern hemispheres, and could automatically alert on optical transients brighter than ~5.5th magnitude that lasted for 12 minutes or more.

After three years of operation, we recorded a seemingly ~5th magnitude optical transient detected for approximately 12 minutes by two *CONCAM* all-sky cameras located in Cerro Pachon -Chile and La Palma -Spain.

The data were also used to deduce upper limits to the frequency of short-timescale bright transient events.

099.07

Improved UBVR$_{\mathrm{CI\ C}}$ to u'g'r'i'z' Transformation Equations: Updated Main Sequence and Giant Star Relations

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[1]University of Wyoming, [2]Lowell Observatory, [3]Austin Peay State University.

Rodgers et al. (2006) began a study on the UBVR_CI_C to $u'g'r'i'z'$ transformation equations by separating each equation by luminosity class. This study was limited in number and color coverage by use of the Smith et al. (2002) and Landolt (1992) standard stars with known luminosities in both photometric systems. We have expanded this data set by observing bright stars with known luminosities and metallicities in both photometric systems. We give updated equations for Main Sequence (luminosity class V) stars and preliminary equations for Giant (luminosity class III) stars. We also investigate if these transformation equations have any metallicity dependencies.

099.08

New DDO Photometric Equatorial Standard Stars Between 9.0 < M$_{48}$ < 16.0: Preliminary Results

Christopher T. Rodgers[1], R. Canterna[1], D. Allen[2], E. Hausel[1], J. A. Smith[3]
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We have begun an undertaking of adding to the DDO standard star list by integrating the popular Landolt (1992) equatorial standard star fields. Our new primary DDO standard stars include the principal UBVR$_C$I$_C$ stars in the equatorial SA fields with fainter stars becoming our secondary standards for that field. We present our preliminary results for the primary standard stars in SA fields 92 through 106 with magnitudes between $9.0 < M_{48} < 16.0$. Secondary

standard stars with magnitudes between $16.0 < M_{48} < 22.0$ will be presented in a subsequent paper.

100: Star Clusters II and HST/ACS Survey of Galactic Globular Clusters
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

100.01

M82 at the Highest Resolution

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We will present the highest spatial resolution images ever obtained of the central region of the nearby prototypical starburst galaxy M82. The images were acquired with the ACS/HRC on board HST, in the equivalent of the U, B, V, I, and H α filters, and with the Laser Guide Star Adaptive Optics facility and the NIRC2 camera at the Keck Observatory in the H and K filters. The images cover the sites of the most recent star formation activity. We are using these images to investigate the properties of the massive Super Star Clusters (SSCs) in M82. Specifically, we examine the spectral energy distributions, light profiles, sizes, and shapes of the SSCs. By combining these with spectral synthesis models and published measurements of the velocity dispersions obtained from ground-based spectroscopy, we derive masses, extinctions, and ages for the SSCs and investigate possible mass segregation and variations in the Initial Mass Function.

100.02

Old Globular Clusters in Nearby Dwarf Irregular Galaxies

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According to the popular hierarchical galaxy formation scenario, the assembly history of present-day early-type galaxies involved numerous mergers of small galactic entities. Dwarf irregular (dIrr) galaxies are widely regarded as being probable building blocks of massive galaxies. Hence, a study of old globular clusters in dIrrs, whose properties reflect the physical conditions at the time of their early formation, and a comparison with GCs in early-type galaxies can be used to quantify the dIrrs' contribution to the assembly of today's massive galaxies and their GC systems. We will present exciting results of our analysis of GC systems in a large sample of Magellanic-type, dIrr galaxies in nearby loose group environments outside the Local Group using deep HST/ACS images. We present their color (metallicity) distributions, luminosity functions, specific frequencies, structural parameters, and spatial distributions as a function of host galaxy luminosity (mass), and discuss the results in the context of the hierarchical galaxy formation scenario.

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100.03

Searching for the Young Super-Star Clusters in NGC 3627

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Searches for optically thick radio HII regions associated with young star clusters has been done primarily towards dwarf starbursts that are free of extended disk synchrotron. Because of this confusion source and the generally weaker star formation in galactic disks, little is known about "supernebulae" associated with SSCs in spiral disks. Deep, arcsecond resolution VLA maps at 20 cm 2 cm of the disk of the nearby actively star forming spiral, NGC 3627, are presented, to study the distribution and properties of its radio HII regions. We discuss the locations, sizes, fluxes and spectral indices of the compact radio sources seen in the highest resolution data. Spectral indices are used to identify and classify young, compact, HII regions. Two to three sources that appear to be compact, massive HII regions associated with disk SSCs are found. These sources are brighter than any HII region complex in the disk of our Galaxy, having ionizing rates of ~10^{52} s^{-1}, and have optically thick turnover frequencies at ~2 GHz over 10 20 pc scales. The sources are found primarily at the ends of the bar, suggesting they form from colliding gas clouds in the strong bar potential. Other sources were identified

as SNR, but several compact sources remain unclassified having non-standard spectral indices.

100.04

Properties of Globular Cluster Populations of Early-Type E+A Galaxies

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Using the unique depth and spatial resolution afforded by the HST/ACS, we study a sample of early-type galaxies from the Malin and Carter (1983) catalog of shell galaxies. We selected galaxies with post-starburst (E+A) spectra to investigate the formation history of stars and globular clusters in early-type galaxies with post-starburst populations. A detailed analysis of their globular cluster systems shows a wide variety of cluster color properties in the sample, ranging from a single peak in the color distribution to multiple peaks. We present evidence for the presence of three distinct sub-populations of globular clusters in at least one galaxy, AM 0139-655. The brightest shells in some sample galaxies harbor some of the youngest clusters observed. This seems to indicate that the same merger event was responsible for the formation of both the shells and the young GCs.

Support for this work was provided by NASA through grant number GO-10227 from the Space Telescope Science Institute.

100.05

Resolved Massive Stellar Clusters in Nearby Starburst Galaxies

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Starbursts in nearby galaxies are often resolved into super star clusters (SSCs) that may be progenitors of globular clusters if they are compact enough to survive mass loss and dynamical processes. In order to study the formation, feedback, early evolution, and fate of SSCs, we obtained high-resolution images of a sample of SSCs and their surrounding stellar populations in NGC 5253, He 2-10, NGC 4449, IC 4662, and NGC 1156, using ACS/HRC on HST in filters that are similar to U, B, V, I, and H-alpha, and using NICMOS in filters similar to J, H, and Ks. We discuss cluster sizes, shapes, and light profiles as a function of wavelength to search for evidence of mass segregation, and employ population synthesis models to estimate SSC age and mass distributions as well as star-formation histories in these galaxies.

100.06

Multi-band Photometry of Globular Cluster Systems

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It has been known through many studies that globular cluster (GC) systems are a powerful tool for probing the formation and evolution of their parent galaxies. Since the discovery of the bimodal color distributions of extragalactic GC systems, the origin of such phenomenon has been the topic of much interest and a source of ongoing debate (e.g., Brodie & Strader 2006). It is widely agreed that the presence of two distinct GC sub-populations with different metallicities is responsible for the observed color bimodality. Recently, however, an alternative explanation has been offered by Yoon, Yi & Lee (2006), in which the non-linear relation between metallicity and color gives rise to color bimodality, without invoking distinct GC sub-systems within individual galaxies. This scenario requires for the ratio of blue GCs to red ones in the color distribution to vary systematically depending on colors with different filter combination for the same sample. With the two distinct sub-populations present, on the other hand, the ratio will not change regardless of the bandpasses.

The predicted number ratio variation in multi-band was reproduced in modeling. Furthermore, the new hypothesis by Yoon et al. (2006) was partially verified in the observations of GC systems (e.g. Peng et al. 2006, Hempel et al. 2005). In order to shed light on the origin of color bimodality, multi-band observations with homogeneous dataset and wider field coverage on extended wavelength range is needed.

100.07

Imaging of Globular Clusters in NGC 4365 with IRAC on the Spitzer Space Telescope

Andrew R. Esselman[1], S. E. Zepf[2], A. Kundu[2], M. Hempel[2]
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We used images from the Spitzer Space Telescope's IRAC (Infrared Array Camera) to study the nature of globular clusters in the elliptical galaxy NGC 4365. Mosaicing, point source extraction, and aperture photometry was done on the images using the Spitzer package MOPEX. We flagged the IRAC sources that matched with globular clusters previously identified in Hubble Space Telescope data. Photometry of the globular clusters from IRAC's 3.6 and 4.5 micrometer bands were compared to the available photometry from the HST data. Photometry was determined over the available wavelengths (gVIzH, 3.6, 4.5 microns) and compared to several standard stellar population models over a wide range of ages and metallicities. The methods of data processing and globular cluster detection are discussed. This work was done at the Michigan State University REU program funded by the NSF.

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100.08

The Cluster Formation Function in Galaxies

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The cluster formation function, which is the distribution of initial masses and absolute magnitudes of star clusters over a large range of conditions, is a somewhat neglected subject, in spite of its importance to our ideas of the cluster formation mechanism. Infrared and radio wavelength studies of cluster formation give relevant information about the masses of pre-cluster assemblies, but the mass distribution of resulting stable clusters over a significant mass range is known only for the Milky Way Galaxy.

We have determined the cluster formation function for three additional galaxies, the Magellanic Clouds and M31, basing our analysis on recent surveys of clusters in those galaxies. Our deepest data are for M31's disk clusters, for which there is now a census of clusters to faint limits, to integrated absolute magnitudes of -2 in V. The formation function for these data is remarkably linear in the (logN)/M(V) plane, when we take into account the fading of the clusters and the detection efficiency of the survey. A similar result is found for the Magellanic Cloud clusters, although available searches are less complete for low cluster masses. We find that the slope of the formation function varies from galaxy to galaxy, possibly depending on a galaxy's Hubble type.

100.09

The HST/ACS Survey of Galactic Globular Clusters: Overview and New Photometry for Nine Clusters

Ata Sarajedini[1], J. Anderson[2], A. Aparicio[3], L. Bedin[4], B. Chaboyer[5], A. Dotter[5], M. Hempel[1], I. R. King[6], S. R. Majewski[7], A. Marin-Franch[1], A. Milone[8], N. E. Paust[9], G. Piotto[8], I. N. Reid[9], A. Rosenberg[3], M. Siegel[10]
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The HST/ACS Survey of Galactic globular clusters is a Treasury project designed to obtain photometry with S/N $\geq$10 for main sequence stars with masses $\geq 0.2M_{\odot}$ in a large sample of globulars using the Advanced Camera for Surveys (ACS) Wide Field Channel. We plan to use these data to address a range of astrophysical questions. Here we present new photometry for the Galactic globular clusters NGC 5466, 6779, 5053, 6144, Palomar 2, E3, Lynga 7, Palomar 1, and NGC 6366. Our CMDs extend reliably from the horizontal branch to as much as seven magnitudes fainter than the main sequence turnoff and represent the deepest CMDs published to-date for these clusters. Using fiducial sequences for three standard clusters (M92, NGC 6752, and 47 Tuc) with well-known metallicities and distances, we perform main sequence fitting on the target clusters in order to obtain estimates of their distances and reddenings. These comparisons along with fitting the cluster main sequences to theoretical isochrones yield ages for the target clusters. We find that the majority of the clusters have ages that are consistent with the standard clusters at their metallicities. The exceptions are E3 which appears to be $\approx$2 Gyr younger than 47 Tuc, and Pal 1, which could be as much as 8 Gyr younger than 47 Tuc. Support for this work (GO-10775) was provided by NASA through a grant from the Space Telescope Science Institute which is operated by the Association of Universities for Research in Astronomy, Incorporated, under NASA contract NAS5-26555.

100.10

The HST/ACS Survey of Galactic Globular Clusters: New Stellar Evolution Tracks, Isochrones and Luminosity Functions

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To aid in the analysis of the HST/ACS survey of Galactice globular clusters, we have calculated a new set of stellar evolution tracks, isochrones and luminosity functions. The stellar evolution tracks use an updated set of basic physics, including the FreeEOS equation of state, new opacities and surface boundary conditions from the PHOENIX model atmosphere code, and include the diffusion of metals and helium. The stellar evolution tracks start on the pre-main sequence and terminate at the onset of thermal pulsations on the asymptotic giant branch. Models with masses from 0.1 to 1.5 solar masses are computed from [Fe/H] = -2.5 to [Fe/H] = 0., in steps of 0.5 dex. For each [Fe/H] value, tracks and isochrones with [α/Fe] = -0.2, 0.0, +0.2, +0.4, +0.6 and +0.8 are available.

Isochrones were calculated using two independant color calibrations, and are available in F606W and F814W ACS-WFC filters, F606W and F814W WFPC2 filters, and ground based BVI. These isochrones range in age from 2 to 15 Gyr. Portable Fortran codes are provided that can:

(1) interpolate the isochrones to any [Fe/H] within the bounds of the original calculations,

(2) create luminosity functions with a power law IMF from the isochrones, and

(3) create synthetic horizontal branches for older stellar populations.

The stellar evolution tracks, isochrones, and Fortran codes are available at: http://stellar.dartmouth.edu/~models/hst_gc.html

Support for this work (GO-10775) was provided by NASA through a grant from the Space Telescope Science Institute which is operated by the Association of Universities for Research in Astronomy, Incorporated, under NASA contract NAS5-26555.

100.11

The HST/ACS Survey of Galactic Globular Clusters: Luminosity Functions

Nathaniel Paust[1], I. Reid[1], I. King[2], A. Aparicio[3], G. Piotto[4]
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Using data collected as part of the Hubble Space Telescope Advanced Camera for Surveys (ACS) study of Galactic gobular clusters, we present photometry and luminosity functions (LFs) extending several magnitudes below the main sequence turn off for a sample of Galactic globular clusters. These clusters have been selected from the larger ACS survey based on the Trager et al. (1995) catalog of globular cluster surface brightness profiles in order to select two groups of clusters: one with seemingly normal profiles and one with unusual profiles. The LFs have been compared to stellar models from the DSEP code (Chaboyer et al. 2001) using several different statistical methods to determine parameters such as age, distance modulus, and IMF slope. Future work on this project will result in a large homogenous sample of LFs and mass functions which will be useful in a wide range of astronomical projects.

Support for this work (GO-10775) was provided by NASA through a grant from the Space Telescope Science Institute which is operated by the Association of Universities for Research in Astronomy, Incorporated, under NASA contract NAS5-26555.

100.12

The HST/ACS Survey of Galactic Globular Clusters: The Sagittarius Dwarf Spheroidal System

Michael Siegel[1], S. R. Majewski[2], A. Sarajedini[3], B. Chaboyer[4], A. Rosenberg[5]
[1]University of Texas, [2]University of Virginia, [3]University of Florida, [4]Darmouth College, [5]Instituto de Astrofisica de Canarias, Spain.

As part of The HST/ACS Survey of Galactic Globular Cluster, we have imaged the globular clusters that are canonical members of the Sagittarius dSph galaxy (Sgr), including M54, which is either in or along the line of sight of the core of the Sagittarius dSph. The M54 field CMD, which extends to more than five magnitudes below the M54 main sequence turn-off (MSTO), clearly shows multiple RGBs and a complex array of other features, especially at the Sgr/M54 MSTO. We revise the parameters of the other nominal Sgr member clusters and the Sgr core using ACS main sequence fiducials as well as the new stellar evolution isochrones constructed specifically for the ACS survey.

The distance to the Sgr core is a key constraint on theoretical models of the tidal disruption of the dSph and the distance scale of its extensive star streams. Our MS-fitting to the four central Sgr globular clusters provides one set of distance estimates to the Sgr system. We also identify five Milky Way globular clusters in/near the Milky Way bulge -NGC 6624, NGC 6809, NGC 6681, NGC 6637 and NGC 6652 -for which our CMDs also include the main sequence of the central body of Sagittarius at fainter magnitudes. Thus, we can also measure the relative distance moduli between Sgr and these generally well-studied foreground bulge clusters. Through both the direct MS-fitting and relative MS comparisons to foreground clusters, we find that the Sgr core is likely to be some 20-30% farther than the canonical distances derived or used in many earlier investigations of the Sgr system.

Support for this work (GO-10775) was provided by NASA through a grant from the Space Telescope Science Institute which is operated by the Association of Universities for Research in Astronomy, Incorporated, under NASA contract NAS5-26555.

100.13

The HST/ACS Survey of Galactic Globular Clusters: Relative Ages

Alfred Rosenberg[1], A. Marín-Franch[2], A. Aparicio[1], G. Piotto[3], B. Chaboyer[4], A. Sarajedini[2]
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University of Florida, [3]Astronomy Department, Padova University, Italy, [4]Department of Physics and Astronomy, Dartmouth College.

Based on our large and homogeneous photometric database of globular cluster observations taken with the Advanced Camera for Surveys aboard the Hubble Space Telescope, a set of distance and reddening independent relative age indicators have been measured. The high quality of the color magnitude diagrams (CMDs) allows us to explore several variations of the classical age methods. The ″vertical method″ measures the magnitude difference between the main sequence turn-off (MSTO) and the horizontal branch (HB), the level of which is largely insensitive to age. The ″horizontal method″ measures the color difference between the MSTO and the red giant branch at a certain magnitude above the MSTO. The third method we will apply to our sample is similar to main sequence fitting. The observed CMDs are so well defined along the main sequence that we are able to superpose all the clusters in the same metallicity group and directly determine the differences in the color and magnitude of their turnoffs. This was practically impossible for previous databases because of the limited quality of the main sequence photometry. The observed ″vertical″, ″horizontal″ and main sequence fitting parameters will be analyzed in six metallicity subgroups and compared to the relations predicted by a library of isochrones constructed for this survey. Using the three independent methods and different theoretical models we will test the self-consistency of the results and the models at the same time.

100.14

The HST/ACS Survey of Galactic Globular Clusters: Absolute Ages of Selected Clusters

Iain N. Reid[1], J. Anderson[2], A. Aparicio[3], B. Chaboyer[4], A. Dotter[4], G. Piotto[5], A. Marin-Franch[6], A. Rosenberg[7]
[1]STScI, [2]Rice University, [3]Instituto Astrofisica de Canarias, Spain, [4]Dartmouth College, [5]Universita di Padova, Italy, [6]University of Florida, [7]Instituto de Astrofisica de Canarias, Spain.

The HST/ACS GGC Survey provides reliable photometry from ~ 6 magnitudes below the main sequence turn-off to the level of the horizontal branch (~3.5 magnitudes brighter than the turn-off) for 65 Galactic globular clusters. The absolute ages of a sub-sample of those clusters, which have low reddenings and well determined chemical compositions, have been determined. The ages were derived from a large Monte Carlo simulation, in which the various physical inputs required to produce isochrones (such as nuclear reaction rates, opacities and colour transformations) were varied within their known uncertainties. Each Monte Carlo isochrone was tested to see if it provided a reasonable fit to the colours and absolute magnitudes of local calibrating sub-dwarfs. Isochrones that were unable to correctly reproduce the position of the local calibrating stars in a colour-magnitude diagram were discarded. Isochrones passing this test were used to determine the distance to the cluster, via main sequence fitting between the theoretical isochrone and the observed main sequence in each of the individual globular clusters. The age of the globular cluster was then determined from the absolute magnitude of the point on the sub-giant branch that is 0.04 mag redder than the turn-off. This simulation takes into account all sources of error in the age determination process and leads to a robust determination of the absolute ages of the globular clusters.

Support for this work (GO-10775) was provided by NASA through a grant from the Space Telescope Science Institute which is operated by the Association of Universities for Research in Astronomy, Incorporated, under NASA contract NAS5-26555.

101: Structure of Stellar Winds
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

101.01

The dM/dt of O-rich OH/IR Stars is Strongly Modulated

B. M. Lewis[1]
[1]Arecibo Obs..

Hubble images of the Cat's Eye and Egg nebulae exhibit concentric rings, so when they were AGB stars, their mass-loss rates were strongly modulated with a period of ~100 years. Most OH/IR stars share this feature since:-

(1) The NIR colors of OH/IR stars fall on a tight locus in a two-color 2MASS plot, but the most massive objects with the reddest IRAS colors are widely distributed, instead of being at its red end, as would occur if shells were generated by a constant dM/dt. Our (AJ 132, 489) DUSTY models with a range of constant dM/dt or ages for detached shells both trace the locus when one uses a stellar SED matching its bluest colors and cold silicate dust. Hence the wide NIR color distribution of the thermally pulsing OH/IR stars with the reddest IRAS colors is an artifact of a modulated dM/dt.

(2) The resurrection of 1612 MHz masers in the OH/IR star IRAS 19479+2111. We (MN 364, 783 2005) successfully modelled Arecibo observations of the disappearance of 1612 MHz masers from OH/IR stars on a time-scale of a decade assuming a step decrease in dM/dt. We used a time-dependent model for the consequent changes in the OH column density and a radiative transfer code to follow the masers. The decline in the 1612 MHz masers is traced to changes in the 53 μm pump, consequent on changes in reprocessing of the stellar SED when dust in the zone around the dust-formation radius is removed by the ongoing expansion of the circumstellar shell. The reappearance of 1612 MHz masers in IRAS 19479+2111 (BAAS 37, 1335 2005) indicates the resumption of significant dM/dt and dust formation after a period of reduced dM/dt. This low mass star clearly experiences a strong modulation of its dM/dt.

101.02

Observations of Post-Asymptotic Giant Branch Objects in the Magellanic Clouds with the Spitzer Infrared Spectrograph

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[1]Air Force Research Lab, [2]Cornell University, [3]University of Western Ontario, Canada, [4]Mt. Stromlo Observatory, Australia, [5]National Geospatial-Intelligence Agency.

We present mid-infrared spectra of two sources in the Magellanic Clouds observed with the Spitzer Infrared Spectrograph (IRS). The spectrum of the object in the Small Magellanic Cloud (SMC), MSX SMC 029, is dominated by a cool dust continuum with an unusual set of spectral features. The IRS data reveal both emission from polycyclic aromatic hydrocarbons (PAHs) and absorption at 13.7 micron from C2H2. This rare combination has been seen in only two other sources, AFGL 2688 and IRAS 13416-6243, both post-asymptotic giant branch (AGB) objects. As in these sources, the PAH spectrum has the unusual traits that the emission peak in the 7-9 micron complex lies beyond 8.0 micron and that the 8.6 micron feature is as strong as the C-C modes that ought to peak ~7.7-7.9 micron. The spectrum of the object in the Large Magellanic Cloud, SMP LMC 11, is dominated by absorption features from acetylene, benzene, and polyactylenic chains, many of which are detected in an extragalactic object for the first time. The IRS spectrum from SMP LMC 11 is similar to the infrared spectrum of the post-AGB object AFGL 618. While the optical properties of this object resemble those of a planetary nebula (PN), the infrared spectrum is more consistent with an object in transition from the AGB to PN. Comparisons between MSX SMC 029, SMP LMC 11, AFGL 2688, and AFGL 618 lead us to conclude that MSX SMC 029 is also a very young post-AGB object, probably having evolved off the AGB in only the past few hundred years. As such, MSX SMC 029 is only the 3rd post-AGB object identified in the SMC.

This work is based on observations made with Spitzer, operated by JPL/Caltech under a NASA contract. Support was provided by NASA in part through an award issued by JPL/Caltech.

101.03

Synthesis of Observables from Numerical Simulations of Magnetized Hot-Star Winds

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With the recent detection of large scale magnetic fields on several O and B stars, the anomalous X-ray emission detected from a subset of hot stars, and advances in numerical modeling, there is increasing interest in the role magnetic fields play in hot stars. We present synthesized diagnostics of magnetic hot stars, derived from state-of-the-art numerical simulations of both slowly rotating O stars with strong winds (e.g. theta1 Ori C) and rapidly rotating B stars with weaker winds and stronger fields (e.g. sigma Ori E). The numerical simulations include 2-D ZEUS MHD simulations, as well as rigidly-rotating magnetosphere (RRM) simulations of the more magnetically dominated winds of early B stars. We present results on rotationally modulated H-alpha emission, as well as x-ray emission arising from magnetically channeled wind shocks and centrifugally driven magnetospheric breakout with the associated magnetic reconnection.

101.04

X-ray Emission Line Profiles from Clump Bow Shocks in Stellar Winds

Alexander Burke[1], R. Ignace[2], J. P. Cassinelli[3]
[1]Vassar College, [2]East Tennessee State University, [3]University of Wisconsin.

Clumpiness in the flows of massive star winds is an issue of growing importance for the interpretation of spectral diagnostics from these sources, including the formation of X-ray emission profiles. High resolution data from Chandra and XMM-Newton appear to demand clumped wind flow to explain the observed line profile shapes. Hydrodynamic simulations of hypersonic wind flow impacting a solid spherical clump yield a semi-analytic solution for the emissive properties of the adiabatically cooling, hot gas component. We present model line profiles based on these hydrodynamic results for an ensemble of wind clumps, and discuss the applicability of the model to data.

A.B. and R.I. acknowledge funding by a partnership between the National Science Foundation (NSF AST-0552798) Research Experiences for Undergraduates (REU) and the Department of Defense (DoD) ASSURE (Awards to Stimulate and Support Undergraduate Research Experiences) programs. R.I. and J.C. acknowledge support provided by the NASA/Chandra Theory program, grant award TM4-5001.

101.05

High Resolution Radio Observations of the Nebulae of Luminous Blue Variable Stars

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Luminous Blue Variable (LBV) stars represent an important, but short-lived, evolutionary phase of massive stars marked by extreme mass-loss events. The ejecta from these events appear as associated LBV nebulae (LBVN). Radio observations of the LBVN can provide insight into previous and current mass loss rates of the star, as well as the details of expansion into the surrounding ISM. Here, we report new multi-frequency, multi-configuration Very Large Array (VLA) observations of seven Galactic LBVN. We present preliminary 8.5 and 22.5 GHz results on LBVN sources AFGL2298, NaSt1, G79.29+0.46, G26.47+0.02, the Galactic Center Pistol Star, Galactic Center FMM362 and LBV 1806-20. These high-resolution observations reveal structure in the LBVN.

101.06

Velocity Structure in the Chromosphere and Wind of VV Cephei

Wendy H. Bauer[1], P. D. Bennett[2], A. Brown[3]
[1]Wellesley College, [2]Eureka Scientific, [3]CASA, University of Colorado.

VV Cephei is an eclipsing binary system composed of an M2Iab supergiant primary with an extended atmosphere and wind and a hot companion, probably an early B main-sequence star. This hot companion provides an astrophysical light source whose orbital motion can be used to probe the structure of the M supergiant atmosphere.

The system was observed with the STIS spectrograph at 21 epochs between 1997 and 2003, which extended from total eclipse through and just beyond first quadrature. Some absorption features, generally due to neutral elements or singly ionized ions of low ionization potential, weaken and disappear during the "chromospheric eclipse" phase. Many of these chromospheric lines appear doubled, especially in the early phases of chromospheric eclipse. Other absorption features, generally due to low-lying levels of singly ionized atoms arise in the wind of the M supergiant, and persist throughout the cycle.

We present radial velocity measurements for these absorption features as measured from the STIS observations. The wind features have a nearly constant radial velocity, -20 km sec^{-1} relative to the systemic velocity. The trend of the chromospheric features' radial velocities tracks the orbital motion of the M supergiant.

This work was based on observations made with the NASA/ESA Hubble Space Telescope, obtained at the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5-26555. These observations are associated with program GO-7269, and were supported by NASA through a grant from the Space Telescope Science Institute.

101.07

Multi-dimensional Simulations of Helium Shell Flash Convection

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[1]Los Alamos National Laboratory, [2]Centre de Recherche Astronomique de Lyon Ecole Normale Supérieure, France, [3]Keele Astrophysics Group, School of Physical and Geographical Sciences, Keele University, United Kingdom.

The Asymptotic Giant Branch (AGB) phase is the most productive evolutionary phase in terms of nucleosynthesis for low and intermediate mass stars. Nucleosythesis in these stars is aided by the mixing and heating triggered by recurrent He-shell flashes. Extreme nuclear energies (corresponding to 10^8L_sun) are generated during these thermonuclear flashes. This results in efficient shell convection with multiple implications for nucleosynthesis and further evolution. The evolution of AGB stars, including these He-flashes, has in the past been studied exclusively with one-dimensional stellar evolution codes that have to adopt simplifying assumptions on mixing, especially at convective boundaries. Here, we report on efforts to augment these studies with 2-d and 3-d hydrodynamic models of convective mixing in the AGB He-shell. We characterize the dominant morphology of He-shell flash convection. As opposed to the shallow surface convection in A-type stars studied by Freytag et al. (1996), coherently moving convective cells do not cross the convective boundary significantly. In other words, penetration is minimal for this convection zone. We find that convective motions induce a rich spectrum of internal gravity waves in the neighboring stable layers. Interactions of these (mainly horizontal) oscillations with the convective boundary, as well as oscillations with convective characteristics within the stable layers, do cause a finite amount of mixing across the convective boundary. Our preliminary analysis of this mixing is consistent with semi-analytical results obtained from observations and 1D-stellar evolution simulations.

101.08

The 3D Morphology of VY CMa

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[1]Univ. of Minnesota, [2]Univ. of Washington, [3]Institute for Astronomy.

The extreme red supergiant and powerful infrared source and OH maser, VY CMa, is one of the most luminous evolved stars known. It also has an extensive visible circumstellar nebula. Previous multi-wavelength images and long-slit spectroscopy revealed spatially and kinematically distinct arcs and clumps of knots ejected in discrete episodes over the past 1000 years. However, the direction of the outflows and orientation of the structures in the nebulosity were not known. Fortunately, VY CMa provides us with a unique opportunity to determine the 3D morphology of its ejecta.

We report new HST observations of VY CMa. We have obtained second epoch multi-color images to measure the transverse motions which when combined with the Doppler velocities, yields the vector motion. We have also obtained polarization images which, together with the color derived from the images, can be used to derive the line of sight distribution of the different features in the nebula. The combined information on the kinematics, direction of the outflows, and relative locations of the numerous arcs and knots and ejecta allow us to produce a 3D image of VY CMa. This is not a model but based on real data. We believe that this is the first time a 3D image of an astronomical object has been produced from this type of combined observations.

101.09

VY Canis Majoris: The Astrophysical Basis of Its Luminosity

Robert D. Gehrz[1], R. M. Humphreys[1], T. J. Jones[1]
[1]*Univ. of Minnesota.*

The luminosity of the famous red supergiant VY CMa (L = 4 5 x 10^5 L) is well-determined from its spectral energy distribution and distance, and places it near the empirical upper luminosity limit for cool hypergiants. In contrast, its surface temperature is fundamentally ill-defined. Implications for its location on the HR Diagram and its apparent size are discussed.

101.10

VLBA Observations of the SiO Masers in the Eruptive Variable V838 Monocerotis

Mark J. Claussen[1], H. E. Bond[2], S. Starrfield[3], K. H. Healy[3]
[1]*NRAO,* [2]*STScI,* [3]*Arizona State University.*

We report on high angular resolution observations (beamsize ~ 300 microarcsec) of the SiO masers in the enigmatic eruptive variable V838 Monocerotis. The SiO masers were first discovered by Deguchi et al. (2005) in February 2005, some 3 years after the optical outburst in January 2002. The spectral profiles of the SiO masers are similar to those seen in AGB/Mira circumstellar envelopes, where the masers are found within a few stellar radii above the photosphere. Six epochs of observations separated roughly at 2 3 month intervals have been made using the NRAO Very Long Baseline Array (VLBA), ranging from October 2005 to September 2006. We will present the images from these observations for both v=1 and v=2 J = 1->0 transitions of the masers (at 7 mm); the analysis of these images will provide kinematic information on the circumstellar gas, and the astrometry of the maser spots will allow an estimate of a lower limit to the distance of the source. We will discuss these results in the context of other estimates of the distance and the infrared dust emission and possible pumping mechanisms for the masers.

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101.11

Observations of the 6 Centimeter Lines of OH in OH/IR Stars and Star Forming Regions

Laura K. Zschaechner[1], V. L. Fish[2], L. O. Sjouwerman[2], Y. M. Pihlstrom[3], M. J. Claussen[2]
[1]*University of Montana,* [2]*National Radio Astronomy Observatory,* [3]*University of New Mexico.*

Recent observational and theoretical advances have given rise to ambiguities regarding the model for OH maser pumping in OH/IR stars. While ground-state OH lines have already been observed, the detection of excited-state OH lines would provide additional constraints on theoretical pumping models. To date, the only positive detections of excited-state OH emission in OH/IR stars have been a 4750 MHz maser in AU Gem and 6035 MHz maser emission in NML Cyg.

We report on Very Large Array observations of the 4750 and 4765 MHz OH lines toward 45 sources, most of which are OH/IR stars. All of the sources have previously exhibited ground-state maser emission. We do not detect excited-state emission in any evolved star at the 100 mJy level (5 σ). However, masers in the 4765 MHz transition are detected toward two star forming regions: Mon R2 and LDN 1084. Masers in each of these sources have been previously detected and have shown significant variability in the past. the 4765 MHz maser in Mon R2, which had exhibited two distinct flares, one of which surpassed 75 Jy before disappearing in 1998 December, appears to be undergoing a new flaring event.

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101.12

Joint VLBA/VLTI Observations of the Mira Variable GX Mon

David A. Boboltz[1], M. Wittkowski[2], K. Ohnaka[3], T. Driebe[3]
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We present preliminary results from coordinated polychromatic observations of the Mira variable star GX Mon made with the Very Long Baseline Array (VLBA) and the Very Large Telescope Interferometer (VLTI). VLBA observations of the SiO maser emission combined with concurrent VLTI observations made with the mid-infrared science instrument (MIDI) allow us to study the circumstellar environment of evolved stars at the various distances probed by the different techniques. Here we present the first images of the v=1, J=1-0 (43.1 GHz) and the v=2, J=1-0 (42.8 GHz) SiO masers in the circumstellar atmosphere of GX Mon. We relate these images to the stellar diameter and characteristics of the nearby circumstellar dust formation zone as measured for the first time by VLTI-MIDI.

102: Variable Stars and Distance Scale
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

102.01

Hubble Space Telescope Fine Guidance Sensor Parallaxes of Galactic Cepheid Variable Stars: Period-Luminosity Relations and Applications

George F. Benedict[1], B. E. McArthur[1], M. W. Feast[2], T. G. Barnes[3], T. E. Harrison[4], R. J. Patterson[5], J. W. Menzies[6], J. L. Bean[1], W. L. Freedman[7]
[1]*Univ. of Texas, Austin,* [2]*University of Capetown, South Africa,* [3]*National Science Foundation,* [4]*New Mexico State University,* [5]*Univ. of Virginia,* [6]*South African Astronomical Observatory, South Africa,* [7]*Carnegie Institution.*

We present new absolute trigonometric parallaxes and relative proper motions for nine Galactic Cepheid variable stars: l Car, zeta Gem, beta Dor, W Sgr, X Sgr, Y Sgr, FF Aql, T Vul, and RT Aur, with an average parallax error of 8%. Two stars (FF Aql and W Sgr) required the inclusion of binary astrometric perturbations, providing Cepheid mass estimates. With these parallaxes we compute absolute magnitudes in V, I, K, and Wesenheit W_{VI} bandpasses, corrected for interstellar extinction and Lutz-Kelker bias. Adding our previous absolute magnitude determination for δ Cep, we construct Period-Luminosity relations (PLR) for ten Galactic Cepheids.

We compare our new PLR with those adopted by several recent investigations, including the Freedman and Sandage H_0 projects. Adopting our PLR would tend to increase the Sandage H_0 value, but leave the Freedman H_0 unchanged. Comparing our Galactic Cepheid PLR with those derived from LMC Cepheids, we find the slopes for K and W_{VI} identical in the two galaxies within their respective errors. Our data lead to a W_{VI} distance modulus for the Large Magellanic Cloud, m-M=18.50±0.03. Recently derived metallicity corrections yield a corrected LMC distance modulus of m-M=18.40±0.05. Applying our PLR directly to Cepheids in NGC 4258 provides a distance modulus, m-M=29.21±0.02, in good agreement with the maser distance modulus, m-M=29.29±0.15. From our metallicity-corrected LMC distance modulus and the Macri et al. (2006) difference in distance moduli we obtain m-M=29.28±0.08.

To further improve extragalactic distance determinations, parallaxes of additional long-period Cepheids would be extremely valuable, but will require the microarcsecond precision of, for example, the Space Interferometry Mission (SIM).

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102.02

A Theoretical Investigation into Period-Color relations for Cepheids in the Small Magellanic Cloud

Shashi Kanbur[1], C. Ngeow[2], G. Feiden[1]
[1]SUNY at Oswego, [2]University of Illinois.

We present preliminary results of a theoretical investigation into the Cepheid Period-Color (PC) relation for the SMC. We construct a large grid of full amplitude, hydrodynamic models of low metallicity Cepheids and develop theoretical PC relations as a function of phase. We compare these relations with observations and formulate a possible theoretical framework to explain the variation of the PC relation in the Galaxy, LMC and SMC as a function of phase, metallicity and period. We briefly discuss the implications of our work on the Cepheid Period-Luminosity (PL) relation.

102.03

A Testimator Based Approach to Investigate the Non-linearity of the LMC Cepheid Period-Liminosity Relation

Richard Stevens[1], A. Nanthakumar[1], C. Ngeow[2], S. Kanbur[1]
[1]SUNY Oswego, [2]University of Illinois.

We study the linearity or non-linearity of the LMC Cepheid PL relation using a new statistical method ″the testimator″. We apply this technique to a number of independent LMC Cepheid data sets, including those that have been augmented by additional long period Cepheids. Our results show that there is a change of slope at longer period ranges for all data sets. This strongly supports previous results, using the F test, that the observed LMC PL relation is non-linear with a break period at around 10 days.

102.04

A Theoretical Investigation into the Properties of RR Lyraes at Maximum and Minimum Light.

Greg Feiden[1], S. Kanbur[1], R. Szabo[2], C. Ngeow[3]
[1]SUNY Oswego, [2]University of Florida, [3]University of Illinois.

We construct a large grid of full amplitude hydrodynamic models of RRab stars. We confirm earlier findings that, at minimum light, the PC relation is flat and eluucidate the physical reason for this: the interaction of the hydrogen ionization front and photosphere at low densities. Traditionally the properties of RRab stars at minimum light have been used to estimate reddenings. Based on our findings we propose a modification of this method: using the properties of RRab stars with periods greater than about log P = -0.2 to estimate reddensings.

102.05

An Empirical Investigation of the Effect of Metallicityon Linear vs. Non-linear Cepheid Period-Luminosity relations.

Daniel Crain[1], S. kanbur[1], C. Ngeow[1]
[1]SUNY Oswego.

In recent years, evidence has emerged that the Cepheid period-lminosity (PL) relation in the LMC may be non-linear with two distinct slopes for short (P < 10 days) and long (P > 10 days) respectively. In contrast the Galactic PL relation has been found to be linear. Since the LMC and the Galaxy have different metallicity, the non-linearity of the Cepheid PL relation may be caused by metallicity.

We present the preliminary results of an ongoing study to investigate metallicity effects on possible non-linearities in the Cepheid PL relation. We use the Cepheids in IC 1613, M31, M33, NGC6822, NGC300 and NGC3109, from ground based observations, that have a wide spread in metallicity.

102.06

A Cepheid Distance to the Coma Cluster: Initial Progress Report

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We have begun a 180 orbit project using the Advanced Camera for Surveys to search for and phase Cepheid variables in two spiral galaxies in the core of the Coma cluster. A direct application of this canonical primary distance indicator at Coma's recession velocity of 7000 km/s will measure the far-field Hubble constant free of many of the systematic uncertainties which beset current determinations relying on secondary indicators. Establishing the far-field H_0 with Cepheids will provide one of the strongest links in the extragalactic distance scale. Reducing the uncertainty in the far-field H_0 will help constrain the equation of state of the dark energy. We will directly calibrate the fiducial fundamental plane of elliptical galaxies in Coma, as well as the Thomson optical depth of the cluster for comparison with the 30 to 300 Ghz Sunyaev-Zeldovich spectrum.A S/N=5-10 or better can be reached for Cepheids with periods of 40d to 70d at mean light in 5 orbits with the F606W filter if H_0 is approximately 70 km/s/Mpc. Each of the two target galaxies will be observed 12 times, for a duration of 5 orbits, optimally spaced for periods of 40-70d, providing robust detection and phasing information. An additional 6 observational visits using the F814W filter are planned.

We will present a progress report of the first few epochs of data which will be in hand by the time of the January 2007 AAS meeting.

102.07

Improving the Distance Scale: NICMOS and ACS/HRC observations of Cepheids in the Maser Galaxy NGC 4258

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We present results from HST NICMOS and ACS/HRC observations of a subset of 300 Cepheids in the maser-host galaxy NGC 4258 that we discovered with HST ACS/WFC on Cycle 12 (Macri et al., ApJ 653, 2006).

NGC 4258 is a key galaxy for the Extragalactic Distance Scale because of its accurate and precise geometric distance, which will soon be known to ~3% (Humphreys et al, in preparation). The distance measurement is obtained through VLBI observations of water maser emission originating from a sub-parsec annular region within a nearly edge-on, warped accretion disk, bound by a supermassive black hole in the nucleus of the galaxy.

We present H-band Cepheid Period-Luminosity relations for 21 variables located in our inner field (solar metallicity) and 14 variables located in our outer field (LMC metallicity). Additionally, we present Vand I-band blending statistics for the Cepheids that were imaged with both ACS/WFC and HRC. We discuss the additional constraints that the H-band P-L relations and the blending corrections impose on the relative distance modulus between the LMC and NGC 4258 and its implications for the Hubble Constant.

Funding for this program was provided by NASA through STScI, as part of HST GO programs 9810 and 10399.

103: White Dwarfs: Search, Survey, Study, and Understand?
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

103.01

White Dwarf Kinematics vs Mass

Chris Wegg[1], E. S. Phinney[1]
[1]*Caltech.*

We have investigated the relationship between the kinematics of young (<3x10^8 years) DA white dwarfs and their mass using proper motions. Our sample is largely taken from the color selected SDSS catalog (Eisenstein et. al. 2006) which has spectroscopic temperature and gravity determinations. We find that the dispersion decreases with increasing white dwarf mass. This can be explained as a result of less scattering by objects in the Galactic disk during the shorter lifetime of their more massive progenitors. In addition we have investigated whether the kinematics of the highest mass white dwarfs (>1 solar mass) is consistent with the expected relative contributions of single star evolution and mergers.

103.02

The Search for White Dwarfs in the Sandage Two-color Survey of the Galactic Plane

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[1]*NOAO,* [2]*Dept. of Astrophysics, Div. of Physical Sciences, American Museum of Natural History.*

A study of the bright UV sources identified by Lanning in the Sandage Two-color Survey of the Galactic Plane yielded more than 200 sources with significant proper motion. Subsequent analysis suggests nearly two-thirds of the sources are likely to be previously un-identified white dwarfs. A follow-up spectroscopic program is being prepared with the goal of confirming the nature of the white-dwarf candidates. On-going analysis of the white dwarfs, when combined with other known Galactic Plane white dwarfs, indicates the presence of a selective distribution. Scanning of the Sandage plates is a continuing project and will very likely result in significantly increasing the number of white dwarfs found and available for future analysis.

103.03

Improved Photometric Distances for White Dwarfs

Jay B. Holberg[1], E. M. Sion[2], T. D. Oswalt[3]
[1]*Univ. of Arizona,* [2]*Villanova University,* [3]*Florida Institute of Technology.*

Accurate distances and luminosities for white dwarfs help establish a number of basic observational properties for degenerate stars. Such collective properties as luminosity functions, space densities, and space motions are all tied directly to reliable distance estimates for large numbers of stars. As the number of direct trigonometric parallaxes will remain limited for the near future, we apply the recent results of improved photometric calibrations to large samples of white dwarfs having high quality optical and near IR photometry, as well as spectroscopic temperatures and gravities. Improved photometric distances (and luminosities) are estimated. Comparisons with trigonometric parallaxes and the determination of residual reddening will be discussed, as well as estimates of distance uncertainty.

This work is supported by NSF Grants AST 0507797 (JH) and AST 0206115 (TO).

103.04

The Space Motions of DQ White Dwarfs

Ralph Wasatonic[1], E. Sion[1], G. McCook[1], J. Holberg[2]
[1]*Villanova University,* [2]*University of Arizona.*

The web-based Villanova White Dwarf Catalog(http://www.astronomy.villanova.edu/WDCatalog/) currently contains 5,557 white dwarfs of which 93 DQ white dwarfs, (including 40 DQ stars discovered through the SDSS) were analyzed for T_{eff}, log g and C/Heby Dufour, Bergeron and Fontaine (2005, ApJ, 627, 404). We present the results of a kinematical analysis of the 93 DQ stars. For 53 DQ stars (not including the SDSS sample), the velocity dispersions σ (U), σ (V) and σ (W) and σ <T> are 67 km/s, 77 km/s, 49 km/s, and 85 km/s respectively while for a sample of 81 DA stars in the same range of M_v as the DQ stars, the respective velocity dispersions are 45, 31, 26, and 37 km/s respectively. Our results are discussed in the context of characterizing their evolutionary ancestors.

We acknowledge with gratitude the support of this work by NSF grant 05-07797.

103.05

The Hunt for Nearby White Dwarfs

John P. Subasavage, Jr.[1], P. Bergeron[2], T. J. Henry[1], P. Dufour[2], N. C. Hambly[3], T. D. Beaulieu[1], RECONS
[1]*Georgia State University,* [2]*University of Montreal, Canada,* [3]*University of Edinburgh, United Kingdom.*

White Dwarfs (WDs) serve as test beds to probe into astrophysically interesting questions such as (1) the ages of star clusters and Galactic components (i.e. disk, halo), (2) Galactic evolution, (3) halo dark matter constituents, (4) stellar structure theory, and (5) stellar evolution theory. The nearby WD population provides the brightest and most easily studied representatives.

How confident are we that all of the nearest WDs have been identified? In an effort to answer this question, we have begun an initiative to identify and characterize new nearby WDs, particularly in the southern hemisphere. We identify new WDs using medium resolution (R ~1000) optical spectroscopy, and estimate physical parameters and distances using optical photometry combined with 2MASS near-infrared photometry. For objects within 25 pc (Catalogue of Nearby Stars, and NStars Database horizons), we determine a trigonometric parallax via CTIOPI (Cerro Tololo Inter-American Observatory Parallax Investigation).

Of the 43 new WD systems discovered so far, 21 are likely within 25 pc, a volume that contains 107 WDs with trigonometric parallaxes. A spectroscopic observing run in December will likely increase these values. Interesting objects include two that are likely double degenerates including one with a magnetic component, one that is a cool (T$_{eff}$ ~5000 K) likely mixed atmosphere WD with deficient flux at near-infrared wavelengths, and three that are metal-rich. Observations are underway via the Hubble Space Telescope to resolve four potential double degenerates (the new magnetic WD and three other previously known WDs) for dynamical mass determinations.

All ground-based observations are obtained as part of the SMARTS (Small and Moderate Aperture Research Telescope System) Consortium at CTIO. We wish to thank NASA's Space Interferometry Mission, the National Science Foundation, the Space Telescope Science Institute, and GSU for their continued support.

103.06

Meet Your Local White Dwarf Neighbors: A Census of the 20 pc Sample

Sean Foran[1], E. Sion[1], J. Holberg[2], G. McCook[1]
[1]*Villanova University,* [2]*University of Arizona.*

We present an updated census of the white dwarf stars within 20 pc of the sun using the web-based Villanova White Dwarf Catalog (http://www.astronomy.villanova.edu/WDCatalog/). Among the sample of 119 stars within this volume, there are 64 DA (H-rich) stars, 52 non-DA (He-rich) stars, 32 DC (no spectral features) stars, 13 DQ (molecular carbon) stars, 5 DZ (He-rich with Ca II) stars, 1 peculiar DBQA star, and 11 magnetic degenerates of which four are He-rich magnetic DQ stars. We discuss our derived local space density of white dwarfs, estimate the space densities of each spectroscopic subclass, estimate formation rates, the binary fraction,

and the space motions of the sample. We discuss the implications of these formation rates for current scenarios of white dwarf progenitorship and spectral evolution.

This work is supported by NSF grant 05-07797.

103.07

FUSE Observations of the Very Cool DB White Dwarf GD408

Pierre Chayer[1], S. Desharnais[2], F. Wesemael[2], J. W. Kruk[1]
[1]Johns Hopkins Univ., [2]University of Montreal, Canada.

The traces of carbon observed in helium-rich white dwarfs with effective temperatures below 19,000 K are thought to be dredged-up by convection reaching the interface between the helium envelope and the carbon core. The dredge-up model predicts that the carbon contamination of the atmosphere is maximum for stars with an effective temperature around 11,000 K, roughly the temperature at which the surface convection zone is the deepest. The detection of carbon has been most successful for helium-atmosphere stars on the cool side of this maximum, in the so-called DQ stars. At these temperatures, carbon is detected through the neutral carbon lines or the Swan bands, and the abundances determined are in good agreement with the predictions of the dredge-up model. In order to test the model on the hot side of the maximum, amongst the DB stars, we analyze the Far Ultraviolet Spectroscopic Explorer (FUSE) spectrum of the very cool DB white dwarf GD 408. With an effective temperature of 14,000 K, GD 408 is the coolest DB observed by FUSE. Its ultraviolet spectrum displays the CII doublet at 1036.337 and 1037.018 Angstroms and the Lyman beta line of hydrogen.

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103.08

Kinematical and Statistical Study of Magnetic White Dwarfs

Edward M. Sion[1], R. Wasatonic[1], G. McCook[1], J. Holberg[2]
[1]Villanova Univ., [2]Univ. Arizona.

We present the results of a kinematical analysis of all known magnetic white dwarfs in the web-based Villanova White Dwarf Catalog (http://www.astronomy.villanova.edu/WDCatalog/) for which there are sufficient data to estimate the vector components of the space motion, U, V, W, with respect to the sun. This sample of magnetic degenerates consists of 43 stars with field strengths ranging from 0.5 MG to 700 MG and T_{eff} ranging from 4500K to 40,000K. The magnetics are subdivided into ''hot'' and ''cool'' samples for comparison with the motions and velocity dispersions of non-magnetic DA stars in the same ranges of M_v. The average velocities $\langle U \rangle$, $\langle V \rangle$, $\langle W \rangle$ and the velocity dispersions σ (U), σ (V) and σ (W) in the ''hot'' and ''cool'' ranges of M_v are all substantially smaller than the non-magnetic DA values in same M_v ranges. This result is consistent with higher than average magnetic white dwarf masses. We discuss implications of our study for identifying the progenitors of the magnetic white dwarfs.

We acknowledge with gratitude the support of this work by NSF grant 05-07797.

103.09

G29-38: Mode Identification

Susan E. Thompson[1]
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We present identification for 6 modes on the pulsating white dwarf star G~29-38 using optical time series spectroscopy from the VLT. Using a 6 hour spectral series we find 13 pulsation modes between 200 and 1000 seconds, 5 of which are combinations or harmonics. For the brightest modes, we measure the periodic line shape variations of H-beta, H-gamma, and H-delta. By fitting across each Balmer line, we measure the shape of the spectral line using a combination of independently varying Gaussian and Lorentzian functions. By comapring our measurements with limb-darkened models and previous time series spectroscopy of G~29-38, we confirm the spherical degree of 2 known modes and add the spherical degree of 4 new modes, two of which have a spherical degree greater than 1. These new mode identifications will better constrain asteroseismological models of the interior of this star. Additionally we measure the periodic Doppler shifts of the spectral lines associated with the brightness variations. We place them in the context of the convective driving theory and discuss a new combination mode that has an associated velocity variation. We thank NASA and the AAS for funding this project through the AAS small research grants.

103.10

FUSE Observation of the Ultra-Massive White Dwarf GD 50

Jean Dupuis[1], P. Chayer[2], S. Vennes[3], V. Hénault-Brunet[4]
[1]Canadian Space Agency, Canada, [2]Johns Hopkins University, [3]Florida Institute of Technology, [4]McGill University, Canada.

GD 50 is one of the most massive DA white dwarfs known with a mass of 1.2 M_{sun}. Identifying the progenitors of ultra-massive white dwarfs is important as they may set an upper limit on the mass of stars that will evolve into white dwarfs. It has also been suggested that ultra-massive white dwarfs may form through the coalescence of double-degenerate systems. More interest was generated about GD 50 after an observation by the EUVE (Extreme Ultraviolet Explorer) satellite revealed the presence of the Lyman series of singly ionized helium in the extreme-ultraviolet spectrum of GD 50 (Vennes, Bowyer, & Dupuis, 1996, ApJL, 461, 103). Although the helium detected is clearly of photospheric origin, a physical mechanism by which a significant abundance of helium is maintained in the atmosphere of GD 50 has not yet been identified. In order to further investigate the source of helium detected in the atmosphere of GD 50, we present an analysis of the FUSE (Far Ultraviolet Spectroscopic Explorer) spectrum of this ultra-massive white dwarf. The FUV spectrum does not exhibit any metal lines with the exceptions of a few absorption lines associated with gas in the local interstellar medium. We derive stringent upper limits on the abundance of metals, and we discuss whether the non-detection of metals in the atmosphere of GD 50 could rule out the accretion mechanism for explaining the observed helium abundance.

103.11

A New Look at GD358: Using Nonlinear Light Curves to Constrain Convection

Judith L. Provencal[1], H. Shipman[1], M. Montgomery[2], Whole Earth Telescope Team
[1]Univ. Of Delaware Delaware Asteroseismic Research Center, [2]University of Texas.

We introduce the Delaware Asteroseismic Research Center and present preliminary results from XCOV25, the first sponsored by DARC. DARC is sponsored by Mt. Cuba Observatory, with the goal of supporting and facilitating international collaboration in observational and theoretical stellar seismology. We present an overview of preliminary results from the May 2006 WET run on GD358. This run has the goal of using GD358's nonlinear light curves as a probe of convection.

103.12

Quantifying Turbulence: A Nonlinear Approach

Nada Jevtic[1], J. S. Schweitzer[2]
[1]Richard Stockton College, [2]University of Connecticut.

Nonlinear projective noise reduction is one way to extend the useful frequency range in the power spectra of quasiperiodic stellar light curves. This method can also be used to estimate the time scale of the turbulent contribution. The neighborhood which yields the best noise reduction results in phase space is a reflection of the phase-space scale of turbulent processes. This scale, in turn, is dependent on the time structure of the excursions off the phase-space trajectory. The most effective neighborhood choices for the case of two DB white dwarfs, PG 1351+489 and GD358, are compared and the implications of these choices are discussed.

104: X-ray to IR Observations of Compact X-ray Objects
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

104.01

Shedding New Light on the Stellar Graveyard: Compact Objects in the Mid-IR

Magaretha L. Pretorius[1], S. Wachter[1], D. Hoard[1]
[1]*California Institute of Technology.*

We will present results from our Spitzer Space Telescope program to characterize the infrared emission of interacting binaries containing compact objects (i.e., white dwarfs, neutron stars and black holes). Such binaries have been ″traditionally″ observed primarily at short wavelengths because accretion-generated luminosity, which peaks in the optical-UV, dominates the radiated energy of most systems. Hence, relatively little is known about their infrared properties. We will present spectral energy distributions for catalcysmic variables and X-ray binaries. In addition, we will also characterize the infrared properties of the local environments of these sources, in particular for the heavily embedded population of X-ray binaries recently identified by INTEGRAL.

104.02

Radio Emission Signatures of the Crab Pulsar's High Frequency Interpulse

Timothy H. Hankins[1], J. A. Eilek[1]
[1]*New Mexico Tech..*

We have made ultra-high time resolution measurements of individual giant pulses from the Crab Nebula pulsar. We find that the time and frequency signatures of the interpulse are distinctly and dramatically different from those of the main pulse. The giant pulses occurring at the phase of the main pulse can occasionally be resolved into short-lived nanoshots which span modest fractional bandwidths. We believe that these nanoshots are produced by soliton collapse in strong plasma turbulence. At centimeter wavelengths the giant interpulses are very different. Their dynamic spectrum contains well-defined, narrow, microsecond-long emission bands. We have detected these proportionally spaced bands from 4.5 to 10.5 GHz. The interpulse frequency structure can easily be distinguished from interstellar decorrelation effects by its distinctive behavior on short timescales. We show here examples of both the main pulse and interpulse, and we speculate on possible new models for the emission.

104.03

Multi-Wavelength Studies of Potential X-ray Counterparts to Unidentified EGRET Gamma-Ray Sources

Mallory Roberts[1]
[1]*Eureka Scientific.*

The AGILE and GLAST high-energy gamma-ray telescopes are both launching this year. Here we present a variety of observations of likely X-ray counterparts to Galactic sources detected by EGRET, the previous high-energy gamma-ray telescope. These will be the brightest sources for the new generation of gamma-ray telescopes.

105: YSO / Star Formation II
AAS Poster, Monday, 9:20am-6:30pm, Exhibit Hall 4

105.01

Characterizing Star Formation Activity in Infrared Dark Cloud Cores

Edward T. Chambers[1], J. M. Jackson[1], J. M. Rathborne[2], R. Simon[3]
[1]*Boston University,* [2]*Harvard-Smithsonian Center for Astrophysics,*
[3]*Universitat zu Koln, Germany.*

We have found evidence for active high-mass star formation in compact millimeter cores within Infrared Dark Clouds (IRDCs). IRDCs were discovered by the ISO and MSX infrared surveys as extinction features in the mid-infrared. We examined 38 of the highest extinction IRDCs in the millimeter continuum and found 189 compact cores, 140 of which are cold, compact and unassociated with 8 micron emission. Each IRDC invariably contains at least one cold, compact core, and many IRDCs contain several. These cold, compact cores have sizes and masses of ~ 0.5 pc and 120 Msun. Roughly 30 percent of these cores show evidence for active star formation including (1) enhanced, slightly extended emission at 4.5 microns which might arise from shocked molecular hydrogen, (2) broad line widths (delta v ~ 10 km/s) of HCN(4-3) and CS(3-2), and the detection of SiO(2-1), a well-known shock tracer, (3) bright, compact 24 micron emission that indicates a deeply embedded protostar, and (4) maser emission, a signpost for high-mass star formation. The large number of active cores we find toward IRDCs suggests that IRDCs are indeed the earliest stages in the evolution of star-forming molecular clumps. Here we present the statistical results from our survey of IRDC cores.

105.02

Infrared Spectroscopy of Low Mass Stars in the Cepheus A Star Forming Region

Eric S. Boyd[1], A. Steinhauer[1], E. Lada[2]
[1]*SUNY Geneseo,* [2]*University of Florida.*

We present the results of a near-infrared spectroscopic survey of the cluster Cepheus A (Cep A). We used FLAMINGOS on the KPNO4m, to obtain JH spectra of low mass stars in the central region of the cluster. The spectra for 26 members were classified by means of their J and H water absorption features. The spectral types ranged from M1 to M6 with subclass errors of 0.5-1. These spectral types were combined with J H K photometry and placed on an H-R diagram. Comparison to Baraffe models yielded a median age of 1.35Myr.

105.03

Current Star Formation in the Perseus and Ophiuchus Molecular Clouds

Jes K. Jorgensen[1], D. Johnstone[2], H. Kirk[3], P. C. Myers[1], Y. L. Shirley[4], L. E. Allen[1]
[1]*Harvard-Smithsonian Center for Astrophysics,* [2]*Herzberg Institute of Astrophysics,* [3]*University of Victoria,* [4]*Steward Observatory.*

We present a census of the population of deeply embedded young stellar objects in the Perseus and Ophiuchus molecular cloud complexes based on combinations of Spitzer Space Telescope mid-infrared data from the ″Cores to Disks″ (c2d) legacy team and JCMT/SCUBA submillimeter maps from the COMPLETE team. We construct unbiased samples of protostars based on the mid-infrared colors of the Spitzer sources and the concentrations of the SCUBA cores. For Perseus in particular, the mid-infrared sources with 24 micron detections and red [3.6]-[4.5] colors are located close to the center of the SCUBA cores, typically within a few thousand AU of their peaks. The narrowness of the spatial distribution of mid-infrared sources around the peaks of the SCUBA cores suggests that no significant dispersion of the newly formed YSOs has occurred. This argues against the suggestion that motions of protostars regulate the time scales over which significant (Bondi-Hoyle) accretion can occur. We use the samples of YSOs to compare

the time scales for evolution through the preand protostellar stages and to estimate the star formation efficiencies of each of the two clouds.

105.04

HST NICMOS Polarization Observations of Massive YSOs

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Massive Young Stellar Objects (YSOs), like low-mass YSOs, appear to be surrounded by optically thick envelopes or disks and have regions, often bipolar, that are seen in polarized scattered light at NIR wavelengths. Whereas a low-mass YSO has a relatively simple accretion disk and bi-polar cones of scattered light, the massive YSO's morphology is confused by the presence of multiple stars, other YSOs, and obscuring dense molecular clouds within the same cluster core. Unlike low-mass YSOs, it has been suggested that massive YSOs form, not by accretion from their surrounding disks, but instead by coalescence of low-mass stars in the cores of dense stellar clusters.

We are using the high spatial resolution of NICMOS on Hubble Space Telescope to examine the disks and outflow regions of massive YSOs in star-forming regions within a few kpc of the Sun to identify YSOs that perhaps might have been formed by coalescence instead of disk accretion. Here we report on 2 micron polarimetry of S255-IRS1 and NGC6334-V. S255-IRS1 consists of two YSOs (luminosities corresponding to early B stars) with overlapping scattered light cones; neither YSO is aligned with the local magnetic field. NGC6334-V consists of a double-lobed bright reflection nebula seen against a dark region, probably an optically thick molecular cloud. Our polarization measurements show that the illuminating star lies ~ 2'' south of the line connecting the two lobes; this star is not detected at 2 micron, but there are a small radio source and a MIR source at this location. We discuss the asymmetric appearance of all three YSOs.

Support for this work was provided by NASA through grant number GO-10519 from the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS5-26555.

105.05

Spectroscopic Investigation of Companion Stars in Herbig AeBe Binary Systems

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Herbig AeBe (HAEBE) binary systems are good environments for the study of pre-main sequence stellar evolution in companion stars whose mass may be significantly lower than that of the primary star. Measurements of the spectral type and surface gravity of the companion star in the system allow it to be placed on the H-R diagram, where theoretical evolutionary model tracks can then constrain its mass and age, and comparisons can be made between these low mass stars and those formed without the presence of a high mass star. Because of the extinction associated with objects in star forming regions, the near-infrared offers a less obscured wavelength region than the optical through which to study these objects. Medium (R=1,700 & 6,000) and High (R=18,000) Resolution near-infrared (NIR) spectra were gathered for the analysis of these companion stars. We present two different ways to measure Teff and estimate Log g from the spectra of late type stars, depending on the spectral resolution. At high resolution, detailed model fits to the shapes of the Na lines at 2.2 microns and the (2-0) 12CO bandhead at 2.29 microns provides an accurate way to measure effective temperature and surface gravity, in addition to allowing for values of vsini, veiling, and radial velocity to be estimated. At medium resolution, the equivalent widths of 10 of the strongest absorption lines present in the NIR spectrum were measured to determine Teff at a lower accuracy. Preliminary results show that these techniques are effective for characterizing late-type comparisons. Analysis of two stars is discussed; more data is needed to address statistical questions about the nature of HAEBE companions. This work was supported by the National Science Foundation under grant no. 0353843.

105.06

Observations and Models of Very Low Luminosity Objects Discovered with the Spitzer Space Telescope

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Recent Spitzer Space Telescope observations of low-mass protostars have shown that many objects have luminosities $<$ 0.1 Solar Luminosities, and the discovery of these objectas has led us to define a new class of Very Low Luminosity Objects (VeLLOs). Assuming spherical mass accretion at a rate of about 2E-06 Solar Masses per year onto a star with a typical protostellar radius of about 4 Solar Radii, an object on the stellar/substellar boundary would have an accretion luminosity of L ~ 1.2 Solar Luminosities. VeLLOs, with luminosities more than an order of magnitude lower than this, are difficult to understand in the standard model of star formation. We report on a systematic search for such objects in Spitzer observations of nearby star-forming regions, obtained as part of the ″From Molecular Cores to Planet Forming Disks″ Legacy Project. We also present radiative transfer models of several VeLLOs in order to investigate the nature of these objects, and we suggest a possible mechanism for their very low luminosities.

105.07

Star Formation in the Small Magellanic Cloud: the young star cluster NGC 602

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We have discovered a population of young stars in the young stellar cluster NGC 602 in the Small Magellanic Cloud (SMC), from observations with the Hubble Space Telescope (HST) and the Spitzer Space Telescope (SST). NGC 602 is located in the SMC's wing, a low density region far from the main body of the galaxy, low in both gas and stellar content and displaying the low chemical abundance of the SMC. Deep optical imaging from the Advanced Camera for Surveys (ACS) aboard the HST has revealed the existence of an extensive and distinct pre-Main Sequence population, with stellar masses in the range 0.6â€“3 Mo.. These pre-Main Sequence stars formed coevally with the central cluster approximately 5 Myr ago.

A second population of young stellar objects (YSOs) is revealed by SST images of the region in all four bands of the Infrared Array Camera (IRAC). These very young objects formed even more recently than the stars seen in HST/ACS images, and some are still embedded in dust and gasl. We infer that star formation started in this region ~5 Myr ago with the formation of the central cluster, and propagated outwards over a timescale of a couple of Myr.

105.08

The Effect of Varied Initial Conditions on the Evolution of Protoplanetary Disks

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[1]Indiana Univ..

We present a series of three-dimensional hydrodynamics simulations of gravitationally unstable protoplanetary disks with globally constant cooling times. The purpose of these simulations is to study the effects of varying the initial surface density profile, equation of state, and cooling time. All non-fragmenting disks exhibit the same phases of evolution described by Mejía et al. (2005) axisymmetric cooling, a burst in a well-defined multi-armed mode, and a transition to an asymptotic behavior in which heating and cooling are roughly balanced over much of the disk. The burst tends to be weaker for initial surface density profiles that fall more steeply with *r*. Regardless of initial surface density profile, the outer disk redistributes its

mass to follow an approximate $\Sigma \propto r^{-5/2}$ power law. Comparison of different equations of state show that, for a given cooling time, a disk with $\gamma = 7/5$ is more likely to fragment than one with $\gamma = 5/3$. By varying the cooling time with both equations of state, we are able to confirm the $t_{cool}\Omega < 8.25$ *and 5.14 fragmentation criterion for* $\gamma = 7/5$ *and 5/3, respectively, as found by Rice et al. (2005).*

105.09

Radiative Transfer Model Fitting of Hubble NICMOS Data for the Class I Protostar TMC-1A (IRAS 04365+2535)

Susan Terebey[1]
[1]*Cal. State Univ. at Los Angeles.*

We present scattered light models of the class I protostar TMC-1A (IRAS 04365+2535) located in the Taurus star-forming region. In previous work we modelled the nearby source TMC-1 (IRAS 04381+2540) (Terebey et al. 2006, ApJ, 471, 308). This work compares results for the two class I protostars, based on high-spatial resolution Hubble Space Telescope NICMOS Data. The data are fit using a Monte Carlo scattering code to generate model simulations. Previous work has shown that the extended nebulosity seen around protostars at near-infrared wavelengths can be explained by stellar photons that scatter off circumstellar dust. Here the assumed density distribution consists of the TSC collapse model (″infall envelope″), a conical outflow cavity, and a geometrically thin but opaque disk. We find both objects, TMC-1A and TMC-1, can be explained in this framework with only modest changes in parameters. The data for TMC-1A also show evidence for spiral-like features. We discuss possible explanations for this effect.

105.10

Statistics of Turbulence Probed by Water Masers in Star Forming Regions

Benjamin H. Ripman[1], V. Strelnitski[1]
[1]*Maria Mitchell Observatory.*

We use published VLBI results to investigate the statistical properties of the velocity fields traced by H_2O masers in eleven galactic regions of star formation. Previous work by Strelnitski et al. (2002) established that H_2O masing spots in such regions appear to probe turbulent media and demonstrated that the two-point velocity correlation functions for the line-of-sight components of velocity traced by the masers could be approximated by power laws, with the exponents near the classical Kolmogorov value of 1/3 expected for high-Reynolds number incompressible turbulence. In the present project, we undertook a more in-depth investigation of the two-point velocity correlation functions for both previously studied and new water maser sources with published VLBI maps. We confirm that the velocity correlation functions can be satisfactorily approximated by power laws for all these sources, but we observe that a single power-law fit for the whole observed span of spatial scales describes the data worse than fits applied over constrained ranges of scale. At intermediate scales, we found that the power law exponents were near the Kolmogorov value. At smaller scales, however, there was a pronounced steepening of the slopes, which may be an indication that considerable dissipation of energy in supersonic turbulence starts at spatial scales larger than both the Kolmogorov microscale and the possible dissipation scale due to the formation of random shock waves hypothesized by Strelnitski et al. (2002). At the largest scales, we found a pronounced flattening of the slopes, which we attribute to the increased relative importance of regular components of motion (expansion and/or rotation) at these scales. This project was supported by the NSF/REU grant AST-0354056 and the Nantucket Maria Mitchell Association.

105.11

Multiplicity and the Nature of Companions in Herbig Ae/Be Systems

Bernadette Rodgers[1], N. van der Bliek[2], S. Thomas[3], G. Doppmann[4]
[1]*Gemini Obs., Chile,* [2]*NOAO CTIO, Chile,* [3]*UCO Lick Observatory,* [4]*NOAO.*

Multiplicity of young stars as a function of stellar mass provides critical constraints to models seeking to explain the star formation process as a function of mass and environment. While multiplicity studies of low mass T Tauri stars have been fairly exhaustive, a systematic study of Herbig Ae/Be (HAEBE) stars is still lacking. These intermediate mass young stars represent the ″missing link″ between the T Tauris and the elusive high mass young stars, for which the star formation process is still not well understood.

We present further results of our ongoing near-infraed imaging and spectroscopy study. Our results show that the companions of Herbig Ae/Be stars are not typically classical T Tauri stars. Of those studied so far, most early type (Be) primary stars have similar early type companions. Later type (Ae and Fe) HAEBEs are more likely to have low mass companions, however these companion stars often lack emission lines and so appear to be different than the typical classical T Tauri population. New binary candidates are presented and various characteristics of the companions as a function of primary mass are presented and discussed.

105.12

Monte Carlo Simulations Of The Rotational Evolution Of PMS Stars

Lucas A. Cieza[1], N. Baliber[2], N. Counselor[1]
[1]*Univ. Of Texas, Austin,* [2]*Univ. Of California at Santa Barbara.*

We describe a Monte Carlo code that simulates the evolution of angular momentum of pre-main-sequence stars in the context of the disk-braking paradigm. The code is similar to that presented by Rebull et al. (2004), but includes several improvements. The code allows us to set parameters such as the distributions of masses, ages, and disk dissipation timescales, all of which are constrained by observations. Also, we use the evolution of stellar radii predicted by theoretical tracks to evolve the periods of disk-less, unregulated stars and to calculate the amount of angular momentum drained as a function of time from stars regulated by disks. We present quantitative comparisons between models and recent observations of young stellar clusters in order to constrain disk-braking parameters.

105.13

Spitzer Observations of YSO's in the Witch Head Nebula (IC 2118)

Tim S. Spuck[1], M. T. Heath[1], L. M. Rebull[2], T. E. Roelofsen Moody[3], B. Sepulveda[4], E. Sharma[4], C. Weehler[5], S. P. Weiser[1]
[1]*Oil City Area Sr. High School,* [2]*SSC/JPL/Caltech,* [3]*New Jersey Astronomy Center for Education,* [4]*Lincoln High School,* [5]*Luther Burbank High School.*

Two high-Galactic latitude molecular clouds (HLC) in the region of IC 2118, the Witch Head Nebula, appear to be forming stars (Kun et al. 2004). Star formation in HLCs, while rare, may be the origin of some of the apparently isolated T~Tauri stars revealed by ROSAT. At only ~210 pc away, the clouds in IC 2118 are thought to be excited by Rigel. Kun et al. (2004) reported the discovery of three T~Tauri stars in this region. Our 2005 pilot project surveyed a 15x15 arc-minute region at the head of the cloud and approximately quadrupled the number of suspected young objects in this region (Spuck et al. 2005). With additional Spitzer Telescope time in 2006, we observed ~2 square degrees further along the nebula. Using color-color plots, we have identified many candidate young objects throughout the nebula. In this poster, we will present color-color plots and SEDs of these stars, criteria for their selection, and discuss follow-up observations at other wavelengths to confirm the status of the suspected young objects. These observations are part of the Spitzer Space Telescope Research Program for Teachers and Students.

105.14

The Velocity Field and the Spatial Distribution of the "Hot Spots" in Methanol Masers: a Statistical Study

Phuongmai N. Truong[1], B. H. Ripman[2], V. Strelnitski[3]
[1]*Texas A&M Univ.,* [2]*Bowdoin College,* [3]*Maria Mitchell Obs..*

We used available interferometric maps to study statistical properties of the velocity filed and spatial distribution of the observed "hot spots" in three Class I and one Class II methanol maser sources. In most sources, both the velocity difference between the pairs of spots and the average density of the neighbors to a spot are adequately represented by a power law function of the spot separation. Both dependences can be interpreted as manifestation of a turbulent flow, although the total range of spot separation is not large enough to exclude other interpretations. The formal average fractal dimension of the observed spatial distribution of maser spots is 1.2+/-0.4 for the Class I sources and 1.8+/-0.3 for the Class II source. These low values of fractal dimension can be a manifestation of strong intermittency of the underlying turbulence, but the limited range of the mapped spatial scales does not allow us to exclude clustering of hot spots imitating low fractal dimension by a maser amplification in a homogeneous turbulent medium. For the Class I sources, the average slope of the velocity correlation function, measured over the whole range of spot separations, is 0.65+/-0.13, and for the Class II source it is 0.54+/-0.08. These values are significantly higher than the classical Kolmogorov value of 1/3 for the initial subrange of incompressible turbulence, which may indicate considerable dissipation of turbulent energy on all the scales probed by methanol masers. This project was supported by the NSF/REU grant AST-0354056 and the Nantucket Maria Mitchell Association.

105.15

Spitzer Imaging of NGC 2467: Evidence for Triggered Low-Mass Star Formation in HII Region Environments

Keely D. Snider[1], J. J. Hester[1], S. J. Desch[1], K. R. Healy[1], J. Bally[2]
[1]Arizona State Univ., [2]University of Colorado.

Lada and Lada (2003) found that as many as 90% of all low-mass stars within 2kpc of the Sun formed in clusters, and many of these clusters contain massive O and B stars. We are using Spitzer observations to independently asses the relationship between low and high-mass star formation. We are interested in exploring the extent to which HII region environments affect the process of low-mass star formation itself. In this poster, we present new Spitzer observations of the HII region NGC 2467. We present IRAC (3.6, 4.5, 5.8, and 8.0μm) and MIPS 24μm observations of this region, covering ~600 square arcminutes. The images presented here show a region of ionized gas pushing out into the surrounding molecular cloud. The region is powered by an O6V star, there are also two other clusters of massive stars in the region. We have identified more than 50 sources that have infrared excesses in one or more mid-IR colors. Sources were defined to have an excess if [3.6]-[4.5] > 0.2 mags or if [5.8]-[8.0] > 0.5 mags. There are ~30 sources that have an excess in two IRAC colors. We present color-color diagrams of the sources and also show the distribution of candidate Young Stellar Objects (YSOs). We find that YSOs are not randomly distributed in NGC 2467. Of the 30 sources with an infrared excess in two colors, more than 75% are located near the edge of the HII region in gas that has been compressed by HII region expansion. These Spitzer data support the hypothesis that a significant fraction of low-mass star formation in NGC 2467 is triggered by HII region expansion. Overall, there is a growing body of evidence to support the conclusion that low-mass star formation proceeds differently in massive star forming regions as compared to isolated dark clouds.

105.16

Self-Gravitational Collapse Of A Slowly Rotating Interstellar Gas Cloud

John K. Wall[1]
[1]Retired.

The results of a computer simulation of the self-gravitational collapse of a slowly rotating interstellar gas cloud are presented. The cloud is modeled as axially symetric, and initially of uniform density. In the data presented the cloud is assumed initially to be in ″solid body″ rotation with the rotation rate bounded by the balance between gravitational and the maximum centrifugal forces. The model includes the effects of viscosity, and pressure in the vicinity of the forming protostar.

105.17

Spitzer Observations of Massive Protostars Associated with Methanol Masers

Audrey E. Simmons[1], S. L. Skinner[1], M. Guedel[2]
[1]Univ. of Colorado, [2]Paul Scherrer Inst., Switzerland.

Methanol masers, detected in the radio at 6.7 or 12.2 GHz, are formed by stimulated microwave emission and are often found toward massive star-forming regions, sometimes without accompanying radio continuum emission or ultra-compact HII regions. This suggests that they are signposts of the earliest stages of high-mass star formation. The precise location where methanol masers form in the protostellar environment is not well known. Knowing where they lie in relation to rotating disks or high velocity outflows will help clarify the relationship between maser activity and high-mass star formation. We present preliminary analysis of Spitzer observations of four massive protostars traced by methanol masers (IRAS 20126+4104, AFGL 5180, S233, S269). Each protostar was imaged with the Spitzer Infrared Array Camera (IRAC) in subarray mode in all four IR channels, ranging from 3.6 to 8.0 microns. We will discuss the mid-IR morphology relative to the accurately known methanol maser positions.

This study is supported by the Spitzer Science Center through JPL grant 1264905.

105.18

Large Magnetic Fields and OH Maser Motions in W75 N

Vincent L. Fish[1], M. J. Reid[2]
[1]NRAO Jansky Fellow, [2]Harvard-Smithsonian Center for Astrophysics.

We present Very Long Baseline Array (VLBA) observations of the 1665 and 1667 MHz OH masers in the massive star forming region W75 N. Magnetic field strengths as large as 40 mG are deduced from Zeeman splitting and multi-transition overlap near continuum source VLA 2. Comparison of the maser positions with similar VLBA data taken four years previously allows for analysis of maser proper motions. Most masers are moving at an average speed of 3-5 km/s. However, the brightest (> 400 Jy) maser, located near VLA 2, is moving at over 50 km/s with respect to the rest of the masers in W75 N. Most bright maser spots are recovered between the two epochs, except near VLA 2. These characteristics suggest that the masers near VLA 2 may be tracing an energetic outflow. Motions in the southeasternmost cluster of maser spots may be indicating expansion around a small unseen exciting source.

The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

105.19

New Young Stellar Aggregates in Perseus as Revealed by the Spitzer/MIPS c2d Legacy Program

Luisa M. Rebull[1], K. Stapelfeldt[2], c2d team
[1]SSC/Caltech/JPL, [2]JPL.

We present observations of 10.6 square degrees of the Perseus molecular cloud at 24, 70, and 160 um with the Spitzer Space Telescope Multiband Imaging Photometer for Spitzer (MIPS). Of 3950 point sources identified at 24 um, 1141 have 2MASS counterparts. A third of these 1141 sources populate regions of the Ks vs. Ks-[24] diagram that are distinct from background SWIRE galaxies, and thus are likely to be cloud members with infrared excess. Nearly half (46%) of these 24 um excess sources are distributed outside the IC 348 and NGC 1333 clusters. The intercluster region contains several tightly clumped (~0.1 pc) young stellar aggregates which exhibit a wide variety of infrared spectral energy distributions (SEDs) characteristic of different circumstellar environments. One possible explanation is a significant age spread among the aggregate members. Alternatively, if the members are ″coeval,″ then remarkably rapid circumstellar evolution would be required to produce Class I and Class III sources within close proximity to one another.

105.20

Cluster Formation in Isolation: Spitzer's View of Bok Globule CB 34

Dawn E. Peterson[1], R. A. Gutermuth[2], M. F. Skrutskie[1], S. T. Megeath[3], J. L. Pipher[4], L. E. Allen[2], P. C. Myers[2]
[1]Univ. of Virginia, [2]Harvard-Smithsonian Center for Astrophysics, [3]Univ. of Toledo, [4]Univ. of Rochester.

Recent surveys of stars forming over entire molecular clouds have shown that the majority of stars form in clusters (e.g. Carpenter 2000, Allen et al. 2006). Therefore it has become increasingly important to observe and understand star formation in the clustered environment. A sample of young stellar clusters of varying stellar densities has been surveyed with the Spitzer Space Telescope. However, most of these clusters are parts of larger star formation complexes, and may be influenced by external forces such as radiation and winds from neighboring OB stars. CB 34 is an example of a Bok globule, an optically opaque small dark cloud, that harbors a small group of stars forming in relative isolation. Based on initial analysis of 1-8 μm photometry from IRAC and the Two Micron All Sky Survey (2MASS), we identified 9 Class 0/I and 14 Class II young stellar objects within the small, 4.5' x 4.5' region encompassing CB 34. This unusually high number of protostars compared with Class II sources is particularly intriguing because it implies a high rate of star formation. Therefore we have begun a larger study of this region in order to determine why and how CB 34 started forming stars at such a high rate.

105.21

The Near-IR to Submillimeter Opacity Ratio toward Low-mass Star-forming Cores

Yancy L. Shirley[1], T. L. Huard[2], A. M. Stutz[1], D. J. Wilner[2], K. M. Pontoppidan[3], L. G. Mundy[4], N. J. Evans II[5]
[1]Univ. of Arizona, [2]CfA, [3]Caltech, [4]Univ. of Maryland, [5]Univ. of Texas.

The submillimeter opacity is a prominent source of uncertainty in mass estimates and in determination of the physical structure of low-mass star-forming cores. As part of a larger effort with the Cores to Disk Spitzer Legacy team (c2d) to better constrain the dust opacity in these dense cores, we have directly compared deep near-IR observations from HST NICMOS and the NTT with Spitzer Space Telescope mid-IR and SCUBA submillimeter observations of the Class 0 protostellar core B335 and starless core L694-2. We develop a new method to constrain the dust opacity at 850 and 450 microns vs. 2.2 microns that accounts for the variations of density and temperature along the stellar lines-of-sight. The opacity ratio is used to constrain a new dust model (Pontoppidan et al.) appropriate for dense, low-mass cores and the new dust model is used to update the physical model of B335.

105.22

Variations in the Extinction Law, Ice Abundance, and Dust Grains in Molecular Cloud Cores

Tracy L. Huard[1], K. M. Pontoppidan[2], A. Boogert[3], C. Knez[4], Y. L. Shirley[5]
[1]Harvard-Smithsonian CfA, [2]Caltech, [3]NOAO Gemini Science Center, Chile, [4]University of Maryland, [5]Steward Observatory.

With deep ground-based near-infrared observations and mid-infrared observations from the Spitzer Space Telescope, we characterize the infrared extinction law in dense molecular cloud cores and show that it is different than that in the diffuse interstellar medium. Furthermore, in the densest regions of the cores, this law is significantly different than that in the less dense core regions. These differences may be attributed to evolution of both grain composition, such as with ice mantling, and grain sizes. To estimate the effect of an evolving composition, we analyze the shapes and varying depths of ice and silicate features in infrared spectra, obtained from ground-based and Spitzer IRS observations, of background stars probing a wide range of extinctions in cores. We present and compare models of the dust grain populations in three regions of the interstellar medium: the diffuse interstellar medium, moderately dense regions of molecular cloud cores, and the densest regions of cores. In constructing these models, we make use of near-infrared, mid-infrared, and submillimeter observations toward cores. Thus, these comprehensive, high resolution models sufficiently characterize dust opacities in star forming regions for the wide spectral range, 1 850 um.

106: Education with Large Astronomical Surveys AAS Special, Monday, 10:00-11:30am, 613-14

Chair

Carol A. Christian[1]
[1]STScI.

106.01

Education / Outreach with Large Surveys Overview

Carol A. Christian[1]
[1]STScI.

The creation of education resources to enhance science and technical skills and engage the public in understanding science have been integrated into main stream astronomical research efforts. Most of the resulting materials and resources have centered on small data sets culled by the resource developer. With the emergence of the National Virtual Observatory, the Sloan Digital Sky Survey, WMAP, GOODS, and others as well as the promise of observatories such as the Large Synoptic Survey Telescope, education utilizing such vast data stores has exciting potential. This kind of education has never been done before. This session is crafted to present the current thinking on the use of survey data for education, and to stimulate a discussion resulting in new strategies and collaborations.

106.02

LSST Survey Data Models for EPO Interaction

Kirk Borne[1]
[1]GMU / LSST / QSS Group Inc..

The LSST project is unique in designing its data management and data access systems with the public and community users in mind. The enormous volume of data to be generated by LSST is staggering: 15 Terabytes of raw images per night with processed data, metadata, images, and catalogs growing at a rate of 15 Petabytes per year. LSST will also generate up to 100,000 astronomical alerts per night, for 10 years. The entire professional astronomical community is not large enough to follow up on all of these events and discoveries. The LSST EPO team is examining models for interaction with the survey data, particularly in how the community (amateurs, teachers, students, and general public) can participate in the discovery process. We will outline some of our models of community interaction for inquiry-based science using the LSST survey data, from social networking to public astronomy databases, and we invite discussion on these topics.

106.03

Hands on Universe Applications

Carl Pennypacker[1]
[1]Lawrence Berkeley Lab..

We are slowly gaining experience and developing plans where students use large surveys for their own education and inspiration. Such education and research has perceived benefits for both the education and the scientific communities, and holds the potential to create broad and substantial support for astronomy as one of the most powerful and effective ways to "teach science by doing science." Such goals are supported by many science standards, but have remained elusive in fundamental ways until recently. Follow-up telescopes often are key to enable a complete scientific experience. We strive to make easy (for a broad range of students) studies of variable stars, asteroids, variable quasars, and other transient phenomena. Objects that vary or move on time scales less than a school year hold multiple thrill and engagement factors for many students. A number of challenges exist to the smooth implementation of such a system, but most obstacles seem to be eroding or at least becoming less formidable due to the continual efforts of a large and inspired community of educators, astronomers and others. Progress with student use of the Sloan Digital Sky Survey will be explained, along with some thoughts on the hopeful use of the PanSTARRS system -the proposed ″Frontiers of Discovery″ program. Very careful attention must be paid to software tools and data bases that allow such access by young people, and some experience and hopes will be discussed.

106.04

Teacher Education

Vivian Hoette[1]
[1]*Yerkes Observatory.*

Abstract for Education with Large Astronomical Surveys talk was not received.

106.05

LSST EPO Plans & Challenges

Suzanne Jacoby[1]
[1]*LSST Corporation.*

Scheduled to see ″first light″ in 2013, the 8.4-meter LSST will be able to survey the entire visible sky every three nights with its three-billion pixel digital camera, probing the mysteries of Dark Matter and Dark Energy. LSST will open a movie-like window on objects that change or move on rapid timescales: exploding supernovae, potentially hazardous near-Earth asteroids as small as 100 meters, and distant Kuiper Belt Objects.

The potential for education and outreach with the LSST is as far reaching as the telescope itself. All data are public and offered through an EPO program that actively engages the public in the universe. In this talk, we give a brief overview of the EPO Operations Plan for LSST, describe challenges known to the EPO team, and invite discussion.

106.06

Education with SDSS Data: Activities and Lessons Learned

M. J. Raddick[1]
[1]*JHU.*

We have been developing and maintaining the SkyServer web site (http://skyserver.sdss.org), which offers the complete dataset of the Sloan Digital Sky Survey to educators, for the past five years. We have developed tools for displaying and searching the data, both as images and measured parameters. We have also developed a set of exercises that use these data to teach science at levels from elementary school through introductory college. In this talk, we will demonstrate the resources we have made available, and we will discuss the lessons we have learned from developing and maintaining these resources. We hope that these lessons will be useful for other education and public outreach programs, and for teachers who want to use data from large astronomy surveys with their students.

106.07

The Challenges of Using Virtual Observatories in the Classroom

Robert T. Sparks[1]
[1]*NOAO.*

The Internet has made data that was previously available only to professional astronomers available to anyone with an Internet connection. Several programs have developed over the years to attempt to bring this data into the classroom.

There are many challenges to introducing astronomy data in the classroom. These can include issues of computer use, finding the correct data analysis tools, the learning curve associated with your tools, and time constraints. I will discuss how to bring astronomy data into the classroom and how to address some of the common challenges teachers face.

106.08

Introducing High School Science Teachers to Quasar Research Using the Cyberinfrastructure

Michelle Nichols (Yehling)[1], L. Fortson[1]
[1]*Adler Planetarium & Astronomy Museum.*

This is an exciting time for astronomy research never before has so much astronomy data been easily available to the general public. The hard part has been packaging the research of that data into digestible pieces. Organizations are bringing amazing possibilities to teachers, students, and the public by utilizing the connectivity and capabilities of the Internet. In late 2005, the National Science Foundation funded several two-year cyberinfrastructure demonstration projects. One team that received support, including the Adler Planetarium & Astronomy Museum, Hands-On Universe (HOU), the Sloan Digital Sky Survey (SDSS), and The Collaboratory Project at Northwestern University, has designed a teacher professional development and student research program to allow participants to actively participate in quasar research using tools made available through the cyberinfrastructure and SDSS data. This endeavor was built on a prior project also funded through NSF: the Strategic Technology Astronomy Research Team (START) Collaboratory. The goal of the new project is to bring 21st century science research techniques into high school classrooms using large Internet-accessible astronomy databases, remote-request telescopes, web visualization, and online tools. The initial teacher professional development program began in Summer 2006 at the Yerkes Observatory, and the student research project began in Fall 2006 in several classrooms around the country. At the Special Session, team members will give a design overview of the project and classroom activities, as well as preliminary results of implementation of the project with students.

106.09

The Amateurs' Love Affair with Large Datasets

Aaron Price[1], S. H. Jacoby[2], A. Henden[3]
[1]*AAVSO/Tufts University,* [2]*LSST Corporation,* [3]*AAVSO.*

Amateur astronomers are professionals in other areas. They bring expertise from such varied and technical careers as computer science, mathematics, engineering, and marketing. These skills, coupled with an enthusiasm for astronomy, can be used to help manage the large data sets coming online in the next decade. We will show specific examples where teams of amateurs have been involved in mining large, online data sets and have authored and published their own papers in peer-reviewed astronomical journals. Using the proposed LSST database as an example, we will outline a framework for involving amateurs in data analysis and education with large astronomical surveys.

107: The Future of Astronomy and Astrophysics at NASA
AAS Special, Monday, 10:00-11:30am, 611-12

Chair

Jack O. Burns[1]
[1]*Univ. of Colorado at Boulder.*

107.01

CAPP Panel Discussion: The Future of Astronomy & Astrophysics at NASA

Jack O. Burns[1]
[1]*Univ. of Colorado at Boulder.*

The president's proposed budget for FY2007 for NASA sets out significant reductions in the growth for space science funding, as well as reductions to previously planned Explorer and Flagship missions. With this proposed budget and recent changes in NASA's Advisory structure, this is a good time to assess the state of astronomy and astrophysics at NASA. The AAS Committee on Astronomy & Public Policy has assembled a distinguished panel to discuss the FY2007 budget and what it implies for the future.

Panel Members:

Dr. Jack Schmitt, Chair of NAC (confirmed).Dr. Anneila Sargent, Cal Tech, chair of NRC Board of Physics and Astronomy (confirmed).Dr. Neil deGrasse Tyson, American Museum of Natural History, member of NAC.Dr. Garth Illingworth, University of California at Santa Cruz, Chair of AAAC (confirmed)Dr. Len Fisk, University of Michigan, Chair of SSB and ex-officio member of NAC (confirmed).

108: HAD III
HAD Oral, Monday, 10:00-11:30am, 608-10

Chair

Sara Schechner[1]
[1]*Harvard U..*

108.01

The Tunguska Event and the History of Near-Earth Objects

Donald K. Yeomans[1]
[1]*JPL.*

At 7:17 o'clock in the morning of June 30, 1908 a 60 meter-sized asteroid exploded over the Tunguska region of Russian Siberia, leveling trees for some 22 miles from the blast center. Today, the Tunguska blast is used as the only example of a witnessed and documented Earth impact by a substantial near-Earth asteroid. Although striking Earth with the impact energy of 15 mega tons of TNT, the Tunguska event had very little effect upon contemporary views of Earth impacts by neighboring comets and asteroids. While Edmond Halley had pointed out in 1694 that comets could strike the Earth with catastrophic consequences, the far more numerous potentially hazardous asteroids were unknown until the discovery of asteroid 1862 Apollo in 1932 the first asteroid found to actually cross the Earth's orbit. It was only in the second half of the last century when astronomers generally believed that the moon's craters were largely due to asteroid impacts rather than volcanoes and more recent still before the realization that there are likely more than 20,000 asteroids large enough to cause serious consequences to Earth's surface and close enough to Earth's orbit to pose a near-term threat. The Tunguska event of 1908 could have been used to lead toward these conclusions much earlier but this was not to be the case because of the lack of information on this remote event, the initial unwillingness of most professional astronomers to attribute the lunar craters to impact events and because it was realized only recently that the Earth's neighborhood is crowded with potential asteroid impactors.

108.02

Einstein's Jury -The Race to Test Relativity

Jeffrey Crelinsten[1]
[1]*The Impact Group, Canada.*

It is common belief that Einstein's general theory of relativity won worldwide acceptance after British astronomers announced in November 1919 that the sun's gravitational field bends starlight by an amount predicted by Einstein. This paper demonstrates that the case for Einstein was not settled until much later and that there was considerable confusion and debate about relativity during this period. Most astronomers considered Einstein's general theory too metaphysical and abstruse, and many tried to find more conventional explanations of the astronomical observations. Two American announcements before the British results appeared had been contrary to Einstein's prediction. They came from Lick and Mt. Wilson observatories, which enjoyed international reputations as two of the most advanced astrophysical research establishments in the world. Astronomers at these renowned institutions were instrumental in swaying the court of scientific opinion during the decade of the 1920s, which saw numerous attempts to measure light-bending, as well as solar line displacements and even ether-drift. How astronomers approached the "Einstein problem" in these early years before and after the First World War, and how the public reacted to what they reported, helped to shape attitudes we hold today about Einstein and his ideas.

108.03

The Numbers of Scientific Papers Depend Only on the Numbers of Scientists

Helmut A. Abt[1]
[1]*Kitt Peak National Obs..*

For five sciences (physics, astronomy, geophysics, mathematics, and chemistry) I counted the numbers of papers published annually in 1970-2004 in 5-27 major journals in each field. The totals were divided by the numbers of members in the appropriate American societies, e.g. The American Physical Society. Corrections were made for non-American papers. The quotients (American papers per society member per year) are generally constants and show no jumps due to improved instrumentation (e.g. CCDs, Hubble, Keck, computer speeds). These tell us that the numbers of papers depend only on the numbers of research scientists, although the quality and content of those papers improve with technical improvements.

108.04

Quasars and the Caltech-Carnegie Connection

Edward R. Waluska[1]
[1]*James Cook University, Australia.*

A collaborative relationship existed between the California Institute of Technology(Caltech) and the Carnegie Institution of Washington (Carnegie) beginning in 1946, when a formal agreement was made between the two groups of trustees. This agreement was designed to integrate Mount Wilson Observatory with the new unfinished Palomar Observatory into a single scientific entity. During the period from 1946 to 1979, much astronomical research was done at both institutions as a direct result of this collaboration. Part of this research included the first identification of a radio source with an apparently stellar object by Allan Sandage of Carnegie and Thomas Matthews of Caltech in 1960, and the first identification of the spectral lines from a radio source associated with such an object by Maarten Schmidt of Caltech in 1963. This paper examines how the discovery of these objects, which came to be known as quasars, and the subsequent research on these objects, impacted the relationship between Caltech and Carnegie, such that the relationship was formally dissolved in 1980. In this paper, the controversy surrounding the discovery and the interpretation of quasars is examined to provide further understanding about the working relationship when the two institutions were formally collaborating. Some of the data used in this paper were drawn from interviews of the researchers themselves, and this research forms part of a dissertation for a PhD degree from James Cook University in Townsville, Australia.

109: AGN Variability, Interactions and Environments AAS Oral, Monday, 10:00-11:30am, 3A

109.01

Discovery of a Probable Triple Quasar

Stanislav G. Djorgovski[1], F. Courbin[2], G. Meylan[2], D. Sluse[2], D. Thompson[3], A. Mahabal[1], E. Glikman[1]
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We report the discovery of a first known probable case of a physical triple quasar (not a gravitational lens). A previously known double system, QQ 1429-008 at z = 2.076, is shown to contain a third, fainter QSO component at the same redshift within the measurement errors. Deep optical and IR imaging at the Keck and VLT telescopes has failed to reveal a plausible lensing galaxy group or a cluster, and moreover, we are unable to construct any viable lensing model which could lead to the observed distribution of source positions and relative intensities of the three QSO image components. Therefore, we conclude that this system is most likely a physical triple quasar, the first such close grouping known at any redshift. The projected component separations in the restframe are ~ 30 50 kpc for the standard concordance cosmology, typical of interacting galaxy systems. The existence of this highly unusual system supports the standard picture in which galaxy interactions lead to the onset of QSO activity.

109.02D

The X-ray Variability of Seyfert Galaxies

Kevin Marshall[1]
[1]Georgia State Univ..

Strong and variable X-ray emission has long been known to be a universal property of active galaxies. However, despite years of study, the exact nature of the variability remains relatively unknown. We present here results of a multi-year monitoring campaign of a sample of Seyfert galaxies (3C 120, Mkn 509, 3C 390.3, and Akn 120), carried out using the Rossi X-ray Timing Experiment (RXTE). For Mkn 509, we also present results of optical monitoring. Mkn 509 shows a strong correlation between X-ray and optical variations, with the optical leading the X-ray by 25 days. We also investigate the rms-flux relationship in our sample. The two radio loud objects in our sample (3C 120, 3C 390.3) show a clear correlation between flux and rms variability, while the two radio-quiet objects (Akn 120, Mkn 509) show no such relationship. Monte Carlo simulations were used to estimate the shape of the underlying power spectrum, and we find that all of our objects have a break frequency below which the power spectrum flattens. The relationship between optical and X-ray variability is discussed, along with connections to galactic X-ray binaries.

109.03

Monitoring of a Dramatically Variable C IV Mini-BAL in the Quasar HS1603+3820

Toru Misawa[1], M. Eracleous[1], J. C. Charlton[1], N. Kashikawa[2]
[1]Penn State Univ., [2]National Astronomical Observatory of Japan, Japan.

We present eight high-resolution spectra of an optically bright quasar, HS1603+3820 (z_em=2.542), taken over an interval of 4.2 years (1.2 years in the quasar rest frame) with Subaru Telescope and Hobby-Eberly Telescope, for the purpose of monitoring absorption lines that are physically associated to the quasar. Among eight C IV absorption systems in this quasar spectrum, only one mini-BAL system at z_abs~2.43, which was already identified as an intrinsic system based on partial coverage analysis (Misawa et al. 2003,2005), showed dramatic time variability. We fitted Voigt profiles to the mini-BAL, and found that there were no clear correlations between the fit parameters such as the column density, Doppler parameter, and coverage fraction. This result suggests that the mini-BAL absorber has an inhomogeneous internal structure. Another important observational clue is that all absorption components in the system varied in concert, which suggests the observed time variability was due to a change of the ionization conditions (not due to the gas motion) in the mini-BAL absorber. Because such rapid UV continuum variability is not expected in luminous quasars such as our target, we suggest that a variable screen of material between the quasar continuum source and the absorber is the cause of the changes in the ionization state

of the mini-BAL system. We acknowledge support from NASA grant NAG5-10817.

109.05

Reverberation Mapping of the BLRG 3C390.3

Matthias Dietrich[1], B. M. Peterson[1]
[1]The Ohio State University.

Reverberation mapping of the broad line region (BLR) has become a standard tool in studying the size, structure, and mass of the central black hole of AGN. Recent work by Peterson et al. (2004)

and by Bentz et al. (2006) has

established a flatter radius luminosity relation for AGN as previously assumed. To provide improved measurements, i.e., smaller uncertainty of the BLR radius and hence the black hole mass of several AGN, we monitored the Broad-Line Radio Galaxy (BLRG) 3C390.3. From mid September until early December 2005 optical spectra were observed for 28 epochs, using the 2.4m Hiltner telescope at MDM Observatory. Simultaneously to the spectra g-band photometry data were obtained. During the monitoring campaign the g-band continuum of 3C390.3 varied with an amplitude of ~10 %, as well as the AGN continuum F(5100). We measured emission line light curves for Halpha, Hbeta, Hgamma, HeI5876, and HeII4686. The delays and profile variations will be presented. The implications on the size and structure of the BLR and the mass of the central black hole will be discussed.

109.06

HCN Observations of Four High Redshift Galaxies and QSOs

Yu Gao[1], C. Carilli[2], P. Vanden Bout[3], P. Solomon[4]
[1]Purple Mountain Observatory, China, [2]NRAO-AOC, [3]NRAO-CV, [4]University at Stony Brook.

We present here sensitive new HCN(1-0) observations of four high-redshift galaxies including two submillimeter (submm) galaxies and two QSOs with the VLA. We have marginally detected (at the 3-4σ level) HCN(1-0) emission in submm galaxy SMM J16359+6612, thanks to the highly magnified gravitational lens and the widely separated lens components, once the three lens components are stacked in the image domain. The HCN source appears to be double with a separation of ≤ 2''$ (barely resolved), consistent with the the spatial offset of the two CO velocity components, the optical and near-IR morphologies, the double-horn CO profiles, and other circumstantial merger evidences. Our new HCN observations, combined with previous HCN detections and upper limits, strongly constrain the HCN/CO ratios at high-redshift to be comparable to that of local ultraluminous infrared galaxies (ULIRGs). We also show that the FIR--HCN correlation established in local star-forming galaxies extends to high-redshift with same scatter though the FIR/HCN ratios in these high-redshift sources appear systematically higher than that of local galaxies and ULIRGs.

109.07

Radially-Inflowing Molecular Gas Deposited by a X-ray Cooling Flow

Jeremy Lim[1], Y. Ao[2], V. Dinh[1]
[1]ASIAA, Taiwan, [2]Purple Mountain Observatory, Chinese Academy of Sciences, China.

Galaxy clusters are immersed in hot X-ray-emitting gas that constitutes a large fraction of their baryonic mass. Radiative cooling of this gas, if not adequately balanced by heat input, should result in an inflow of cooler gas to the central dominant giant elliptical (cD) galaxy. Although a straightforward prediction made nearly twenty years ago, the occurrence of such X-ray cooling flows is widely questioned as gas at lower temperatures is often not

found at the predicted quantities. The exceptions are cD galaxies harbouring large quantities of cool molecular gas, but the origin of this gas is uncertain as ram-pressure stripping or cannibalism of gas-rich cluster galaxies provide viable alternatives to cooling flows. Here, we present the most direct evidence yet for the deposition of molecular gas in a cD galaxy, Perseus A, from a X-ray cooling flow. The molecular gas detected in this galaxy is concentrated in three radial filaments with projected lengths of at least 2 kpc, one extending inwards close to the active nucleus and the other two extending outwards to at least 8 kpc on the east and west. All three filaments coincide with bright Hα features, and lie along a central X-ray ridge where any cooling flow is strongest. The two outer filaments exhibit increasingly blueshifted velocities at smaller radii that we show trace radial inflow along the gravitational potential of the galaxy. The innermost filament appears to be settling into the potential well, and may fuel the central supermassive black hole whose radio jets heat gas over a large solid angle in the north-south direction. Our results demonstrate that X-ray cooling flows can indeed deposit large quantities of cool gas, but only intermittently along directions where the X-ray gas is not being reheated.

109.08

Intergalactic Metal Pollution at the Highest Observable Redshifts

Emma V. Ryan-Weber[1], M. Pettini[1], P. Madau[2]
[1]IoA, Cambridge, United Kingdom, [2]University of California, Santa Cruz.

We have discovered two strong CIV absorption systems at z=5.7238 and 5.8290, respectively, towards the z=6.28 QSO SDSS J1030+0524. These observations, obtained with the Infrared Spectrometer And Array Camera (ISAAC) on the European Southern Observatory Very Large Telescope (ESO VLT), demonstrate that QSO absorption line spectroscopy can be successfully extended to near-infrared wavelengths to probe the intergalactic medium near the end of the reionization epoch. Although only two QSOs have been searched for CIV absorption at these redshifts, there is no obvious indication yet of a downturn in the cosmological mass density of CIV, Omega(CIV). The results, if representative of the global average, suggest that a large fraction of intergalactic metals may already have been in place at redshifts above 6. Alternatively, the CIV systems may be associated with the ionized outflow from an actively star-forming galaxy at the same redshift. Two candidate z>5.5 galaxies that lie within 90 kpc of the QSO sightline could be the source of the intergalactic metals we detect.

110: Circumstellar Disks: Early
AAS Oral, Monday, 10:00-11:30am, 204

110.01D

High-Resolution Imaging and Modeling of Circumstellar Debris: Architectures of Planetary Systems

Michael Fitzgerald[1], P. Kalas[1], J. R. Graham[1], G. Duchêne[2], C. Pinte[2]
[1]UC Berkeley, [2]Laboratoire d'Astrophysique, Observatoire de Grenoble, France.

Circumstellar debris disks consist of dust freshly generated by the attrition and evaporation of primitive asteroids and comets. They are analogs to our Kuiper Belt and therefore inform the the architecture of trans-Neptunian space around other stars. We wish to study the diversity of these planetary systems around stars of different masses. I present high-resolution observations of debris disks, both imaging of their scattered light with adaptive optics coronagraphy, and of thermal emission in the mid-IR. AU Microscopii is a nearby M dwarf with such a disk. Coronagraphic Keck Adaptive Optics images processed with my speckle-suppression algorithm show a blue color, from optical to the near-IR, with a blue color gradient in the disk beyond 35 AU. I discuss a Monte Carlo radiative transfer code to simultaneously model the scattered light colors and SED. I compare a multi-zoned model of the grain size and space distributions to the physical model of Strubbe & Chiang (2006). In this scenario, a ring of parent bodies at ~40 AU produces dust which diffuses into an outer extended disk due to stellar wind and radiation pressure. Comparison of the scattered light modeling to measurements of the disk in polarized light indicates the dust grains must be porous. I also present the first mid-IR images of warm dust grains around the Beta Pic analog HD 32297 (A0V). The structure of the thermal emission indicates an optically thin ring of grains at ~65 AU. A ring of parent bodies at this location may be responsible for the production of small, warm grains. I also present high-resolution near-IR Keck imaging of the scattered light disk, which is blue in color. Like in AU Mic, the outward diffusion of these small grains from the ring may be responsible for the disk's scattered light color.

110.02

SiO Outflow Observations of Young Massive Stellar Objects with Linearly Distributed Methanol Maser Emission

James M. De Buizer[1], R. Redman[2], P. Feldman[2], S. Longmore[3], J. Caswell[4]
[1]Gemini Obs., Chile, [2]NRC/HIA, Canada, [3]UNSW, Australia, [4]ATNF, Australia.

Linearly distributed methanol masers are associated with young massive stars and have been generally hypothesized to trace edge-on circumstellar disks around them. Several of these sources have been recently imaged in near-infrared H_2 emission (an outflow indicator) and it was discovered that the methanol masers were often aligned with the position angle of H_2 emission on the fields. It was therefore argued that this is evidence that the methanol masers are instead associated with outflows from these young massive stars. However, because H_2 can be excited by means other than outflow, we have undertaken a series of observations in an independent outflow indicator, namely SiO. We performed single-dish observations with the JCMT to detect SiO (6-5) in 7 out of 9 fields from the H_2 survey. Wide wings were found in the SiO lines, supporting the outflow hypothesis. Interferometric follow-up observations of SiO (2-1) with the ATCA at high-spatial resolution have now been analyzed for 4 of the fields where SiO (6-5) was detected. These observations showed the SiO (2-1) emission to be distributed spatially at similar position angles to the methanol masers distributions for all four sources. We conclude that this is further and very convincing evidence that linearly distributed methanol masers are generally associated directly with outflows and not disks.

110.03

The Likelihood of Supernova Enrichment of Circumstellar Disks

Jonathan P. Williams[1]
[1]Univ. of Hawaii.

Cluster statistics suggest that about 60% of stars form in groups with more than 1000 members. Such large groups are expected to contain at least one massive star that will undergo a supernova within the average circumstellar disk lifetime of 3 Myr. The Orion proplyds are the closest example of such an environment. I will present the first mass measurements of the dust in these disks from observations at 880 microns with the Submillimeter Array that show that sufficient material exists in several objects to form planetary systems on the scale of our Solar System. The presence of the short lived radionucleide, 60Fe, in meteorites shows, unambiguously, that at least one supernova exploded close to either the collapsing core that formed our Sun or the planetary disk itself. Gathering recent information on young embedded clusters, I show a simple analytical model and Monte Carlo simulations that estimate the likelihood of supernova enrichment of a young circumstellar disk. I conclude the likelihood is only a few percent under a range of star formation scenarios and discuss the implications for reconciling the meteoritic and astronomical evidence of our origins.

110.04

New Debris Disks Around Solar-Type Stars Imaged with the HST/ACS Coronagraph

John E. Krist[1], K. Stapelfeldt[1], G. Bryden[1], C. Chen[2]
[1]JPL, [2]NOAO.

MONDAY

We present V-band images of debris disks surrounding two nearby solar-type stars imaged for the first time in scattered light with the Hubble Space Telescope Advanced Camera for Surveys coronagraph. The disks were first resolved in the infrared by the Spitzer Space Telescope. The first disk appears as an inclined ring with inner and outer radii of 130 and 170 AU, with the outer edge apparently truncated. The scattering by the dust grains appears isotropic ($g<0.1$) and there is no evidence for any significant asymmetries. This may be the faintest disk imaged with HST. The second disk is seen out to a noise-limited distance of 100 AU and may also be a ring.

110.05

Modeling Scattered Light Images from a Planet-Forming Disk

Hannah Jang-Condell[1], A. P. Boss[1]
[1]Carnegie Inst. of Washington.

We calculate simulated images of a planet-forming circumstellar disk in scattered light emission. The simulated images bear no correlation to the vertically integrated surface density of the disk, but rather trace the density structure in the tenuous upper layers of the disk. Although the density at high altitudes are not directly related to activity at the midplane, the very existence of structure at high altitudes along with high time variability are themselves indicators of gravitational instability within the disk. The time scale for variations is much shorter than the orbital period of the planet, which facilitates obsesrvation of the phenomenon. Scattered light images may not necessarily be able to tell us where exactly a planet might be forming in a disk, but can still be a useful probe of active planet formation within a circumstellar disk. This research was supported by the NASA Astrobiology Institute under Cooperative Agreement NNA04CC09A.

111: Dust, Starbursts and Obscured AGN
AAS Oral, Monday, 10:00-11:30am, 6A

111.01

The Revealing Dust: Mid-infared Diagnostics of Nuclear Activity in Hickson Compact Groups

Sarah Gallagher[1], K. E. Johnson[2], A. E. Hornschemeier[3], J. C. Charlton[4], J. E. Hibbard[5]
[1]UCLA, [2]UVA, [3]GSFC, [4]PSU, [5]NRAO.

The multiple and ongoing gravitational interactions in compact galaxy groups make this setting eminently suitable for studying the influence of environment on nuclear activity. We present a sample of 12 nearby Hickson Compact Groups with a complete suite of 3.6-24 micron Spitzer imaging. Mid-infrared nuclear photometry is a sensitive tracer of dust heated by the ionizing continuum of hot stars or active galactic nuclei. We compare mid-infrared diagnostics of nuclear activity to optical line identifications in the literature, and discuss the challenges of distinguishing the source of ionizing radiation in these galaxies.

This project is supported by the Spitzer Science Center.

111.02

The Top 15 Luminous Obscured Quasars: SED, Luminosity and Absorption Properties

Mari Polletta[1], D. Weedman[2], C. Lonsdale[1], S. Hoenig[3], H. Smith[1], J. Houck[4]
[1]UC, San Diego, [2]Department of Astronomy, Cornell University, [3]Max-Planck-Institut fur Radioastronomie, Germany, [4]IRS Science Center, Center for Radiophysics & Space Research, Cornell University.

We present a remarkable population of z~2 obscured and extremely luminous QSOs. The sample was selected in the largest Spitzer surveys (SWIRE & NDWFS) by means of their extremely red infrared colors and bright mid-infrared fluxes. Follow-up observations with the IRS provide spectroscopic redshifts and constrain their mid-infrared luminosities. The sample includes the most luminous 15 obscured QSOs currently known. Their SEDs are modeled using a clumpy dust torus and their infrared absorption is estimated for both the continuum emission and the Silicate absorption feature at 9.7 micron. For a sub-sample of five sources for which X-ray data are available, the dust covering factor is estimated and dust extinction is compared with X-ray absorption. The properties of these luminous QSOs are discussed in the context of AGN evolutionary scenarios and absorber models.

111.03D

The Nature of Dust-Reddened Quasars

Tanya Urrutia[1], R. R. Becker[1], M. Lacy[2], M. D. Gregg[1]
[1]UC, Davis, [2]Spitzer Science Center, Caltech.

In the last few years X-ray and Infrared surveys have shown that optically selected quasars constitute less that half of the total quasar population. Dust-reddened quasars present a new and largely uninvestigated quasar population, which may have many members, which are at an earlier stage in their quasar activity in which gas and dust debris from the merger shield the view into the active nucleus. We have carried out surveys to identify these so-called red quasars and have followed them up with Chandra, HST and the VLA.

My talk will focus on Hubble ACS images of 13 Type-1 dust reddened quasars selected from the FIRST/2MASS survey. The images show strong evidence of interaction in 11 of the 13 quasars even before performing quasar subtraction. None of the host galaxies fits a perfect elliptical profile. The red quasar phenomenon seems to have an evolutionary explanation in that the young quasar spends a fraction of its lifetime enshrouded in an interacting galaxy as has been recently suggested by theoretical simulations. This might

be further indication of a link between AGN and Starburst galaxies.

111.04

A HCN and HCO+ Multi-transition Line Survey in Active Galaxies: AGN versus Starburst Environments

Melanie Krips[1], R. Neri[2], S. Garcia-Burillo[3], F. Combes[4], S. Martin[1], A. Eckart[5], G. Petitpas[1], A. Peck[1]
[1]Harvard-Smithsonian Center for Astrophysics, SMA project, [2]IRAM, France, [3]OAN, Spain, [4]LERMA, France, [5]University of Cologne, Germany.

Based on recent multi-line studies (mainly HCN, HCO+ and CO) in active galaxies, the molecular gas properties close to an AGN seem to differ significantly from those close to a starburst (SB). The origin of the differences is mostly unknown and could be everything from systematically different densities, -temperatures, -abundances to additional non-collisional excitation of the gas. We thus carried out multi-transition observations with the IRAM 30m of HCN and HCO+ in 12 nearby active galaxies, containing either an AGN and/or SB, to analyse their gas density, temperature and abundance as a function of their activity type. To reduce biases due to source filling factors and the difficulty to separate AGN from SB environments within the IRAM 30m beam for some sources, we started follow-up interferometric observations of HCN and HCO+ at the SMA and IRAM PdBI in a few selected sources at high angular resolution and sensitivity. We will discuss first results of these observations which suggest non-standard molecular abundances around AGN as main cause for the differences seen in the molecular gas properties compared to SB environments.

111.05D

Using X-rays to Probe the Physical Properties of Astrophysical Dust

Andreea Petric[1], F. Paerels[1]
[1]Columbia Univ..

It has become increasingly clear that understanding astronomically significant processes at high and low redshift, such as galactic evolution, accretion onto supermassive black holes, star formation, feedback of processed metal-rich material into the ISM and IGM, is not possible without a proper understanding of the physical properties of astrophysical dust.

X-ray observations can provide a detailed picture of the structure of grains in high-energy environments through the detectioncand analysis of X-ray absorption fine structure (XAFS) features which can provide a method for estimating the fraction of crystalline grains. Also, dust particles scatter X-rays, and many such dust scattering halos have been observed around distant Galactic X-ray sources the most remarkable of which is that around Cyg X-3. A spectrum with the Chandra High Energy Transmission Grating Spectrometer (HETGS) of this halo is available and permits a deeper investigation into the geometry, and line-of-sight grain distribution and chemical composition.

111.06D

Dust within Central Regions of Seyfert Galaxies

Rajesh P. Deo[1]
[1]*Georgia State Univ..*

We present Spitzer Space Telescope Infrared (IR) spectroscopy and the *Hubble Space Telescope* WFPC2 archival imaging of dust and gas within the central engines of Seyfert Galaxies. Using spectroscopy, we constrain the physical properties of the warm dust heated by the AGN; using imaging, we identify large-scale cold dust features in central regions of Seyfert galaxies. In particular, we characterize the IR spectral energy distributions of Seyfert galaxies using the Spitzer archives and provide diagnostics that allow separation of the AGN and the starburst components. We aim to answer some of the following basic questions: what is the geometry and structure of the dust obscuration? what is it's temperature, density and distance from the continuum source? We use this information to test the Unified model and the presumed existence a torus-like geometry for the dust obscuration. We combine the results from the IR spectroscopy and the broad-band image analysis of the central regions of Seyfert galaxies to understand the gas and dust inflow to the central engine.

112: Formation History of Galaxies
AAS Oral, Monday, 10:00-11:30am, 605-07

112.01

The Current Mass Function of Galaxies

Michael Pierce[1], R. C. Berrington[1]
[1]*Univ. Of Wyoming.*

We make use of recent photometric and kinematic surveys of nearby galaxies to construct the current mass function of galaxies. Models of hierarchical merging predict that the mass function of galaxies will evolve over time and with environment. We compute the mass within the radius containing 80% of the optical light and construct mass functions for both elliptical and spiral galaxies. We suggest that this function can be used to quantify the mass evolution of these systems and discuss its relevance to high-redshift galaxy surveys and numerical simulations.

112.02D

High Resolution Optical Velocity Fields of LSB Galaxies and the Density Profiles of Dark Matter Halos

Rachel Kuzio de Naray[1]
[1]*Univ. Of Maryland.*

We present high resolution Halpha velocity fields and derived rotation curves of a sample of almost two dozen low surface brightness galaxies. The velocity fields have been obtained using the DensePak Integrated Field Unit on the WIYN telescope. These observations test the basic tenant of cold dark matter structure formation that galaxy mass halos should be cuspy. We find the data to show that the dark matter density profiles are of lower density and more core-like than predicted in a LambdaCDM cosmology. We also use the two-dimensional data to test for the presence of noncircular motions and their effect on the interpretation of the observations. This research was supported by NSF grant 0505956.

112.03

Structure and Formation of Massive Galaxies with Old Stellar Populations at z=1.5

Elizabeth J. McGrath[1], A. Stockton[1]
[1]*Inst. for Astronomy.*

Observational evidence has been mounting over the past decade that at least some luminous (~2 L_*) galaxies at high redshift have formed nearly all of their stars within the first billion years after the big bang. These are examples of the first major episodes of star formation in the universe and provide insights into the formation of the earliest massive galaxies. We have examined in detail the morphologies and stellar populations of seven z=1.5 passively evolving galaxies using high resolution HST NICMOS and ACS imaging data as well as medium resolution Keck spectroscopy. Almost all of these galaxies appear to be relaxed systems, with smooth morphologies at both rest-frame UV and visible wavelengths. Furthermore, spectral synthesis modeling favors a single burst of star formation more than 2 Gyr before the observed epoch. We note, however, that the prevalence of old stellar populations does not necessarily correlate with early-type morphologies, as the light profiles for several of these galaxies appear to be dominated by massive exponential disks. This evidence for massive old disks, along with the uniformity of stellar age across the disk, suggests formation by a mechanism better described as a form of monolithic collapse than as a hierarchical merger. There is at least one case, however, that appears to be undergoing a ″dry merger″, which may be an example of the process that converts these unusual galaxies into the familiar spheroids that dominate galaxies comprising old stellar populations at the present epoch.

We acknowledge our collaborators in the HST observations, Gabriela Canalizo, Masanori Iye, and Toshinori Maihara. This research was supported by NSF grant AST03-07335 and HST grant GO-10418.01-A.

112.04

New Constraints on the History of Star Formation of Elliptical Galaxies

Ricardo P. Schiavon[1], G. J. Graves[2], R. W. O'Connell[1], S. M. Faber[2]
[1]*Univ. of Virginia,* [2]*University of California.*

Results of the analysis of high quality stacked spectra of SDSS red-sequence galaxies will be presented. New accurate stellar population synthesis models for Lick indices from 4000 to 5300 Angstroms are used to estimate not only the mean ages of stars in galaxies from the strengths of the Balmer lines in their integrated spectra, but also the age spread of those stars, thus posing stronger constraints on the histories of star formation in these galaxies. The new models can also be used to estimate the mean stellar abundances of iron, carbon, nitrogen, magnesium and calcium in these galaxies. In particular, their nitrogen abundances pose new constraints on the timescale for star formation in early-type galaxies. Evidence from stellar ages and abundances indicates that the bulk of the stars in early-type galaxies seems to have been formed during a brief period of star formation ($<$ 1 Gyr) before z ~ 1.2. However, small amounts of more recent star formation are required to match the data.

112.05

The Spatial Distributions of Globular Cluster Systems

Eric Peng[1], M. Takamiya[2], P. Cote[1], M. J. West[3], J. P. Blakeslee[4], L. Ferrarese[1], A. Jordan[5], S. Mei[6]
[1]NRC-HIA, Canada, [2]University of Hawaii, [3]Gemini Observatory, Chile, [4]Washington State University, [5]ESO, Germany, [6]l'Observatoire de Paris, France.

The ACS Virgo Cluster Survey is a Hubble Space Telescope program to obtain g and z ACS imaging of 100 early-type galaxies in the nearby Virgo Cluster. One of the main goals of this survey is to study globular cluster (GC) systems in an unprecedentdedly deep and homogeneous fashion across a wide range of host galaxy properties. The spatial density distributions of GCs preserves information on both early and late galactic merging. I will present the spatial distributions of GCs in Virgo early-type galaxies and discuss the implications of these results for their formation.

112.06

An X-ray, IR, and Submillimeter Flare of Sagittarius A*

Daniel P. Marrone[1], F. K. Baganoff[2], M. Morris[3], J. M. Moran[4], A. Ghez[3], S. Hornstein[3], D. Dowell[5], M. W. Bautz[2], G. R. Ricker[2], W. N. Brandt[6], G. P. Garmire[6], J. Lu[3], K. Matthews[7], G. Bower[8], J. Zhao[4], R. Rao[9]
[1]Univ. Of Chicago, [2]MIT Kavli Institute, [3]UCLA, [4]Harvard-Smithsonian CfA, [5]JPL, [6]Penn State University, [7]Caltech, [8]UC Berkeley, [9]ASIAA, Taiwan.

Energetic flares are observed in Sgr A* from radio to X-ray wavelengths. The rapid modulation timescales of these flares, particularly in the IR and X-ray bands, suggest that the emission originates from close to the black hole, so a complete understanding of these outbursts should reveal the conditions in the inner accretion regions. In recent years multi-wavelength observing campaigns have detected simultaneous flares in the IR and X-ray, but these data leave great freedom in interpretation with physical models. Here we present a flare observed over several hours on July 17, 2006 with the Chandra X-ray Observatory, the Keck II telescope, the Caltech Submillimeter Observatory, and the Submillimeter Array. This is the first flare to be captured in the submillimeter, IR, and X-ray, a wavelength range that contains the bulk of the emitted energy. We measured the evolution of the flare intensity and spectral index in each band; the flare duration ranged from an hour in the X-ray to several hours in the submillimeter and there is a significant temporal offset between the onset of the submillimeter and X-ray flares. The addition of the spectral index measurements and the submillimeter data provide stronger constraints on the flaring mechanism than were possible in previous flares, and we discuss the insights derived from these data.

112.07

Flaring Activity of SgrA*: Adiabatic Expansion of Nonthermal Plasma

Farhad Yusef-Zadeh[1], M. Wardle[2], D. A. Roberts[3], C. O. Heinke[1], C. D. Dowell[4], W. D. Cotton[5], G. C. Bower[6], F. K. Baganoff[7]
[1]Northwestern Univ., [2]Macquarie University, Australia, [3]Northwestern Univ. & Adler Planetarium, [4]Cal Tech, [5]NRAO, [6]UC Berkeley, [7]MIT.

The compact radio source SgrA* at the Galactic center is known to be variable in radio, millimeter, near-IR and X-rays. The flaring activity in near-IR and X-rays is thought to arise from the inner 10 Schwarzschild radii of the 3-4 $\times 10^6$ M☉ black hole coincident with SgrA*. Recent VLA measurements showed the evidence of flaring activity with a duration of about two hours similar to that seen in sub-millimeter wavelengths. In addition, the light curves showed a possible time delay of about 20-40 minutes between the

43 and 23 GHz peak emission. To confirm the time delay picture, we recently re-observed Sgr A* with the VLA in several epochs including simultaneous observations with the CSO and Chandra. The light curves and their corresponding cross-correlation peak are consistent with the 43 GHz peak emission leading the 23 GHz peak emission. Sub-millimeter and X-ray light curves also support a similar picture. These measurements imply that the burst of emission is due to an expanding outflow, which cools on a dynamical time scale as it moves away from SgrA*. A simple model by van der Laan (1966) or a jet model can explain the behavior of SgrA*.

113: Galaxy Clusters I
AAS Oral, Monday, 10:00-11:30am, 6B

113.01D

Hydrodynamic Models of AGN Feedback in Cooling Core Clusters

John C. Vernaleo[1], C. S. Reynolds[1]
[1]Univ. of Maryland.

Energetic arguments indicate that AGN should be capable of heating the inner regions of clusters enough to offset radiative cooling; truncating massive galaxy formation and solving the cooling flow problem. We have used high resolution, three dimensional, hydrodynamic simulations to model these interactions. We show that the inclusion of the full jet dynamics (as opposed to modeling the interaction with isotropically inflated bubbles) leads to the formation of low density channels that can, in principle, prevent the thermalization of the jet kinetic energy in the cooling core. Hence, some additional process beyond the simple hydrodynamic interaction of a fixed direction jet is required in order for AGN feedback to successfully offset radiative cooling. We report on work in progress in which the effects of jet precession and thermal conduction are included. This work was partly funded by the Chandra Cycle-5 Theory program under grant TM4-5007X.

113.02

Color and Morphological Evolution in Galaxy Clusters since z ~ 1.5

Mark Brodwin[1], P. Eisenhardt[1], A. H. Gonzalez[2], A. Stanford[3], D. Stern[1], S. Perlmutter[4], SCP, NDWFS, IRAC, FLAMEX, AGES
[1]JPL/Caltech, [2]University of Florida, [3]UC Davis, [4]UC Berkeley.

Using a probabilistic photometric redshift-based wavelet detection algorithm in the multi-wavelength IRAC Shallow Survey/NDWFS Boötes field, we have a assembled a catalog of 292 candidate galaxy clusters and groups spanning $0 < z < 2$, of which 93 are at $z > 1$. To date we have confirmed 8 $z > 1$ clusters, making this the largest existing sample of spectroscopically confirmed clusters at these redshifts. We are currently accumulating deep ACS, IRAC and MIPS data for the 18 highest significance clusters and groups at $z > 1$, with which we will measure morphologies, stellar masses and star formation rates in massive cluster galaxies during the peak era of structure formation. A preliminary analysis of the color evolution of the full cluster sample shows that between $0 < z < 1.5$ cluster galaxies are well described by short-burst passive evolution models with high formation redshifts, $z_f > 3$. Indeed, the highest redshift clusters provide the strongest such constraints, favoring formation redshifts of z_f = 4-5. In addition, we find evidence of a significant decline in the elliptical fraction with redshift, and a corresponding increase in the incidence of late-type or disturbed morphologies in ACS images of spectroscopically confirmed $1 < z < 1.5$ clusters.

113.03D

Characteristics of Megaparsec-scale Structures in the Horologium-Reticulum Supercluster of Galaxies

Matthew C. Fleenor[1], J. A. Rose[1], W. A. Christiansen[1], M. Johnston-Hollitt[2], R. W. Hunstead[3], W. Saunders[4]
[1]University of North Carolina, [2]University of Tasmania, Australia, [3]Sydney University, Australia, [4]Anglo-Australian Observatory, Australia.

We have undertaken a comprehensive spectroscopic survey of the Horologium-Reticulum supercluster (HRS) of galaxies, which includes over 2500 galaxy redshifts in the direction of the intercluster regions. Exclusively, these intercluster redshifts are obtained with the six-degree field (6dF), multi-fiber spectrograph at the Anglo-Australian Observatory. In con-

junction with the wide-field, 1.2 m UK Schmidt telescope, 6dF is the ideal supercluster observatory because we are able to obtain coherent information over large areas of the sky, as is the case with a supercluster. Our goal is to resolve the "cosmic web" of filaments, voids, and sheets surrounding the HRS and to examine the interrelationship between them.

Specifically, we find 6 void structures in the HRS region with $10 < R_{VOID} < 15$ h^{-1} Mpc that are completely absent of 6dF galaxies to a scaled radius of $R/R_{VOID} < 0.8$ for our observational limits (except for a single galaxy in one void). To discover the voids, we implement the GyVe software tool that provides a 3-D, interactive visualization environment. We observe that matter (galaxies and clusters) is not distributed evenly around these voids, but seems to follow a highly ordered arrangement. Volume-normalized, radial profiles of galaxy number counts also indicate the effects of environment and location for each void.

MCF thanks the following institutions/agencies for significant funding during my graduate career: University of North Carolina, NASA North Carolina Space Grant Consortium, Sigma Xi Research Society, the AAS, and the NSF.

113.04

A Robust Estimator of the Small Scale Galaxy Correlation Function

Nikhil Padmanabhan[1], M. White[2], D. J. Eisenstein[3]
[1]Lawrence Berkeley National Laboratory, [2]University of California, Berkeley, [3]University of Arizona.

We present a new estimator, ω, of the small scale galaxy correlation function that is robust against the effects of redshift space distortions and large scale structures. The estimator is a simple weighted integral of the redshift space correlation function and is simply related to a filtered version of the real space correlation function, allowing for a direct comparison with theory, without a need to model nonlinear redshift space distortions. This has a number of advantages over the more traditional w_{p} estimator, including (i) an insensitivity to large scale structures and the details of the truncation of the line of sight integral, (ii) improved noise properties and (iii) a compact kernel in ξ(r).

113.05

Search for Fossil Groups using NVO Technologies

Walter A. Santos, Jr.[1], O. Lopez-Cruz[2], D. Lindler[3], T. Tamura[4], C. Mendes de Oliveira[1], L. Sodre, Jr.[1]
[1]Astronomy Institute University of Sao Paulo, Brazil, [2]INAOE, Mexico, [3]Sigma Space Corporation, [4]ISAS/JAXA, Japan.

Fossil groups exhibit extended X-ray halos similar to those in poor clusters; however, in the optical they show a dominant luminous elliptical galaxy surrounded by fainter companions, tantamount to Bautz-Morgan I, I-II clusters. As anticipated in dynamical studies and high resolution numerical simulations, it has been suggested that fossil groups could be the end-product of the collapse of dense groups or poor clusters. We have cross-matched the SDSS and the ROSAT All-Sky Survey to search for fossil groups using National Virtual Observatory (NVO) technologies (e.g., OpenSkyQuery & SkyView). We have found a large number of fossil groups candidates, some of them have been included in a XMM-Newton observing proposal, in order to analyze in more detail the extended X-ray emission. We present preliminary results based on the analysis of archival data. This work was partly developed as an NVO Science Project during the latest NVO Summer School. Also this work was supported by FAPESP and CNPq.

113.06D

Mapping the Local Density and Velocity Fields

David J. Radburn-Smith[1]
[1]STScI.

Peculiar motions are a powerful tool for examining the underlying mass distribution of the local Universe. By using new tracers of the local velocity-field we are able to constrain models of the density-field based on all-sky galaxy surveys. These models allow us to study the dynamics of the local Universe and address issues such as the cause of the Local Group (LG) motion relative to the CMB.

Key to our understanding of the LG motion is a study of the Great Attractor, a nearby supercluster buried in the Zone of Avoidance. A new survey of this region, together with recent multi-band imaging, reveals the dominant structure to be a large filament approximately 120 Mpc long.

Finally, a new reconstruction of the local density and velocity fields based on the first all-sky, X-ray selected, galaxy cluster catalogue is presented. This catalogue offers a complementary mapping to the usual infrared based catalogues that tend to undersample the cores of clusters. Combining the two maps affords us a better understanding of the true mass distribution in the local Universe.

114: Nearby Galaxies and ANGST
AAS Oral, Monday, 10:00-11:30am, 3B

114.01

The ACS Nearby Galaxy Survey Treasury: Overview

Julianne Dalcanton[1]
[1]Univ. of Washington.

The ACS Nearby Galaxy Survey Treasury program (ANGST) consists of a carefully crafted imaging survey of a volume-limited sample of galaxies in the Local Universe outside the Local Group. The resulting images will allow unprecedented measurements of: (1) the SFH of a >100 Mpc^3 volume of the Universe with a time resolution of Delta[log(t)]=0.25; (2) correlations between spatially resolved SFHs and environment; (3) the structure and properties of thick disks and stellar halos; and (4) the color distributions, sizes, and specific frequencies of globular and disk clusters as a function of galaxy mass and environment. To reach these goals, we are using a combination of wide-field tiling, pointed deep imaging, and archival data to carry out a uniform analysis of the ancient and recent star formation histories of ~70 galaxies within a volume-limited sample extending to ~3.5 Mpc, with an extension to the M81 group. For all galaxies, a radial strip of imaging will cover out to beyond the optical radius and will reach photometric depths of at least 2 magnitudes below the tip of the red giant branch throughout the limits of the survey volume. Additional deep pointings will reach SNR~10 for red clump stars, sufficient to recover the ancient star formation history (SFH) from the color-magnitude diagram for the galaxies that provide more than 99% of the star formation in the local volume. The resulting analysis will produce photometric information for several million stars.

114.02

The ACS Nearby Galaxies Survey Treasury: Recovering Spatially Resolved Recent Star Formation Histories

Evan D. Skillman[1], ANGST team
[1]Univ. of Minnesota.

Because the supergiant phase of stellar evolution is short relative to the main sequence phase, it is possible to use them as chronometers to reconstruct the spatially resolved recent star formation histories of galaxies (cf., Dohm-Palmer et al. 1997, AJ, 114, 2514). Under the aegis of a cycle 14 HST program to observe a sample of M81 group dwarf galaxies (GO-HST-10605), we have used the star formation history codes of Dolphin (2002, MNRAS, 332, 91) to re-engineer the programs used in Dohm-Palmer et al. and produced automated codes with a wide range of applicability. The ANGST database will allow us our first opportunity to make the transition from analyzing prototypes to analyzing a statistically meaningful sample of galaxies. This promises real progress in quantifying the role of feedback in the evolution of galaxies.

This work is supported by NASA grants HST-GO-10605.01-A and

HST-GO-10915.06-A

114.03

The ACS Nearby Galaxies Survey Treasury: First Age and Metallicity Distributions

Benjamin F. Williams[1], J. Dalcanton[1], D. Weisz[2], A. Dolphin[3], A. Seth[4], E. Skillman[2], R. Covarrubias[1], J. Harris[3], ANGST team
[1]Univ. of Washington, [2]University of Minnesota, [3]Steward Observatory, [4]CfA.

The ANGST data set (see associated talk by Dalcanton) from the HST/ACS is providing the deepest color-magnitude diagrams (CMDs) yet measured for several nearby galaxies. These CMDs are already revealing the wide variety of stellar populations present in this volume-limited sample of galaxies. Detailed star formation history measurements on these data are underway, and I will discuss the status of these measurements including some preliminary age and metallicity distributions describing the stellar populations contained in our ACS fields. These distributions provide detailed information about the evolution of galaxies and will be essential for attempts to reconstruct the evolution of our local ~100 Mpc^3.

We acknowledge support from NASA through HST grant GO-10915.

114.04

The ACS Nearby Galaxies Survey Treasury: The Recent Star Formation History of DDO 06

Daniel R. Weisz[1], ANGST team
[1]Univ. of Minnesota.

The ANGST data set is providing an unprecedented wealth of high quality data that allows us to construct both the global and recent star formation histories (SFHs) of numerous galaxies in the Local Volume. As an initial example of our work, I will present the global and spatially resolved recent SFH of DDO 6, a Dwarf Irregular galaxy located in the Sculptor Filament. The SFH of DDO 6 shows an early period of star formation from ~12-14 Gyrs ago followed by a period of relative quiescence until ~1 Gyr ago. Within the last ~ 500 Myrs, I will show how the regions of star formation propagate throughout the galaxy, which provides insight into the mechanisms that trigger star formation. The same type of analysis will be performed on all the dwarf galaxies in the ANGST domain, which will provide unique insight into recent star formation processes and galaxy evolution.

This work is supported by NASA grant HST-GO-10915.06A

114.05

Modes of Star Formation in an Early Universe Laboratory: An HST/ACS Survey of Hickson Compact Groups

Jane C. Charlton[1], S. C. Gallagher[2], C. Gronwall[1], J. English[3], P. R. Durrell[4], R. Chandar[5], K. E. Johnson[6], W. N. Brandt[1], D. M. Elmegreen[7], M. Eracleous[1], G. P. Garmire[1], J. E. Hibbard[8], P. Hickson[9], A. E. Hornschemeier[10], S. Hunsberger[1], K. A. Knierman[11], A. Maybhate[12], C. Mendes de Oliveira[13], J. S. Mulchaey[5], C. Palma[1], B. C. Whitmore[12], A. I. Zabludoff[11], S. G. Zonak[14]
[1]Penn State Univ., [2]UCLA, [3]U. Manitoba, Canada, [4]Youngstown State Univ., [5]OCIW, [6]Univ. of Virginia, [7]Vassar College, [8]NRAO, [9]Univ. of British Columbia, Canada, [10]NASA Goddard, [11]Univ. of Arizona, [12]STScI, [13]Univ. of Sao Paulo, Brazil, [14]Univ. of Maryland.

We describe our ongoing Cycle 15 program to obtain BVI HST/ACS imaging of 12 of the nearest Hickson compact galaxy groups, with z<0.02. We are assembling a multi-wavelength dataset for these groups, including Spitzer, Chandra, GALEX, Swift/UVOT, VLT, and ground-based imaging and spectroscopy. For selected regions, hosting the most recent star formation, we will also obtain HST/WFPC2 U-band and ACS/H-alpha images. In the ensemble of 12 groups we expect to study more than 1000 star clusters forming inside and outside of galaxies, 4000 old globular clusters in >40 giant galaxies, over 20 tidal features, >15 AGNs, and widespread intragroup gas. The different modes of star formation triggered by repeated and ongoing gravitational encounters in these groups will illuminate those that occur in the high redshift universe.

114.06D

The Star Formation Rate Density of the Local Universe from SINGG

Daniel Hanish[1], G. R. Meurer[1], SINGG Team
[1]Johns Hopkins Univ..

We use Hα data from SINGG (The Survey for Ionization in Neutral Gas Galaxies) to measure the star formation rate density of the local universe. SINGG is a survey of nearby galaxies selected by their HI content, resulting in a sample free of many of the biases common to other surveys of star-forming galaxies. Our results, derived from over 300 galaxies, confirm that star formation has drastically decreased in gas-rich galaxies since z~1.5. Additionally, we break down the Hα and R-band luminosity densities in terms of the integrated properties of our sample, including HI mass, stellar luminosity, dynamical mass, and surface brightness. We find that the SINGG sample covers a wider range in each of these variables than do optically-derived samples, and that significant star formation occurs in types of galaxies which would not be included in many other samples. A comparison of the dynamical masses of our galaxies with their stellar and HI masses shows significant evidence of downsizing: the most massive galaxies have a larger fraction of their mass locked up into stars than HI, while the opposite is true for less massive galaxies.

114.07

The Stellar Populations in the Outer Banks of Massive Disk Galaxies

Roelof De Jong[1], GHOSTS team
[1]STScI.

In recent years we have started to appreciate that the outer banks of galaxies contain valuable information about the formation process of

galaxies. In hierarchical galaxy formation the stellar halos and thick disks of galaxies are formed by accretion of minor satellites, predominantly in the earlier assembly phases. The size, metallicity, and amount of substructure in current day halos are therefore directly related to issues like the small scale properties of the primordial power spectrum of density fluctuations and the suppression of star formation in small dark matter halos after reionization.

We will show initial results from our ongoing HST/ACS GHOSTS (Galaxy Halos, Outer disks, Star clusters, Thick disks, and Substructure) survey of the resolved stellar populations of 14 nearby, massive disk galaxies. We will show that the smaller galaxies have no significant halo. We will present the stellar populations of a very low surface brightness stream around M83, the first such a stream resolved into stars beyond those of the Milky Way and M31. Finally, we will show that the old RGB stars of the thick disk in an edge-on galaxy truncate at the same radius as the young thin disk stars, providing insights into the formation of both disk truncations and thick disks.

115: Pulsars and White Dwarfs I
AAS Oral, Monday, 10:00-11:30am, 201

115.01

A New Analytical Model for Bulk and Thermal Comptonization in Accretion Powered X-Ray Pulsars

Peter A. Becker[1], M. T. Wolff[2]
[1]George Mason University, [2]Naval Research Laboratory.

We describe a new theoretical model for the formation of the emergent spectra in accretion-powered X-ray pulsars. The model is based on an explicit treatment of the bulk and thermal Comptonization occurring in a standing, radiation-dominated shock located in the pulsar accretion column.

Using a rigorous eigenfunction expansion method, we obtain a closed-form expression for the Green's function describing the upscattering of monochromatic seed radiation injected into the column. The Green's function is convolved with bremsstrahlung, cyclotron, and blackbody source terms to calculate the emergent photon spectrum. The scattering of the seed photons in the shock naturally produces an X-ray spectrum with a relatively flat continuum leading up to a high-energy exponential cutoff. The results are in good agreement with the observed spectra for X-ray pulsars covering a very large range in luminosity, including bright sources such as LMC X-4 and Her X-1 as well as low-luminosity sources such as X Per.

115.02D

Probing Binary Evolution Using the Pulsar Fossil Record

Robert D. Ferdman[1], I. H. Stairs[1], M. Kramer[2], M. A. McLaughlin[3], A. Faulkner[2], D. C. Backer[4], P. Demorest[4], D. J. Nice[5], M. Burgay[6], F. Camilo[7], N. D'Amico[6], G. Hobbs[8], D. R. Lorimer[3], A. G. Lyne[2], R. Manchester[8], A. Possenti[6]
[1]University of British Columbia, Canada, [2]Jodrell Bank Observatory, United Kingdom, [3]West Virginia University, [4]University of California, [5]Bryn Mawr College, [6]INAF, Italy, [7]Columbia University, [8]ATNF, Australia.

The Parkes Multibeam Pulsar Survey has yielded a significant number of very interesting binary and millisecond pulsars. Two of these objects are part of an ongoing timing study at the Green Bank Telescope (GBT). PSR J1756-2251 is a double-neutron star (DNS) binary system. Its orbital properties show it to be a similar system to PSR B1913+16, the original binary pulsar system discovered by Hulse and Taylor. Mass measurements of this system thus provide another important opportunity to test the validity of General Relativity, and to study the evolutionary history of DNS systems. PSR J1802-2124 is part of the relatively new and unstudied ″intermediate-mass″ class of binary pulsars. These typically spin with periods in the tens of milliseconds, and often have relatively massive (> 0.7 solar masses) white dwarf companions. GBT observations over the past two years have enabled us to detect the Shapiro delay in this system. This has led to the determination of the individual masses of the neutron star and white dwarf companion, providing constraints on the mass-transfer history in this unusual system.

115.03D

X-ray Emission from Millisecond Pulsars

Slavko Bogdanov[1]
[1]Harvard University.

I have conducted a detailed study of the X-ray study of rotation-powered millisecond pulsars (MSPs). The majority of MSPs are found to exhibit low-luminosity thermal radiation from their heated polar caps. In terms of X-ray properties, there are no apparent differences between MSPs in globular clusters and the field of the Galaxy. Two globular cluster MSPs are found to exhibit X-ray/optical properties remarkably similar to accreting X-ray MSPs in quiescence and may be the missing link between accretionand rotation-powered MSPs. I present a model of the thermal emission from MSPs, which allows constraints on the emission properties, magnetic field geometry, and compactness of the underlying neutron star.

115.04

New XMM Observations of the Accreting Millisecond X-ray Pulsar SAX J1808.4-3658 in Quiescence

Craig O. Heinke[1], R. Wijnands[2], P. G. Jonker[3], R. E. Taam[1]
[1]Northwestern Univ., [2]University of Amsterdam, The Netherlands, [3]Utrecht University, The Netherlands.

We have performed a second observation of SAX J1808.4-3658 in quiescence (after the first in 2001, Campana et al. 2002). Reanalyzing both observations, our observation finds SAX J1808.4-3658 at a 30% lower (2 sigma) observed flux level, Fx(0.5-10 keV)=$3.1*10^{-14}$ ergs/cm^2/s. The spectrum is similar to the previous quiescent observation, consistent with a power-law of photon index 1.8 without strong evidence for a neutron star atmosphere component. Considering the new distance (3.5 kpc) recently calculated by Galloway and Cumming, we constrain the bolometric luminosity from the neutron star to $L_{NS,bol}<10^{31}$ ergs/s, the lowest yet measured. This low quiescent luminosity requires enhanced neutrino cooling from the neutron star core, more than can be provided by either kaon or pion condensates in the core.

115.05

The Distribution of Ages, Magnetic Fields and Spin Periods of Millisecond Pulsars

Bulent Kiziltan[1], S. E. Thorsett[1]
[1]Department of Astronomy & Astrophysics, U.of California, Santa Cruz.

The origin of the bimodal magnetic field distribution of **Millisecond Pulsars** (MSPs) has been a subject of debate for more than 14 yrs. We show that the *effect of secular acceleration* **to the observed spin down rate of some of the nearby PSRs is significant. We will review the latest age and magnetic field distribution of MSPs and discuss the ramifications on the initial spin periods, characteristic ages, evolution and the accretion history of MSPs.**

115.06

Big, Smart Dishes to Find Thousands of New Radio Pulsars

Joeri van Leeuwen[1]
[1]UC, Berkeley.

The 300-m diameter Arecibo radio observatory in Puerto Rico is the biggest dish in the world and since the installation of ALFA (the Arecibo L-Band Feed Array) it can look in seven different directions simultaneously. This makes it very well suited for finding new dim sources spread over the sky: distant dark galaxies or far-away radio pulsars for example. I will focus on the latter, discussing the results of the currently ongoing radio pulsar survey (many recycled and normal new radio pulsars, some in extremely relativistic orbits) and explaining what we can expect in the next two years -a thousand new pulsars and perhaps the first neutron star-black hole binary?

Evolving away from the single big dish concept, the Allen Telescope Array will combine 42-100 smaller dishes, with large beams on the sky and wide frequency coverage.

LOFAR is a low-frequency radio telescope of revolutionary design that is currently being constructed and will be operational in 2007. In stark contrast to radio dishes, LOFAR is the first telescope that relies on a central supercomputer to combine the signals of ten thousand individual dipoles to form several extremely sensitive, independently steerable beams on the sky. I will discuss the impact LOFAR will have on our research into the epoch of reionisation, transient sources, ultra high energy cosmic rays, deep extragalactic surveys and pulsars.

Finally I will discuss how the Square Kilometre Array will combine and super-size these three telescope approaches, promising to find all pulsars in the Galaxy, and more.

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1) Niels Stensen fellow. This work is supported through NSF grant AST-0507807

115.07

The External Pollution of GD 362: The Bulk Composition of an Extra-Solar Asteroid?

Carl Melis[1], D. Koester[2], B. Zuckerman[1], B. Hansen[1], M. Jura[1]
[1]UC, Los Angeles, [2]University of Kiel, Germany.

Keck HIRES (Vogt et. al 1994) and NIRSPEC (McLean et. al 1998) spectroscopy of GD 362 reveals the greatest number of atomic and ionic species ever documented in a white dwarf. We determine abundances of H, He, Na, Mg, Al, Si, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Sr, and upper limits on C and O in the star's photosphere. The discovery of helium requires substantial modification of previously accepted stellar parameters derived assuming a hydrogen-dominated atmosphere.

MONDAY

GD 362 has a dusty circumstellar disk. If the disk resulted from the tidal disruption of an asteroid, then our measured elemental abundances represent the first thorough study of the bulk composition of an extrasolar minor planet.

116: Advanced Physics in the Pre-High School AP, IB and Dual Enrollment Courses
AAPT Invited, Monday, 10:00-11:30am, 310

Chair

Paul Hickman[1]
[1]*Science Education Consultant.*

117: The Once and Future Role of Women in Astronomy
AAPT Invited, Monday, 10:00-11:30am, 615

Chair

Jill Marshall[1]
[1]*UT at Austin.*

117.01

Dorrit Hoffleit: A Century of being a Woman in Astronomy

Dorrit Hoffleit[1], P. L. Gay[2]
[1]*Yale University,* [2]*Southern Illinois University Edwardsville.*

From working as one of Harlan J. Smith's female calculators in 1928 to running Maria Mitchell Observatory in 1957 to being an emeritus research scientist at Yale University today, Dr. Dorrit Hoffleit has been a professional woman in astronomy for 78 years and an astronomy lover for a century. She has faced both accolades, starting with the Carolyn Wilby Prize in 1938 for her dissertation work, as well as discrimination, most notably being hired at the Aberdeen Proving Ground at a sub-professional rating during WWII. Through both good and bad, she kept her eye on the stars, and her focus on doing the best work she could. In this presentation, Dr. Hoffleit reflects on her experiences and her inspirations in an video-interview. Additionally, archival film provided by the AAVSO will be shown.

117.02

Women in Physics and Astronomy

Rachel Ivie[1]
[1]*American Institute of Physics.*

Compared with other scientific fields, women are extremely underrepresented in physics, although their representation has increased in the last 30 years. Almost half of all high school physics students are female, yet the percentage of physics bachelor's degrees earned by women has never been higher than 23%. Women earned 29% of the PhDs awarded by stand-alone astronomy departments in 2004. In contrast, women earned only 16% of the PhDs awarded in physics. In addition, very few Hispanic and African-American women earn physics degrees in the US. Representation of women on physics and astronomy faculties continues to be low. However, our data show that women's representation on physics and astronomy faculties is consistent with degree production in the past. We have recently collected new data on female physics and astronomy faculty. These data will be discussed, along with data on the types of faculty positions into which women are hired. New statistics on female department chairs also will be presented.

117.03

The Progress, Status, and ″Roles″ of Women in Astronomy

Lynne Hillenbrand[1]
[1]*Caltech.*

I offer the perspective of a ″thirty-something″ professor of astronomy at a major research university on the progress, status, and ″roles″ of women in this field. Through a combination of assembled statistics, hearsay, and personal narrative I hope to illustrate some of the modern triumphs and also the modern challenges that have come with the forward strides of women participating in professional astronomy.

118: Nanoscale Physics in the Classroom
AAPT Special, Monday, 10:00-11:30am, 616

Chair

Paul W. Zitzewitz[1]
[1]*University of Michigan-Dearborn.*

118.01

National Center for Learning and Teaching in Nanoscale Science and Engineering (NCLT)

Nicholas Giordano[1]
[1]*Purdue University.*

The NCLT is an NSF-sponsored, collaborative project involving traditional scientists, science educators, and learning science researchers from Northwestern University, the University of Michigan, the University of Illinois at Chicago and at Urbana-Champaign, and Purdue University. This talk describes NCLT efforts in several areas: (1) Research into how and where nanoscience concepts can be introduced into the 7-12 curriculum, (2) How to design grade-appropriate nanoscience activities at the 7-12 level, (3) The design and implementation of professional development programs to enable teachers to integrate nanoscience into traditional chemistry, physics, biology, and mathematics classes.

The NCLT research is also addressing the larger issue of how emerging new interdisciplinary science topics can be introduced into 7-12 science classrooms.

Supported by NSF through grant ESI-0426328.

118.02

Resource Materials for Nanoscale Science and Technology Education

George Lisensky[1]
[1]*Beloit College.*

Nanotechnology and advanced materials examples can be used to explore science and engineering concepts, exhibiting the ″wow″ and potential of nanotechnology, introducing prospective scientists to key ideas, and educating a citizenry capable of making well-informed technology-driven decisions. For example, material syntheses an atomic layer at a time have already revolutionized lighting and display technologies and dramatically expanded hard drive storage capacities.

Resource materials include kits, models, and demonstrations that explain scanning probe microscopy, x-ray diffraction, information storage, energy and light, carbon nanotubes, and solid-state structures.

An online Video Lab Manual, where movies show each step of the experiment, illustrates more than a dozen laboratory experiments involving nanoscale science and technology. Examples that are useful at a variety of levels when instructors provide the context include preparation of self-assembled monolayers, liquid crystals, colloidal gold, ferrofluid nanoparticles, nickel nanowires, solar cells, electrochromic thin films, organic light emitting diodes, and quantum dots.

These resources have been developed, refined and class tested at institutions working with the Materials Research Science and Engineering Center on Nanostructured Interfaces at the University of Wisconsin-Madison (http://mrsec.wisc.edu/nano).

118.03

Small Talk: Conversations about Nanotechnology through Podcasts

Stephanie V. Chasteen[1], P. Doherty[1]
[1]*Exploratorium Teacher Institute.*

Why didn't we all just stay home today? Partly, we like to hear people talk. It's more fun than reading. Podcasts (downloadable audio files created on a computer) allow us to easily become radio producers and exploit the power of audio. The listener may relate on an intimate level to discussions, conversations, and stories that are communicated through this medium. Therefore, science topics with strong societal or human connections are ideal candidates for podcasting. Nanotechnology has the potential to change the world through advances in medicine, computing, environmental sensing, renewable energy, fuel, and more. The public remains largely uninformed, however, about nanotechnology, and its potential benefits and risks. I will show you how we have used podcasts to broadcast conversations with researchers about nanotechnology. I will also talk about other public programs at the Exploratorium which engage the public in discussions about this emerging science. (See http://www.nisenet.org/)

118.04

Nanoscale Physics Inquiry Activities

Jill N. Johnsen[1]
[1]*Exploratorium.*

A series of inquiry activities have been developed through the Nano Education and Outreach (NEO) Program, a graduate student development program offered through the Nanoscale Informal Science Education (NISE) Network at the Exploratorium in San Francisco, to introduce students to the field of nanoscale physics and nanotechnology. Geared for middle school through high school students, these inquiry activities investigate the physical and chemical properties of nanoscale materials and advances and research in nanotechnology. A series of new inquiry activities will be presented along with an overview of the NEO program.

119: Resource Collections and Communities Online through ComPADRE
AAPT Special, Monday, 10:00-11:30am, 303

Chair

Bruce Mason[1]
[1]*OU.*

119.01

Overview of the Student Collection on ComPADRE

David Donnelly[1]
[1]*Texas State University San Marcos.*

The Nucleus is the student collection in the ComPADRE digital library. The collection has been developed with two main goals: to provide valuable resources to physics and astronomy students, and to build an online student community. The author will present the salient features of the collection, and discuss their historical development. The author will also discuss the student collection in the context of the entire ComPADRE project. The relation of the collection to the other collections in ComPADRE will also be discussed.

119.02

AstronomyCenter.org: Your Online Destination for Astronomy Education Resources

Gina Brissenden[1], S. Deustua[2]
[1]*Univ. of Arizona,* [2]*American Astronomical Society.*

AstronomyCenter.org is the "Astro 101" archive of the NSF National Science Digital Library and part of ComPADRE. Instructors can use the archive (or "collection") to find curriculum materials, images, classroom demonstrations, labs, online learning resources, evaluation instruments, and articles about teaching strategies in astronomy education. Items in the archive are categorized by *type* of material (e.g. labs, images, pedagogy) and by *topic* (e.g. cosmology, stars, astronomy education). Each item includes a brief description, and many of the items include reviews. In addition, AstronomyCenter.org can help instructors organize materials in the archive within a "Filing Cabinet," add annotations to the materials, and share the materials with others. AstronomyCenter.org is only as good as our community makes its. We are seeking additional exemplary materials, as well as reviews of existing materials. In this session we will discuss how you can become an active member of the AstronomyCenter.org community.

119.03

Physics To Go: an Outreach Digital Library

Edward V. Lee[1]
[1]*American Physical Society.*

Physics to Go, part of the NSF-funded ComPADRE digital library, is a collection of websites for informal physics learning. This talk will present Physics To Go's homepage features, show how these features are created, how resources are identified, and how Physics To Go complements other physics outreach websites.

MONDAY

119.04

The Physics Front: Resources for High School Physics & Physical Science Teachers

Cathy M. Ezrailson[1]
[1]*Texas A&M University.*

The overarching goal of the Physics Front, (part of ComPADRE -Physics and Astronomy digital library) is to provide enhanced accessibility to quality physics teaching resources for all pre-college teachers of physics and the physical sciences with special materials for new and "cross-over" teachers.

Some highlights/features of the site are:

• A collection of physics-related topics with units of instruction including content, tutorials, labs and reference materials.

• Descriptions of some PTRA manuals with example activities.

• A "Welcome to the Profession" statement from the New Physics Teacher Manual.

• Classroom techniques and best practices.

• Simulations and images to enhance instruction for students.

• Special features and help for the new physics teacher

• Discussion Forums

• Filing cabinet for sharing and organizing teaching materials

Advantages of using The Physics Front:

• Peer -reviewed materials

• Connections with other physics teachers nation/worldwide

• Content and pedagogy support

• Venue for sharing, accessing and archiving exemplary teacher-designed materials

• Opportunity to contribute to a dynamic and growing online physics teacher community

120: Significant Advances in Low Temperature Physics AAPT Special, Monday, 10:00-11:30am, 307-08

Chair

Warren Hein[1]
[1]AAPT.

120.01

Absolute Zero

Russell J. Donnelly[1], D. Sheibley[2], M. Belloni[2], D. Stamper-Kurn[3], W. F. Vinen[4]
[1]University of Oregon, [2]Davidson College, [3]UC, Berkeley, [4]University of Birminham, United Kingdom.

Absolute Zero is a two hour PBS special attempting to bring to the general public some of the advances made in 400 years of thermodynamics. It is based on the book "Absolute Zero and the Conquest of Cold" by Tom Shachtman. Absolute Zero will call long-overdue attention to the remarkable strides that have been made in low-temperature physics, a field that has produced 27 Nobel Prizes. It will explore the ongoing interplay between science and technology through historical examples including refrigerators, ice machines, frozen foods, liquid oxygen and nitrogen as well as much colder fluids such as liquid hydrogen and liquid helium. A website has been established to promote the series: www.absolutezerocampaign.org. It contains information on the series, aimed primarily at students at the middle school level. There is a wealth of material here and we hope interested teachers will draw their student's attention to this website and its substantial contents, which have been carefully vetted for accuracy.

120.02

Ultracold Quantum Gases

Daniel Stamper-Kurn[1]
[1]University of California, Berkeley.

Continuing the long tradition of low temperature physics, ultracold quantum gases are used today to study subtle order and emergent phenomena of many-body quantum systems. I will touch of some of these exciting developments, including atom optics and the nascence of quantum atom optics, explorations of novel quantum fluids, and the diversity of ultracold, strongly-correlated atomic systems.

120.03

Significant Advances in Low Temperature Physics

William F. Vinen[1]
[1]University of Birmingham, UK, United Kingdom.

The turbulent flow of a fluid has been studied since the time when Leonardo da Vinci drew his beautiful illustrations of it. It is of enormous importance: in practical situations ranging from meteorology to marine engineering; and in the theoretical study of non-linear dynamics, where it presents us with some of the most challenging problems. But it remains only imperfectly understood. Recently the range of fluids in which turbulence is studied has been broadened to include superfluids, which exist only at very low temperatures, in which the rotational motion characteristic of turbulence is subject to quantum restrictions, and in which there is no viscosity to dampen the turbulent flow. The lecture will address three questions. How does the quantization of rotational motion influence turbulence? What happens to turbulent flow when there is no viscous dissipation? And can the study of quantum turbulence throw light on its classical counterpart?

121: SPS Undergraduate Research Outreach AAPT Oral, Monday, 10:00-11:30am, 617

Chair

Gary White[1]
[1]American Institute of Physics.

121.01

SPS Intern Contributions to ComPADRE and SOCK

Katherine N. Zaunbrecher[1]
[1]University of Louisiana at Lafayette.

This summer I interned with the Society of Physics Students (SPS), developing 1) on-line resources for undergraduate physics majors and 2) an outreach tool for local SPS chapters.

ComPADRE, digital resources for physics and astronomy education, is sponsored by NSF. The Nucleus is a part of the ComPADRE collection specifically for undergraduate students. It provides scholarship and summer research clearinghouses, as well as a discussion forum, monthly contests, and more. This summer was spent developing the new student lounge, which is now a part of the Nucleus, expanding the clearinghouses, and developing new contests and polls.

The SOCK, or SPS Outreach Catalyst Kit, is a catalyst that is available for SPS chapters who are interested in doing outreach but who may not know where to begin. The 2006 SOCK was developed this summer by the SPS Interns based on temperature, in conjunction with the Absolute Zero Campaign. The materials included in the kit were chosen based on their potential to engage students in the classroom.

Sponsored by Jack Hehn of AIP.

121.02

Astronomy and Education

Kristen Greenholt[1], S. Deustua[2]
[1]Society of Physics Students, [2]American Astronomical Society.

The mission of the Educational Office of the American Astronomical Society (AAS) is "to optimize the contributions of both the AAS and its members to enhanced science literacy for all, provide encouragement and to broaden educational opportunities for all, with particular attention to groups under-served in the physical sciences, and ensure that undergraduate and graduate programs in astronomy prepare not only the next generation of professional astronomers but also broadly trained individuals with strong technical and scientific backgrounds." [1] These objectives were realized in our bi-focal research this summer. First, we analyzed the education policy objectives set forth in the national agenda, through legislation sparked by the Rising Above the Gathering Storm (RAGS) Report, such as the American Competitiveness Initiative (ACI) and the Preserving America's Competitive Edge (PACE) Acts. We compared the goals of these pieces of legislation with the educational goals of the American Astronomical Society, and drafted a paper demonstrating the alignment of the two, in order to effectively show the support of AAS for legislation which seeks to enhance and improve science education. Second, we studied the location and distribution of dust in IC4402, using Image Reduction Analysis Facility (IRAF) programs. We observed clear dust lanes in the galaxy, with a distribution that did not appear to be symmetric, consistent with our expectations.

(1) AAS website, http://www.aas.org/education/edoffice.htm#edoffice, Accessed from the web, 1 October 2006.

121.03

Studying a Quantum 'Bounce'

David L. Sheibley[1], M. Belloni[1]
[1]Davidson College.

In quantum mechanics, a localized wave packet serves as the analog to a classical particle. Motions of such packets, whether free or bound, are often studied. The intermediate step between a free packet and a packet in the infinite square well (ISW) is the single 'bounce' of a quantum wave packet off a single infinitely high and thick potential energy wall. This case is particularly interesting because much of the dynamics can be solved exactly using the method of images. This process uses two wave packets that are mirror images of each other, both in position and in momentum. We will discuss the general solution to this problem and also our series solution of the Wigner *quasi*-probability distribution in phase space. This 'mirror bounce' solution is tested for validity by comparison with results for the infinite square well under similar conditions.

Work on this project was sponsored by Mario Belloni.

121.04

Microsized Objects in Optical Tweezers with Orbital Angular Momentum

Kyle A. Brandenburg[1]
[1]*Xavier University.*

Recently, micromechanical elements which are rotated with light have been suggested as optically driven motors. An opto-mechanical rotation can be generated by linear momentum transfer from photons to helical structures. Light can directly transfer two kinds of angular momentum to tiny objects making them spin: spin angular momentum which is associated with circular polarization and orbital angular momentum which can be described as light with a helical momentum vector. We were able to trap and rotate a number of beads within a laser trap with orbital angular momentum. By analyzing the speed at which these beads rotate we hope to deduce the amount of force with which the laser powers this simple motor. We will present our own studies in this interesting subject and discuss some possible applications in physics and biology.

121.05

True Color Holography with Three Wavelengths

Jeremy R. Swearingen[1]
[1]*Xavier University.*

Single wavelength holography provides a three-dimensional snapshot of an object?s size, shape, and position relative to the holographic medium. However, single wavelength holography is limited because it does not preserve the integrity of the original object?s color. When the hologram is played back, the object in the hologram will appear to be the color of the wavelength used to record the hologram. This can be remedied by employing multiple wavelengths, namely three: red, blue, and green as to create a ?pseudo white? laser beam. To achieve this pseudo white beam, the red, blue, and green lasers must be merged with the appropriate dichroic filters and passed through the same spatial filter to expose the hologram as if the light was all coming from the same source. I will discuss the setup used to record these ?true color? holograms and the difficulties in developing them.

121.06

The Effects of Magnetic Fields on Cooling Fans

Raphael G. Cherney[1]
[1]*Brownell-Talbot School.*

It was observed that power supplies failed during large physics experiments around magnetic fields. These failures may be due, in part, to the effects of magnetic fields on the cooling fans. A solenoid was built to replicate the environment. Multiple cooling fans were tested, and measurements were taken on the size of the current drawn by the fan and the speed of the rotation of the motors. The study found two problems: induced currents and the Hall Effect. The largest factor was observed to be the orientation of the fan with respect to the magnetic field.

121.07

Evaluation of a Novel Design for an Electrostatic Quadrupole Triplet Ion Beam Lens

L. R. Burns[1], J. D. Bouas[1], S. Matteson[1], D. L. Weathers[1]
[1]*Ion Beam Modification and Analysis Laboratory (IBMAL) — University of North Texas.*

We describe the design and evaluation of an electrostatic quadrupole triplet lens constructed to focus ion beams of up to 200 keV in energy. The lens was built to be used in an apparatus for fundamental sputtering studies. These studies are motivated in part by a desire to understand the influence of low-energy physiochemical processes on surfaces and atmospheres exposed to the solar wind in the inner Solar System. The lens is very compact and incorporates a feature to induce octupole fields that can correct for spherical and other octupole-order aberrations. Two methods were used to evaluate the lens: observation of the focused beam spot on a specially fabricated target while systematically varying lens voltages, and the grid-shadow technique. The latter demonstrated that octupole-order aberrations were completely corrected in one direction when the lens quadrupoles were operated individually with appropriate octupole excitations. This research was made possible by a grant from the National Science Foundation through the Physics Research Experience for Undergraduates (REU) Program at the University of North Texas. Additionally, funding was provided by the Ronald E. McNair Post-baccalaureate Achievement Program at the University of North Texas.

MONDAY

121.08

Packets in the Classical Asymmetric Infinite Square Well

Robert W. Correll[1]
[1]*Davidson College.*

In quantum mechanics, it is common to compare the probability distribution of a particle with its classical analog. In particular, the comparison between "stationary states" and classical probability distributions is often used to illustrate the Correspondence Principle in quantum mechanics. An alternative approach is to compare a quantum wave-packet with a similar collection of classical particles with slightly varying initial conditions. We will use computer simulations to compare classical "expectation values" and phase-space distributions with their quantum analogs, focusing in particular on the asymmetric infinite square well. Emphasis will be placed on the relationship between classical and quantum phenomena and results.

121.09

Sonoluminescence at Carthage: Sound into Light

Lukas K. Swanson[1], D. Arion[1], K. Crosby[1]
[1]*Carthage College.*

Single bubble sonoluminescence is a phenomenon in which acoustic energy traps and compresses a bubble resulting in the emission of light through an, as of yet, unidentified mechanism. Mathematical modeling of the single bubble system allows for theoretical predictions of the bubbles interior atmosphere such as radius, pressure and temperature as a function of time. Profiling of the light through polarization measurements, wavelength specific filter imaging as well as raw image analysis may give further insight as to the dynamics of the trapped bubble and a possible mechanism. Results of the linear polarization measurements indicate that the light emitted is not linearly polarized. Long exposures of the light clearly reproduce previously reported data of the high energy, short wavelength end of the visible spectrum by the bluish-violet glow emanating from the bubble. The procedure and design improvements of the apparatus that were made make the phenomenon of sonoluminescence more accessible to study as an undergraduate. My AAPT sponsors are Prof. Douglas Arion and Prof. Kevin Crosby.

122: Warner Prize for Astronomy
Plenary, Monday, 11:40am-12:30pm, Ballroom 6

122.01

The Formation of The Solar System and The Origin of Planetary Spins

Re'em Sari[1]
[1]*Caltech.*

Discovery of extrasolar planets and disks around young stars as well as of objects in the outskirts of our own solar system have dramatically changed our view of planets and their formation. Given constraints from these observations, we describe a scenario for the formation of our own solar system. We argue that the number of planets we see today was set by stability criteria. More objects than seen today formed very quickly. In the outer solar system, where the binding to the Sun is weak, Neptune-size objects were ejected while in the inner solar system mergers occurred via giant impacts. Following this phase of planet formation the objects had significant eccentricities and inclinations. The current circular and coplanar orbits were established later, by dynamical friction on residual small bodies. We provide a timeline for these stages of planet formation and discuss a possible origin of the planetary spins.

123: Presidential Address and Awards Presentation
AAPT Invited, Monday, 1:00-2:00pm, Ballroom 6

Chair

Richard Peterson[1]
[1]*Bethel Univ..*

124: Formation and Detection of Habitable Planets
AAS Special, Monday, 2:00-3:30pm, 611-12

Chair

Nader Haghighipour[1]
[1]*Univ. of Hawaii.*

Chair

Karen J. Meech[1]
[1]*Inst. for Astronomy.*

124.01

The Limits of Organic Life in Planetary Systems

John Baross[1]
[1]*University of Washington.*

Since Earth is the only planet that unequivocally supports living ecosystems, it is logical to first look for life elsewhere that resembles Earth-life. Earth-life requires liquid water, either light or a chemical energy source, other nutrients including nitrogen, phosphorus, sulfur, iron and a large number of elements in trace concentration. Additionally, chemical disequilibria are required to fuel the maintenance and growth of organisms. Thus the search for extraterrestrial life is focused on planets and moons that currently have or have had liquid water; that have a history of geological and geophysical properties that favor the synthesis of organic compounds and their polymerization; and that provide the energy sources and nutrients needed to sustain life. However, inasmuch as we can use Earth-life as a point of comparison, we are also limited by our almost complete lack of data about possible alternative biochemistries. We begin any extraterrestrial search by assuming carbon-based life. The key arguments in favor of carbon-based life are the ubiquity of organic compounds in the universe and the ability of carbon to form stable compounds with a high number of different inorganic elements, thus creating the wide variety of structural, catalytic and informational macromolecules that make up Earth-life. But how versatile and adequate is the carbon-based life model to environmental conditions that have either not been adequately explored on Earth, or that extend beyond the bounds found on Earth? Are there alternate carbon-based biochemistries that would allow organisms to exist under more extreme conditions than can Earth-life? What are the limitations to evolutionary innovations in carbon-based life? These questions will be discussed with emphasis on our search for life on planets and moons that have environmental conditions that are outside the bounds of Earth life including Titan, deep subsurface of Europa and Earth-like planets in other solar systems.

124.02

What Comets Tell us About Prebiotic Chemistry in Protoplanetary Disks

Karen Meech[1]
[1]*Institute for Astronomy, University of Hawaii.*

Sophisticated ground-based instrumentation on large telescopes, along with new space mission results are revealing new information about comets which provides insight into the chemistry of the proto-planetary disk out of which they formed. This new chemical information is changing our paradigm of solar system formation. This talk will review results from recent ground-based observations as well as results from the NASA Deep Impact mission. It has long been expected that comet surfaces must be thermally processed, and that inferring primordial chemical composition from the observed escaped gas is difficult because of chemistry which may occur in the gas cloud after leaving the nucleus. The Deep Impact mission provided clear evidence for thermal processing of the surface layers. There was a large increase in the organic fraction seen in the ejecta post-impact, and in the relative abundances of some organic species. Accepted comet formation models have postulated that the comet is built up of discrete cometesimals which may exhibit chemical heterogeneity as a result of radial migration in the disk. Images from the Deep Impact mission, however, showed layered structure on the comet which may have implications for different formation scenarios. Deep Impact observers saw evidence for crystalline silicates, similar to those seen in other comets, requiring a high-temperature crystallization mechanism in the disk. In addition to summarizing the current state of comet observations as they constrain our understanding of protoplanetary disk chemistry, we will discuss the types of observations that can be made as new facilities come on line and the Rosetta mission returns information, in particular to explore D/H chemistry.

This material is based upon work supported by the National Aeronautics and Space Administration through the NASA Astrobiology Institute under Cooperative Agreement No. NNA04CC08A issued through the Office of Space Science.

124.03

Planetary Environmental Signatures for Habitability and Life

Victoria Meadows[1]
[1]*Spitzer Science Center.*

In the coming decades, the search for life beyond our Solar System will use astronomical telescopes, such as NASA's Terrestrial Planet Finder and ESA's Darwin missions, to directly detect extrasolar terrestrial planets, and obtain time-resolved photometry and disk-averaged spectra. Photometry will provide a first order characterization, but spectroscopy will be our most powerful tool for probing extrasolar planetary environmental conditions. Spectra of an extrasolar planet can be used to search for signs of habitability, a planet's ability to support life, by determining the presence and nature of an atmosphere, and attempting to constrain the surface temperature. Spectroscopy may also reveal biosignatures, life's global-scale effects on a planetary environment. These biosignatures may manifest themselves as disequilibrium concentrations of gases in the atmosphere, characteristic surface reflectivity or emissivity, or temporal variability in planetary characteristics. The synergistic combination of information from several wavelength regions can also be used to provide a more robust determination of habitability and

the presence of life. Because extrasolar terrestrial planets may be significantly more diverse than those seen in our own Solar System, interdisciplinary theoretical modeling will be required to understand the likely range of planetary spectra we may find, and to assist in the spectral retrieval of planetary properties. The Virtual Planetary Laboratory (VPL) is a suite of interdisciplinary computer models, first developed under the auspices of NASA's Astrobiology Institute, used to explore the environments and spectral appearance of plausible terrestrial planets beyond our Solar System. Here, we will use VPL modeling results for Solar System planets, and for synthetic Earth-like planet environments around F, G, K and M stars to provide a brief overview of what could be learned about extrasolar terrestrial planet habitability, or the presence of life, using remote-sensing techniques.

This work was supported by NASA Astrobiology Institute's CAN-00-OSS-01.

124.04

Detection of Habitable Planets

Wesley A. Traub[1]
[1]*JPL.*

To be potentially habitable, a planet must be situated such that the combined effect of stellar luminosity and orbital semi-major axis will permit liquid water to exist on its surface. To be habitable, liquid water must exist on the planet's surface. To detect a habitable planet, we must measure or infer these properties. Missions to measure potential habitability are Kepler and SIM-Planetquest. Missions to measure habitability are TPF-C and Darwin/TPF-I. This talk will focus on the expected results from these missions, and the scientific value gained from the combination of these results.

124.05

Habitable Planet Formation; A Review of Current Status

Nader Haghighipour[1]
[1]*Institute for Astronomy, University of Hawaii.*

Although it is now widely accepted that terrestrial planets of our solar system have formed through collision of planetesimals and protoplanetary objects, the formation of Earth as a habitable planet and the origin of its water are still unknown. The discovery of now more than 200 extrasolar planets have made this matter even more complicated since, as shown by several researchers, many of these systems can be potentially habitable and harbor Earth-like objects. In this talk, I will review the status of the current theories of habitable planet formation, within the context of both our solar system and extrasolar planets, and will discuss the applicability of these theories in identifying probable targets for future space missions.

124.06

***Kepler* Mission Development**

William J. Borucki[1], D. Koch[1], N. Batalha[2], T. Brown[3], D. Caldwell[4], J. Christensen-Dalsgaard[5], E. Dunham[6], T. Gautier[7], J. Geary[8], R. Gilliland[9], J. Jenkins[4], D. Latham[8], D. Monet[10]
[1]*NASA/Ames Research Center,* [2]*San Jose State University,* [3]*Las Cumbres Observatory,* [4]*SETI Institute,* [5]*Aarhus University, Denmark,* [6]*Lowell Observatory,* [7]*Jet Propulsion Lab,* [8]*Smithsonian Astrophysical Observatory,* [9]*Space Telescope Science Institute,* [10]*U.S. Naval Observatory.*

Kepler is a Discovery-class mission designed to determine the frequency of Earth-size and smaller planets in and near the habitable zone of cool dwarf stars. The instrument is a wide field-of-view (FOV) differential photometer with a 100 square degree FOV that continuously and simultaneously monitors the brightness of more than 100,000 main-sequence stars with sufficient precision to detect transits by Earth-size planets.

As part of the Kepler Mission, a ground-based observation program is underway to measure the effective temperature, log(g), metallicity, and size of 10^7 stars in the FOV brighter than 19^{th} magnitude. The resulting catalog allows the Kepler Mission to choose well-characterized late-type dwarfs and to exclude giants and early spectral types from the target list. The catalog will be the most comprehensive study of stars in this portion of our galaxy. An asteroseismic study of several thousand bright stars will also be conducted. It is expected to yield detailed information about the size, mass, and age of these stars.

In October, an intensive, 5-day Critical Design Review of the mission was conducted by two review teams. The teams' findings are being used to refine the mission development as assembly and testing of the flight components progress. Development is on schedule for a launch on November 1, 2008.

In preparation for the launch, Participating Scientist and Guest Observer Programs are being developed. The first is expected to be announced in early 2007 while the latter is expected in 2008. The Participating Scientist Program will call for interested members of the science community to propose research programs that complement and enhance those of the Kepler Science Team. The following year, the Guest Observer Program will entertain astrophysical research on any of type of target in the Kepler FOV.

125: Galactic and Extragalactic Surveys Using AzTEC AAS Special, Monday, 2:00-3:30pm, 204

Chair

Gary Davis[1]
[1]*Joint Astronomy Centre.*

MONDAY

125.01

Session Overview and AzTEC Instrument Performance

Grant Wilson[1], P. A. Ade[2], I. Aretxaga[3], J. Austermann[1], J. J. Bock[4], D. Hughes[3], Y. Kang[5], S. Kim[5], J. Lowenthal[6], P. Mauskopf[2], K. Scott[1], M. Yun[1]
[1]*University of Massachusetts,* [2]*Cardiff University, United Kingdom,* [3]*INAOE, Mexico,* [4]*California Institute of Technology,* [5]*Sejong University, Republic of Korea,* [6]*Smith College.*

AzTEC is a new 144 element bolometer receiver destined as a first-generation instrument for the Large Millimeter Telescope. From November 2005 and through January 2006, AzTEC made science observations at the 15m James Clerk Maxwell Telescope (JCMT). Approximately 1/2 of the available time was spent mapping the submillimeter galaxy population in blank and biased fields. Overall, over 1 square degree of sky was mapped with uniform coverage in each of five primary fields making this the largest set of surveys of the submillimeter galaxy population ever performed. Hundreds of new submillimeter galaxies have been detected. Here we discuss the instrument, our mapping technique, and a brief summary of the data reduction process. We conclude with a brief summary of the overall impact of these surveys on our understanding of the submillimeter galaxy population.

125.02

AzTEC Observations of the SHADES Fields at λ=1.1mm

Mark Halpern[1], J. Dunlop[2], SHADES and AzTEC consortia
[1]*University of British Columbia, Canada,* [2]*Institute for Astronomy, United Kingdom.*

We report the results of mapping the full SCUBA HAlf Degree Extragalactic Survey (SHADES) fields at λ=1.1 mm with AzTEC on the James Clerk Maxwell Telescope. The SHADES program has already established robust 850 micron catalogues for these fields and assembled follow-up data at other wavelengths from X-ray to radio. We present a comparison between the 850 micron and 1.1 mm catalogues and new constraints on mm wavelength galaxy Spectral Energy Distributions and source densities.

125.03

AzTEC COSMOS Survey

Min Su Yun[1], P. A. Ade[2], I. Aretxaga[3], J. Austermann[1], J. J. Bock[4], D. Hughes[3], Y. Kang[5], S. Kim[5], J. Lowenthal[6], P. Mauskopf[2], K. Scott[1], G. Wilson[1]
[1]Univ. of Massachusetts, [2]Cardiff University, United Kingdom, [3]INAOE, Mexico, [4]California Institute of Technology, [5]Sejong University, Republic of Korea, [6]Smith College.

The Cosmic Evolution Survey (COSMOS) is a 2 square degree HST/ACS survey specifically designed to probe galaxy evolution as a function of time and environment (PI: N. Scoville). In addition to the extensive HST data, the COSMOS team has acquired deep multi-wavelength data from radio to X-ray (VLA, Spitzer, NOAO, CFHT, Subaru, Galex, Chandra, XMM). Spectroscopic surveys are currently under way using Magellan, Kecks, and VLT, and an extensive photometric redshift database is also being assembled. Future surveys using major new instruments such as Herschel are also being planned. To take advantage of these rich complementary databases, we have undertaken a 1100 micron imaging survey of a 30' x 30' field centered just north of the earlier mm/submm surveys by the Bolocam on CSO and MAMBO on the 30-m telescope, with a small overlap. We will present some of the preliminary results from the survey.

125.04

A Deep AzTEC Map of the GOODS-North Field

Douglas Scott[1], E. Chapin[1], I. Aretxaga[2], J. Austermann[3], K. Coppin[1], M. Crowe[1], L. Frey[1], A. Gibb[1], M. Halpern[1], D. Hughes[2], Y. Kang[4], S. Kim[4], J. Lowenthal[5], T. Perera[3], A. Pope[1], K. Scott[3], G. Wilson[3], M. Yun[3]
[1]University of British Columbia, Canada, [2]INAOE, Mexico, [3]University of Massachusetts, [4]Sejong University, Republic of Korea, [5]Smith College.

The Great Observatories Origins Deep Survey North field is a roughly 0.05 square degree region with close to the deepest data at all wavebands from X-ray to radio. Hence if one selects objects in one band and can securely identify the counterparts at other bands, then the Spectral Energy Distributions and derived properties can be readily obtained with no need for follow-up observations. We have used AzTEC on the JCMT to image the whole of the GOODS-N region, resulting in what is probably the deepest existing 1.1mm ″blank field″. We describe comparison of the AzTEC image with 0.85mm data from the SCUBA camera, and discuss the SEDs of identified galaxies.

125.05

An AzTEC 1.1mm Survey of a Highly-biased Extragalactic Field Tracing Accelerated Galaxy Formation at z~3.8 towards 4C41.17

David Hughes[1], P. A. Ade[2], I. Aretxaga[1], J. Austermann[3], J. J. Bock[4], J. Dunlop[5], E. Gaztanagal[1], R. Ivison[5], Y. Kang[6], S. Kim[6], J. Lowenthal[7], P. Mauskopf[2], A. Montana[1], M. Plionis[1], K. Scott[3], I. Smail[8], J. Stevens[9], J. Wagg[1], G. Wilson[3], M. Yun[3]
[1]Instituto Nacional de Astrofisica, Optica y Electronica, Mexico, [2]Cardiff University, United Kingdom, [3]U. Massachusetts, [4]Caltech, [5]Institute of Astronomy, Royal Obs., United Kingdom, [6]Sejong University, Republic of Korea, [7]Smith College, [8]University of Durham, United Kingdom, [9]University of Hertfordshire, United Kingdom.

Aztec has recently conducted a sensitive, wide-area (300 sq. arcmin's) continuum survey at 1.1mm using the 15-m James Clerk Maxwell Telescope towards 4C41.17, a powerful high-redshift (z ~ 3.8) radio galaxy. These Aztec data, which cover an area >40 times larger than our previous SCUBA survey, reveal a significant over-density of luminous, massive dust-enshrouded galaxies, compared to the results from lower-redshift blank-field sub-mm surveys. One natural interpretation of these new AzTEC data is that the over-density is tracing a large (5 x 5 Mpc) ″proto-cluster″ structure at z~3.8 associated with the environment of 4C41.17, within which the formation of ultra-luminous starburst galaxies (with rest-frame FIR luminosities >5 x 10^12 Lsun or SFRs > 500 Msun/yr) is taking place at an accelerated rate. Proving the physical association of these massive optically-faint starbursts with the environment of this high-z AGN, and not with the blank-field sub-mm population, for which 50% of the population lies at $1.9 < z < 2.9$, remains an outstanding problem. In this presentation we will describe the AzTEC survey, the empirical evidence for this protocluster structure in the early universe, and the planned multi-wavelength follow-up observations of the brightest AzTEC sources towards 4C41.17 that may demonstrate that we are witnessing accelerated galaxy formation, via an increased rate of merging gas-rich galaxies within a rapidly-developing gravitational potential. AzTEC is one of the suite of instruments destined for the 50-m Large Millimeter Telescope (LMT). We will conclude this presentation with a summary of future LMT observations that will trace the evolution of obscured star-formation in the dynamic environments towards a significant sample of intermediate and high-z powerful AGN with greater sensitivity and spatial resolution.

126: Job Applicants: Top 10 Questions You Should Ask AAS Special, Monday, 2:00-3:30pm, 201

Chair

Anita Krishnamurthi[1]
[1]NASA's GSFC.

Chair

Kirk Borne[1]
[1]George Mason University.

126.01

AAS Committee on Employment Panel Introduction

Kirk Borne[1], M. N. Fanelli[2], L. J. Storrie-Lombardi[3], A. Krishnamurthi[4]
[1]George Mason University, [2]Texas Christian Univ., [3]Caltech, [4]NASA's GSFC.

Many younger astronomers are unaware of the dangers and pitfalls that await them in the job market. Issues related to fringe benefits (if any), moving expenses, medical coverage for family members, teaching versus research expectations, etc. can lead to misunderstandings and to serious difficulties if these are not addressed early in the job interview process. The AAS Committee on Employment has often received letters from concerned junior members of the society, who feel that they needed more guidance and assistance in entering the job market for the first time. The major areas of concern have included those just listed, but there may be others. The session is structured as a panel presentation, whose members are asked to prepare in advance their top 10 questions that job applicants should ask, and we will instruct our panel members not to discuss their list at all with the other panel members prior to their presentations. This will ensure independent viewpoints and novel responses. The panel will consist of astronomers who have different perspectives on this issue, including old and young, postdoc and beyond, academic and non-academic. To kick off the session, we will invite a brief humorous presentation of the Top Ten List, in the style of The Night Show host David Letterman.

127: Circumstellar Disks: Not So Early AAS Oral, Monday, 2:00-3:30pm, 608-10

127.01

HST/ACS Coronagraphic Observations of the HD 163296 Circumstellar Disk

John P. Wisniewski[1], M. Clampin[1], C. Grady[2], D. Ardila[3], H. Ford[4], D. Golimowski[4], G. Illingworth[5], J. Krist[6], HST ACS Science Team
[1]NASA GSFC, [2]Eureka Scientific/NASA GSFC, [3]Spitzer Science Center, [4]JHU, [5]Lick Observatory, [6]JPL.

We present Hubble Space Telescope Advanced Camera for Surveys (HST/ACS) coronagraphic observations of the Herbig Ae star HD 163296. HD 163296's scattered light disk was resolved in the F606W and F814W filters in observations obtained in 2003 and in the F435W filter in observations obtained in 2004. The color of the disk, as determined by analysis of azimuthally averaged surface brightness profiles of the 2003 data, generally matches the observed color of HD 163296. While the 2003 epoch data do not exhibit any clear evidence of radial or azimuthal asymmetries, a distinct spiral arm structure is present in the 2004 (F435W) data. This spiral structure is spatially coincident with one of the two ansae reported in STIS white-light coronagraphic imaging of HD 163296 (Grady et al. 2000). We discuss the possible origin of the observed morphological differences in our multi-epoch dataset in context with previous efforts to spatially resolve the disk (Grady et al. 2000, 2005).

127.02

The Circumstellar Environment of HD 97048: *HST*/ACS Scattered-Light Imaging and Dust Modeling

Ryan L. Doering[1], M. Meixner[2], S. T. Holfeltz[2], J. E. Krist[3], D. R. Ardila[4], I. Kamp[5], M. C. Clampin[6], S. H. Lubow[2]
[1]Univ. of Illinois, Urbana, [2]STScI, [3]Jet Propulsion Laboratory, [4]Spitzer Science Center/IPAC, [5]ESA/STScI, [6]NASA Goddard Space Flight Center.

We present a resolved scattered-light image of the circumstellar environment around the Herbig Ae/Be star HD 97048 using the *Hubble Space Telescope* Advanced Camera for Surveys in its coronagraphic mode. The observations were carried out with the 1.8″ occulting spot through the F606W (broad *V*) filter. Dusty material is traced out to an angular distance of ~4″ from the star's position. The material's azimuthally-averaged surface brightness peaks at $r = 2''$ (the innermost measurable radius) and drops off as r to the -3.3 power. Filamentary structure resembling spiral arms similar to that seen in Herbig Ae/Be disks is observed. Such structure has been attributed to the influence of orbiting planets or stellar encounters. Radiative transfer modeling will provide a detailed analysis of HD 97048's circumstellar dust. We will use an axisymmetric code to derive dust parameters including mass, composition, grain size distribution, geometry, and inclination angle. NASA/STScI GO-10425.01 supported this work.

127.03

Models of Be Star Disks Constrained by Long-baseline Interferometry

Christopher Tycner[1], C. E. Jones[2], T. A. Sigut[2], L. Thomson[2], A. Molak[2]
[1]U.S. Naval Observatory, [2]Univ. of Western Ontario, Canada.

We demonstrate how theoretical models of the circumstellar disks surrounding Be stars are constrained by interferometric observations that spatially resolve the circumstellar regions. The disk models are constructed using a non-LTE radiative transfer code developed by Sigut & Jones, which incorporates a number of improvements over previous treatments of the thermal structure, including a realistic chemical composition. We show that the disk models of three Be stars, κ Dra, υ Cyg, and β Psc agree with the interferometric observations only for particular ranges of the disk parameters, which results in specific density structure and temperature distribution constraints.

C.T. acknowledges that this work was performed in part under contract with the Jet Propulsion Laboratory (JPL) funded by NASA through the Michelson Fellowship Program. JPL is managed for NASA by the California Institute of Technology. C. E. J. and T. A. A. S. acknowledge financial support from NSERC.

127.04D

Observations of Intermediate Mass Stars and their Circumstellar Environments with Nulling Interferometry

Wilson M. Liu[1]
[1]Univ. of Arizona.

We present results from 10 micron nulling interferometric observations of intermediate mass stars at the 6.5 m MMT and Magellan I observatories. These observations include a survey of 13 Herbig Ae stars, in order to characterize the distribution warm circumstellar dust, as well as observations of main-sequence A-type stars, with the purpose of detecting exozodiacal dust in the habitable zone of these systems. For the Herbig Ae observations, we conclusively spatially resolve three disks, surrounding HD 100546, AB Aur, and HD 179218. We find evidence that objects with mid-IR SEDs in Meeus et al. (2001) Group I (constant to rising mid-IR flux with increasing wavelength) are more resolvable. We also find a correlation between disk size vs. sub-mm SED slope and fractional IR luminosity. For the survey of main-sequence stars, we present limits on levels of exozodiacal emission and spatial distribution for 6 nearby stars. These include observations of Vega where we have constrained the density of habitable zone dust to 650 zodis, evidence that the circumstellar debris is collisionally dominated.

127.05

Infrared Emission from Aliphatic and Aromatic Hydrocarbons in Cool Radiative Environments

Gregory C. Sloan[1], M. Jura[2], W. W. Duley[3], K. E. Kraemer[4], L. D. Keller[5], B. A. Sargent[6], A. Li[7], J. Bernard-Salas[1], W. J. Forrest[6], J. D. Green[6], C. J. Bohac[6], D. M. Watson[6], J. R. Houck[1]
[1]Cornell Univ., [2]UCLA, [3]Univ. Waterloo, Canada, [4]Air Force Research Lab., [5]Ithaca College, [6]Univ. Rochester, [7]Univ. Missouri.

The Infrared Spectrograph (IRS) on the Spitzer Space Telescope has observed several spectra with emission features similar to the well known features from polycyclic aromatic hydrocarbons (PAHs), but shifted to longer wavelengths. The IRS sample builds on the previous sample observed with the Short-Wavelength Spectrometer on the Infrared Space Observatory, which included the post-asymptotic giant branch (AGB) objects AFGL 2688 and IRAS 13416-6243. New sources include MSX SMC 029, which has evolved off of the AGB, the early carbon star HD 100764, the K giant HD 233517, the intermediate-mass T Tauri star SU Aurigae, and several cool Herbig AeBe stars. The wavelength shifts of the hydrocarbon emission features in these spectra are consistent with those expected from mixtures of aromatic and aliphatic hydrocarbons, and they appear in environments once considered too cool to excite PAH emission. The aliphatic bonds which have survived in these cool radiation fields would be stripped in the harsher radiation fields associated with more typical PAH emission.

This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA in part through an award issued by JPL/Caltech.

MONDAY

128: Education Across the Spectrum
AAS Oral, Monday, 2:00-3:30pm, 605-07

128.01

Johannes Kepler's Intelligent Design

Paul M. Wallace[1]
[1]Berry College.

In the last decade, the theory labeled ″Intelligent Design″ has exacerbated long-standing conflicts between religion and science. This issue will be addressed from the perspective of the philosophy and science of Johannes Kepler (1571-1630), whose unconventional belief in design lived in harmony with his revolutionary physical astronomy.

128.02

Is Debunking Intelligent Design an Effective Approach to Teaching?

Alex Storrs[1], T. F. Slater[2], CAPER team
[1]Towson Univ., [2]Univ. of Arizona.

Good teaching demands that faculty establish students' prior knowledge and beliefs and use this to guide instruction. One of the most important beliefs many students bring with them into science instruction is religious faith. Over 80% of undergraduates claim some sort of religious affiliation (Lindholm 2004) and a fifth of these rely on a literal interpretation of the Bible. Instructors must acknowledge the deep convictions of many undergraduates, and not dismiss them as "unscientific". It is our position that teaching a science course while pretending that human affairs and convictions do not impact the scientific enterprise is not only misguided, but ineffective at providing students a liberal undergraduate education.

While including "Intelligent Design" (ID) in public school classes has been thoroughly repudiated (e.g Kitzmuller v. Dover) many students equate ID to "God". Debunking ID thus appears to prove that "God" doesn't exist. When faced with a choice between beliefs developed over a lifetime and a single science course, the natural position for students will be to discard science when it seems in direct conflict.

We propose a short discussion at the start of the first class which elicits and values student perspectives. This can defuse some of the tension experienced by students of faith and allow them to learn more science, developing better attitudes toward science. This is in contrast to simply telling students that "there is no room for faith in the objective pursuit of science." At minimum we should provide students with references to modern discussions of science and religion issues and examples of scientists of faith who are able to fully resolve seemingly disparate issues between their scientific life and their religious convictions, even when full exploration of these topics is beyond the scope of the course.

References:

Lindholm, J. (2004): http://www.spirituality.ucla.edu/Publication%20&%20Reports/Lindholm%20USC%20chapter.doc

128.03

And now... Equations!

Ran Sivron[1]
[1]Baker Univ..

With the introduction of ″Ranking Tests″ some quantitative ideas were added to a large body of successful techniques for teaching conceptual astronomy.

We incorporated those methods into our classes, and added a new ingredient: On a biweekly basis we included a quantitative excercise: Students working in groups of 2-3 draw geometrical figures, say: a circle, and use some trivial geometry equations, such as circumference = 2 x pi x r, in solving astronomy problems on 3'x4' white boards.

A few examples included: Finding the distance to the moon with the Aristarchus method, finding the Solar Constant with the inverse square law, etc.

Our methodolgy was similar to problem solving techniques in introductory physics. We were therefore worried that the students may be intimidated. To our surprize, not only did most students succeed in solving the problems, but they were not intimidated at all (that is: after the first class...) As a matter of fact, their test results improved, and the students interviewed expressed great enthusiasm for the new method.

Warning: Our classes were relatively small <40 studets). For larger classes TA help is needed.

128.04

Using Streaming Video in Delivery of an On-Line Astronomy Course

Terrence F. Flower[1]
[1]College of St. Catherine.

The teaching of Introductory Astronomy using the Internet has been practiced at the College of St. Catherine to reach students not able to physically attend class on campus. A number of different delivery systems have been employed and refined over the years. Currently we provide a blend of streaming video (some real-time, some digitally recorded) with interactive dialog and questions between student and instructor after each modular presentation. Laboratory sessions are conducted with demonstrations of activity in the streaming video format and some actual live streaming video from the college's observatory. Exams and class evaluations are conducted on-line as well. Digital streamed presentations are archived so students may access them as necessary.

128.05

"Workshop Astronomy" at Dickinson College

Windsor A. Morgan, Jr.[1]
[1]Dickinson College.

Dickinson College, a 2400-student liberal arts college in Carlisle, Pennsylvania, is recognized for the development of *Workshop Physics.* This innovative, calculus-based introductory course combines physics lectures and laboratories with integrated hands-on, small-group sessions. It allows students to do experiments, so that they will make their own observations and, with the guidance of the professor discover the principles of physics themselves.

Since spring 2006, I have been developing an introductory solar-system astronomy course in the "Workshop" format at Dickinson. Students participate in discussions with their classmates and investigate astronomical concepts with computer simulations and guided inquiry. I emphasize "practical" astronomy (such as lunar phases, sky motions, and seasons) and physics concepts (such as density and Doppler shift); thus, my students become familiar with the basics of astronomy before developing a better understanding of the solar system. In my paper, I will discuss class activities and will evaluate their efficacy based on a comparison with traditionally-taught astronomy courses.

128.06

Integrating Observatories and Planetaria into Survey Astronomy Laboratory Curricula

Michael N. Fanelli[1]
[1]Texas Christian Univ..

A few hundred thousand students enroll in "Astro 101" courses each year in the US to meet natural science curriculum requirements. Laboratories associated with these courses contain a variety of programmatic elements such as dark (and day-) time observing, computer based labs, and the use of a planetarium. The development of robust automated mounts for small telescopes, coupled with modestly priced cooled CCD cameras has provided new possibilities for survey astronomy labs use of large numbers of locally-produced digital imagery in a variety of experiments. I will describe template lab curricula (12-14 labs per semester) which utilize images obtained from a campus observatory as the primary component of a survey astronomy lab. For those fortunate enough to host a planetarium, I will describe some unorthodox planetarium labs which can also be built into the lab curriculum.

128.07

A Study of 8th Grade Students Learning the Moon's Phases Using Various Multimedia Platforms

Timothy Young[1], M. Guy[1]
[1]Univ. of North Dakota.

A study of eight 8th grade students shows that preadolescents of this age group can obtain scientific understanding of the phases of the Moon. This is consistent with other studies. In a series of mini-instruction sessions with various learning media, two groups of 4 preadolescents were guided through understanding the phases of the Moon. Group pre-interviews were compared to group post-interviews to assess that scientific understanding had taken place. In addition to protocol followed for instruction of the moon's phases, we introduced the concept of eclipses to identify turning points in the student's reasoning while holding on to the concept of phases. We present results that show that scientific understanding can proceed as a step by step process as the concept is developed during the instruction period. However we find that process can become complicated when new physical conditions are introduced and need to be explained within a working model of the phases of the Moon. We find this develops as a rethinking of the concept which at times of confusion can result in the preadolescent arriving at a wrong answer to a question. We present data of a pre-survey and 3 week post-survey that indicates some degradation of the concept has occurred. We speculate that with further minimal, directed learning that the understanding of the Sun Earth Moon system can be retained beyond the period of instruction.

129: Galaxy Clusters II
AAS Oral, Monday, 2:00-3:30pm, 6B

129.01

The Clustering of Galaxy Groups: Dependence on Mass and Other Properties

Andreas A. Berlind[1]
[1]New York Univ..

We investigate the clustering of galaxy groups and clusters in the SDSS using the Berlind et al. (2006} group sample, which is designed to identify galaxy systems that each occupy a single dark matter halo. We estimate group masses from their abundances, and measure their relative large-scale bias as a function of mass. Our measurements are in agreement with the theoretical halo bias function, given a standard LCDM cosmological model, and they tend to favor a low value of the power spectrum amplitude sigma_8. We search for a residual dependence of clustering on other group properties at fixed mass, and find the strongest signal for central galaxy color in high mass groups. Massive groups with less red central galaxies are more biased on large scales than similar mass groups with redder central galaxies. We show that this effect is unlikely to be caused by errors in our mass estimates, and is most likely observational evidence of recent theoretical findings that halo bias depends on a ′′second parameter′′ other than mass, such as age or concentration. To compare with the data, we study the bias of massive halos in N-body simulations and quantify the strength of the relation between halo bias and concentration at fixed mass. In addition to confirming a non-trivial prediction of the LCDM cosmological model, these results have important implications for the role that environment plays in shaping galaxy properties.

129.02D

The Equilibrium Structure of Dark Matter Halos in a Λ-Dominated Universe

Michael T. Busha[1], A. E. Evrard[1], F. C. Adams[1]
[1]Univ. Of Michigan.

The far future provides an excellent laboratory for studying cosmological structures. The eventual dominance of the cosmological constant causes the universe to enter a phase of exponential deSitter expansion during which dark matter halos are allowed to relax without interruptions from mass accretion. Using of suite of N-body simulations evolved to scale factor a = 100 in an ΛCDM universe, I present the equilibrium structure of halos and investigate the importance of mergers in setting this structure. Halos in equilibrium have a greatly simplified radial phase space profile characterized by a single zero-velocity surface that unambiguously defines the halo edge. The radial density profile for such halos is well fit by an NFW profile internal to r200, but is to shallow at larger radii and better fit by a truncated Hernquist profile. In order to study the importance of hierarchical merging in setting the equilibrium structure, I also present results form ΛWDM-like simulations with initial power spectra that suppress the early formation of small halos. Using these simulations, I present a modified fit to the mass accretion of Wechsler et al. (2002) that better characterizes halo growth at all epochs. At the end of the simulations, we recover density profiles and phase space structures that are virtually unchanged between the CDM and WDM cosmologies. A systematic concentration shift can be characterized in terms of the halo formation epoch, ac. Once substructure effects are removed the phase space distributions are equally unchanged.

129.03D

Environment, Kinematics, & Star Formation History of Infalling [OII] Emitters in z=0.4 cluster Abell 851

Taro Sato[1], C. L. Martin[1]
[1]UC, Santa Barbara.

Rich cluster A851 presents filamentary structures along which the galaxies may be accreted. We selected cluster [OII] emitters to i ~< 23 and r = 2 Mpc, using narrowband [OII]3727 imaging, and followed up spectroscopically using Keck LRIS & DEIMOS. We find that typical [OII] emitters are dusty starbursts with decay timescales of ~< 1 Gyr, with the frequency of bursts comparable or higher than z ~ 1 field galaxies. Their kinematics suggests they are accreted to the cluster only recently and tend to reside in the infall groups. We conclude the starbursts are likely triggered in the infall groups via galaxy-galaxy interactions, which could be enhanced due to the dynamically active state of the cluster. There is also a hint of differential evolution between dwarfs and giant [OII] emitters in the densest environments. We also present the preliminary results from our ongoing work using bulge-dominated cluster galaxies to constrain the feedback effect of enhanced AGN/starburst activities on the cluster-scale properties as observed in such well-known X-ray scaling relations as the Lx-T relation.

129.04

Simulating Cosmic Reionization from Pop II and III Stars

Hy Trac[1], R. Cen[1]
[1]Princeton University.

Cosmic reionization is one of the least understood epochs in the evolution of the universe, but the signatures in 21cm radiation from neutral hydrogen and in the KSZ effect from free electrons will provide powerful constraints on early star formation and cosmological parameters. Updated observations from SDSS and WMAP are consistent with a generic model of patchy reionization beginning as early as z ~ 20 and ending about z ~ 6. In order to study patchy reionization for different star formation histories, we have run several high-resolution N-body + radiative transfer simulations with up to 24 billion particles and 360^3 RT grid cells. The RT calculations utilized a new ray tracing algorithm in which the initially O(N^2) scaling is converted to O(N) as the radiation filling factor approaches unity in the limit of complete reionization. We demonstrate that the current observational constraints require a star formation history where both Pop III and Pop II stars are significant sources of photoionizing radiation. This work is partially supported through the NSF grant AST-0407176 and NASA grant NNG06GI09G.

129.05

A z=0.45 DLA With Only Weak MgII Absorption?

Therese Jones[1], J. C. Charlton[1], A. C. Mshar[1], G. J. Ferland[2], P. C. Stancil[3]
[1]Penn State Univ., [2]University of Kentucky, [3]University of Georgia.

We have detected FeI, MnII, CaI, and CaII absorption from one of the clouds of a multiple cloud weak MgII absorber (W(2796)=0.14 Angstroms) at z=0.4523, along the line of sight toward the quasar HE0001-2340. No other extragalactic absorber has detected FeI, and the ratio of FeI to FeII is even larger in this cloud than in Milky Way molecular cloud lines of sight. Using a Cloudy photoionization model, we have attempted to derive the physical conditions of this system. Two of the clouds have properties of typical MgII clouds, but we have been unable to produce the observed FeI/FeII and MgI/MgII ratios for the FeI-rich cloud. This raises questions about the validity of the charge transfer rates for these elements in the low temperature regime. We explore various possibilities with altered rates. Although we have not been able to fit the system with current Cloudy charge

transfer rates, our results indicate that the cloud is cold and has a high density, suggesting that it is a DLA. We cannot confirm this because the spectrum is black in the Lyman series region due to a strong system at higher redshift. We speculate about what unusual circumstances lead to detected FeI and relatively weak MgII in this unique object. This system was studied using resolution R=45,000 data UVES/VLT data from the ESO archive, and research was supported by the National Science Foundation under Grant AST-07138 and by the REU Supplement Program.

129.06D

From Galaxy Clustering to Dark Matter Clustering

Jaiyul Yoo[1], D. H. Weinberg[1]
[1]The Ohio State Univ..

I describe two methods for estimating the amount of dark matter and characterizing its clustering. Adopting the halo occupation distribution (HOD) framework, I develop an analytic model for combining galaxy-galaxy lensing and galaxy clustering to constrain the matter density parameter ($Omega_m$) and the matter fluctuation amplitude (sigma8). I present new constraints on $Omega_m$ and sigma8 obtained by applying to galaxy clustering and galaxy-galaxy lensing measurements for SDSS galaxy samples.

Using galaxy clustering measurements on small scales, I construct scale-dependent bias shapes to improve estimates of the linear matter power spectrum over a large dynamic range, tightening constraints on cosmological parameters obtainable from the SDSS-II galaxy sample.

130: Instrumentation for Ground-Based and Airborne Observatories
AAS Oral, Monday, 2:00-3:30pm, 3B

130.01

The Hertz/SMT Submillimeter Polarimeter

David T. Chuss[1], D. J. Benford[1], S. H. Moseley[1], J. G. Staguhn[1], G. M. Voellmer[1], E. J. Wollack[1], M. Krejny[2], G. Novak[2], C. Y. Drouet d'Aubigny[3], D. R. Golish[3], C. Kulesa[3], C. K. Walker[3], R. F. Loewenstein[4]
[1]NASA's GSFC, [2]Northwestern University, [3]University of Arizona, [4]Yerkes Observatory, University of Chicago.

The Hertz instrument is a 350 micron polarimeter operating on the SMT on Mt. Graham in Arizona. This polarimeter uses variable-delay polarization modulators (VPMs) to switch the polarization state of the incoming radiation before detection. These modulators operate by introducing a variable phase delay between orthogonal linear polarization states. For Hertz, two such modulators are used in series in order to fully characterize the polarization state of the astronomical polarization. We present the preliminary instrument characterization from the first light tests of the instrument.

130.02

SHARP: The SHARC-II polarimeter at the Caltech Submillimeter Observatory

John E. Vaillancourt[1], M. Attard[2], C. D. Dowell[3], R. H. Hildebrand[4], M. Houde[2], L. Kirby[4], M. Krejny[5], H. Li[6], G. Novak[5], H. Shinnaga[7]
[1]Caltech, [2]U. Western Ontario, Canada, [3]JPL/Caltech, [4]U. Chicago, [5]Northwestern, [6]Harvard-Smithsonian CfA, [7]CSO.

The Submillimeter High Angular Resolution Camera II (SHARC-II) is a 12×32 pixel camera used with the 10 meter diameter Caltech Submillimeter Observatory (CSO). We have deployed an optics module between the telescope and camera which converts SHARC-II into a sensitive imaging polarimeter, "SHARP." The camera and polarimeter currently operate at wavelengths of 350 and 450 µm; we are planning an additional passband at 620 µm. The incident beam is split into two orthogonally polarized components by the SHARP optics module and re-imaged onto opposite ends of the SHARC-II array. The result is a dual-beam 12×12 pixel polarimeter. The modular nature of the optics design allows the user to easily switch between polarimeter and camera modes during a single observing session. Here we review the optical design of SHARP, report on the instrument's performance, and review our data reduction methodology. SHARP will be used to study the magnetic field structure and dust emission properties in young stellar objects, Galactic clouds, and external galaxies. We present the first polarimetric maps of celestial sources made from SHARP observations and compare them to previous results.

This work has been supported by NSF grants AST 02-41356 and 05-05230 to Northwestern University and 05-05124 to the University of Chicago.

130.03

Gemini North Laser Adaptive Optics Performance: First Science Data

Chadwick A. Trujillo[1], F. Rigaut[1], D. Gratadour[1], M. Bec[1], T. Beck[1], S. Chan[1], A. Matulonis[1], G. Trancho[1], B. Walls[1], A. Stephens[1], M. Boccas[1], K. Grace[1], P. Gundu[1], C. d'Orgeville[1], M. Sheehan[1], J. White[1], K. White[1], R. Wyman[1], G. Herriot[2], J. Veran[2]
[1]Gemini Obs., [2]NRC-HIA, Canada.

The Gemini North Laser Guide Star Adaptive Optics system, Altair/LGS, has been offered for science use in semesters 2006B and 2007A with both NIRI (near-infrared imaging and spectroscopy) and NIFS (near-infrared integrated field unit spectroscopy). Altair/LGS uses a 589 nm laser beacon projected into the sodium layer at roughly 90 km altitude to sense and correct high-order atmospheric turbulence and primary mirror shape. An additional natural guide star is needed nearby to correct low-order tip/tilt only, allowing a roughly 3 magnitude decrease in guide star brightness and a wider corrected field than non-laser systems.

We examine the first available science data for system performance parameters useful for potential users. The primary indicators of performance are signal-to-noise ratio increase, Strehl ratio and angular resolution as a function of tip/tilt guide star brightness. Also critically important for science is guide star availability as a function of galactic latitude and declination, corrected field of view, and guide star angular separation. We examine all of these metrics using the first science data collected with the Altair/LGS system and review planned performance enhancements directly relevant to science users.

130.04

Progress Report on GISMO, a 2 mm Bolometer Camera Optimized for the Study of High Redshift Galaxies

Johannes Staguhn[1], D. Benford[1], C. Allen[1], S. Moseley[1], T. Ames[1], R. Arendt[1], W. Brunswig[2], D. Chuss[1], E. Dwek[1], A. Kovacs[3], S. Maher[1], C. Marx[1], T. Miller[1], S. Navarro[2], E. Sharp[1], A. Sievers[2], G. Voellmer[1], E. J. Wollack[1]
[1]NASA's GSFC, [2]IRAM, Spain, [3]MPIfR, Germany.

The 2 mm spectral range provides a unique terrestrial window enabling groundbased observations of the earliest active dusty galaxies in the universe and thereby allowing a better constraint on the star formation rate in these objects. We present a progress report for our bolometer camera GISMO (the Goddard-IRAM Superconducting 2-Millimeter Observer), which will obtain large and sensitive sky maps at this wavelength. The instrument will be used at the IRAM 30 m telescope and we expect to install it at the telescope in Spring of 2007. The camera uses an 8x16 planar array of multiplexed TES bolometers, which incorporates our recently designed Backshort Under Grid (BUG) architecture. The optical design incorporates a 100 mm (4 inches) diameter silicon lens cooled to 4 K, which provides the required fast beam of 0.9 lambda/D. With this spatial sampling, GISMO will be very efficient at detecting sources serendipitously in large sky surveys, while the capability for diffraction limited observations is preserved. With the background limited performance of the detectors, GISMO will provide significantly greater imaging sensitivity and mapping speed at this wavelength than has previously been possible. The major scientific driver for the instrument is to provide the IRAM 30 m telescope with the capability to rapidly observe galactic and extragalactic dust emission, in particular from high-z ULIRGs and quasars, even in the Summer season. The instrument will fill in the SEDs of high redshift galaxies at the Rayleigh-Jeans part of the dust emission spectrum, even at the highest redshifts. Our source count models predict that GISMO will serendipitously detect one galaxy every four hours on the blank sky, and that one quarter of these galaxies will be at a redshift of $z > 6.5$.

130.05D

A Survey of 3.3 Micron PAH Emission Using FLITECAM

Erin C. Smith[1]
[1]*UCLA.*

We have conducted a survey of 3.3 micron PAH emission in carbon stars, planetary nebulae, star forming regions and reflection nebulae using FLITECAM, a 1-5 micron camera and spectrometer developed for SOFIA. The survey sample was selected from ISO and IRAS target lists. All selected PNs have C/O ratios greater than 1. The initial survey was performed with FLITECAM on the Shane 3-meter telescope at Lick Observatory. FLITECAM's grism spectroscopy mode was used to obtain R~1700 spectra at both L and K band. In total, 41 objects were surveyed including 28 PNs, 6 carbon stars, 2 reflection nebula, 2 star forming regions and 3 galaxies, yielding 27 PAH detections. Using FLITECAM's wide field of view for imaging (almost 8' diameter), 3.3-micron PAH emission maps were made of NGC 7027, NGC 1333, the Orion Bar, the Trapezium and Sh 2-201 using a custom narrow band filter. These maps showed spatial displacement of PAH emission from Brackett-gamma emission. The maps were then used to place the most prominent PAH emission regions on the FLITECAM slit for follow-up spectroscopy. Additional follow-up was carried out using the NIRSPEC instrument on the Keck 2 telescope. For the more extended objects several slit positions were used to fully sample the PAH emission. The PAH emission feature exhibits changes in both central wavelength and overall shape depending on distance from the central UV source.

130.06

High Contrast and Extreme AO Experiments on the Palomar Hale Telescope

Gene Serabyn[1]
[1]*JPL.*

A number of extreme adaptive optics (ExAO) and high contrast experiments are either underway or in development at JPL for deployment to Palomar's Hale telescope. First, by reimaging a clear, off-axis telescope subaperture onto an adaptive optics (AO) system's deformable mirror, ExAO performance levels can be achieved with existing systems. We have recently implemented such a system, and have already used it on the telescope to achieve stellar Strehl ratios exceeding 90% in the infrared. We have also achieved good AO correction to wavelengths as short as the B band, where a binary separated by 0.34 arc sec was very well resolved. We have also carried out high-contrast coronagraphy experiments with a four-quadrant phase mask coronagraph, where a 100:1 stellar rejection was achieved. Future plans include a variety of additional coronagraphic tests, as well as the deployment of a dual aperture fiber nuller.

131: Pulsars and White Dwarfs II
AAS Oral, Monday, 2:00-3:30pm, 3A

131.01

Spitzer Space Telescope Observations of SGR and AXP Environments

Stefanie Wachter[1], C. Kouveliotou[2], S. Patel[3], D. Figer[4], P. Woods[5]
[1]*Caltech,* [2]*MSFC,* [3]*NSSTC/USRA/MSFC,* [4]*Rochester Institute of Technology,* [5]*Dynetics.*

Both Anomalous X-ray Pulsars (AXPs) and Soft Gamma Repeaters (SGRs) are thought to be manifestations of magnetars, i.e. neutron stars with ultrahigh magnetic fields. However, the specific physical characteristics that differentiate the two classes of objects remain unclear. We now also know of a small sample of radio pulsars with magnetic field strengths approaching or overlapping those of the AXPs, but they do not display the same type of high energy properties. This raises the question why some neutron stars are ″ordinary″ radio pulsars, while others are X-ray and gamma-ray emitting magnetars. It has been suggested that magnetars have more massive progenitors than radio pulsars, and/or that the environment in which they form might influence the type of phenomena the resulting magnetar displays. Several of the AXPs appear to be associated with supernova remnants, while embedded clusters of massive stars have been found in the immediate vicinity of three SGRs. Since both AXPs and SGRs are distributed close to the Galactic plane, high extinction makes studies in the optical difficult. We will present results from our Spitzer Space Telescope program aimed at characterizing the environment in which these objects form. We will describe the detection of diffuse cluster emission, evidence for mass loss events of the progenitor star and the mid-IR SEDs of sources surrounding the magnetars.

This work is based in part on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

131.02

Deep Searches for Radio Pulses and Bursts from AXPs

Fronefield Crawford, III[1], J. W. Hessels[2], V. M. Kaspi[3]
[1]*Franklin & Marshall College,* [2]*Astronomical Institute ″Anton Pannekoek″, University of Amsterdam, The Netherlands,* [3]*McGill University, Canada.*

We report on deep searches for radio emission from four Southern anomalous X-ray pulsars (AXPs). Observations were conducted near 1400 MHz in July and August 1999 with the center beam of the multibeam receiver on the Parkes 64-m telescope. The data were searched for persistent periodic emission, single pulses, and bursts at a wide range of dispersion measures. No detections of any kind were made, and we set upper limits on the radio emission from these sources. Given the association between the radio emission and the transient X-ray behavior of XTE J1810-197, continued radio searches of these and other AXPs at different epochs are warranted.

131.03

Observational Implications of a Fall-back Crust around a Quark-nova Compact Remnant: Application to AXPs and SGRs

Denis A. Leahy[1], R. Ouyed[1], B. Niebergal[1]
[1]*Univ. of Calgary, Canada.*

Mass is ejected from a quark stars formed by the Quark-Nova process (Ouyed, Dey and Dey, 2002 A&A, 390, L39; Keranen, Ouyed and Jaikumar 2005 ApJ, 681, 485). Some fraction of this ejecta is below escape velocity and falls back toward the compact object. If the magnetic field of the compact object is high enough, the fall-back material forms a shell of iron-rich material which then evolves quasi-statically. We explore the formation and evolution of such a fall-back crust (so-called because the material originates in the crust of the neutron star progenitor to the quark-nova). We find the resulting properites have application to the observed properties of Soft Gamma-ray Repeaters (SGRs) and Anomolous X-ray Pulsars (AXPs). These observed features of SGRs and AXPs are: (i) the two types of bursts (giant and regular); (ii) the spin-up and spin-down episodes during and following the bursts with associated persistant increases in period derivative ; (iii) the energetics of the boxing day burst, SGR1806+20; (iv) the presence of an Iron line as observed in SGR1900+14; (v) the correlation between the far-Infrared and the X-ray fluxes during the bursting episode and the quiescent phase; (vi) the hard X-ray component observed in SGRs during the giant bursts, and (vii) the discrepancy between the ages of SGRs/AXPs and their supernova remnants. We also find a natural evolutionary relationship between SGRs and AXPs in our model which predicts that only the youngest SGRs/AXPs are most likely to exhibit strong bursting.

We acknowledge funding for this research from the Natural Science and Engineering Research Council of Canada.

131.04

Proper Motion of Compact Objects

Patrick B. Cameron[1], S. R. Kulkarni[1]
[1]Caltech.

It is now generally appreciated that the space velocities of compact objects (pulsars, magnetars, LMXBs and black hole binaries) directly inform us of their origin and constrain their lifetime. Here, we report of a proper motion program that we been carrying out using the adaptive optics system at Palomar (natural guide star) and Keck (laser guide star). We also report on IR identifications of magnetars. This program is a precursor of the program we hope to undertake with the Space Interferometer Mission.

131.05

SPITZER IRS Spectroscopy of Highly-Obscured X-ray Binaries

Dae-Sik Moon[1], D. L. Kaplan[2], W. T. Reach[3], F. A. Harrison[4], J. Lee[5]
[1]University of Toronto, Canada, [2]MIT, [3]Spitzer Science Center, [4]Caltech, [5]UCLA.

We present the results of SPITZER IRS spectroscopy of the three highly-obscured X-ray binaries: IGR J16318-4848, XTE J0421+641, and GX 301-2. The hydrogen column densities towards these sources in X-ray observations have been estimated to be greater than $10^{23}/cm^2$, sometimes reaching $10^{24}/cm^2$, which makes them some of the most heavily obscured sources known. Our IRS observations revealed the existence of multiple continuum components from these sources in the mid-infrared, together with numerous emission lines. The strong continuum emission may represent the circumstellar dust which is likely responsible for the heavy obscuration of these sources. One interesting feature is that while IGR J16318-4848 and GX 301-2 are somewhat similar to each other in the mid-infrared, XET J0421+641 appears to be different from them. Our results demonstrate the importance of mid-infrared observations to understand these new growing number of highly-obscured X-ray binaries.

131.06

Cool Companions of White Dwarfs from 2MASS

D W. Hoard[1], S. Wachter[1], L. K. Sturch[2], A. M. Widhalm[3], K. P. Weiler[4], J. W. Wellhouse[3], M. Gibiansky[2]
[1]California Institute of Technology, [2]Harvey Mudd College, [3]New Mexico State University, [4]DePaul University.

Detecting low mass stellar companions to white dwarfs (WDs) offers many advantages compared to main sequence primaries. In the latter case, faint low mass companions are often hidden in the glare of the more luminous main sequence primary, and radial velocity variations are small and, therefore, difficult to detect. Since WDs are less luminous than main sequence stars, the brightness contrast compared to a potential faint companion is significantly reduced. Most importantly, the markedly different spectral energy distributions of the WDs and their low mass companions makes the detection and separation of the two components relatively straightforward even with simple broad-band multi-color photometry. We have shown in Wachter et al. (2003) that the 2MASS near-IR color-color diagram can easily and efficiently identify candidates for unresolved WD + red dwarf binaries. Our follow-up observations (e.g., Farihi et al. 2006) have shown that a large fraction of these candidates are confirmed as previously unknown binary stars. Here, we present results from our full survey of the 2235 WDs from the McCook & Sion (1999) Catalog using the 2MASS All-Sky Data Release. We have identified an additional large sample of candidate WD + red dwarf binaries, as well as a number of systems that may contain extremely low mass stellar or substellar companions.

Support for this work was provided by the National Aeronautics and Space Administration (NASA) under an Astrophysics Data Program grant issued through the Office of Space Science. This research made use of the NASA/Infrared Processing and Analysis Center (IPAC) Infrared Science Archive, which is operated by the Jet Propulsion Laboratory/California Institute of Technology (CIT), under contract with NASA, and data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and IPAC/CIT, funded by NASA and the National Science Foundation.

131.07

Pulsar Timing and Gravitational Wave Detection: Current Status and Future Prospects

Fredrick Jenet[1]
[1]Center for Gravitational Wave Astronomy/Univ. of Texas at Brownsville.

The unique properties of radio pulsars allows for the direct detection of low frequency gravitational waves (G-waves). This talk will outline G-wave detection techniques using pulsar observations. The current status of the Parkes Pulsar Timing Array (PPTA) will be discussed including current limits on the stochastic G-wave background. These results will be placed in the context of super massive black hole formation and evolution, early universe evolution, and cosmic string formation scenarios. The future prospect of low frequency G-wave detection will also be discussed including the expected results from the full PPTA data set and the SKA.

131.08D

Energetic Outflows from Young Neutron Stars

Joseph Gelfand[1]
[1]Harvard Univ..

Young neutron stars have a large impact on their surroundings in several different ways, varying from the giant flares emitted by ″magnetars″ neutron stars with surface magnetic fields 100-1000x stronger than those of typical radio pulsars to the magnetic bubbles called Pulsar Wind Nebulae created by the relativistic wind produced by ″ordinary″ neutron stars. In this talk, I will discuss recent

observational work on the radio nebula produced by 27 Dec. 2004 Giant Flare from SGR 1806-20, as well as work on G328.4+0.2, the largest and most radio-luminous pulsar wind nebula in the Milky Way. Both of these these systems provide information of the physics of the neutron stars as well as on the supernova explosion which formed them.

132: UDF, GOODS and High Redshift Galaxies AAS Oral, Monday, 2:00-3:30pm, 613-14

132.01

Evolution of the Rest-Frame UV LF from z~8 to z~4

Rychard Bouwens[1], G. D. Illingworth[1]
[1]UC, Santa Cruz.

Sufficient HST ACS and NICMOS data are now available to probe the evolution of the rest-frame UV LF from z~8 to z~4. These data come in the form of two deep wide-area ACS GOODS fields, four even deeper ACS pointings, and one ultra deep ACS pointing (the Hubble Ultra Deep Field), with more than 20 arcmin**2 of deep NICMOS data available over these areas. From these data, we have assembled large samples of galaxies at redshift z~4, 5 and 6 (containing >4200 galaxies, >1000 galaxies, >500 galaxies, respectively). We have derived luminosity functions, luminosity density and star formation rates in a very robust and consistent way to very faint luminosities (0.01L* to 0.04L*). The faint end slopes of these luminosity functions are remarkably uniform and steep (alpha = -1.7), indicating little evolution from z~6 => z~4. L* brightens considerably over this period, but the overall change in the luminosity function is such as to lead to little change in the luminosity density and star formation rate over this period. We also have detected galaxies at z~7-8 and set limits at z~10 directly and through Spitzer observations of z~7 galaxies. These results show strong evidence that the evolution we see at z~4-6 continues into the reionization epoch. In this presentation, we will summarize the remarkable changes that are occurring in the rest-frame UV LF over the first 1.5 Gyr of cosmic time.

132.02

Spitzer/IRAC Confirmation of z850-dropout Galaxies in the Hubble Ultra Deep Field: Stellar Masses and Ages at z~7

Ivo F. Labbe[1], R. Bouwens[2], G. Illingworth[2], M. Franx[3]
[1]OCIW, [2]UCSC/Lick, [3]Leiden Observatory, The Netherlands.

Using ultradeep Spitzer IRAC imaging from GOODS we study the mid-infrared properties of z850-dropout candidates in the Hubble Ultra Deep Field. We clearly detect two sources at 3.6micron and 4.5micron, with rest-frame optical-infrared colors strongly suggesting they are galaxies at z~7. Fitting stellar populations to the SEDs, we find rest-frame colors U-V = 0.2-0.4 (AB), V-band luminosities 0.6-3 x 10^{10}Lsun, stellar masses 1-10 x 10^9 Msun, and ages 50--200 Myr. I will discuss their star formation history, the stellar mass density at z=7, and implications for reionization.

132.03

16 micron Imaging of the GOODS Fields

Harry I. Teplitz[1], R. Chary[1], J. W. Colbert[1], B. Siana[1], D. Elbaz[2], M. Dickinson[3], C. Papovich[4]
[1]Spitzer Science Center, [2]Saclay, France, [3]NOAO, [4]UA.

We present Spitzer 16 micron imaging of the Great Observatories Origins Deep Survey (GOODS) fields. We survey 150 square arcminutes in each of GOODS-North and GOODS-South, to an average 3 sigma depth of 0.05 mJy and 0.085 mJy respectively. We detect more than 500 sources in each field. Local templates suggest that detected sources span a wide range of LIR from 10^9 to 10^{12} Lsun. We examine the 16 to 24 mircon flux ratio and conclude that it shows evidence for the detection of redshifted PAH emission at z>0.8.

132.04D

Exploring the Optical and Infrared Evolution of Galaxies Since z=1

Jason Melbourne[1]
[1]UC, Santa Cruz.

We track the evolution of galaxy optical and mid-infrared luminosity, and half-light radius, for 900 blue galaxies in the Great Observatories Origins Deep Survey (GOODS). We find that since *z*=1 the total infrared luminosity of a typical spiral galaxies has declined more rapidly than for peculiar/merger types. We suggest that gas consumption in disk galaxies results in lower star formation rates and hence lower total infrared luminosity with time. The optical luminosity of blue galaxies has also declined with time. Assuming a linear shift in M_B *with z, we use a maximum likelihood method to quantify the luminosity evolution of GOODS-N galaxies with respect to a volume limited local sample from the Sloan Digital Sky Survey. We find that the amount of evolution is dependent on galaxy size. Under these assumptions, large (*$R_{1/2} > 5$ *kpc), and intermediate sized (*$3 < R_{1/2} < 5$ *kpc) galaxies, experienced* ΔM_B *=1.53 (+0.10, -0.13) and 1.65 (+0.18, -0.08) magnitudes of dimming since z=1. This can be explained by a simple exponential decline in star formation with an e-folding time of 3 Gyr. Meanwhile, small galaxies, or some subset thereof, have experienced more evolution, 2.55 (+/-0.38) magnitudes, different from galaxies with larger size at the 2-sigma level. This factor of ten decline in luminosity can be explained by sub-samples of starbursting dwarf systems that fade rapidly, coupled with a decline in burst strength or frequency. Samples of bursting, luminous, blue, compact galaxies at intermediate redshifts have been identified by various previous studies.*

This work was supported in part by the NSF Science and Technology Center for Adaptive Optics managed by UC Santa Cruz under the cooperative agreement No. AST-9876783.

132.05

Revisiting the Hubble Sequence : Comparative Studies with Sloan Digital Sky Survey and the Hubble Ultra Deep Field

Preethi Nair[1], R. G. Abraham[1]
[1]University of Toronto, Canada.

Recent large surveys of galaxies have advanced morphological studies tremendously, moving this field from the subjective art of morphological classification to a quantitative science of physical morphology. The *Hubble Space Telescope* (*HST*), and in particular, the Hubble Deep Fields, have provided a vast resource of photometric, spectroscopic, and morphological data on high redshift galaxies, and the challenge now is to link these high redshift observations with their low redshift counterparts. Systematic studies have been initiated to quantify galaxy morphology and extend the structural parameters that form the basis of the Hubble sequence to higher redshifts (Abraham et al. 1996a; Brinchmann et al. 1998;Bouwens et al. 1998; Conselice 2003). The comparative study of high and low redshift morphology, however, is not straightforward. Complications arise in interpreting observations due to redshift-dependent selection effects, biases, and incompleteness. The most fundamental difficulty has been the lack of a good, complete, digital sample of nearby galaxies. This has limited the morphological type and luminosity range in most digital surveys of local galaxies conducted so far (Frei et al. 1996) which in turn has limited our knowledge of the basic properties that characterize distant galaxies.

We are using publicly available data from the Sloan Digital Sky Survey (SDSS) and high redshift data from the HST-ACS Ultra Deep Field (UDF) as well as the Gemini Deep Deep Survey (GDDS) to conduct a quantitative comparison of low and high redshift galaxy morphologies. We have determined a quantitative morphological parameter space (M-space) which adequately represents the diverse morphologies observed in the universe. Using M-space we show that local analogs to even very peculiar high redshift galaxies do exist and attempt to constrain their number density as a function of redshift.

132.06

Discovery of a galaxy at redshift 6.96 and its implications on galaxy formation era

Masanori Iye[1], K. Ota[2], N. Kashikawa[1]
[1]National Astronomical Obs., Japan, [2]University of Tokyo, Japan.

We found a Lyman alpha emitter at redshift z=6.96 in the Subaru Deep Field. A SuprimeCam imaging survey with 15 hours total exposure through a narrowband filter (centered at 973nm with FWHM of 22nm) yielded 41, 533 objects down to NB973=24.9 at 5 sigma detection. Photometric comparison of their NB973 magnitudes with those in B, V, R, i', and z' bands resulted in isolating only two objects with significant excess in NB973 band. Follow-up FOCAS spectroscopy of the brighter object, IOK-1, showed a clear Lyman alpha emission with typical skewed profile at 968.2nm, indicating its redshift at z=6.964, thus making this object the most distant galaxy spectroscopically confirmed.

The number of detected Lyman alpha emitters at redshift 7 is only 1/6-1/3 of what we expected from the number density at redshift 6.6 in the same field. The decline of the number density of Lyman alpha emitters from redshift 5.7, through 6.6, to 7.0 appears to be a systematic feature and similar result was reported also from HST NICMOS imaging survey for candidate galaxies at z~7-8 by Bouwens and Illingworth (2006). These results imply 1) the cosmic re-ionization was not completed at z~7 and Lyman alpha photons were attenuated by remaining intergalactic neutral hydrogen and/or 2) the universe at z~7 was still too young to bring up massive luminous galaxies

132.07

The Advanced Camera Galaxy Redshift Survey

Brenda L. Frye[1], N. Benitez[2], D. Coe[2], H. Ford[3], D. Bowen[4], G. Illingworth[5], P. Guhathakurta[5], M. Franx[6], ACS Science Team
[1]Dublin City Univ., Ireland, [2]Instituto de Astrofisica de Andalucia, Spain, [3]Johns Hopkins University, [4]Princeton University, [5]University of

California at Santa Cruz, [6]Leiden University, Netherlands Antilles.

New deep HST Advanced Camera for Surveys (ACS) images are revolutionizing the field of strong lensing by providing record numbers of multiply-imaged galaxies, from zero to 30 behind the most well-studied and most massive cluster A1689, enabling strong constraints on the underlying total mass. With the ultradeep imaging of our key targets, photometric redshifts provide a useful and fast means of obtaining redshifts, but spectroscopic redshifts are found to be necessary for identification of the highest-z galaxies in the sample. We present the catalog of ground-based redshifts toward the massive lensing cluster Abell 1689. We have obtained 98 robust redshifts of new objects. These objects show evidence for cluster magnification compared to the field. Eight new high-z galaxies are presented, z>3, including the third brightest Lyman-break galaxy known, and bright enough for high resolution follow-up work. The multiply-imaged high-z background galaxies are used to construct the 2d model deflection field, which yields a total mass profile that does not have a core but flattens toward the center, consistent with cold dark matter simulations (Broadhurst, et al. 2005).

132.08

IRAC-selected Extremely Red Objects in the GOODS Fields

Haojing Yan[1], GOODS Team
[1]Carnegie Observatories.

Using the deep Infrared Array Camera (IRAC) observations of the Great Observatories Origins Deep Survey (GOODS) Spitzer Legacy Program, we construct a large sample of IRAC-selected Extremely Red Objects (IEROs). Such IEROs are luminous in IRAC passbands, but are very faint or even invisiblein optical. Our previous work in the HUDF shows that such a population is likely dominated by very massive, passively-evolving, very old galaxies at

z~2.4. This current study will extend to a much wider field, and will investigate 1) the fraction of passively-evolving galaxies; 2) the overlapping fraction between IEROs and other types of red galaxies such as EROs and DRGs; 3) the contribution of IEROs to the global stellar mass density; and 4) their possible progenitors and descendants.

133: YSOs and Early Type Stars
AAS Oral, Monday, 2:00-3:30pm, 6A

133.01D

Molecular Clouds and Star Formation: A Multi-wavelength Study of Perseus, Serpens, and Ophiuchus

Melissa Enoch[1]
[1]Caltech.

The earliest phases of star formation, from prestellar cores to Class I protostars, are best observed at far-infrared to millimeter wavelengths. Here we analyze large-scale Bolocam 1.1 mm surveys of Perseus (7.5 sq. deg.), Ophiuchus (10.8 sq. deg.), and Serpens (1.5 sq. deg.) in combination with Spitzer IRAC and MIPS maps from the c2d Legacy Program. The Bolocam 30″ resolution observations trace optically thin dust emission, which is a measure of the total mass in dense cores. Combining the millimeter data with Spitzer infrared data allows us to separate starless cores from those with internal luminosity sources (protostellar cores). From a comparison of the properties of the starless and protostellar core populations in each cloud, we infer how formation of a central protostar alters core properties. The starless core sample reveals pre-collapse initial conditions, and enables a comparison of the prestellar core mass function to the stellar initial mass function. From Spitzer IRAC and MIPS photometry together with Bolocam flux densities, we calculate bolometric temperatures and luminosities for the coldest protostellar sources in each cloud, and compare to protostellar evolutionary models. Different protostellar classification methods are considered, and our classifications are used to estimate lifetimes for the prestellar and Class 0 phases. We discuss how these results further our understanding of the processes controlling star formation on molecular cloud scales.

133.02

SMA Observations of IRDC Cores: An Active Hot Core and a Quiescent Cold Core

James M. Jackson[1], J. Rathborne[2], E. Chambers[1], Q. Zhang[2], R. Simon[3]
[1]Boston Univ., [2]Center for Astrophysics, [3]University of Cologne, Germany.

Infrared Dark Clouds are a distinct class of interstellar gas cloud identified as dark extinction features seen in silhouette against the bright Galactic background at mid-IR wavelengths. Our recent 1.2 mm continuum emission survey of IRDCs reveal many compact (< 0.5 pc) and massive (10 to 2100 $M_\odot$) cores within them. These pre-stellar cores hold the key to understanding IRDCs and their role in star formation. About 1/3 of these cores show evidence for active star-formation; shocked gas, outflows, and embedded protostars. The remaining 2/3 of these cores show no signs of active star formation and may be massive starless cores. Here we present recent high angular resolution molecular line maps and sub-mm continuum images obtained with the SMA Interferometer toward two of the most massive cores; one activley forming stars and the other more quiescent. These images elucidate their subparsec structure, and reveal whether the cores are likely to produce a single high-mass star, or a cluster of lower-mass stars. Toward the active core we see many molecular lines indicating that this is a hot molecular core, in an early stage in the formation of a high-mass protostar.

133.03

VLBA Determination of the Distance to Taurus and Ophiuchus with 1% Precision

Laurent Loinard[1]
[1]Centro de Radioastronomia y Astrofisica, UNAM, Mexico.

Using multi-epoch VLBA observations spread over one to two years of T Tauri stars in the Taurus and Rho-Ophiuchus star-forming regions, we have measured the trigonometric parallax, and therefore the distance, of these two important regions of star-formation with a precision of about 1%. Since several sources have been considered in each case, we can estimate the depth of the clouds, as well as their mean distance. We also measured the proper motions of the sources, and can therefore determine their velocity vectors. In the case of Taurus, significant velocity differences are found between the southern part of the cloud (where T Tau is located) and the central regions.

133.04

Long-term Infrared Variability of FU Oriand EX Lup-type Stars

Agnes Kospal[1], P. Abraham[2], D. Ardila[3]
[1]Konkoly Observatory/Caltech, [2]Konkoly Observatory, Hungary, [3]Caltech.

FU Orionisand EX Lupi-type stars are low-mass pre-main sequence stars exhibiting large, 5 mag optical outbursts powered by enhanced accretion from the circumstellar disk to the star. We investigate the brightness evolution of these stars in the nearto far-infrared wavelength regime, where the emission is dominated by the circumstellar material. We utilize Spitzer data to obtain the spectral energy distribution (SED) of the stars, and compare these SEDs with ones derived from IRAS, ISO, MSX, 2MASS and ground-based measurements taken in the last 25 years. We report, for the first time, clear flux changes at infrared wavelengths for several targets. The observed flux variations help us to gather information on the structure and energetics of the circumstellar material and to clarify its role in the eruption.

133.05

X-ray Variability in the Young Massive Triple θ^2 Ori A

Norbert S. Schulz[1], P. Testa[1], D. P. Huenemoerder[1], K. Ishibashi[1], C. R. Canizares[1]
[1]Kavli Institute for Astrophysics and Space Research, MIT.

Massive stars rarely show intrinsic X-ray variability. The only O-stars credited to be intrinsically variable are theta[1] Ori C due to effects from magnetic confinement of its wind, and theta[2] Ori A suspected of similar activity. In the latter case early Chandra observations have shown rapid variability on time scales of hours. We determined X-ray fluxes from all observations with Chandra and find that the star shows very strong variability over the last 5 years in addition to short term varibility. There indications that this variability is connnected to the 21 day orbital period of the massive spectrocopic binary causing eruptive outbursts near periastron. A second large outburst of the X-ray source in November 2004 was observed with the high resolution transmission grating spectrometer onboard Chandra and we compare the emissivity and line properties in states of low and high flux. The outburst event in stellar terms is one of the most powerful ever observed and the most energetic one in the ONC with a lower total energy limit of 1.5 $\times 10^{37}$ ergs. Both flux states reveal high X-ray emissivities with temperatures well above 25 MK, during outbursts over 100 MK. The line diagnostics show that under the assumption that the He-like ions are photoexcited the line emitting regions in the low states are very close to the O-star's photosphere, whereas the high states indicate somewhat larger separation. We discuss the results in the context of stellar flares, magnetic reconnection, and binary interactions. We argue that the high X-ray states are possibly the result of reconnection events from magnetic interactions of the primary and secondary star of the spectroscopic binary. Effects from wind collisions seem unlikely for this system. The low state emissivity and R-ratios strengthen the predicament that X-ray emission is enhanced by magnetic confinement of the primary wind.

133.06D

Metallicity-Induced Fragmentation and the Transition from Pop III to Pop II

Britton D. Smith[1], S. Sigurdsson[1]
[1]Pennsylvania State Univ..

Numerical simulations of the formation of pop III stars suggest that they were much more massive than the pop II and pop I stars observed today. This is due to the collapse dynamics of metal-free gas, which is regulated by the radiative cooling properties of molecular hydrogen. We study how the collapse of gas-clouds is altered by the addition of metals to the star-forming environment. We create a method to include the radiative cooling of all elemental species from H to Zn, with any abundance patterns, in numerical simulations of cosmic structure formation. This method uses interpolation over tables of externally computed cooling rates produced with the photoionization software, Cloudy. In order to determine the critical metallicity required for a star-forming core to undergo fragmentation, we perform numerical simulations similar to those of the first stars with varying levels of metal enrichment. We use the adaptive mesh refinement hydrodynamic/n-body code, Enzo, along with our newly created metal cooling routines. Our simulations show that gas clouds endowed with a metallicity of approximately $10^{-3.5}$ solar metallicity will fragment and form multiple objects, which is in excellent agreement with earlier studies and predictions. Additionally, we examine the spectrum of masses created at different metallicities. This work is the first step in numerically simulating the transition from pop III to pop II star formation that took place early in the history of the universe. This work is funded by a Hubble Theory Grant.

133.07

Quantitative Analysis of Resolved X-ray Emission Line Profiles of O Stars

David H. Cohen[1], M. A. Leutenegger[2], A. ud-Doula[3], S. P. Owocki[3]
[1]Swarthmore College, [2]Columbia University, [3]Bartol Research Institute, University of Delaware.

The resolved x-ray emission line profiles of O stars carry a significant amount of information about the kinematics of the hot plasma in their massive stellar winds. They provide important clues to the x-ray production mechanism, and via the effects of continuum absorption, also place key constraints on conditions in the bulk, cool wind. Initial interpretations of the relatively symmetric form of observed profiles suggested significant mass-loss rate reductions, but recent studies argue that the profile shapes can be affected by wind clumping and the associated porosity, as well as by resonance scattering. We report here on the results of quantitative model fitting to several relatively high-resolution, high signal-to-noise Chandra and XMM-Newton spectra of O stars. We interpret the results of this analysis in light of recent adjustments to O star mass-loss rates based on the analysis of UV data and also in light of state-of-the-art 2D numerical simulations of the line-force instability. We show that reduced optical depth is statistically favored over porosity when high-quality data are quantitatively analyzed and that, in any case, porosity can only significantly affect line profile shapes when unrealistically large porosity scales are assumed. Further, we show that resonance scattering seems to be important in understanding the longer-wavelength oxygen and nitrogen lines in O stars with very dense winds, but is probably not significant for most other lines in the x-ray spectra of O stars or in hot stars with lower mass-loss rates.

We acknowledge support from grant AR5-6003X to Swarthmore College from the Chandra X-ray Center at the Smithsonian Astrophysical Observatory.

134: Recruiting the Next Generation of Physics Teachers AAPT Invited, Monday, 2:00-3:30pm, 310

Chair

Paul Hickman[1]
[1]Science Education Consultant.

134.01

Recruiting the Next Generation of Physics Teachers: National Concerns

Theodore Hodapp[1]
[1]American Physical Society.

Physics teachers preparation is in a crisis in this country. We now prepare only about a third of all physics teachers needed to help educate a growing number of high school physics students. Middle school instruction is in worse shape with more than 40% of all teachers having no major, no minor, nor appropriate certification to teach physical science. Only 15% of all science lessons in elementary classrooms have been judged as ″very good″ in a recent study. This presentation will provide an overview of these concerns, and discuss exemplary ideas to address these dramatic needs. The posters that follow as well as the upcoming Physics Teacher Education Coalition meeting in Boulder, CO (3-4 March 2007, www.PTEC.org) focus on ways in which we can actively recruit more teachers, and provide them with the skills needed to embark on a successful and rewarding career as a teacher of physics.

135: Student Difficulties with Mathematics in Upper-Division Physics AAPT Invited, Monday, 2:00-3:30pm, 307-08

Chair

Edward Redish[1]
[1]University of Maryland.

135.01

Easing the Transition to Upper-division Physics

Corinne Manogue[1], Paradigms in Physics
[1]Oregon State University.

Why is the transition to upper-division physics so difficult? What do students mean when they say they don't know how to start a problem? I will share lessons learned from the Paradigms in Physics Project about how we can help students learn to apply the math they DO know to models of the physical world instead of using it for mere algebra and calculus games.

135.02

Investigating Student Connections Between Mathematics and Thermal Physics

John R. Thompson[1]
[1]University of Maine.

As part of work on teaching and learning in upper-level undergraduate thermal physics courses, we are exploring student functional understanding of mathematical concepts required for productive reasoning about thermal and statistical physics. We find evidence that students do not make connections between the physical situations or processes under study and the mathematical concepts or algorithms needed for analysis of the physics.

Examples will be provided from integrals and path integrals in the context of P-V diagrams, and from partial derivatives in the context of material properties and the Maxwell relations. With integration, our results suggest that while students may indeed have difficulties associated with the physical concepts in question, mathematical difficulties compound the problem. In particular, some students lack a functional understanding of two fundamental concepts of integration: the Riemann sum and the Fundamental Theorem of Calculus, both of which strongly impact whether a given variable is a state function or not. With partial differentiation, we find that although students are able to take partial derivatives easily, many students have difficulty understanding the mathematical and/or physical significance of their differentiation, even after instruction. Results from research are being used to develop instructional materials to address specific difficulties.

Supported in part by NSF Grant #PHY-0406764.

135.03

Students' Construction of Understanding of Abstract Vector Spaces

Thomas J. Bing[1]
[1]University of Maryland.

Many upper level physics classes are concerned with abstract vector spaces. Building a wavefunction from eigenfunctions of the Schrodinger equation and decomposing a wave on a string into normal modes are two prominent examples. When physics students first encounter these abstract vector spaces, they are relatively familiar with Cartesian vector spaces and the use of functions in graphical, algebraic, and simple calculus contexts. Constructing a notion of an abstract vector space involves a complicated combination of these relatively familiar ideas. Not only does something new emerge from this combination, but the original conceptions of, for example, Cartesian vectors are often modified as well. We analyze the thinking of second and third year physics majors as they work on Cartesian and string wave problems concurrently. Several analysis frameworks, including cognitive blending, will be used in an attempt to understand the dynamics of this construction of understanding for abstract vector spaces.

136: Physics Teaching Around the World
AAPT Oral, Monday, 2:00-3:30pm, 619

Chair

Gordon Ramsey[1]
[1]Argonne Nat'l Lab..

136.01

Teaching Gravitational Wave Astronomy in China

Robert J. Stone[1]
[1]University of Texas-Brownsville.

This past summer five researchers associated with the Center for Gravitational Wave Astronomy at the University of Texas in Brownsville presented a course in gravitational wave astronomy in Nanjing, China. Eighty Chinese graduate students attended and represented twenty universities and four astronomical observatories. The instructors implemented cooperative learning throughout the course, a teaching strategy that was unfamiliar to many of the students at this level. More than 95 percent of the students indicated that this type of training and the content taught were excellent. As a result of this school, UTB, Nanjing University, and Beijing University continue to collaborate in an exchange of students and professors. UTB will host a professor and two graduate students in 2006-07 and will return the summer of 2007 to again conduct another course.

136.02

Fifth Global Colloquium on Engineering Education

Gerhard L. Salinger[1]
[1]National Science Foundation.

The Fifth Global Colloquium on Engineering Education held in Rio de Janeiro in October had three tracks: Primary Secondary Education; Engineering for the Americas and Curriculum for Global Education. A new component of this colloquium is to support the attendance of about 50 engineering graduate students from around the world. The rationale is to stimulate the interest of the students in engineering education so that they continue this interest throughout their careers. This talk describes the conferences and draws lessons for physics education.

136.03

A Model for Bilingual Physics Teaching: ″The Feynman Lectures ″

Heqing W. Metzner[1]
[1]Tangshan Teachers College Physics Department, China.

Feynman was not only a great physicist but also a remarkably effective educator. The Feynman Lectures on Physics originally published in 1963 were designed to be GUIDES for teachers and for gifted students. More than 40 years later, his peculiar teaching ideas have special application to bilingual physics teaching in China because:

(1) Each individual lecture provides a self contained unit for bilingual teaching;

(2)The lectures broaden the physics understanding of students; and

(3)Feynman's original thought in English is experienced through the bilingual teaching of physics.

136.04

Implementing active-learning strategies to improve physics learning in Latin America

Hugo Alarcon[1], G. Zavala[1], R. Fernandez[2], J. Benegas[3]
[1]TecnolÃ³gico de Monterrey, Campus Monterrey, Mexico, [2]Universidad Catolica del Norte, Chile, [3]Universidad Nacional de San Luis, Argentina.

It is evident that the most effective active-learning strategies to improve physics learning at the college level have been developed in the United States. Recently, some universities in Latin America have begun adopting such methods as a part of institutional projects, or motivated by national projects led by education authorities. In this work we will present two cases, a large-scale implementation of Tutorials in Introductory Physics (1) in Mexico supported by the institution as a part of a change in its educational model, and a medium-scale implementation of this method in Chile supported by the national government. In both experiences, the professors involved in the educational experience have previously participated in a training workshop that prepared them for implementing this strategy in the classroom. The training workshop, described elsewhere (2), was designed also under active learning premises, so teachers completed the proposed activities in the same way as their students will do. We will present the first results of these two projects.

References:

(1) McDermott, L. C., Shaffer, P. S., & PER (1998). ″Tutorials in Introductory Physics″, Prentice Hall, translated as ″Tutoriales para Física Introductoria″ (2001) Prentice Hall, Buenos Aires..

(2) Zavala, G., Alarcón, H. and Benegas, J. (2005). ″Innovative training of in-service teachers for active learning: A short teacher development course based on Physics Education Research″, accepted for publication, J. of Sc. Teach. Ed.

This work has been partially supported by Tecnológico de Monterrey through the Chair in Physics Education Research and by MECE Educación Superior Program (Chile).

136.05

A Masterclass in Particle Physics for High School Students

Kenneth Cecire[1], T. Entwistle[2]
[1]Hampton University, [2]Ward Melville High School.

The European Particle Physics Outreach Group (EPPOG) developed the Masterclass in 2004 to bring particle physics to high school classrooms in Europe. They put real data on a website (http://wyp.teilchenphysik.org/mc.htm) from the Large Electron-Positron (LEP) collider at CERN. Students analyze this data and draw conclusions at their schools. They then compare their results with those found at other schools in Masterclass live video conferences hosted by CERN over the internet.

In March 2004, six students at Ward Melville High School on Long Island were sponsored by QuarkNet and Brookhaven National Laboratory to become the first U.S. team to participate in the EPPOG Masterclass. The Ward Melville group was positive about the experience and their results tracked well with those of their colleagues in the video conference from high schools in Greece, Slovakia, and Poland.

136.06

Assessing Teaching Med-Nursing Physics Replacing Introductory Physics in Nursing College

Wen-Ruey Wang[1], Y. Lin[1], K. Chen[1]
[1]Central Taiwan University of Science and Technology, (CTUST), Taichung, Taiwan, Taiwan.

The introductory physics is taught by a physics teacher who integrated nursing technique with the text in the nursing format, in nursing language and demonstrating in class the operation of nursing instruments, with lecture support from a nursing teacher. This is teaching med-nursing physics. The null hypothesis is rejected under the alternative hypothesis that teaching med-nursing physics is superior than teaching traditional introductory physics in the nursing college of the study university, by a traditional trained physics teacher. The study design is a case group comparing with 6 groups of controls, who from 24and 5-year-discipline systems are taking or took the introductory physics. The superiority testing is relied on the accessment form that has 10 questions on the introductory physics, and 10 questions on nursing technique. The SAS procedure of GLM has been employed for the 1-way ANOVA on the 20 accessment questions, under scoring systems.

136.07

Ten Years of GLAPHI Method Developing Scientific Research Abilities

Hector R. Vega-Carrillo[1]
[1]Universidad Autonoma de Zacatecas, Mexico.

During the past ten years we had applied our method, GLAPHI, to teach how to do scientific research. The method has been applied from freshman students up to PhD professionals. The method is based in the search and analysis of scientific literature, the scientific question or problem, the approach of hypothesis and objetive, the estimation of the project cost and the timetable. It also includes statistics for research, author rights, ethics in research, publication of scientific papers, writting scientific reports and meeting presentations.

In this work success and fails of GLAPHI methods will be discussed.

Work partially supported by CONACyT (Mexico) under contract: SEP-2004-C01-46893

137: Undergraduates Research Astronomy and Physics AAPT Oral, Monday, 2:00-3:30pm, 616

Chair

Chris D. Impey[1]
[1]Univ. of Arizona.

137.01

Demonstration of Electrostatic Orbits in Weightlessness

John Janeski[1], K. Andring[1], S. Banerjee[1], D. Campbell[1], D. Keedy[1], B. Hoffmeister[1], S. Quinn[1]
[1]Rhodes College.

In August 2006, a team of students from Rhodes College performed an experiment in microgravity aboard NASA's specialized C-9B aircraft known as the “Weightless Wonder.” The goal of the experiment was to establish an orbit between two electrically charged spheres. The similar forms of Newton's Law of Gravitation and Coulomb's Law suggest that such electrostatic orbits are possible. However, to our knowledge, an electrostatic orbit has not previously been demonstrated. This presentation will describe our experiment and show video footage of the electrostatic orbits that we achieved in weightlessness. Professor Brent Hoffmeister is the AAPT sponsor.

137.02

Building the CHEPREO Undergraduate Learning Community

Laird H. Kramer[1], G. O'Brien[1], P. Pamela[1], J. M. Saul[1]
[1]Florida International University.

The Center for High-Energy Physics Research Education and Outreach (CHEPREO) is an NSF-supported project that continues to build a learning, teaching, and research community of high school studentsand teachers, undergraduate and graduate students, as well as university faculty. CHEPREO's goal is to generate excitment about physics and science, support inquiry-based instructional methods in the classroom, and increase physics enrollment at both the high school and college level by using high energy physics as a base. This talk will focus on results from our undergraduate learning community where students serve as CHEPREO fellows, assisting in the inquiry-based classroom and performing high-energy physics research. Support of the fellows has spawned substantial change throughout the department. Work supported by NSF Award #0312038

137.03

SiO Maser Monitoring at the University of Minnesota, Morris

Gordon McIntosh[1]
[1]University of Minnesota, Morris.

For the past five years the silicon monoxide maser emission from several stars has been monitored by observers at the University of Minnesota, Morris. The Haystack Radio Telescope in Westford, MA, operated by the Massachusetts Institute of Technology, has been remotely operated to carry out the observations. Undergraduate students have been involved in the observations, data reduction, data analysis, and interpretations. A number of student presentations have resulted from this long term project. The project and some of its results will be presented.

137.04

Correlation of R Cassiopeia's SiO Maser Properties

Anne Hayes[1], G. McIntosh[1]
[1]University of Minnesota, Morris.

Silicon monoxide masers originate in the circumstellar environment of many long period variable stars. SiO emission from R Cassiopeia has been observed over several stellar periods in the v = 0, 1, 2, and 3, J=1-0 transitions. The integrated intensities have been analyzed for correlations. Since the masers are observed to occur at different distances from the star, the correlations constrain the possible pumping mechanisms.

137.05

Orbital Parameters of R Aquarii

Gustav Rustan[1], G. McIntosh[1]
[1]University of Minnesota, Morris.

R Aquarii is a long period variable star that exhibits silicon monoxide maser emission and is part of a binary system. Published velocity data for R Aqr has been collected and combined with SiO data taken at the University of Minnesota, Morris, in an effort to determine the orbital parameters of the binary system. The last determination was 17 years ago, a considerable fraction of the suspected orbital period, and the time span of the velocity data has more than doubled. Accurate orbital information is essential to the understanding of the mass transfer mechanism that may be occurring in this system and similar binary star systems. The recent SiO data suggest that the period may be 35 years, rather than the previous estimate of 44 years.

137.06

Superhumps and Period Variability of V795 Her

Daniel R. Malutich[1], R. P. Olenick[1], I. B. Voloshina[2]
[1]University of Dallas, [2]Moscow State University, Russian Federation.

We present new photometric data, taken at the Crimean Laboratory of Sternberg Astronomical Institute and University of Dallas, on the suspected intermediate polar V795 Her. Photometry reveals a period of 0.115487 days. This period, when compared with past observations, shows a slight modulation and even a complete disappearance in mid-1990. Light curves of V795 Her are also shown to demonstrate some superhump activity. Superhumps as the possible result of accretion disk precession are discussed.

138: Hypervelocity Stars
Plenary, Monday, 3:40-4:30pm, Ballroom 6

138.01

Hypervelocity Stars Ejected from the Galactic Center

Warren R. Brown[1]
[1]Smithsonian Astrophysical Observatory.

A massive black hole in a dense crowd of stars will inevitably eject a few stars completely out of the Galaxy. In 2005 we discovered the first such ″hypervelocity star:'' a short-lived star three times the mass of the Sun, very similar to the stars seen in the Galactic Center, but ~110 kpc distant and moving away at over 700 km/s. We have designed a successful survey to find more hypervelocity stars. I will describe our most recent results, including the possible discovery of stars ejected from the Galactic center on bound trajectories. Our hypervelocity stars tell us about the history of stars encountering the central massive back hole, and the types of stars orbiting around it.

139: Probing the Gas Content of Galaxy Groups: A Radio Perspective
Plenary, Monday, 4:40-5:30pm, Ballroom 6

139.01

Probing the Gas Content of Galaxy Groups: A Radio Perspective

Eric M. Wilcots[1]
[1]Univ. of Wisconsin.

The current state of our understanding of the nature of the gas content of galaxy groups, derived largely from a large body of X-ray observations, leaves us with two key questions. First, what are the relative fractions of the hot, warm/hot, and neutral gas in galaxy groups, and how is each phase distributed within groups? Second, how has the gas content of galaxy groups evolved over time and what is its relationship to the dynamical evolution of the group? The results from a number of investigations of the HI content and deep searches for diffuse synchrotron emission in groups are now shedding light on the evolution of the gas content of galaxy groups.

140: Hot Topics in Nanoscience
AAPT Invited, Monday, 6:00-8:00pm, 616

Chair

Melissa Eblen-Zayas[1]
[1]Carleton College.

140.01

Nanoelectronic Devices What We Can Do and Why It's Fun

Douglas Natelson[1]
[1]Rice University.

Over the last two decades, there have been remarkable advances in our ability to fabricate electronically interesting structures on length scales down to single atoms. I will briefly discuss our research in this area, emphasizing what we can and can't do, and how nanoelectronic devices can be more than potential technologies; they are tools for studying physics and chemistry in novel systems. Specific devices to be discussed include nanoscale wires, transistors made from single small molecules, and transistors made from plastics rather than traditional semiconductors. Learning about these systems requires a mixture of knowledge from physics, chemistry, and engineering disciplines.

140.02

Atomic Scale Friction and Microscale Machines: These Squeaky Wheels will get no Grease.

Jacqueline Krim[1]
[1]North Carolina State University.

There is widespread belief that the future is likely to be dominated by MEMS

(Micro-Electro-Mechanical Systems) and/or NEMS (Nano-Electro-Mechanical Systems) devices, which will be used in such diverse applications as gas and pressure sensors, accelerometers, chemical analytic ′′microlaboratories'', and airborne ′′nanosatellites''. Because MEMS devices must react to mechanical signals, many employ construction topologies that

require physical motion and the concomitant lubrication which prevents heating/melting and wear of the device. It is well established however that the macroscopic laws governing friction and wear are inapplicable at the molecular scale. The need to carry out new and fundamental research relevant to the development of optimal, or even operational submicron-scale mechanical systems is therefore increasingly important.

140.03

Voyage at the Nanoscale

Gregory J. Salamo[1]
[1]*University of Arkansas.*

Recent clever techniques for fabricating nanosize materials, one-atomic-layer-at-a-time, have simultaneously opened a door to a fantastic adventure at the frontier of physics, chemistry, biology, and engineering. Nanosize materials simply do not behave as the bulk. Indeed, the rules that govern the growth and behavior of these tiny structures are unexplored. In this talk we will discuss our recent efforts to be the architect of their shape, size, density, and position of nanostructures and along the way, the interactions between them that lead to their optical and electrical behavior.

141: Learning Sciences and Learning Technologies: A Convergence
AAPT Invited, Monday, 6:00-8:00pm, 303

Chair

S. R. Chaudhury[1]
[1]*Christopher Newport University.*

141.01

The Mathematics of Motion in Middle School: Findings from a Large Scale Study

Jeremy Roschelle[1]
[1]*SRI International.*

The SimCalc Project (http://www.simcalc.umassd.edu) has developed an integration of technology and curriculum based upon learning science principles and aimed at democratizing access to the mathematics of change and variation. Beginning in middle school, we introduce the topics of proportionality, function, and rate of change though multiple representations. In a large scale randomized experiment, we are testing replacement units based upon this approach with approximately 100 7th grade and 80 8th grade teachers. This talk will discuss results from our work and implications for science instruction, for example, for the feasibility of a physics-first sequence beginning in 9th grade.

141.02

Supporting Classroom Interaction with Networked Tablet PCs

Richard Anderson[1]
[1]*Univ. of Washington.*

Classroom Presenter is a Tablet PC based classroom interaction system. The system is used to allow students to contribute their work in real time to slide based lectures. This can be used to support a teaching style based on classroom assessment, peer learning, and inclusion of student work in discussion. I will present an overview of the system, describe how it has been used in range of science courses, and discuss how students and instructors have reacted to Classroom Presenter.

141.03

Technology-Enhanced Learning in Science (TELS)

Marcia Linn[1]
[1]*UC, Berkeley.*

The overall research question addressed by the NSF-funded echnology-Enhanced Learning in Science (TELS) Center is whether interactive scientific visualizations embedded in high quality instructional units can be used to increase pre-college student learning in science. The research draws on the knowledge integration framework to guide the design of instructional modules, professional development activities, and assessment activities. This talk reports on results from the first year where 50 teachers taught one of the 12 TELS modules in over 200 classes in 16 diverse schools. Assessments scored with the knowledge integration rubric showed that students made progress in learning complex physics topics such as electricity, mechanics, and thermodynamics. Teachers encountered primarily technological obstacles that the research team was able to address prior to implementation. Powerful scientific visualizations required extensive instructional supports to communicate to students. Currently, TELS is refining the modules, professional development, and assessments based on evidence from the first year. Preliminary design principles intended to help research teams build on the findings will be presented for audience feedback and discussion.

141.04

Understanding the Atomic-Scale World with the Molecular Workbench

Robert F. Tinker[1]
[1]*The Concord Consortium.*

The Molecular Workbench (MW) is a sophisticated system for developing and delivering interactive learning activities to teach basic concepts that govern atomic and nanoscale phenomena. The system is based on a molecular dynamics model that calculates the motion of atoms, molecules, and other objects in real time as a result of the applicable forces, including Lennard-Jones potentials, electrostatic potentials, elastic bonds, and external fields. Light-atom interactions are modeled with photons of selectable energy that interact with the excited states of atoms.

The built-in authoring functions can be used to create or modify learning activities. The ease of creating MW materials has led to over 200 activities contributed by staff and collaborators. Many are housed in a database with fields that include an overview, learning objectives, a description of the central concepts addressed, textbook references, and extensions.

MW has been used extensively in classrooms in grades 7-14. In several settings student learning gains have been measured using a pre-posttest design. Research results will be reported that show

Overall increases in understanding of atomic scale phenomena at high school and community college levels.

The ability to transfer understanding of atomic-scale phenomena to new situations and to reason about macroscopic phenomena on the basis of atomic-scale interactions.

Better understanding of difficult questions that required immersive visualization and prediction

MW is written in Java, so it runs under all common operating systems, including Mac OSX, Windows, and Linux. It is open source, so it can be shared and copied by any user.

142: Women Using Physics: Alternative Career Paths
AAPT Invited, Monday, 6:00-8:00pm, 615

Chair

Margaret Hill[1]
[1]*Southeast Missouri State University.*

142.01

Reflections on a Career in Radio Science

Irene C. Peden[1]
[1]University of Washington.

Why would a WWII-generation teenager select an engineering career? Dr. Peden outlines the background, motivations and patterns of personal interest that led to her choice in the wartime “climate” of that period, including the influence of teachers and parents. She remembers experiencing the need to undertake graduate studies 10 years later, and recalls why she chose an academic career. She later became a leader in campus and national efforts to improve the professional climate for women, and will comment on the variation s in campus attitudes toward diversity over the years. Finally, she offers her thoughts on the special challenges for faculty that are presented by student views of their own responsibilities and roles in engineering education, and reflects on the impact of these factors on the science/mathematics/ engineering “pipeline” .

142.02

Women Using Physics: Alternate Career Paths, The Private Sector

Jessica Tams[1]
[1]FUN Technologies.

For those who have spent their careers inside the safe walls of academia, the word is a little scary. Can I compete? Will I fit in? What do I need to know? Am I prepared? Will I succeed? While many would say: Yes! You are ready to excel! This isn’t actually the case. The private sector comes with many unanticipated shocks to many of us, especially women. This isn’t a group project.

This session will discuss entering a quickly growing and competitive technical field and what one can do to prepare for continued success.

Preparing and Entering the Private Sector * Women with technical skills are a desired part of the private workforcein general women posses stronger people skills, are more reliable and often more well rounded than their male counterparts. Key factors we will discuss to landing that first job:

· Expand your knowledge base with current applications of technology

· Preparing a solid employment pitch to highlight strengths: Overcoming stereotypes

· Don’t show them your bad side: Why some student projects may hurt you

· The private sector attitude toward performance and entry level expectations

Excelling in the Private Sector *

Now that we have landed a job * for better or worse we are now all about making money and exerting control. What to keep in mind while working in the private sector:

· The formative first years: focus on your weaknesses and practice, practice, practice

· Men & Women in the workplace: what women subconsciously do to hurt their careers

· Politics: Working in a team environment

· Polish & Detail & Reliabilit

142.03

Physics in Aerospace and Military Applications

Hong Tat[1]
[1]Boeing Company.

Aerospace, which includes both commercial and military applications, provides a wide variety of challenging opportunities in physics. I have worked primarily in the area of sensors with projects including airport baggage scanners and defect detection for the Space Shuttle. In my current role on the Army’s Future Combat Systems, we use physical models to predict battlefield sensor performance. This talk will focus on the physical principles involved in modeling electro-optical sensor performance, including the fundamental concept of minimum resolvable contrast and minimum resolvable temperature curves. I will also touch upon my experiences at Boeing and give an overview of the range of physics-related projects at Boeing.

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143: Electronic Journaling: Fostering Reflection and Building Community
AAPT Special, Monday, 6:00-8:00pm, 310

Chair

Ingrid Novodvorsky[1]
[1]University of Arizona.

143.01

Connecting Master Teachers to Build a Community of Support for Teachers of Physics

Paul Hickman[1], M. Fetters[2]
[1]Science Education Consultant, [2]Western Michigan University.

A teacher’s work is often isolating. The unique position of a Teacher-in-Residence (TIR) can be equally or even more isolating, since they are working in institutions across the country. Face-to-face meetings at conferences help, but two electronic venues have become the primary modes of support, that connect and nurture the 35 master teachers called TIRs in the PhysTEC project.

The first is the TIR Handbook website developed by our early TIRs to help new folks learn about the players, the project and their role. The second is the closed TIR listserv. By asking the TIRs to reflect on and respond to monthly journal prompts, we experienced a six-fold increase in the list activity and the postings were more thoughtful. We will demonstrate how these journal responses have proved to be a valuable data source for the project and a way to tease out common interests, initiate collaborations and begin building a vibrant learning community.

Supported in part by NSF (PHY-0108787)

143.02

Interactive, Collaborative, Electronic Learning Logs in the Physics Classroom

Chris Gosling[1]
[1]Saranac Lake High School / SUNY Buffalo State.

I describe my experiences using Hickman’s *Interactive Collaborative Electronic Learning Logs* teaching HS Physics. ICE Learning Logs are written in student groups to answer questions posed by the instructor, who then in turn responds to each group’s entry before the next class. These logs were used with non-physics majors in both algebra and calculus-based introductory physics courses, and also at the high school level.

I found ICE Learning Logs were found to be a clear improvement over traditional student journals. Excerpts from group entries will be presented to demonstrate the group identities that formed as well as the utility of the journals to probe for conceptual understanding. In addition, the ICE Learning Logs served as an excellent resource for students to review before exams and also to examine for critical moments to reflect on in formal essays.

Hickman, P. (2000). Assessing student understanding with interactive-electronic-collaborative learning logs. *ENC Focus, 7(2)*, 24-27.

Sponsored by the National Science Foundation DUE0302097 and SUNY-Buffalo State Physics

144: Bringing Physics by Inquiry to K-12 Classrooms, Part I
AAPT Oral, Monday, 6:00-8:00pm, 211

Chair

Peter Shaffer[1]
[1]Univ. of Washington.

144.01

Teaching Inquiry Science in the Elementary-school Classroom

Dan Jordan[1], D. L. Messina[2], L. C. McDermott[2]
[1]Olympic View Elementary School, [2]University of Washington.

Bringing reform instruction to the elementary school classroom requires a teacher to have strong content understanding as well as an understanding of what it means to teach and learn through inquiry. For the past two years, I have participated in the NSF-funded Summer Institute and ongoing academic-year Continuation Course offered by the Physics Education Group at the University of Washington. In this talk, I will discuss how working through modules in *Physics by Inquiry*[1], the research-based curriculum developed by the group, has strengthened my understanding of topics I am expected to teach. I will also describe how the additional support provided by the Continuation Course has extended my professional development through its emphasis on reflection on teaching practice and the implementation of inquiry in the K-12 classroom.

Sponsored by Lillian C. McDermott.

1. L.C. McDermott and the Physics Education Group at the University of Washington, *Physics by Inquiry*, New York, NY, John Wiley & Sons, Inc. (1996).

144.02

Bringing Inquiry Science to K-5 Classrooms

Paula L. Schachtel[1], D. L. Messina[2], L. C. McDermott[2]
[1]Seattle Public Schools, [2]University of Washington.

As a science coach in the Seattle School District, I am responsible for helping other elementary teachers teach science. For several years, I have been participating in a program that consists of intensive NSF Summer Institutes and an ongoing academic-year Continuation Course. Teachers in this program work through modules in *Physics by Inquiry*, a research-based curriculum developed by the Physics Education Group at the University of Washington.[1] I will discuss how this type of professional development has deepened my understanding of topics in physical science, helped me to teach science by inquiry to my own students, and enabled me to assist my colleagues in implementing inquiry science in their K-5 classrooms. Sponsored by Lillian C. McDermott.

1. A research-based curriculum developed by L.C. McDermott and the Physics Education Group at the University of Washington, *Physics by Inquiry*, New York, NY, John Wiley & Sons, Inc. (1996.)

144.03

Teaching Inquiry Science in the Middle-school Classroom

Eleanor I. Martino[1], D. L. Messina[2], L. C. McDermott[2]
[1]Seattle Country Day School, [2]University of Washington.

For several years I have been participating in the NSF-funded Summer Institutes and ongoing academic-year Continuation Course offered by the Physics Education Group at the University of Washington. The in-depth content understanding necessary for me to implement inquiry successfully in my middle-school classroom has grown as a result of these professional development opportunities. *Physics by Inquiry*[1], a research-based curriculum developed by the group, addressed my understanding of topics relevant to the curricula I am expected to teach and served as a model both for content and instructional practice. In this talk, I will discuss the implementation of inquiry in my classroom and the effects on student achievement. I will also provide examples of the ways that collaboration with other teachers has contributed to my professional development.

Sponsored by Lillian C. McDermott.

1. L.C. McDermott and the Physics Education Group at the University of Washington, *Physics by Inquiry*, New York, NY, John Wiley & Sons, Inc. (1996).

144.04

Assessing an inquiry-oriented mechanics unit for high school students

Michael P. O'Byrne[1], M. R. Stetzer[2], L. C. McDermott[2]
[1]Interlake High School, [2]University of Washington.

A unit on mechanics, based on *Physics by Inquiry*[1] by the Physics Education Group at the University of Washington, has been tested in a high school classroom. Development of the instructional materials was guided by experience gained from the NSF Summer Institute and academic-year programs for inservice teachers offered by the group. Questions have been administered both in class and online in order to assess student understanding before, during, and after instruction. Specific examples will be presented.

1. *Physics by Inquiry,* L.C. McDermott and the Physics Education Group at the University of Washington, Wiley (1996).

144.05

Adapting an Inquiry-oriented Kinematics Curriculum for High School Students*

Matthew D. Randall[1], M. R. Stetzer[2], L. C. McDermott[2]
[1]College of Education, University of Washington, [2]University of Washington.

The *Kinematics* module from *Physics by Inquiry*[1] has been adapted for and tested in a high school classroom. The adaptation was based on experience gained both as a preservice teacher in special courses taught by the Physics Education Group at the University of Washington, and also as an instructor in a six-week NSF Summer Institute taught by the group. Pretests and post-tests have been administered to assess the effectiveness of the curriculum in improving student understanding of kinematics. Recent results will be presented.

* This work has been supported in part by the Knowles Science Teaching Foundation.

1. *Physics by Inquiry,* L.C. McDermott and the Physics Education Group at the University of Washington, Wiley (1996).

144.06

An Inquiry-oriented Mechanical Waves Unit for High School Students*

Thomas J. Knapton[1], R. G. Piccioni[1], M. Kryjevskaia[2], L. C. McDermott[2]
[1]Garfield High School, [2]University of Washington.

During the past two years, a unit on mechanical waves has been implemented and assessed in a high school classroom. The unit was adapted from a new module from *Physics by Inquiry*[1], a laboratory-based curriculum for K-12 teachers developed by the Physics Education Group at the University of Washington. The adaptation and implementation of the unit as well as recent results from student pretests and post-tests will be discussed.

Sponsored by Lillian C. McDermott.

1. *Physics by Inquiry,* L.C. McDermott and the Physics Education Group at the University of Washington, Wiley (1996).

144.07

Adapting an electric circuits curriculum for the high school classroom

Scot A. Hovan[1], M. R. Stetzer[2], L. C. McDermott[2]
[1]Mahtomedi High School, [2]University of Washington.

MONDAY

A unit based on the *Electric Circuits* module from *Physics by Inquiry*[1] has been designed for and tested in a public high school classroom. Both the adaptation and the implementation of the unit were informed by three years of participation in an NSF Summer Institute for Inservice Teachers taught by the Physics Education Group at the University of Washington. Challenges exist in using such an approach in high school physics classrooms. This implementation addresses challenges such as utilization of the physical classroom space, group material organization, and strategies for improving the effectiveness of group work. Results from pretests and post-tests that have been administered to students will be discussed.

1. *Physics by Inquiry,* L.C. McDermott and the Physics Education Group at the University of Washington, Wiley (1996).

145: Students' Use of Mathematics in Physics Contexts AAPT Oral, Monday, 6:00-8:00pm, 307-08

Chair

Francis Tam[1]
[1]Frostburg State Univ..

145.01

Do We Need Remedial College Math Courses?

Anne O. Hughes[1], D. Khatri[1]
[1]University of the District of Columbia.

Entering college freshmen, in increasing numbers, in practically every public institution of higher learning are in need of one or two remedial math courses. This is particularly a big problem at the Historically Black Colleges and Universities where a large number of remedial math course sections are offered to meet the growing demand for such courses. For most of these students, graduation is delayed by at least a year. In addition, these students continue to be taught by teaching methodologies that did not work for them even in high schools resulting in disgust and hatred for math. This situation makes entry for these students into STEM areas difficult and is the perfect recipe for failure in STEM disciplines if they enroll in college level courses. The University of the District of Columbia (UDC) is no exception.

A first attempt was made in summer 2006 to remedy this situation. The problem for this exploratory research study was to ascertain if a short, intensive six-week project in basic math and introductory algebra would produce a recognizable improvement in the math performance of entering UDC freshmen students as measured by the UDC math placement test.

The results are eye opening. On the pre-test for basic math (005), the mean score for the group (N=10) was 35.6, with the passing score being 70. On the post-test, the mean increased to 63.4 showing an improvement of 78 percent. The authors will present the results of this research study at the conference

145.02

Equations In Science: Are They Hindering the Development of Reasoning Skills?

Suzanne White Brahmia[1]
[1]Rutgers University.

The science curricula start using fairly sophisticated mathematics concepts in middle school. A few examples of mathematical representations that are typically found in middle school textbooks include variables and algebraic representations such as V=IR and density=m/v, integers to represent different directions of motion, acceleration etc., exponential population growth and half-life, vectors to represent force, and the concept of zero for electrical neutrality. Rather than getting the opportunity to learn mathematical reasoning and methods in context, the students are instructed to memorize equations and plug in some numbers, almost like playing the children's game "MadLibs"[1].

In this talk I will show some examples from middle school curricula that correlate to the pervasive difficulty students have at the college level of representing words using equations, performing simple algebra to solve for an unknown quantity, and understanding the use of positive and negative signs in 1-d (and, thus, vectors in 2-d). I propose a hypothesis that college students' difficulty in mathematical representations are related to first experiences of the use of equations in science, and grade-appropriate math methods taught in the context of the first physical science courses will produce better reasoning skills at the college level.

[1] MadLibs is copyrighted by Penguin Putnam Inc. A story is pre-written but is missing a few words. With no knowledge of the story itself, a partner is asked for some nouns, verbs etc. that get plugged into the story. The story is then read aloud with the words plugged in to a humorous end.

145.03

Connecting Math and Motion: A Covariational Approach

Robert J. Culbertson[1], A. S. Thompson[1]
[1]Arizona State University.

We define covariational reasoning as the ability to correlate changes in two connected variables. For example, the ability to describe the height of fluid in an odd-shaped vessel as a function of fluid volume requires covariational reasoning skills. Covariational reasoning ability is an essential resource for gaining a deep understanding of the physics of motion. We have developed an approach for teaching physical science to in-service math and science high school teachers that emphasizes covariational reasoning. Several examples of covariation and results from a small cohort of local teachers will be presented.

145.04

Principles of Covariation in the Introductory Physics Classroom

Adam S. Thompson[1], R. J. Culbertson[1]
[1]Arizona State University.

Covariational reasoning (CR) is the ability to correlate changes in two connected variables. Studies done with CR have shown that this ability is essential in developing student proficiency in algebra and calculus. In the present study, CR was used in the introduction of physics concepts in a conceptual physics course for community college students. We will discuss the correlation of student proficiency in physics and CR.

145.05

Teaching Kinematics as a Way to understand Calculus and Graphs

Genaro Zavala[1], H. Alarcon[1]
[1]Tecnologico de Monterrey, Mexico.

In our institution we have implemented a remedial course in which one of its sections is dedicated to kinematics in one dimension. In that section we spend some time working with graphs understanding concepts from mean velocity to instantaneous velocity as a way to understand broader concepts such as mean rate-of-change and instantaneous rate-of-change. Students calculate instantaneous velocity by three methods: using the graph, using the ratio of change of position to time interval when the time interval is sufficiently small, and using derivatives. Students are able to compare the three methods realizing that the first method gives them an approximation; the second one, by using significant figures, is able give them the correct answer; and the last method give them the correct answer. At the end of the section, students are able to construct velocity graphs from position graphs and vice versa, position graphs from velocity graphs.

145.06

Student Understanding of Probability and Introductory Statistical Physics in Upper-division Courses on Thermal Physics

Michael E. Loverude[1]

[1]California State University Fullerton.

This talk describes part of an ongoing investigation of student learning in the context of upper-division courses in thermal physics. In particular, we will examine student understanding of the fundamental concepts of statistical physics, and the underlying mathematics of probability. Our results suggest that students lack a deep understanding of the statistics of binary systems like coin flips, calling into question their ability to apply these results to simple physical systems. We will provide examples of student responses and written explanations and discuss implications for instruction.

145.07

Student Solutions to First-Order Differential Equations in Intermediate Mechanics

Michael C. Wittmann[1], K. E. Black[1]
[1]University of Maine.

We find that students solving a variety of first order linear differential equations in a sophomore level mechanics class emphasize certain reasoning resources over others. Contrary to informal commentary by many observers, students can often do the math, but they stick to purely mathematical reasoning paths when physical insight can simplify the problem for them. For example, they emphasize the indefinite integral rather than using physically meaningful limits of integration when solving integrals after separation of variables. Also, they often leave solutions mathematically complete while not paying attention to the unique physical solution. We observe a context dependence based on the formalism used to ask the question. We also observe consistent results in both small group ″mini interviews″ and on examination questions. Even on identical questions asked months apar, students show little consistency in their solution methods. We give specific examples in this talk. (Sponsored in part by NSF grants REC-0633951 and DUE-0442388.)

145.08

Using Mathematics to Inform Conceptual Reasoning about Quantum Tunneling

Jeffrey T. Morgan[1], M. C. Wittmann[2]
[1]University of Northern Iowa, [2]University of Maine.

Previously, we have reported on work at the University of Maine investigating how undergraduate physics students reason about the phenomenon of quantum mechanical tunneling.(1) The majority of our interview sessions involved a series of qualitative questions regarding a square-barrier tunneling scenario. For a select group of students, we began second interview sessions by asking them to solve the time-independent Schrodinger equation prior to answering a series of conceptual questions. All were able to produce reasonably correct solutions, which could be used throughout the interview to reason about the answers to many of our questions. However, in several instances students either failed to refer to the mathematics when responding, or seemed to struggle with understanding their equations and how the mathematics informed the correct responses, suggesting a discontinuity between their mathematical reasoning and their physical reasoning.

1. M. C. Wittman, J. T. Morgan, and L. Bao. Addressing student models of energy loss in quantum tunneling. Eur. J. Phys. **26**, 939-950 (2005).

146: Apparatus for Astronomy Education AAPT Poster, Monday, 6:00-8:00pm, 617

Chair

M. A. H. Klassen[1]
[1]Swarthmore College.

146.01

Teaching Astronomy at Columbus State University using Small Radio Telescopes

Zodiac T. Webster[1]
[1]Columbus State University.

Astronomy is inherently fascinating to students but dark skies and good weather are not often scheduled during the school day. Radio telescopes provide an all-weather, all-day opportunity for astronomical observations. Columbus State University (CSU) has installed two “Small Radio Telescopes” for use by undergraduate students to pursue extra-curricular research in introductory astronomy. These telescopes are relatively affordable and are designed to be remotely operated through a Windows, Linux, or Macintosh environment. They are capable of diffraction-limited observations of the Sun and galactic Hydrogen in the ‘L-band’. A comprehensive website of projects suitable for high-school students and undergraduates is maintained by a group at MIT. This website ensures users are not left to explore the telescope’s abilities blindly. Students with varied interests learn about the nature of science by using an instrument that doesn’t lend itself to pretty pictures. Radio telescopes also provide a slight engineering flavor drawing in students who might not otherwise be interested in astronomy. This poster will provide a summary of installation, calibration, and future plans, and will share some observations by undergraduates at CSU.

146.02

Experimental and Theoretical Challenges of Creating Electrostatic Orbits in Weightlessness

Kevin W. Andring[1], B. Hoffmeister[1], S. Banerjee[1], J. Janeski[1], S. Quinn[1], D. Keedy[1], D. Campbell[1]
[1]Rhodes College.

In January 2006, a team of students from Rhodes College was awarded flight time aboard NASA’s specialized C-9B aircraft known as the “Weightless Wonder” to perform an experiment in microgravity. This experiment demonstrated a prediction of Coulomb’s Law that two oppositely charged spheres should orbit each other under certain conditions. However a number of issues complicate this demonstration such as polarization effects (which affect the nature of the inverse square law and thus the stability of orbits), fluctuations in the microgravity conditions, and the effects of air pressure and humidity on charge leakage. This poster will discuss how we resolved these issues to successfully perform our experiment under the mentoring of Brent Hoffmeister and Shubho Banerjee.

146.03

Using Microsoft PowerPoint as an Astronomical Image Analysis Tool

Bernhard Beck-Winchatz[1]
[1]DePaul University.

Engaging students in the analysis of authentic scientific data is an effective way to teach them about the scientific process and to develop their problem solving, teamwork and communication skills. In astronomy several image processing and analysis software tools have been developed for use in school environments. However, the practical implementation in the classroom is often difficult because the teachers may not have the comfort level with computers necessary to install and use these tools, they may not have adequate computer privileges and/or support, and they may not have the time to learn how to use specialized astronomy software. To address this problem, we have developed a set of activities in which students analyze astronomical images using basic tools provided in PowerPoint. These include measuring sizes, distances, and angles, and blinking images. In contrast to specialized software, PowerPoint is broadly available on school computers. Many teachers are already familiar with PowerPoint, and the skills developed while learning how to analyze astronomical images are highly transferable. We will discuss several practical examples of measurements, including the following:

-Variations in the distances to the sun and moon from their angular sizes

-Magnetic declination from images of shadows

-Diameter of the moon from lunar eclipse images
-Sizes of lunar craters
-Orbital radii of the Jovian moons and mass of Jupiter
-Supernova and comet searches
-Expansion rate of the universe from images of distant galaxies

146.04

Simulating the Nature of Science: Cosmology Distilled

Tim Erickson[1]
[1]*eeps media.*

We will show the latest version of our nature-of-science simulation system, in which students work in groups as researchers to uncover the structure of the (simulated and abstract) universe. They make observations, develop hypotheses, and publish their results. This community of scholars gradually builds up an understanding of their new field of research, as revealed in their journal articles. Along the way, the student-researchers see their hypotheses shattered by new data, and even have to deal with funding issues, since observations are not free.

Some teachers are enthusiastic about this as a way to do writing across the curriculum. More important, though, is how experiences like this can help students see how science really works: that it takes teamwork, diverse ideas, and tenacity in addition to plain old smarts. It also helps students distinguish between conjectures that are truly scientific and those that aren't. This work is supported by NSF; we'll show how the system works.

147: Supernova Neutrino Astrophysics Plenary, Tuesday, 8:30-9:20am, Ballroom 6

147.01

Supernova Neutrino Astrophysics and Associated Nucleosynthesis

Wick Haxton[1]
[1]*University of Washington.*

Core-collapse supernovae are one of the major engines governing the evolution of metals in galaxies. Difficulties in numerically modeling these explosions and their potential sensitivity to unknown neutrino physics are among the uncertainties that are currently slowing progress. I describe some of the issues, including the potential consequences of dense seas of trapped neutrinos and of the unknown 1-3 neutrino mixing angle.

Nucleosynthesis -such as the r-process and the neutrino-process -are useful diagnostics of the explosion. I describe recent observations that may help us better define the explosive environments responsible for such nucleosynthesis.

148: Poster Session III AAPT Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

148.01

Exploring Systematic Error With Digital Video

M. A. H. Klassen[1], P. C. Bloom[2]
[1]*Swarthmore College,* [2]*North Central College.*

Digital video acquisition and analysis has become user-friendly and affordable with the advent of webcams and software such as Vernier's LoggerPro. The analysis of the ballistic trajectory of a ball has been a fixture in the physics lab curriculum at Swarthmore College for many years. When we updated the experiment to use digital video rather than stroboscopic photography, the data acquisition and analysis became almost trivial. We realized this gave us the opportunity to use an experiment with very precise data and a well-defined expected result (the acceleration due to gravity, g) to teach about systematic error and ways to correct for it. In this paper we describe modifications to the lab procedure that demonstrate systematic errors due to calibration, perspective effects, and air drag.

148.02

100% Online College Physics at Chemeketa Community College

Erik L. Jensen[1]
[1]*Chemeketa Community College.*

Chemeketa Community College has offered college physics in an entirely online format since fall term of 2005. This poster will provide information on the format of the course including the student lab kits. This poster will also provide data on the success of the course as quantified by recruitment, retention, and performance of students. This data from online students will be presented alongside data from students in the same course taught simultaneously in a traditional format.

148.03

Effect of a Web-based Tutoring System on Introductory Physics Students*

Tom Carter[1], T. Smith[2], M. Wittman[2]
[1]*College of DuPage,* [2]*University of Maine.*

We will show the initial review of the effect of implementing the web-based physics tutoring and homework system, TYCHO, at the College of DuPage. The College of DuPage is a two-year college in suburban Chicago. TYCHO is provided by the University of Illinois at Urbana-Champaign and includes a subset of problems called Interactive Examples which have extensive Socratic tutoring and assistance available. We will compare the average normalized gains on conceptual evaluations such as the FMCE and results of more quantitative exams for classes taught by the same instructor before and after the system was implemented. We will also look at students' impressions of the system based on survey results. A more detailed analysis of these results will be presented at later meetings.

*This research supported in part by NSF CCLI grant DUE-0510614.

148.04

Bibliographic Research Projets

Carlos Delgado[1]
[1]*Community College of Southern Nevada.*

Undergraduate college students, when taking traditional physics courses, receive instruction on new knowledge (lectures), problem-solving strategies (tutorials), and hands-on skills (laboratories). Due to time constraints, little attention is usually paid to the development of students' research abilities. Bibliographic research is the first step in any serious scientific project. This poster will show a way to develop this ability in a General Physics class. Students will present their bibliographic research reports on several topics assigned in such a class.

148.05

Characteristics of the General Physics student population.

Gary L. Hunt[1]
[1]*Boise State University.*

Are pre-medical students different than the other students in a General physics class? They often appear to be different, based on how often they seek help from the instructor or how nervous they are about 2 points on a lab report. But are these students different in a measurable characteristic?

The purpose of this study is to better understand the characteristics of the students in the introductory physics classes. This is the first step toward improving the instruction. By better understanding the students the classroom, the organization and pedagogy can be adjusted to optimize student learning.

The characteristics to be investigated during this study are:

· student epistemological structure,

· student attitudes,

· science course preparation prior to this course,

· study techniques used,

· physics concepts gained during the class

· performance in the class.

The data will be analyzed to investigate differences between groups. The groups investigated will be major, gender, and traditional/nontraditional students.

148.06

Intervention activities to improve the reasoning ability of students at risk in introductory physics

Vincent P. Coletta[1], J. Phillips[1]
[1]Loyola Marymount University.

We describe a number of activities we have begun using in interventions targeting students who are at risk in introductory college physics courses. Some are adaptations of the work of others with pre-high school children, including Philip Adey in Great Britain (Cognitive Acceleration though Science Education), Reuven Feuerstein in Israel (Instrumental Enrichment), and Kurtz and Karplus in the U. S. in the 70’s (Numerical Relationships). We have also added some other activities, including Sudoku strategy development.

148.07

Bachelor of Science in Medical Physics Program at Ryerson University

Tetyana Antimirova[1]
[1]Ryerson University, Canada.

A new Bachelor of Science in Medical Physics program at Ryerson University, Toronto, Ontario was launched in Fall 2006. The program builds on Ryerson’s strong existing capabilities in biomedical physics research. The program’s point of entry is the common first year during which all students in Biology, Chemistry, Contemporary Science and Medical Physics programs complete the foundation courses that include physics, calculus, biology, chemistry, and introduction to computing. In addition to the foundation courses, the first-year studies include an orientation course that supports the students in making a successful transition to university studies. The courses beyond the first year include such topics as radiation therapy, image analysis, medical diagnostics and computer modeling techniques. In the final year the students will undertake an independent, faculty-supervised thesis project in an area of personal research interest. Co-op and industrial internship options are available. Our program promotes natural interaction between physics, life sciences, mathematics and computing. The flexibility built into our curriculum will open a variety of career options for our graduates.

148.08

Does it Matter Where You Sit?

Brian A. Pyper[1], S. Thompson[1]
[1]BYU-Idaho.

This work represents preliminary research on correlations between students’ choice of seats and course grade in a 60-seat lecture-based Physical Science course. Follow-up research is ongoing.

148.09

Peer-assessment of Homework Using Rubrics

Sahana Murthy[1]
[1]Massachusetts Institute of Technology.

An assessment system that supports learning involves student participation in productive activity, distribution of effort evenly across topics and weeks, communication of clear expectations by instructors, and detailed, frequent and quick feedback that reinforces learning goals [1]. One way to meet the above goals is by means of peer assessment. This also engages students in the process of evaluating scientific information. In an introductory calculus-based class, we are implementing a system in which each student assesses another student’s weekly homework problems. To guide students through the process, we provide them with evaluation rubrics that have descriptors for various criteria that each problem is assessed on. The criteria include: physics content, relevant representations, modeling the situation, problem-solving strategy and reasonableness of answer.

Does peer-assessment support student learning and help student development of evaluation abilities? To gain some insight, we assigned evaluation questions on an exam in our course and another equivalent introductory course. Results of student performance will be compared, and correlations between the development of evaluation abilities and student performance on analytic and conceptual questions will be discussed.

[1]Gibbs, G. & Simpson, C. (2003). Does your assessment support your students’ learning? Journal of Learning and Teaching in Higher Education, 1, 1.

148.10

Seeing Physics Outside the Classroom Through Journal Writing

J. Johanna Hopp[1]
[1]University of Wisconsin Stout.

As educators, we want students to realize the importance of physics in their everyday lives. Furthermore, we want to provide students an opportunity to experience physics outside the classroom to reinforce the material we discuss inside the classroom. This poster describes a journal writing assignment that accomplishes both these things for use in introductory physics courses. Students write journals about the physics they experience in their ‘real’ lives. The entries are brief, with a sentence or two describing an observation they made and a few sentences discussing the physics that is involved. Students are encouraged to write about events that involve physical principles discussed in class. This allows the instructor to determine if there are misconceptions about topics. This assignment has been received positively by students and is enjoyable for the instructor. It provides the instructor insights about the students’ experiences and thought processes as they relate to physics.

148.11

Path Integral Understanding in the Context of the Electromagnetic Theory

Maria D. Gonzalez[1]
[1]NMSU.

Introductory electromagnetic courses at the University of Juarez are in general identified by the use of a traditional instruction. The path integral is a fundamental mathematical knowledge to understand the properties of conservative fields such that the electric field. Many students in these courses do not develop the necessary scientific skills and mathematical formalism to understand the fact that the potential difference does not depend on the path followed from one point to another one inside an electric field. It is fundamental to probe the student understanding difficulties to apply the concept of path integral in an electromagnetic context. The use of the software CABRI could become an important didactic choice during the development of the potential difference concept. It was necessary the recollection of data related to the student procedural difficulties in the use of the designed CABRI activities. Sponsor: member Sergio Flores

148.12

Using Case Studies in Calculus-based Physics

Debora M. Katz[1]
[1] *USNA.*

Do your students believe that the physics only works in your classroom or laboratory? Or do they see that physics underlies their everyday experience?

Case studies in physics help students connect physics principles to their everyday experience. For decades, case studies have been used to teach law, medicine and biology, but they are rarely used in physics.

I am working on a calculus-based physics textbook for scientists and engineers. Case studies are woven into each chapter. Stop by and get a case study to test out in your classroom. I would love to get your feedback.

148.13

Results From the CHEPREO Undergraduate Learning Community

Laird H. Kramer[1], G. O'Brien[1], P. Pamela[1], J. M. Saul[1]
[1] *Florida International University.*

The Center for High-Energy Physics Research Education and Outreach (CHEPREO) is an NSF-supported project that continues to build a learning, teaching, and research community of high school students and teachers, undergraduate and graduate students, as well as university faculty. CHEPREO's goal is to generate excitment about physics and science, support inquiry-based instructional methods in the classroom, and increase physics enrollment at both the high school and college level by using high energy physics as a base. This poster will present results from our undergraduate learning community where students serve as CHEPREO fellows, assisting in the inquiry-based classroom and performing high-energy physics research. Support of the fellows has spawned substantial change throughout the department. Work supported by NSF Award #0312038.

148.14

Preparation for Physics Redux

Edward Adelson[1]
[1] *The Ohio State University.*

The textbook for our preparation for physics course has been rewritten ab initio. Like its predecessor, it adapts a spiral approach to dealing with preconceptions, but this version encourages work at higher levels in Bloom's taxonomy and makes students sensitive to how p-prims affect their understanding. As its title: ″All in Proportion: Preparation for Physics″ indicates, it emphasizes how far proportional reasoning will take the student. Classwork is mainly group work, and various techniques are used to encourage students to complete the learning cycle on material that has not been mastered. Both the FCI and the Lawson ″Classroom Test of Scientific Reasoning″ have been given to gauge student progress. Preliminary results will be reported and sample materials will be shown.

148.15

Fostering Critical Thinking in a First Year Seminar Course

Jennifer Blue[1], B. A. Taylor[1], J. Yarrison-Rice[1]
[1] *Miami University.*

How does one engage first year students in a case-based seminar on ethics and science, and more importantly, how does one foster critical thinking in such a course? Most educators will agree that one of the most important goals of any course is to improve our students' critical thinking skills. To get some baseline data on the critical thinking skills the students bring into the university as well as their growth through the semester, we adapted the rubric developed by the Washington State University Critical Thinking Project[1] and used it to score papers written by students in the Ethics in Science course the first time it was taught. Based on those data, new assignments were written for the second iteration of the course. Data from both the first and second iterations will be presented.

[1] www.wsuctproject.wsu.edu

148.16

Crash Videos Spark Inelastic Collisions Interest

George R. Bart[1]
[1] *Truman College.*

There are many popular dramatic crash videos available on the Internet. Introductory physics student interest about the details of inelastic collisions can be significantly aroused by the use of these videos. Sources of the videos will be provided and some of truck crashes will be shown. One dramatic one will be analyzed. It involves MJ of kinetic energy and MN of force. More detail with references is found at http://faculty.ccc.edu/gbart/crashvideo/.

148.17

Interactive Low Tech Lecture Demonstrations for Introductory Physics

Marina M. Milner-Bolotin[1]
[1] *University of British Columbia, Canada.*

The poster will present a few of low tech and low cost, but highly interactive and fun lecture demonstrations which can be successfully implemented in a small as well as in a large introductory physics courses. The advantage of these mini experiments is that being cheap and easily prepared these demos can become small take home projects which the students can share with their friends and families. One of these demonstrations is a modified reaction time experiment using a ruler cut out of paper and paper clips; the second one uses a small spring, a string and a weight (or a ball on a rubber band) to demonstrate the difference between weight and apparent weight; the third one is a simple modification of a Greek Waiter Demo using paper coffee cups and a string and the last one demonstrates production of sound waves in a tube using bubble tea straws. These small lecture demonstrations can make a big difference and will help every physics instructor make his or her introductory physics classes more meaningful, fun and engaging.

148.18

Using Students' Design Tasks to Develop Scientific Abilities*

Xueli Zou[1]
[1] *California State University, Chico.*

In collaboration with the Physics and Astronomy Education Research group at Rutgers University, three different types of student experiments_testing, application, and investigation design_have been developed and implemented in a calculus-based introductory course at California State University, Chico. Students working in small groups are engaged in designing and conducting their own experiments to test a physics principle, build a real-life device, solve a complex problem, or to conduct an open-inquiry investigation. In this poster we will illustrate examples of the design tasks and discuss instructional strategies of implementation.

*Supported in part by NSF DUE # 0242845 and #0088906

148.19

Reflection Shadows: An Unusual Example for Elementary Ray Optics

Lee C. Widmer[1]
[1] *University of Cincinnati.*

Formation of shadows and reflection from plane mirrors are two simple and typical topics in elementary ray optics. In this paper I demonstrate how it is possible to combine the two to create unusual shadows by selectively blocking reflected light. I show examples of the shadows, give a simple analysis of the principles involved and describe how the shadows are created.

148.20

The Effect of Uncertainty Focused Laboratory Instruction on Undergraduate Students

Kwangmoon Shin[1], J. Lee[1], Y. Kang[1], S. Lee[1]
[1]*Seoul National University, Republic of Korea.*

In this study, we instructed uncertainty analysis focused laboratory course. The course was consist of five steps. At first step, we checked students' conceptual state about measurement uncertainty by some paper based questionaries and interview. At second step, we taught them concepts about measurement uncertainty by theoretical lecture. And then, we had an interview with students. We recognized that theoretical lecture was not enough to them to learn and understand measurement uncertainty. So, we divided one class into several groups. we had each group execute measuring gravitational acceleration by various methods. And each group compared their result and other's results. Finally we interviewed students to find their changes in laboratory work and attitudes to experiment. We concluded that some activity of comparing measurement results could help students understand measurement uncertainty and improve students' attitude to experiment.

148.21

Measuring Systematic Errors With Curve Fits

Mark E. Rupright[1]
[1]*Florida Atlantic University.*

Nonlinear curve fitting software can be used to account for systematic error in laboratory measurements. I will give several examples where adding a parameter for a known source of systematic error in curve fits can result in better model/data agreement and provide an estimate of the systematic error present in the measurements.

148.22

Opto-Mechanical Integration

Jenny Magnes[1], D. Burt[1], J. Hartke[1]
[1]*U.S. Military Academy.*

We present for the first time an opto-mechanical integrator. Opto-mechanical integration allows for the opto-mechanical integration of any function. The integrated function can then be determined using curve fitting methods. Furthermore, the original function can be reproduced through numerical or analytical integration. This method is extremely useful as a laboratory exercise to reinforce the concept of integration and its physical implications.

148.23

Extending the Rubber Band Lab for Upper Division Thermodynamics Courses.

Stephen C. Hall[1], K. T. Gimre[1], K. H. Gimre[1], E. A. Townsend[1]
[1]*Pacific University.*

Historically few upper-level undergraduate thermodynamics courses have included lab activities. Developing labs for these courses is motivated by the growing awareness of the importance of providing students hands-on exposure to the physics principles they are learning. We report on a project to develop lab activities exploring the role of entropy and energy in determining pressure in gasses and force in rubber bands. Several authors [1] have described experiments with rubber bands illustrating the entropic origin of the restoring force of a rubber band. It is well known that the pressure in an ideal gas also has an entropic origin. By comparing the behavior of gasses and rubber bands, important aspects of the concept of entropy and its role in systems can be brought out. We describe experiments that compare these systems by measuring P vs T for gasses and f vs. T for rubber bands.

1. See for example, J.P. Byrne, J. Chem. Ed., 71, 531 (1994), and references therein.

148.24

Teaching Electromagnetic Waves in College Physics Laboratory

Roman Y. Kezerashvili[1], L. Leng[1]
[1]*Physics Department, New York City College of Technology, CUNY.*

One of the important educational advantages of the simultaneous study of the electromagnetic waves and light is to show that light and the electromagnetic radiation have the same properties so that the students can visualize the properties of the electromagnetic radiation through observation of light propagation. In our approach we are suggest to study the properties of a microwave radiation and light in parallel. The following experiments can be easily designed and they provide a methodical introduction to electromagnetic theory using the microwave radiation and light: the study of the inverse square law of the dependence of the intensity of radiation (microwave and light) on the distance, the law of reflection and refraction, investigation of the phenomenon of polarization and how a polarizer can be used to alter the polarization of microwave radiation and light, measuring the Brewster's angle, studying interference by performing double-slit experiment for microwave radiation and light. Finally students measure the wavelength of the laser light and microwave radiation using the corresponding versions the Michelson's interferometer, and recognize that these two radiations only differ by the wavelength or frequency.

148.25

Sensitive Altimeter; A Basic Electronics Project for Undergraduates

Harry E. Bates[1], J. Klupt[1], C. Bolling[1], M. J. Earle[1], B. P. Hofmann[1], J. Osman[1], J. L. Sunderland[1], M. Vincent[1]
[1]*Towson University.*

Projects with transducers are useful in the basic electronics laboratory to prepare students that will go to work in industry or attend graduate school in an experimental area of physics when they graduate. During the spring semester of 2006 the class constructed very sensitive altimeters using state of the art pressure sensors and integrated circuit amplifiers. Students participated in the basic design, breadboarding and construction. The project will be described as well as the digital system used to test them at the end of the semester.

148.26

Classical Mechanics Laboratory

Juliet W. Brosing[1]
[1]*Pacific University.*

At Pacific University we have included a lab with our upper division Classical Mechanics class. We do a combination of physical labs (air resistance, harmonic motion, amusement park physics), Maple labs (software), and projects. Presentation of some of the labs, results and challenges with this course will be included.

148.27

Static Friction Unsung Hero of Everyday Introductory Biomechanics

Nancy Beverly[1]
[1]*Mercy College.*

The ability of static friction to accelerate systems does not usually get the attention it deserves in introductory physics. Everyday human contexts abound in our grasp of objects to move them, in our being moved as passengers, and in our own locomotion. Student laboratory, classroom and homework activities have been developed which enable students to explore the vital role of static friction in various biomechanical contexts. Examples will be demonstrated.

148.28

The Scientific Method in a Cup

Bradley W. Carroll[1], M. B. More[1]
[1]Weber State University.

This paper describes an inexpensive hands-on activity that invites students to investigate an intriguing mystery and so discover for themselves the essence of the scientific method. When a spoon is tapped against the bottom of a mug of freshly made hot chocolate, a tone of constantly rising pitch is heard. Students' reactions to this "hot chocolate effect" illustrate how the scientific method may be constructed from the common sense and curiosity present in us all.

148.29

Building a Gravitational Analogy of Electric Circuits Using LEGOs®

James J. Butler[1], E. A. Townsend[2]
[1]Pacific University, [2]National Institute of Standards and Technology.

One of the most powerful techniques that physicists have at their disposal is the ability to make analogies between different physical systems that share common characteristics. Physicists often use their familiarity with a phenomenon in one system to understand a similar phenomenon in an apparently unrelated system. They draw analogies, find commonalities, and examine how the principles that govern each system give rise to similar (or different) behaviors. This is one of the abilities that we want to instill in our students. Introductory physics students often find the concepts of potential difference, current, and resistance particularly challenging. This difficulty is compounded in the analysis of complicated electric circuits that involve combinations of series and parallel resistors. In order to help our students build a conceptual understanding of these systems, we have developed LEGO building exercises that expand on the well-known analogy between gravitational potential energy in mechanical systems and electrical potential energy in circuits. In this analogy a closed circuit is represented by a closed path made of LEGOs. The potential difference across a battery is represented by a sudden change in the height of the path, electrical resistors are represented by ramps with appropriate lengths and slopes, and electrical current is visualized as balls rolling along the path. These exercises are used in both the laboratory and the classroom. Students are required to build LEGO models along with the corresponding electric circuits and explain the analogies between the components of each.

148.30

A 2006 SPS Summer Intern's Experiences, Reflections, and Future Ambitions

Ann Deml[1]
[1]University of Wisconsin River Falls.

As a SPS Summer Intern from the University of Wisconsin-River Falls, I spent nine weeks in the Washington, D.C. area working with the American Physical Society. My work dealt primarily with the development of a ComPADRE outreach website, Physics To Go, which offers the public opportunities to engage in informal physics learning. Specific tasks that I performed included locating content to feature on the homepage, obtaining photographer permissions, and cataloging quality websites into the digital library. At the conclusion of the summer, I accepted an offer to continue working on Physics To Go and have further contributed to its expansion. Participating in this internship has influenced my life in several respects, and as a result, I will be enrolling in a graduate program this coming year. Additionally, I am making plans to participate in a National Student Exchange program and am considering a career with a greater emphasis on research. The internship has served as an invaluable and irreplaceable experience.

149: AGNs, QSOs and Active Galaxies 2
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

149.01

Redshift Studies of Scintillating and Non-scintillating Extragalactic Radio Sources: Direct Detection of the Ionized Intergalactic Medium?

Roopesh Ojha[1], T. Pursimo[2], D. L. Jauncey[3], J. E. Lovell[3], J. Macquart[4], M. S. Dutka[5]
[1]USNO, [2]Nordic Optical Telescope, Spain, [3]ATNF, Australia, [4]Caltech, [5]University of Maryland.

Interstellar scintillation has been shown to be primarily responsible for intraday variability exhibited by extragalactic sources at centimeter wavelengths. The recent MASIV survey has shown that 53% of flat spectrum extragalactic radio sources scintillate; such behaviour is both too common and too important to ignore. A study of the physical properties of scintillating sources is severely handicapped by the absence of reliable redshift measurements for most such objects. This paper presents new redshifts obtained at the 2.6m Nordic Optical Telescope in La Palma, Spain. It also presents a critical evaluation of redshifts obtained from the literature. The entire dataset is then used to examine any difference in the redshift distributions of scintillating and non-scintillating extragalactic radio sources. We report a strong formal detection, with 98% confidence, of a redshift dependence on the fraction of scintillators with a deficit of scintillating sources above a redshift of ~2. This deficit is consistent with angular broadening due to scattering in the intergalactic medium, which then makes the higher redshift sources too large to exhibit interstellar scintillation due to the ISM of our Galaxy. If confirmed, this constitutes a detection of scattering due to the ionized IGM at $z>2$ resulting from intergalactic turbulence and thus detection of energy input into the IGM. More redshifts (particularly of weaker sources which are more likely to be scintillators) are necessary, however, to rule out selection effects including the possibility that the deficit of scintillating sources at high redshift simply results from the paucity of measured redshifts for weaker sources. A companion poster (Lazio et al.) presents a related multi-wavelength VLBI program to study the cores of scintillating and non-scintillating AGN and search for indications of an IGM.

149.02

Scintillating and Nonscintillating AGNs: Their Structure and Intergalactic Scattering

T. J. Lazio[1], R. Ojha[2], A. Fey[2], L. Kedziora-Chudczer[3], J. Cordes[4], D. Jauncey[5], J. Lovell[5]
[1]NRL, [2]USNO, [3]U. Sydney, Australia, [4]Cornell U., NAIC, [5]ATNF, Australia.

We report on a multi-wavelength program to examine the core structure of extremely compact AGN and to search for indications of an intergalactic medium. We have conducted Very Long Baseline Array observations of 58 compact extragalactic sources. Approximately 40% of these objects display interstellar scintillation, in the form of intraday variability, indicative of extremely compact structure (~ 10 microarcseconds).

We confirm earlier, single wavelength observations that found scintillating sources to be more core-dominated than nonscintillating sources (Ojha et al. 2006, ApJS, 166, 37), consistent with expectations from their scintillation. However, scintillating and non-scintillating sources display comparable levels of radio-wave scattering (~ 2 mas at 1 GHz). We also have redshifts for 63% of the sources and find no trend of scattering strength with redshift. We use these observations to place limits on the level of turbulence that the ionized intergalactic medium can support.

A companion poster (Ojha et al.) presents a summary of efforts to increase the number of sources for which redshifts have been measured.

The VLBA is a facility instrument of the National Radio Astronomy Observatory, which is operated by Associated Universities, Inc. under contract from the National Science Foundation. Basic research in radio astronomy at the NRL is supported by 6.1 Base Funding.

149.03

Radio Emission on Subparsec Scales from the Intermediate-Mass Black Hole in NGC4395

J. M. Wrobel[1], L. C. Ho[2]
[1]NRAO, [2]OCIW.

The Seyfert 1 nucleus of NGC4395 is energized by a black hole of mass 3.6e5 Solar masses (Peterson et al. 2005), making it one of only two nuclear black holes of intermediate mass, 1e3 1e6 Solar masses, detected in the radio regime. Building upon UV and X-ray evidence for outflows from this Seyfert nucleus, the VLBI High Sensitivity Array (HSA) was used at 1.4 GHz to search for extended structure on scales greater than 5 mas (0.1 pc). Elongated emission was discovered, extending over 15 mas (0.3 pc) and suggesting an outflow on subparsec scales from this intermediate-mass black hole. The Seyfert nucleus is located at the center of an elliptical star cluster, and the elongation position angle of the subparsec radio structure is only 19 degrees from the star cluster's minor axis.

For details, please see Wrobel & Ho (2006, ApJ, 646, L95).

These HSA observations involved the VLBA, the VLA, and the GBT, which are operated by the NRAO. The NRAO is a facility of the NSF operated under cooperative agreement by AUI.

149.04

Bayesian Quasar Classification in the Optical/Mid-IR

Gordon T. Richards[1], R. Brunner[2], A. Gray[3], M. Lacy[4], A. Myers[2], R. Nichol[5], R. Riegel[3]
[1]Drexel Univ., [2]Illinois, [3]Georgia Tech, [4]SSC, [5]Portsmouth, United Kingdom.

We discuss the optimal selection and photometric redshift estimation of quasars from combined SDSS plus Spitzer-IRAC photometry. Using only the deeper 3.6 and 4.5 micron bands of Spitzer-IRAC and single epoch SDSS photometry, we reliably identify 2580 quasar candidates in the Spitzer FLS, ELAIS-N1/N2, and Lockman Hole fields --roughly a density of 110 per square degree and 10 times the density of the SDSS spectroscopic sample. Photometric redshifts are estimated to be accurate to 4 percent or better for 86 percent of the sample. Such densities and accuracies should allow for powerful investigations of the high-redshift quasar luminosity function and possibly the size scale of the universe through baryon acoustic oscillations if applied to a large area Spitzer-IRAC survey which substantially overlaps the SDSS footprint.

149.05

A Relation Between the Mid-Infrared [NeV]λ14.3μm and [NeIII]λ15.6μm Lines in Active Galactic Nuclei

Charles R. Lawrence[1], V. Gorjian[1], K. Cleary[1], M. W. Werner[1]
[1]JPL.

We present a strong correlation between the [NeV] λ14.3μm and [NeIII] λ15.6μm emission lines arising from the Narrow Line Regions (NLR) of Active Galactic Nuclei (AGN), spanning four orders of magnitude in luminosity. The data are compiled primarily from *Spitzer Space Telescope* observations of nearby Seyfert galaxies (median z=0.01) and 3C radio sources (median z=0.52). This correlation is consistent with earlier studies in the optical/UV bands showing that line ratios arising in the NLR are remarkably constant across AGN. We also show that the correlation allows only a very narrow range in ionization parameter for simple photoionization models. The observed correlation will place tight constraints on alternative models, which predict constant line ratios over a broader range in ionization parameter.

149.06

Mid-Infrared Silicate Features as an Indicator of the Dust Density Distribution in ULIRGs

Matthew Sirocky[1], N. A. Levenson[1], M. Elitzur[1], H. W. Spoon[2], J. Marshall[2]
[1]U. of Ky, [2]Cornell.

The central heating sources in ultraluminous infrared galaxies (ULIRGs) are surrounded by significant amounts of material. Can we determine the dust density distribution of this material? Dust reprocesses the x-ray and ultraviolet radiation of the central source and reemits this radiation in the mid-infrared (MIR) and far-infrared (FIR). Silicate dust has two prominent features in the MIR near 10μm and 18.0μm. ULIRGs show these two spectral features in absorption. There must be a thermal gradient to produce an absorption feature. The depth of the silicate features depends upon the thermal gradient, and the thermal gradient depends upon the dust density distribution. Therefore, the silicate feature depths are directly related to the dust density distribution.

Using the numerical radiative transfer code DUSTY, we model different dust distributions: a simple normally-illuminated slab, a continuous density shell, and a clumpy shell. For a given density structure with optical depths that produce both features in absorption, we find that the ratio of the 10μm and the 18μm depths is generally constant. Departures from this linear relationship are a consequence of variations to the thermal gradient. The relationship between the 10μm and 18μm feature depths, therefore, directly indicates the dust density distribution. Consequently, we find the central heating source spectral shape, be it starburst or active galactic nuclei, does not influence the MIR and FIR spectra with high obscuration.

MMS and NAL acknowledge work supported by the National Science Foundation under Grant No. 0237291.

149.07

Searching for Mid-Infrared AGN Variability in Spitzer's IRAC Calibration Field

Lauren B. Hund[1], M. L. Ashby[2], J. L. Hora[2], J. Surace[3]
[1]Furman University, [2]Harvard-Smithsonian Center for Astrophysics, [3]Spitzer Science Center, Caltech.

We report on a new, extremely sensitive search for mid-IR (3.6 μm) AGN variability in the calibration field for Spitzer's IRAC telescope (the IRAC-CF). To our knowledge, mid-IR variation has never been used as a tool for finding previously undetected AGN, and the IRAC-CF is an ideal resource for performing this search. We developed a sorting algorithm to search the database of over 15,000 distinct 3.6 μm sources for those with clear intrinsic variations in brightness and investigated these individual candidates to determine whether the variation was intrinsic to the source. We found four such sources that exhibited variations on timescales of approximately one year. Planned follow-up optical, IR, and X-ray (Chandra) observations will confirm whether these four candidates are intrinsically varying. We found no sources that appeared to be intrinsically varying on shorter timescales. This research was made possible by NSF grant 9731923 and the SAO REU Summer Intern Program.

TUESDAY

149.08

Modeling of IR Emission from Externally Heated Dust Clouds

Moshe Elitzur[1], A. E. Kimball[2], Z. Ivezic[2], M. Nenkova[3]
[1]Univ. of Kentucky, [2]Univ. of Washington, [3]Seneca College, Canada.

We have modified the code DUSTY to solve the radiative transfer equations for a spherical dust cloud externally illuminated from a single direction. Some of the applications of this code include simulations of the radiation emitted by a clumpy dust torus surrounding an AGN, dust clouds in star-forming regions, and evolved stars with a dusty shell exposed to a strong interstellar radiation field. We discuss in detail the case of an optically thick dust cloud in the radiation field of an AGN. Until now, it has been assumed that radiation emitted from such a dust cloud can be approximated by averaging plane-parallel slab solutions for illumination at different angles; here we critically examine this assumption.

149.09

Red AGNs: Dust Absorption or Intrinsic Continuum Difference?

Monica Young[1], M. Elvis[2], G. Risaliti[3]
[1]Boston Univ., Center for Astrophysics, [2]Center for Astrophysics, [3]Center for Astrophsyics, INAF–Osservatorio Astronomico di Arcetri.

We cross-correlated the Schneider et al. SDSS Catalog with the XMM-Newton archival database to obtain a large sample of quasars. We then applied color and redshift selections (B-R $>$ 1.1 and 1 $\leq$ z $\leq$ 2) to restrict the sample to a manageable size of 18 of the reddest quasars. Seventeen of the 18 are detected to 2σ by XMM. The non-detection is a broad absorption-line quasar and is clearly reddened in the optical. Two of the X-ray detected sample have very flat X-ray spectra ($\Gamma < 1.0$) and are significantly X-ray weak compared to the optical (αox $<$ 1.8) while their signal-to-noise is too low to fit NH, we assume these are obscured due to their flat spectra. An additional three quasars have somewhat flat spectral indices ($1.0 < \Gamma < 1.5$) but normal αox values (αox ~ -1.5).

However, no significant absorption was detected in the X-rays of the higher signal-to-noise spectra and the X-ray spectral indices and αox values are within normal ranges for the rest of the sample. We will analyze the optical spectra to conclude whether dust absorption or an intrinsic continuum difference is the cause of reddening for our sample.

149.10

Decomposing Dusty Galaxies: Probing the Nature of the Obscured Energy Source in ULIRGs

Jason A. Marshall[1], L. Armus[2], V. Charmandaris[3], H. Spoon[1], V. Desai[4], T. L. Herter[1]
[1]Cornell Univ., [2]Spitzer Science Center, [3]Univ. of Crete, Greece, [4]Caltech.

Ultraluminous Infrared Galaxies (ULIRGs) have power outputs rivaling quasars, yet emit nearly all of their energy in the midand far-infrared. Both starburst and/or dust-enshrouded AGN activity have been implicated as the sources of power within ULIRGs. While rare in the local universe, ULIRGs may play a dominant role in producing the far-infrared background and star formation energy density at high redshifts. A sample of more than 100 ULIRGs has recently been observed as part of the Spitzer/IRS GTO program. Here, we apply to this sample a new technique we have developed to decompose the infrared spectral energy distributions of dusty galaxies into emission from silicate and graphite dust at different characteristic temperatures, PAHs, atomic and molecular lines, and stellar photospheres. We also apply the decomposition method to a sample of well-studied template starburst galaxies and AGNs which are used as comparison sources. We use these decompositions to quantify the distribution of luminosities of the various dust and PAH components as a function of total infrared luminosity, as well as the optical, near, and mid-infrared classification of each system. The decomposition method also provides an estimate of the overall dust extinction within each galaxy so that extinction corrected quantities can be estimated, illustrating the potential use of the method as a diagnostic tool to probe the energy sources within deeply enshrouded galactic nuclei.

149.11

Gemini Observations of Mid-IR Emission from the Nucleus of Centaurus A

James T. Radomski[1], C. Packham[2], N. A. Levenson[3], E. Perlman[4], L. L. Leeuw[5], H. Matthews[6], R. Mason[7], J. M. De Buizer[1], C. M. Telesco[2], M. Orduna[2]
[1]Gemini Observatory, Chile, [2]University of Florida, [3]University of Kentucky, [4]University of Maryland, Baltimore County, [5]Rhodes University, South Africa, [6]Herzberg Institute of Astrophysics, Canada, [7]Gemini Observatory.

We present high spatial resolution mid-IR images of the nuclear region of NGC 5128 (Centaurus A). Images were obtained at 8.8μm, N-band (10.5 μm) and 18.3 μm using the mid-IR imager/spectrometer T-ReCS on Gemini South. These images show a bright unresolved core surrounded by low-level extended emission.

We place an upper limit to the size of the unresolved nucleus of 3.1 pc (0.185”) at 8.8μm and 3.4 pc (0.205”) at 18.3μm at the level of the FWHM. The most likely source of nuclear mid-IR emission is from a dusty torus with some contribution from synchrotron emission associated with the jet as well as relatively minor starburst activity. Clumpy tori models are presented which predict the mid-IR size of this torus to be no larger than 0.05” (0.85pc). Surrounding the nucleus is extensive low-level mid-IR. Seen by ISO and Spitzer, this paper presents to date the highest spatial resolution mid-IR images of this extended near nuclear structure. Much of the emission is

coincident with Pa-α sources seen by HST implying emission from star forming areas, however evidence for shock heating, synchrotron emission from the jet, a nuclear bar/ring, and a dusty narrow emission line region is also discussed.

149.12

Characterization of the Baldwin Effect for AGN in the Mid Infrared

Mark Keremedjiev[1], L. Hao[2]
[1]University of Florida, [2]Cornell University.

We present an analysis of a mid infrared Baldwin effect for 68 AGN with z<0.5 using data collected with the Spitzer Space Telescope’s Infrared Spectrograph. Our analysis reveals an anti-correlation between the Equivalent Width of the [SIV] 10.51μm and the mid-IR continuum luminosity. There are also indications of a Baldwin Effect for the [NeII] 12.81μm and [NeIII] 15.56μm, but the realness of the correlation is contaminated by possible star formation activity from the host galaxies. The Baldwin effect for [NeV] 14.32μm is not obvious, implying that a more thorough analysis is still required. The mid-IR Baldwin effect has not been previously analyzed to date and has great implications for both the physics of the ionizing region and the continuum reprocess by dust.

149.13

Optical Color Selection of Faint AGN in the COSMOS Field

Caitlin M. Casey[1], C. D. Impey[1]
[1]Steward Observatory, University of Arizona.

We outline a strategy to select faint ($i_{AB} < 25.5$) AGN candidates for spectroscopic targeting in the COSMOS field (Scoville et al. 2007, ApJS, in press). Similar in design to the SDSS QSO selection algorithm outlined by Richards et al. (2002), this selection picks candidates by their nonstellar colors in *ubvriz* broadband photometry from the Subaru and CFH Telescopes. Although the COSMOS field has been used extensively to survey the galaxy population, QSO optical color selection has not been applied to this faint a level. Since the catalog is complete to magnitude $i_{AB} < 25.9$, we are testing AGN optical color selection at the Seyfert/QSO boundary all the way out to z ~ 3. While stars are easily identified as the dominant contaminant for bright QSO candidate selection at z $<$ 2, we anticipate a high contamination rate from compact red galaxies, which will lower selection efficiency and make the algorithm more complex. To create our candidate pool, we quantify the behavior of the stellar locus in 4D multicolor space. Objects that stray from the locus significantly are tagged as stellar outliers and potential QSO candidates. With a set of ~350 known QSOs (X-ray selected, radio selected, and optically selected from SDSS) and type 1 quasar templates designed by Budavari et al. (2001), we have a “training” data set with which to measure efficiency and completeness as a function of redshift. After initial classification in multicolor space, supplemental morphological selection will be applied to stellar outliers using the Gini coefficient, cross-checked against resolved AGN in the training data set, and a final candidate pool will be determined. Candidates will be observed spectroscopically with the IMACS-spectrograph on the Magellan (Baade) Telescope in Chile. This work was partially supported by NSF’s REU program at the Institute for Astronomy, University of Hawaii.

149.14

Preliminary SEDs of TypeI AGNs of COSMOS Survey

Heng Hao[1], M. Elvis[2], D. English[2], J. R. Trump[3], P. Capak[4], M. Brusa[5], V. Mainieri[5], M. Salvato[4], S. Gezari[4], D. Schiminovich[6], N. Scoville[4], C. Impey[3], J. Huchra[1]
[1]Harvard Univ., [2]CfA, [3]University of Arizona, [4]California Institute of Technology, [5]Max Planck-Institut fur Extraterrestrische Physik, Germany, [6]Columbia University.

COSMOS is a deep and wide multiwavelength survey of a 2 square degree equatorial field including the largest HST ACS survey and has been surveyed deeply at wavelengths from radio (VLA) to X-ray (XMM), including ground-based imaging to AB~26 in 7 bands from 0.3 2 microns, IR imaging from Spitzer and UV imaging from GALEX. In two observing seasons Magellan and VLT spectroscopy has already identified ~500 AGNs.

COSMOS is ideal for the study general form of the the spectral energy distributions (SEDs) of AGNs. Previous studies have been limited to optical selection, or X-ray/UV selection (Elvis et al., 1994), and span a narrow range of maximum/minimum fluxes at all frequencies, restricting the observable SED forms to a narrow 'spectral window'. COSMOS allows 'bolometric' AGN selection using all known techniques.

Here we show the prelimimary results of the SEDs of the first season of AGNs spectroscopially identifed with Magellan/IMACS spectrum. The sample contains 70 Type I AGNs. We find a large variety of SEDs this sample, which is encouraging for the statistical study of the SEDs of AGNs and AGN properties in the near future with the full COSMOS AGN sample.

The HST COSMOS Treasury program was supported through NASA grant HST-GO-09822

149.15

The Spectral Energy Distributions of Normal and Weakly-Active Galaxies

John K. Parejko[1], A. Constantin[1], M. S. Vogeley[1], F. Hoyle[2]
[1]Drexel Univ., [2]Widener Univ..

We present radio to X-ray spectral energy distributions (SEDs) of over 1000 galaxies, which constitutes the largest (by at least a factor of 4) and most uniform multi-wavelength sample yet produced. We perform cross-matching of spectroscopically observed SDSS galaxies with surveys from radio (FIRST), IR (Spitzer and 2MASS), UV (GALEX) and X-ray (ROSAT and XMM-Newton Slew) that produce firm detections in FIRST, 2MASS and GALEX for 1117 galaxies. We provide a statistical analysis of the validity of the SDSS-ROSAT matches. Active galaxies (AGN) were identified based on the presence of strong emission lines in SDSS spectra, and sub-classified as H II, Seyfert, LINER or transition systems according to emission line ratios. The resulting multi-wavelength dataset contains an order of magnitude more actively line-emitting galaxies than any previous sample. We present individual and composite galaxy and AGN SEDs from which we can compute the bolometric luminosity of the central sources and estimate accretion rates for those sources.

149.16

Multiwavelength Properties of Radio-loud Quasars

Brendan P. Miller[1], N. Brandt[1], D. P. Schneider[1]
[1]Penn State Univ..

We present the results of a comprehensive study of the multiwavelength properties of radio-loud quasars (RLQs). Utilizing data from recent large-scale radio (FIRST) and optical (SDSS) surveys, we have amassed a sample of over 400 RLQs with serendipitous Chandra, XMM-Newton, or ROSAT X-ray coverage, of which >80% are detected in the 0.5-2 keV band. These RLQs span greater than five orders of magnitude in luminosity and extend to high redshifts (21% have z>2) and radio-loudness (17% have log R*>3); their g-i colors as a function of redshift are similar to those of SDSS quasars in general. We supplement this primary sample with additional RLQs lying within the Chandra Deep Fields in order to extend our coverage of the l-z plane to lower luminosities. We confirm the tendency for UV-luminous RLQs to have steeper optical-to-X-ray spectral slopes and examine additional correlations involving redshift, radio-loudness, and radio morphology and spectral slope. These calculations are useful for evaluating the dominant source of X-ray emission in RLQs and for characterizing the evolution of RLQs.

149.17

Multiwavelength Observations of the Dwarf Seyfert 1 Galaxy POX 52

Carol E. Thornton[1], A. J. Barth[1], L. C. Ho[2], R. E. Rutledge[3], J. E. Greene[4]
[1]UC Irvine, [2]Carnegie Observatories, [3]McGill University, Canada, [4]Princeton University.

Multiwavelength Observations of the Dwarf Seyfert 1 Galaxy POX 52

POX 52 is an unusual narrow-line Seyfert 1 galaxy, having an estimated black hole mass of order 10^5 solar masses and a dwarf host galaxy with an absolute magnitude of only M_V = -17.6, which gives us a unique opportunity to study black hole-bulge relations in the low-mass regime. We present new observations from a multiwavelength campaign to study its active nucleus and host galaxy. The data include observations from the Chandra and XMM-Newton Observatories, the Hubble Space Telescope, and the Very Large Array. Chandra data show a highly variable point source with a 2.0 10.0 keV luminosity of 0.7 * 10^{42} ergs/s. We will also describe the X-ray spectral shape, the structure of the host galaxy as determined from GALFIT modeling of the HST ACS/HRC images, and the spectral energy distribution of the active nucleus.

149.18

Measuring Accelerations in Water Vapor Megamasers using the Hough Transform

Destry R. Saul[1], J. Braatz[2]
[1]UC Berkeley / NRAO, [2]NRAO.

Circumnuclear water vapor megamasers in AGN can be used to determine distances to the host galaxies. The distance measurement technique combines an analysis of the rotation curve from VLBI data and a determination of the centripetal acceleration of systemic maser features available from monitoring. Here we present an unbiased method for measuring accelerations, based on the Hough transform. Our method involves first identifying the doppler velocities of individual spectral components at each epoch using either a local maximum algorithm or a gaussian component analysis. Next we search for secular drifts in the velocities using a tailored formulation of the Hough transform. We demonstrate the technique using both synthetic data and GBT monitoring data. This research was completed during a NSF Research Experience for Undergraduates.

TUESDAY

149.19

Time Variation in OH Megamaser Emission and Absorption toward Radio Supernovae in Arp 220

Katherine R. de Kleer[1], C. J. Lonsdale[1], P. J. Diamond[2], C. J. Lonsdale[3], G. Smith[4], H. Thrall[2]
[1]MIT Haystack Observatory, [2]Jodrell Bank Observatory, United Kingdom, [3]California Institute of Technology, [4]University of California, San Diego.

We have used VLBI data and resulting images from two epochs separated by 15 months to study the radio supernovae and compact masers in the two colliding nuclei of Arp 220 (IC 4553), an Ultra-Luminous Infrared Galaxy (ULIRG) located at a distance of 76 Mpc (z = 0.018). Arp 220 has 49 confirmed radio supernovae in the two nuclei, and we have discovered OH absorption and maser amplification of the pointlike supernova continuum emission in both the 1665 and 1667 MHz lines. A question we seek to investigate is whether such features originate in material local to and associated with the supernovae, or whether they are due to chance lines of sight through an unrelated diffuse foreground OH medium. We look at these possibilities by analyzing the time variability and spectral properties of the features. We interpret our results in the context of the broader OH megamaser galaxy phenomenon.

149.20

Triggering AGN Through Gravitational Perturbations: An Example of a Student Project Using SDSS-DR5

Richard F. Gelderman[1], S. McMurray[1], S. Smith[1]
[1]Western Kentucky Univ..

The effect of galaxy interactions and other gravitational perturbations on nuclear activity has been investigated using data release five of the Sloan Digital Sky Survey (SDSS). Both the imaging and spectroscopy data products were used to construct a volume-limited sample of relatively nearby galaxies that also produce an AGN spectrum. The sample has been analyzed using the subjective morphological analysis pioneered by Dahari (1984, 1985) and MacKenty (1990). The high-resolution sky coverage of the SDSS allows for definition of a complete and unbiased sample and provides superior multicolor optical imaging of the AGN environments. The results of this student-led project modify the conclusions of previous investigations and indicate that for all AGN gravitational perturbations are always present in the host galaxies.

150: And Yet More Supernovae
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

150.01

Optical/UV Properties of High-z Supernovae Ia

Ryan J. Foley[1], ESSENCE Collaboration
[1]UC, Berkeley.

The largest known systematic error related to type-Ia supernova (SN Ia) distances is SN evolution from low to high redshift. The best method for constraining SN evolution is by looking at differences in spectral properties, especially in the UV. Since an individual high-z SN Ia spectrum typically has a low signal-to-noise ratio relative to low-z spectra, we have generated composite spectra from the sample of spectra of ESSENCE objects. Comparing the composite spectra, we see that high-z SNe Ia are very similar to low-z SNe Ia, however some slight differences in the UV may indicate a different metallicity for the progenitors. Even if these differences do not affect the luminosity, they will affect the K-corrections at high-z and as a result will affect the calculated distances.

150.02

Circles on the Sky: Confirmation of a Light Echo from the Type Ia Supernova 1995E

Peter M. Garnavich[1], J. L. Quinn[2], K. Krisciunas[1]
[1]Univ. of Notre Dame, [2]Central Michigan University.

We show that the resolved source coincident with the position of SN 1995E in NGC 2441 is an expanding light echo. This is only the third confirmed light echo from a well-observed type Ia supernova, the others being SN 1991T and SN 1998bu. The echo candidate was first identified from a 2001 Hubble Space Telescope (HST) "snap-shot" survey of fields containing type Ia events (Quinn et al.). Follow-up HST/ACS images obtained in September 2006 reveal that the source is now a small ring and its size has increased by about 30% over the 2001 STIS image. This is expected for light scattering off a dust sheet 200 pc in front of the supernova. We analyze the echo color to constrain the properties of dust in NGC 2441.

This work is partially supported by NASA grant HST-GO-10892.

150.03

Direct Analysis of Spectra of the Unusual Type Ib Supernova 2005bf

Jerod T. Parrent[1], D. Branch[1], M. Troxel[1], D. Casebeer[1], D. Jeffery[1], E. Baron[1], A. V. Filippenko[2]
[1]Univ. of Oklahoma, [2]Univ. of California Berkeley.

Synthetic spectra are generated with the parameterized supernova (SN) synthetic-spectrum code SYNOW and are compared to spectra of the exceptionally interesting Type Ib SN 2005bf. By definition, Type Ib supernovae are those whose spectra display conspicuous helium lines and no hydrogen lines. We confirm the discovery by Folatelli et al. (2006) that very early spectra (~30 days before maximum light) contain both photospheric-velocity (~8000 km s^{-1}) features of He I, Ca II, and Fe II as well as detached high-velocity features of Hα, Ca II, and Fe II. A comparison of an early spectrum of SN 2005bf to that of the Type Ib SN 1999ex clinches a previously suggested identification of Hα in SN 1999ex and supports the proposition that many if not all Type Ib supernovae eject a small amount of hydrogen. The resemblance of the earliest spectrum of SN 2005bf and a near-maximum-light spectrum of the Type Ic SN 1994I means that a reinterpretation of the spectra of Type Ic supernovae, involving coexisting photospheric-velocity and high-velocity features, should be explored. Implications of these results for the geometry of the SN 2005bf ejecta, which is thought to be highly asymmetrical, are discussed. This work has been supported by NSF grants AST-0204771 and AST-0506028, and NASA LTSA grant NNG04GD36G.

150.04

Uncertainties in Supernova Yields

Patrick A. Young[1], C. L. Fryer[1]
[1]Los Alamos National Laboratory.

Theoretical nucleosynthetic yields from supernovae are sensitive to both the details of the progenitor star and the explosion calculation. We attempt to comprehensively identify the sources of uncertainties in these yields. In this poster we concentrate on the variations in yields from a single progenitor arising from common 1-dimensional methods of approximating a supernova explosion. 3-dimensional effects in the explosion and the progenitor and improved physics in the progenitor evolution are also given preliminary consideration. For the 1-dimensional explosions we find that both elemental and isotopic yields for Si and heavier elements are a sensitive function of explosion energy. Also, piston-driven and thermal bomb type explosions have different yields for the same explosion energy. Yields derived from 1-dimensional explosions are non-unique. Bulk yields of common elements can vary by factors of several depending upon the assumptions of the calculation.

This work was carried out in part under the auspices of the National Nuclear Security Administration of the U.S. Department of Energy at Los Alamos National Laboratory and supported by Contract No. DE-AC52-06NA25396, by a DOE SciDAC grant DE-FC02-01ER41176, an NNSA ASC grant, and a subcontract to the ASCI FLASH Center at the University of Chicago.

150.05

Determining the Type, Redshift, and Phase of a Supernova Spectrum

Stephane Blondin[1], M. E. Salvo[2], J. L. Tonry[3]
[1]Harvard-Smithsonian, CfA, [2]RSAA, ANU, Australia, [3]IfA.

We present an algorithm to identify the types of supernova spectra, determine their redshift, and place constraints on their phase. This algorithm, based on the correlation techniques of Tonry & Davis (1979), is implemented in the SuperNova IDentification code (SNID; Blondin et al., in prep). This code is used by members of the ESSENCE project to determine whether a noisy spectrum of a high-redshift supernova is indeed of Type Ia, as opposed to, e.g., Type Ib/c. Furthermore, by comparing the correlation redshifts obtained using SNID with those determined from narrow emission or absorption lines in the supernova host galaxy, we show that accurate redshifts (with a typical error $\sigma = 0.01$) can be determined for SN Ia for which a spectrum of the host galaxy is unavailable. Last, the phase of a single supernova spectrum can be determined with a typical accuracy of $\sigma = 3$ days.

This work is partially supported by grant AST-0443378 from the US National Science Foundation.

150.06

Generating Pulsar Spin in Supernovae

John M. Blondin[1], A. Mezzacappa[2]
[1]North Carolina State Univ., [2]Oak Ridge National Laboratory.

Using three-dimensional hydrodynamics simulations, we have identified a robust instability of the stalled accretion shock in core-collapse supernovae that is able to generate a strong rotational flow in the vicinity of the accreting proto-neutron star (PNS). Sufficient angular momentum is deposited on the PNS to generate a final neutron star spin period consistent with observations of radio pulsars, even beginning with spherically symmetric, non-rotating initial conditions. This provides a new mechanism for the generation of neutron star spin and weakens, if not breaks, the assumed correlation between the rotational periods of supernova progenitor cores and pulsar spin.

This research used resources of the National Center for Computational Sciences at Oak Ridge National Laboratory, which is supported by the Office of Science of the U.S. Department of Energy under Contract No. DE-AC05-00OR22725.

150.07

Near-Explosion Lightcurves of SNe Ia from the SuperMACHO Survey

Arti Garg[1], C. W. Stubbs[1], P. Challis[1], W. Wood-Vasey[1], S. Blondin[1], M. E. Huber[2], K. Cook[2], S. Nikolaev[2], A. Rest[3], R. Smith[3], K. Olsen[3], N. B. Suntzeff[4], C. Aguilera[3], J. L. Prieto[5], A. Becker[6], A. Miceli[6], G. Miknaitis[7], A. Clocchiatti[8], D. Minniti[8], L. Morelli[8], D. L. Welch[9]
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We present a set four type Ia supernova (SN Ia) lightcurves with dense, pre-maximum sampling. These supernovae (SNe), in galaxies behind the Large Magellanic Cloud (LMC), were discovered by the SuperMACHO survey and span a redshift range of 0.145 to 0.16. Our lightcurves contain some of the earliest pre-maximum observations of SNe Ia to date. We also give a functional model that describes the SN Ia lightcurve shape (in our VR-band). Our function uses the ″expanding fireball″ model of Goldhaber et al. (1998) to describe the rising lightcurve immediately after explosion but constrains it to smoothly join the remainder of the lightcurve. We fit this model to a composite observed VR-band lightcurve of three SNe. These SNe have not been K-corrected or adjusted to account for reddening. In this redshift range, the observed VR-band most closely matches the rest frame V-band. Using the best fit to our functional description of the lightcurve, we find the time between explosion and observed VR-band maximum to be 17.6±1.3(stat)±0.07(sys) rest-frame days for a SN Ia with a VR-band Δm_-10 of 0.52mag. For the redshifts sampled, the observed VR-band time-of-maximum brightness should be the same as the rest-frame V-band maximum to within 1.1 rest-frame days.

150.08

Imaging and Spectroscopy of Ancient Supernovae Light Echoes in the LMC

Douglas L. Welch[1], A. Rest[2], R. C. Smith[2], K. Olsen[2], A. Zenteno[2], C. Aguilera[2], G. Damke[2], N. B. Suntzeff[3], T. Matheson[4], M. Bergmann[5], C. Stubbs[6], A. Garg[6], P. Challis[6], A. C. Becker[7], A. Miceli[7], R. Covarrubias[7], G. A. Miknaitis[8], J. Prieto[9], M. Huber[10], S. Nikolaev[10], K. H. Cook[10], D. Minniti[11], A. Clocchiatti[11], L. Morelli[11], A. Newman[12]
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The SuperMACHO Project reported the discovery of three centuries-old light echo systems associated with already-known supernova remnants in the Dec 22 2005 issue of Nature. Our poster paper presents the results of Gemini South and CTIO 4m imaging and Gemini South spectroscopy of the light echo systems associated with the remnants 0519-69.0, 0509-67.5, and N103B (including 2006B spectroscopy if available). Each of these three remnants associated with light echo systems is believed to be the result of a SN Ia explosion. We also report the discovery of a fourth light echo system apparently unassociated with the above remnants. Supernova light scattered off of LMC ISM dust at a variety of azimuths provides an observational constraint on the anisotropy of each outburst.We estimate the range of ″perspective differences″ available for the three systems based on existing data. The prospects for future LMC supernova light echo discoveries will also be discussed.

150.09

The Discovery of an Eruptive Variable in the LMC with Light Echoes

R. Chris Smith[1], A. Rest[1], N. B. Suntzeff[2], D. L. Welch[3], G. Damke[1], A. Zenteno[1], C. Stubbs[4], A. Garg[4], A. Newman[5], A. Becker[6], G. Miknaitis[7], A. Miceli[6], K. H. Cook[8], S. Nikolaev[8], L. Morelli[9], D. Minniti[9], A. Clocchiatti[9], J. Prieto[10]
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In 2002, the variable V838 Mon went through an extraordinary and unique outburst. The outburst was large amplitude, delta(V)~9, and very luminous. During the outburst its spectrum remained that of an extremely cool supergiant. A rapidly evolving set of light echoes around V838 Mon was discovered soon after the outburst.

We have discovered many echo complexes in the LMC using the SuperMACHO dataset and our difference imaging pipeline. In addition to the supernova light echos previously reported (see Welch et al. and Newman et al. posters), we have also found a light echo complex in the LMC around an AGB variable star which appears similar to V838 Mon. The source presently has an apparent magnitude of 13.5 and an absolute magnitude of at least M_R=-5. We present the difference images and available lightcurves for this new object.

150.10

A Survey for Ancient Supernova Light Echoes in the Milky Way Galaxy

Armin Rest[1], N. B. Suntzeff[2], R. C. Smith[1], D. L. Welch[3], G. Damke[1], A. Zenteno[1], C. Stubbs[4], A. Garg[4], P. Challis[4], A. Newman[5], A. C. Becker[6], G. A. Miknaitis[6], A. Miceli[6], K. H. Cook[7], M. Huber[7], S. Nikolaev[7], L. Morelli[8], D. Minniti[8], A. Clocchiatti[8], J. Prieto[9]
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The SuperMACHO collaboration has discovered echoes from four ancient supernovae (SNe) in the Large Magellanic Cloud using difference image analysis (Rest et. al, 2005). These newly-discovered echoes are as old as the historical SNe in our Galaxy observed by Kepler, Tycho, and others. The surface brightness from the Type Ia SNe should be roughly the same as the LMC echoes, assuming a similar geometry and similar dust filaments. Scaling from the LMC data, we would expect the echoes of these historical lightechoes to be roughly 4-6 degree from their SNRs, move at 30″yr^-1, and be about 30″ wide. We report on our progress in locating similar light echoes in the SMC and near historical Milky Way supernovae (Kepler, Tycho, 1181, Crab, 1006).

150.11

Shock Wave Stability in Core Collapse Supernovae

F. D. Swesty[1], E. S. Myra[1]
[1]SUNY-Stony Brook.

Virtually all proposed mechanisms for core-collapse supernovae are thought to involvethe formation of the shock wave near the edge of the homologous core, formed during the collapse of the iron core of a massive progentior star. The need for multi-dimensional modeling of the evolution of the shock wave has been widely recognized. In this poster we investigate the stability of this shock wave to local perturbations. Such an analysis is challenging since the shock is radiative by means of weak interactions coupling the matter to neutrinos. We futhermore attempt to delinate how shock wave perturbations affect the onset of convection during the prompt-shock era. Our poster presents both semi-analytic and numerical analyses of shock stability.

150.12

Galactic Analogs of the Rings around SN1987A and the Implication thatLBVs are Supernova Progenitors

Nathan Smith[1]
[1]University of California, Berkeley.

I discuss two recently discovered ring nebulae around hot massive stars in our galaxy, where the ring nebulae are nearly identical to that around SN1987A. One is a triple-ring nebula around the luminous blue variable (LBV) candidate HD168625, where an equatorial ring was previously known, but a larger bipolar ringed nebula has now been discovered in Spitzer images. The second object is a previously uncataloged B1.5 supergiant seen projected in the Carina Nebula, which is surrounded by a thin equatorial ring that is identical to SN1987A's. Including the previously known nebula around Sher25 in NGC3603, there are now three examples of circumstellar nebulae in our galaxy that are close analogs of the nebula around SN1987A, and all three of them are around blue supergiants. In the two cases where the stars have been studied in detail (Sher25 and HD168625) it is doubtful that the nebulae were formed through the usual paradigm where a fast wind sweeps up a cool red supergiant wind --instead, they were probably ejected in LBV eruptions. The third object in Carina is a new discovery and needs to be studied further. In any case, these three new ring nebulae and other examples around LBVs hint that blue supergiants can eject bipolar nebulae with equatorial rings, without requiring a previously existing slow disk to constrict the outflow. Their similiarity to SN1987A calls into question ideas about the formation of SN1987A's nebula via a fast/slow interacting wind scenario and its previous red supergiant phase. If SN1987A's nebula was also ejected as a blue supergiant, it may have suffered an episodic mass-loss event analogous to LBV explosions, but at somewhat lower luminosity. This would have important consequences for our understanding of stellar evolution at high masses.

150.13

Light Curves of Supernova/Gamma-Ray Bursts

Dean L. Richardson[1]
[1]Denison Univ..

There are several gamma-ray burst (GRB) optical afterglow light curves that show evidence of an associated supernova. The light, basically, comes from two sources; the GRB jet and the supernova. Photometry data has been collected for 16 of these GRBs. After subtracting out the light of the GRB jet (and the host galaxy when necessary), the resulting supernova light curve was analyzed. A model curve was fit to the observed data by searching through a grid of parameter values for the best fit. The parameters are kinetic energy, total ejected mass and nickel mass. The kinetic energy values range from about 2 to about 30 foe (1 foe = 10^51 erg). The peak absolute magnitudes range from -17.5 to -20.6. In comparison with a previous study on stripped-envelope supernova, we find that these ranges are very similar to those of hypernovae not associated with GRBs.

150.14

Subluminous Type Ia Supernovae in the Supernova Legacy Survey

Santiago Gonzalez[1], A. Howell[1], M. Sullivan[1], A. Conley[1], R. Carlberg[1], Supernova Legacy Survey
[1]University of Toronto, Canada.

Subluminous Type Ia Supernovae (SNe Ia) are preferentially found in old stellar populations, implying progenitor ages of several Gyr, leading to questions as to whether they exist in significant quantities at high redshift. Due to their faintness, there is a bias against identifying these SNe spectroscopically, and it has not been possible to test this hypothesis in previous spectroscopically-confirmed surveys. Furthermore, these SNe have colors which deviate from those of normal SNe Ia, increasing the odds that they will be selected against. Here we extend the stretch method to fit subluminous SNe, and conduct a photometric search of more than 1000 SN candidates detected as part of the Supernova Legacy Survey (SNLS). We find a fraction of photometrically identified SNe Ia over $0.1<z<0.8$ that are subluminous. This is the first evidence for a population of subluminous SNe Ia at high redshift, indicating that selection effects are largely to blame for the previous nondetections. However, the results are also consistent with a lower rate of subluminous SNe Ia at high redshift, expected as star forming galaxies, which produce more overluminous supernovae, start to dominate the SN Ia rate.

150.15

Optical Observations of SN 1999aa

Thea N. Steele[1], R. J. Foley[1], A. V. Filippenko[1], W. Li[1]
[1]University of California, Berkeley.

The distance measurements that have been used in determining the acceleration of the universe are based on type Ia supernova (SN Ia) luminosities calibrated using the light-curve shape. Detailed analysis of SNe Ia, and peculiar objects in particular, lead to a better understanding of the physics associated with the luminosity calibration, hopefully leading to more precise distances. SN 1999aa (and similar objects) is a somewhat peculiar SN Ia with spectral properties intermediate to a normal SN Ia and the prototypical overluminous SN 1991T. Similarly, SN 1999aa's light curves appear to bridge the gap between the normal and overluminous SNe Ia. The incredible homogeneity of SNe Ia (including overluminous objects) suggests that all SNe Ia come from a similar progenitor and have a similar explosion model. Since SN 1999aa has characteristics in common with both normal and overluminous objects, understanding the physics of SN 1999aa-like events may help constrain progenitor and explosion models for both types of objects. We present optical spectra and photometry across four bandpasses for a set of SN 1999aa-like objects. This data suggests that SN 1999aa is the Rosetta stone in understanding the differences and similarities between normal and overluminous SNe Ia.

150.16

The Nearby Supernova Factory

Benjamin A. Weaver[1], G. Aldering[1], C. Aragon[1], S. Bailey[1], S. Bongard[1], M. J. Childress[1], S. Loken[1], P. Nugent[1], S. Perlmutter[1], R. Romano[1], K. Runge[1], R. Scalzo[1], R. C. Thomas[1], C. Baltay[2], A. Bauer[2], D. Herrera[2], D. Rabinowitz[2], E. Pecontal[3], G. Rigaudier[3], P. Antilogus[4], S. Gilles[4], R. Pain[4], R. Pereira[4], C. Buton[5], Y. Copin[5]
[1]Lawrence Berkeley National Laboratory, [2]Department of Physics, Yale University, [3]Centre de Recherche Astronomique de Lyon, France, [4]Laboratorie de Physique Nucleaire et des Hautes Energies, France, [5]Institut de Physique Nucleaire de Lyon, France.

The Nearby Supernova Factory is an international project to discover and study nearby thermonuclear (type Ia) supernovae. The search of targets in the redshift range $0.03 < z < 0.08$ is based on data from the Near Earth Asteroid Tracking (NEAT) program and the Palomar Consortium QUEST camera program at Mt. Palomar. This produces a sample of SNe that is not biased against low-luminosity, low-metallicity hosts. Follow-up observations are performed with the dedicated Supernova Integral Field Spectrograph (SNIFS) at the University of Hawaii 2.2 meter telescope at Mauna

Kea. The goal is to acquire a large and homogeneous spectro-photometric dataset covering the extended optical range (320-1000 nm), and spanning the full life-time of the explosions. This will allow detailed studies of the local Hubble diagram, the SNe Ia physics, the SNe-host galaxy correlations, and will serve as an unprecedented nearby benchmark for the high-z cosmological studies to come.

150.17

Verification Tests for Numerical 2-D Radiation-Hydrodynamics as Applied toa Core-Collapse Supernova Code

Eric S. Myra[1], F. D. Swesty[1]
[1]*SUNY-Stony Brook.*

The simulation of stellar core collapse, shock propagation, and proto-neutron-star evolution presents one of the great computational challenges in modeling a system of coupled radiation and hydrodynamics. We present here a portion of the verification process for our supernova modeling code--a suite of problems that is designed to test the correctness of our algorithm and its implementation. This suite is designed to test many aspects of the code in comparison to known problems having analytic solutions. It includes problems in pure hydrodyanamics, pure radiation, and problems that couple these two components together. Our supernova modeling code is V2D, a multi-species, multigroup, radiation-hydrodynamics code that uses flux-limited diffusion and is capable of modeling pair-coupled neutrino radiation-hydrodynamics. The hydrodynamics is evolved explicitly while the radiation evolution is implicit. The latter employs Newton-Krylov methods together with sparse-approximate-inverse preconditioners to find a fast parallel solution of the non-linear implicit equations. The entire algorithm is designed for straightforward implementation on large-scale, state-of-the-art, parallel-computing architectures.

We gratefully acknowledge the support of the U.S. Dept. of Energy, through SciDAC Award DE-FC02-01ER41185, by which this work was funded. We are also grateful to the National Energy Research Scientific Computing Center (NERSC) for computational support.

150.18

Propagation of the First Flames in Type Ia Supernovae

L. J. Dursi[1], M. Zingale[2]
[1]*Univ. Of Toronto, Canada,* [2]*SUNY Stony Brook.*

While the ′big picture’ of how Type Ia supernovae explode is growing clearer, how it unfolds remains a mystery, and may be responsible for the observed diversity of Type Ia explosions. Understanding and constraining this diversity is necessary if we need to depend on the uniform nature of Type Ia supernovae over cosmological distances.

Here we present recent analytic and numerical work aimed at understanding the early-time burning of the Type Ia which may also play an unexpected role in the late type burning -understanding the balance between local burning, turbulence, and bouyancy. Even in the vigorously turbulent conditions of a convecting white dwarf, thermonuclear burning that begins at a point near the center (within 100 km) of the star is dominated simply by the spherical laminar expansion of the flame, until the burning region reaches kilometers in size. Only once the bubble grows quite large---indeed, resolvable by large-scale simulations of the global system---does significant motion or deformation occur. As a result, any hot-spot that successfully ignites into a flame can burn a significant amount of white dwarf material. This potentially increases the stochastic nature of the explosion compared to a scenario where a simmering progenitor can have small early hot-spots float harmlessly away.

Further, the size where the laminar flame speed dominates other relevant velocities sets a characteristic scale for fragmentation of larger flame structures, as nothing---by definition---can easily break the burning region into smaller volumes. This allows for simple< semi-analytic models of burning, which potentially allows for a rapid speedup of burning when degeneracy begins to lift. A rapid increase of burning at this point has long been thought necessary to explain observations of Type Ia, although where it would come from has been poorly understood.

150.19

The Spatial Correlation of Type Ia Supernovae with Local StarFormation as Measured with GALEX

James D. Neill[1], GALEX Science Team
[1]*California Institute of Technology.*

We use GALEX NUV and FUV imaging of nearby supernova Ia (SN Ia) hosts to study the spatial correlation of SNe Ia with star formation. Our aim is to constrain the timescale between progenitor formation and SN Ia explosion using multi-wavelength imaging that traces progenitor populations of different ages. Recent models consisting of two components for SN Ia production include a large, prompt component correlated with star formation, as well as an additional delayed component correlated with mass. By comparing the GALEX UV--SN Ia correlation, which traces star formation at timescales ~1Gyr, with the Hα correlation, tracing star formation at timescales of ~10Myr, and the IR correlation, tracing mass, we provide a nearby estimate of the relative sizes and timescales for the two components.

GALEX (Galaxy Evolution Explorer) is a NASA Small Explorer, launched in April 2003. We gratefully acknowledge NASA’s support for construction, operation, and science analysis for the GALEX mission.

150.20

Detailed Spectral Analysis of the Type Ib Supernova 1999dn

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[1]*University of Oklahoma.*

We present synthetic spectra of the Type Ib supernova (SN) 1999dn. Using the generalized, non-local thermodynamic equilibrium (NLTE), stellar atmosphere code PHOENIX, we fit model spectra to six different epochs of 1999dn, ranging from ten days before maximum brightness in the R band to 38 days afterward. The models are highly parameterized massive stars with their hydrogen envelopes removed. We largely focus on determining the identity of a feature near 6300 Å, attributed to hydrogen by some previous studies. We present synthetic spectra of models that do not include hydrogen, examining possible alternatives to this identification. These models fit the overall shape of the spectra well, and increasing the metallicity of the model composition to be three times that of the sun produces the 6300 Å feature well. However, we cannot rule out the presence of hydrogen, and future models will include a hydrogen envelope.

This work has been supported by NSF grants AST-0204771 and AST-0506028, and NASA grant NNG04GD36G.

150.21

The Laminar Flame Speedup by Neon-22 Enrichment in White Dwarf Supernovae

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We explore how the thermonuclear burning in a type Ia supernovae is influenced by the composition of the progenitor white dwarf. Type Ia supernovae are one of the premier tools for measuring cosmological properties. Recent observations have suggested that there may be more than one population of progenitor, and the peak luminosity may depend on the composition of the white dwarf. Of particular interest is ^{22}Ne, which is formed during core He burning on the horizontal branch and reflects the CNO abundance of the progenitor main-sequence star. Our focus here is on how the addition of ^{22}Ne affects the rate of carbon burning. We find that the laminar flame speed of a C/O mixture is enhanced when it is enriched with small amounts of ^{22}Ne. This Increase in the laminar flame speed is most important in two regimes, just after ignition near the center of the white dwarf, where the laminar flame speed dominates over the rising of buoyant hot ash, and in regions of lower density ~ 10^7 g cm^{-3} where a transition to distributed burning is conjectured to occur.

150.22

Steady-State Modeling and Possible Detection of HCl in Eta Carinae's -513 km/s Ejecta

Alissa S. Bans[1]
[1]Maria Mitchell Observatory.

A component of Eta Carinae's ejecta with a radial velocity of -513 km/s has recently been found to be conducive to the formation of molecules; CH and OH have most likely been identified there. In order to explain the abundances of the already observed species in this component and also predict possible new detections, we undertook statistical equilibrium modeling with the most recent version of the steady-state chemistry code CLOUDY. One of the many features of this new version was the inclusion of more Cl-bearing species. We found that, under a wide range of physical parameters, relatively high abundances of HCl were consistently predicted by our models. Using the public domain data obtained with the STIS spectrograph aboard the Hubble Space Telescope, we searched for new molecular signatures in the spectrum of the -513 km/s component that were favored by our models. We report a probable detection of the $C^1\Pi$-$X^1\Sigma^+$ electronic band of HCl and a tentative detection of a few rotational components of the $A^1\Pi$-$X^1\Sigma^+$ band. From the observed relative equivalent widths of several rotational components of the $C^1\Pi$-$X^1\Sigma^+$ band, we estimated the rotational temperature of HCl to be $T_r \approx 500 \pm 140$ K and the total column density to be $N \approx 10^{15}$ cm^{-2}. This project was supported by the NSF/REU grant AST-0354056 and the Nantucket Maria Mitchell Association.

150.23

A Hubble Space Telescope WFPC-2 Optical Survey of Dust in the Crab Nebula

Allison M. Loll[1], J. Hester[1], R. Sankrit[2], W. Blair[3]
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Dust formation has been thought to occur in material ejected from core collapse supernovae, and was first detected optically in the Crab Nebula by Woltjer & Vèron-Cetty in 1987. In this poster we examine dust throughout the entire nebula at 0.1" resolution using a *Hubble Space Telescope* WFPC-2 mosaic taken in the F547M (continuum) filter. Our data show that features noted in ground-based studies are comprised of many smaller, concentrated clumps of dust. Blair et al. (1997 ApJS, 109, 473) noted that the dust extinction correlates with the visible line emission that surrounds the synchrotron nebula. By combining our continuum mosaic with three *HST* WFPC-2 mosaics in [S II], [O I] and [O III], we can quantify the correlation between the dust extinction features and line emission. Dust extinction can only occur on the front-side of the remnant, therefore we used Fabry-Perot data (Lawrence et al. 1995 AJ, 109.2635) to distinguish between the front-side and the back-side and also to estimate the amount of emission falling outside of the filter bandpasses. Our analysis shows that most low ionization cores on the front side of the remnant do contain dust. Dust is never found where there is no low-ionization line emission. Since dense concentrations of low-ionization gas form in the Crab as a result of Rayleigh-Taylor instabilities at the edge of the synchrotron nebula (Hester et al. 1996 ApJ, 456, 255), much of the dust is found within Rayleigh-Taylor fingers. We have found one case where there is a dust extinction feature surrounded by, but within, a hole of [O I] and [S II] emission where we believe molecular hydrogen could be found. There are a few places on the front of the remnant where dust is not found despite strong low-ionization emission, and these anomalies will also be discussed.

150.24

Optical Photometry of Supernovae Using the KAIT Pipeline

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[1]UC Berkeley Astonomy Dept.

Since first light in 1997, the robotic Katzman Automatic Imaging Telescope (KAIT) on Mount Hamilton in San Jose, CA, has successfully found over 500 low-z supernovae (SNe). In conjunction to finding SNe, KAIT has also provided a means to amass a database of follow-up photometry for over 200 SNe in UBVRI bands with excellent (typically 2-6 days between observations) temporal coverage. With this wealth of data was the need for software to reduce the raw observation images into light curves. We present the results of the photometry pipeline which was written to automatically reduce KAIT data. The pipeline performs image registration, galaxy subtraction using a template image without the presence of the SN, and Point Spread Function fitting photometry to produce meaningful magnitudes with minimal human interaction. The KAIT pipeline has successfully been run on over 180 SNe with follow-up photometry and will provide the machinery for reductions of future SNe photometry data. We present the light curves and an initial analysis of the results from our pipeline.

150.25

Multidimensional Simulations of Mixing in Zero-Metallicity Supernovae

Candace M. Church[1], A. Heger[2], S. Woosley[1]
[1]UC, Santa Cruz, [2]Los Alamos National Laboratory.

The first generation of stars, which formed from the pristine, metal free gas produced by the Big Bang, are the first objects to enrich this gas through their explosive deaths. By following the evolution of such stars in one dimension we have some understanding of their composition prior to their explosion as supernovae, but one-dimensional models cannot capture the Raleigh-Taylor induced mixing that enriches the outer layers of the star. When zero-metallicity stars less than about 100 solar masses explode as supernovae, some portion of the star falls back onto the black hole, while the rest escapes to enrich the next generation of stars. The composition of the escaped gas will depend on how much mixing occurred between the compositional layers of the star. We present multidimensional simulations of zero-metallicity stars in the last stages of their life, and estimate their resulting nucleosynthetic output. This output may be reflected in abundances observed in very metal poor stars the Galactic halo.

151: Binary Stars
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

151.01

A Radial Velocity Study of Hot Subdwarf Stars with Composite Spectra

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[1]Penn State Univ., [2]Univ. Wyoming.

Many subdwarf B (sdB) stars have composite energy distributions and/or spectra. The companion is a G or K star in most cases. Subdwarf B stars have helium-burning cores near 0.5 solar masses and have very low mass hydrogen envelopes. How the hydrogen envelopes were lost, very near the time of core helium ignition, is of great interest. Many sdB stars that show a composite nature may have formed by Roche lobe overflow (RLOF). The resulting binaries should have orbital periods of order 3 5 y and orbital separations of 2 3 AU. We have selected fifteen moderately bright sdB stars with composite spectra, to monitor for radial velocity variations. We use the bench-mounted Medium Resolution Spectrograph on the Hobby Eberly Telescope. Since January 2005, we have acquired between 3 and 10 observations of each star, over baselines of six months or longer. If these systems were formed by RLOF, we expect to see measurable orbital acceleration in many of these systems over this time span, barring systematic bad luck with orbital phase or inclination. We will describe the status of the program and the findings to date.

151.02

The Eclipsing Binary MY Cygni

Rebecca Tucker[1], J. R. Sowell[1], R. M. Williamon[2]
[1]Georgia Tech, [2]Emory.

Differential UBV photoelectric photometry for the eclipsing binary MY Cyg is presented. The Wilson-Devinney program is used to solve simultaneously the three light curves together with previously published radial velocities. We determine absolute dimensions and estimate the age of the system. We compute color indices for the two stars and estimate color excesses. A comparison is made with the previous solution found with the Russell-Merrill method.

151.03

Analysis of the Spitzer/MIPS24 Light Curve of the M-Dwarf Eclipsing Binary GU Boo

Kaspar von Braun[1], G. T. van Belle[1], D. R. Ciardi[1], S. Wachter[1], D. W. Hoard[1]
[1]*Caltech.*

We present a carefully controlled set of Spitzer 24 micron MIPS time series observations of the M-dwarf eclipsing binary star GU Bootes. These observations serve to characterize the MIPS-24 observing techniques of the spacecraft, precisely establishing the photometric repeatability of this instrument at the tens of microJy level. The data aim to substantiate the previously reported and upcoming observations of extrasolar planet transits at similar flux levels. A further science return is the long wavelength (and thus limb darkening-independent) characterization of such a low-mass object's light curve, allowing for improved characterization of the components' linear radii and other aspects of their surface morphologies. In this presentation, we show GU Boo's 24 micron light curve and give our estimates concerning astrophysical parameters of the binary system. We furthermore give a detailed description of our analysis methods and discuss the comparison between our results and previous optical studies of this system.

151.04

Measurements of Position Angle and Separation of Selected Binary Stars

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[1]*Univ. of Puerto Rico, Humacao.*

We report on measurements of position angle and separation of physical binary systems. Many such systems, characterized as ″neglected binaries″ by the Washington Double Star Catalog of the USNO, are included in our sample lists, some ignored for more than 100 years. The data reported here was acquired at the 31 inch NURO telescope near Flagstaff, AZ. We have found that many stars listed as neglected seem to show no change in separation and position angle for many years, suggesting that they are not physical binaries. We thank the Puerto Rico Space Grant Consortium and the Humacao Campus MARC programs for their support of this project.

151.05

A Light Curve Study and Analysis of the Short-Period Contact Binary XZ Leonis

Jeffrey J. Massura[1], B. J. Hrivnak[1], W. Lu[1]
[1]*Valparaiso University.*

Observations of the short-period eclipsing binary XZ Leo were made with the Valparaiso University telescope during the spring of 2006; complete VRI light curves were obtained. These show minima of nearly equal depths but some variation in the heights of the maxima. The new light curves differ somewhat from previously published ones. Preliminary modeling of the light curves, together with previously published radial velocity data, has been done using the Wilson-Devinney code, and the results of this study will be presented. This research is partially supported by the Indiana Space Grant Consortium.

151.06

Photometric Investigation of the Eclipsing Binary Star BX Dra

Shaukat N. Goderya[1], T. Sykes[1]
[1]*Tarleton State Univ..*

We present here the photometric light curve analysis of the eclipsing binary star BX Dra. The eclipsing binary star BX Dra was observed by Jerry Gunn and Brian Hakes using the Jubilee observatory near Peoria, Illinois and the Meade LX 2000 Hanna City Robotic Telescope and a CCD photometer at Hanna City, Illinois. The data spans over nine nights in 1997 in B and V band-pass filters. We obtained a revised orbital period of 0.579097 days from 15 eclipsing minima. The published spectral classification is A3. The 1993 version of the Wislon-devinney model gave the photometric solutions. The adopted solution indicates that BX Dra is W UMa type contact binary. The mass ratio, q = (m2 /m1, where star 1 eclipses at the primary minimum) = 0.26 suggest that BX Dra is a W UMA system with A-type configuration. Generally contact systems of spectral type A3 have periods ranging from 0.4 to 0.6 days. BX Dra has considerably longer periods and thus appears to be an evolved contact with case B mass transfer. We recommend spectroscopic study of this system.

151.07

FUSE Observations of the Be/X-ray Binary 4U 1145-617(V801 Cen, HD1022567)

Rosina Iping[1], G. Sonneborn[1]
[1]*NASA's GSFC.*

The Be/X-ray binary 4U 1145-619/V* V801 Cen/HD102567 has been observed with the Far Ultraviolet Spectroscopic Explorer(FUSE) to probe the effect of X-ray photoionization. This system is composed of a Be star and neutron star (X-ray pulsar) in a wide orbital period of 186 days. The system contains two quasi-Keplerian (ratio of radial to orbital velocity components less than 0.01) disks: a decretion disk around the Be star and an accretion disk around the neutron star. Both disks are temporary: the decretion disk disperses and refills on time scales of years (dynamical evolution of the disk), while the accretion disk disperses and refills on time scales of weeks to months (which is related to the orbital motion in an eccentric orbit and, on some occasions, also to the major instabilities of the other disk). The accretion disk might be absent over a longer period of time (years), if the other disk is very weak or absent. The X-ray emission of Be/X-ray binaries has a distinctly transient nature and is influenced by the periastron passages and by the dynamical evolution of the decretion disk. The pulsar 4U 1145-619 with a 292-s period ionizes its surroundings as it moves through the binary orbit, producing X-rays while accreting some of the ambient stellar wind from B1Vne star with a mass of ~ 13 Solar Masses. Spectral changes with orbital phase were detected at the two observed phases. We report on the initial results. Additional observations are planned.

151.08

Massive Star Multiplicity: The Cepheids U Aql and W Sgr

Nancy R. Evans[1], D. Massa[2]
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Accurately identifying all the companions in multiple of star systems, especially massive ones, provides insight into star formation. We observed two well-known classical Cepheid binary systems, U Aql and W Sgr, with STIS (Space Telescope Imaging Spectrograph) on the Hubble Space Telescope (HST). In both cases an additional previously unknown component was found. For U Aql, in addition to the component separated by 1.5″, and the hottest star in the system (the companion in the spectroscopic orbit), a third star was seen, midway between the other two both spatially and in brightness. For W Sgr, the companion in the spectroscopic orbit is not the hottest star in the system. Deriving information about this companion which has an energy distribution similar to that of the Cepheid will be discussed. As found previously (2005, ApJ, 130, 789), nearly half of the well-studied Cepheid binaries are actually triple systems.

Funding for this work was provided by HST grant GO-09105.02-A and Chandra X-ray Center NASA Contract NAS8-39073

151.09

Photometric Studies of Two Active Contact Binaries: GSC 2766-0775 and GSC 0619-0232

Ronald G. Samec[1], H. A. Chamberlain[1], C. M. Labadorf[1], R. McKenzie[1], W. Van Hamme[2], D. R. Faulkner[3]
[1]Bob Jones Univ., [2]Florida International Univ., [3]Univ. of S. Carolina.

We present preliminary analyses of two interacting eclipsing binaries based on observations taken at the National Undergraduate Research Observatory (NURO) and the Southeastern Association for Research in Astronomy (SARA) in the fall of 2005 and 2006. Light curves, period studies and synthetic light curve solutions are presented.

Our CCD observations of GSC0619-232 [α(2000) = 01h18m48.501s,δ(2000) = +13°21’07.81″] and GSC 2766-0775 [α(2000) = 23h37m10.660s,δ(2000) = +31°36’44.48″] were taken in the Fall of 2005 and 2006 with the NURO 0.81-m and the SARA 0.9-m reflectors and standard UBVRI filters.

GSC0619-0232 is a totally eclipsing, low amplitude, low mass ratio, short period AW UMa-type system. Calculated eclipse timings included HJD Min I = 2453638.98501(±0.004), 2453643.7976(±0.0087), HJD Min II = 2453639.8350(±0.0040), 2453641.9055(±0.0049), and 2453643.9642(±0.0011). These including five times by Gonzalez-Rojas et. al (2003, IBVS 5437) from their discovery paper, yielded the following ephemeris:

HJD Hel Min I =2452668.3011 (±.0.0008)d + 0.3439685 (±0.0000004)*E

GSC 2766-0775 is a solar type contact binary, discovered by the Semi-Automatic Variability Search. Our light curves during the 2005 and 2006 seasons show variable eclipse amplitudes of 0.70 and 0.76 mags in B for the ″first″ and ″second″ eclipses in 2005 and 0.7 and 0.5 mags in the same eclipses in 2006. A dark region dominates at phase 0.25 in 2005 and 0.75 in 2006, and a cooling of ~0.05 in B-V of the binary is present. Calculated times of minimum light include HJDMin I=2453643.9871(±0.0002)d, 2454018.8517(±0.0004)d and HJDMin II=2453643.8008(±0.001389)d, 2454018.6649(±0.0018)d. The following improved elements were calculated:

HJD Hel Min I =244018.852168 (±.0.0016)d + 0.3757428 (±0.0000015)*E

Light curve solutions are calculated with the updated, 2004 Wilson code.

We wish to thank the NURO and SARA for their allocation of observing time, as well as NASA and the American Astronomical Society for their support.

151.11

HST Observations of Astrophysically Important Visual Binaries

Gail Schaefer[1], H. E. Bond[1], M. Barstow[2], M. Burleigh[2], R. L. Gilliland[1], T. M. Girard[3], D. H. Gudehus[4], J. B. Holberg[5], E. Nelan[1]
[1]Space Telescope Science Institute, [2]University of Leicester, United Kingdom, [3]Yale University, [4]Georgia State University Research Foundation, [5]University of Arizona.

We report on our ongoing HST observations to measure the orbits of four astrophysically important visual binaries. All four are very difficult to resolve from the ground, but can be measured easily at HST resolution. For each binary, we present updated orbital fits, revised dynamical masses, and limits on the presence of third bodies down to planetary mass. The binaries we discuss are as follows:

(1) Procyon (P=40.9 yr) contains a bright F5 IV-V star and its much fainter white-dwarf companion. Combined with ground-based astrometry of the bright star, our initial observation with WFPC2 in 1995 significantly revised downward the derived masses, and brought Procyon A into excellent agreement with theoretical evolutionary tracks. Based on our continued WFPC2 measurements over the past decade, we present an improved orbital solution, revised masses for both components, and tight limits on planetary bodies in the system.

(2) The Sirius system (P=50.1 yr), which contains the nearest and brightest of all white dwarfs, has been followed with HST/WFPC2 imaging since 1997. We revise the dynamical masses of both stars, and are investigating hints of a small perturbation in this system.

(3) G 107-70 (P=18.5 yr) is a close double white dwarf system of nearly equal brightness. We have been following it since 1995 with WFPC2 and FGS, which will enable us also to refine the parallax of the system.

(4) Mu Cassiopeiae (P=20.8 yr) contains a metal-deficient G star and an M dwarf companion. Determining the dynamical mass of the G star would provide the helium content for a metal-poor star. We have observed it since 1997 with WFPC2 and will present an updated orbit. The next few years will be crucial in refining the mass to a level useful for the helium determination.

Supported by STScI grants GO-10990 and GO-10914.

151.12

The Light Curve and Parameters of Eclipsing Binary System FL Orionis

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We have obtained BVRI light curves for the neglected eclipsing binary FL Orionis, as well as times of minimum light to provide a revised period (the first accurate period) and ephemeris. Further, we present a solution of the light curve, solved with the BinaryMaker3 eclipsing binary synthesis program.

Support for this project was received from the Dunham fund for Astrophysical Research and from NSF grant AST-0520812.

151.13

Five New Low-Mass Eclipsing Binary Systems

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We present the discovery of five new low-mass eclipsing binaries with masses between 0.54 and 0.95 $M_\odot$ their photometric light curves, and preliminary models. This is part of a continuing campaign to increase the available data on these interesting systems. Once radial-velocity curves are completed, physical parameters will be determined with an error of less than 2-3%, thus allowing for a rigorous examination of stellar models in the lower-main sequence. Our initial analysis seems to support the current findings that low-mass stars have greater radii than models predict, most likely due to the presence of strong magnetic fields. This work is funded by a partnership between the National Science Foundation (NSF AST-0552798) Research Experiences for Undergraduates (REU) and the Department of Defense (DoD) ASSURE (Awards to Stimulate and Support Undergraduate Research Experiences) programs.

151.14

Light Curve Analysis for W UMa-Type Eclipsing Binary Star Systems

Scott Henderson[1], N. Peach[1], T. Olsen[1]
[1]Lewis & Clark College.

We report results from summer 2006 in an ongoing study of eclipsing binary stars. Our investigations have focused on the measurement and interpretation of light curves for W UMa-type systems 44i Boötis and VW Cephei. These contact binaries have component stars of spectral type G, and revolve with periods of 6.43 and 6.67 hours. Dome automation and scripting capabilities introduced this summer have significantly reduced experimental uncertainties in our data. In support of previous findings we continue to observe an increase in the orbital period of 44i Boo at a rate of 10.4 μs/epoch or 14.2 ms/yr. Residuals computed after incorporating the increasing period suggest an underlying sinusoidal oscillation with a 61.5 year period and amplitude of 648 seconds. AAPT Member Thomas Olsen is sponsoring the lead presenter, SPS Member Scott Henderson, and the co-presenter, SPS Member Nick Peach.

151.15

Orbital Parameters of R Aquarii

Gustav Rustan[1], G. McIntosh[1]
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R Aquarii is a long period variable star that exhibits silicon monoxide maser emission and is part of a binary system. Published velocity data for R Aqr has been collected and combined with SiO data taken at the University of Minnesota, Morris, in an effort to determine the orbital parameters of the binary system. The last determination was 17 years ago, a considerable fraction of the suspected orbital period, and the time span of the velocity data has more than doubled. Accurate orbital information is essential to the understanding of the mass transfer mechanism that may be occurring in this system and similar binary star systems. The recent SiO data suggest that the period may be 35 years, rather than the previous estimate of 44years.

152: Extrasolar Planets V: Host Stars
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

152.01

Investigating the Rotation Periods of Exoplanet Host Stars

Elaine K. Simpson[1], S. Baliunas[1], G. Henry[2]
[1]*Harvard-Smithsonian, CfA,* [2]*Tennessee State University.*

Of approximately 200 exoplanet host stars, we investigate a subset of fifty whose fluxes in the Ca II H and K passbands and b and y photometric passbands have been measured and in several cases, accumulated over a period of years or longer.

The Ca II records from Mount Wilson Observatory's HK Project and highly precise photometric measurements from Tennessee State University's Automated Photoelectric Telescopes at Fairborn Observatory detail variability of surface magnetic features, leading in some cases to a direct measurement of periodicities thought to be associated with rotation.

We discuss findings of rotation in the context of surface magnetic activity, its interannual variability, age and other physical properties of the star. As possible we infer inclination of the stellar rotation axis and its influence on exoplanet detection methods.

This work has been supported by NASA grant JPL-1270064.

152.02

Atmospheric Properties of Brown Dwarfs

Lauren J. McCarthy[1], K. L. Cruz[2]
[1]*Barnard College/AMNH,* [2]*AMNH.*

We present near-infrared spectra of ~100 L dwarfs covering 0.8--2.5 microns obtained with the SpeX spectrograph on the IRTF telescope. We fit these data to synthetic spectra with a range of effective temperatures, gravities, and grain sedimentation efficiencies. From this comparison, we investigate the range of physical properties spanned by the L dwarf spectral class.

152.03

Determining Stellar Parameters With a Fixed Delay Interferometer

Roger Cohen[1], S. Mahadevan[1], J. Ge[1]
[1]*University of Florida.*

We present a method for determining stellar parameters using a new type of radial velocity instrument called Exoplanet Tracker (ET). This instrument combines a fixed delay interferometer with a post-dispersing medium-resolution spectrograph. We test the use of both R=6000 spectra as well as the interferometer fringe visibilities to determine parameters of several mediumto late-type dwarfs via fitting to synthetic models. In light of the upcoming All-Sky Extrasolar Planet Survey (ASEPS), this method will be useful for measuring basic physical parameters (effective temperature, log g , metallicity, and v sin i) of hundreds of thousands of stars which will be surveyed for planets using multiple versions of this type of instrument.

152.04

Characterization of Gravitational Microlensing Planetary Host Stars

David P. Bennett[1], J. Anderson[2], B. S. Gaudi[3]
[1]*Univ. of Notre Dame,* [2]*Rice University,* [3]*The Ohio State University.*

Graviational microlensing is one of a few extrasolar planet detection methods that is able to detect Earth-mass planets in the next few years. Microlensing is most sensitive to planets orbiting in the vicinity of the ″snow line″, which is exterior to the habitable zone and controls gas giant formation. This complements other techniques, like radial velocities and transits, that are most sensitive interior to the habitable zone. Thus, microlensing discoveries will be important for understanding planet formation and for estimating the frequency of Earth-mass planets in the habitable zone, which must be known before the Terrestrial Planet Finder mission can be developed. However, the microlensing light curve observations provide only loose constraints on the properties of the planetary host stars. We show that the properties of the host star can generally be determined with high resolution follow-up observations taken a few years after the planetary microlensing signal is observed. Examples are presented from the extrasolar planets already discovered by microlensing, and we show that the proposed Microlensing Planet Finder (MPF) mission will routinely detect and characterize the planetary host stars.

153: GLAST
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

153.01

The Gamma-ray Large Area Space Telescope (GLAST) Mission

Steven M. Ritz[1], P. F. Michelson[2], C. Meegan[3], J. E. Grindlay[4], GLAST Mission Team
[1]*GSFC & University of MD,* [2]*Stanford University,* [3]*MSFC and NSSTC,* [4]*Harvard University.*

The Gamma-ray Large Area Space Telescope, GLAST, is a mission to measure the cosmic gamma-ray flux in the energy range 20 MeV to >300 GeV, with supporting measurements for gamma-ray bursts from 10 keV to 25 MeV. With its launch in 2007, GLAST will open a new and important window on a wide variety of phenomena, including black holes and active galactic nuclei, the optical-UV extragalactic background light, gamma-ray bursts, the origin of cosmic rays and supernova remnants, and searches for hypothetical new phenomena such as supersymmetric dark matter annihilations and Lorentz invariance violation. In addition to the science opportunities, this poster includes a description of the instruments, the opportunities for guest investigators, and the mission status.

153.02

The Large Area Telescope (LAT) on the Gamma-ray Large Area Space Telescope (GLAST)

Toby H. Burnett[1], GLAST LAT Team
[1]*University of Washington.*

The Gamma-ray Large Area Space Telescope, GLAST, is a low Earth orbit observatory which will study the cosmic gamma-ray sky in the energy range 20 MeV to >300 GeV, and detect gamma-ray bursts photons from 10 keV to 25 MeV. With its launch in 2007, GLAST will allow precision studies of high energy phenomena, including black holes and active galactic nuclei; gamma-ray bursts; the origin of cosmic rays and supernova remnants; and searches for hypothetical new phenomena such as supersymmetric dark matter annihilation, Lorentz invariance violation, and exotic relics from the Big Bang. The high-energy measurements are made by the Large Area Telescope (LAT), which consists of a pair conversion tracker, a hodoscopic crystal calorimeter, a segmented plastic scintillator anticoincidence shield, and a flexible trigger and onboard analysis system. The LAT design is described, along with the expected science performance based on detailed simulations of the instrument's response to expected sources and cosmic rays, including event reconstruction, and a multivariate classification method to improve resolution and distinguish signal and background.

153.03

GLAST Large Area Telescope Multiwavelength Studies: An Invitation to Coordinated Observations

Kent S. Wood[1], D. J. Thompson[2], R. A. Cameron[3], GLAST Collaboration
[1]NRL, [2]NASA-GSFC, [3]SLAC.

High-energy gamma-ray sources are inherently nonthermal, multiwavelength objects. With the launch of the Gamma-ray Large Area Space Telescope (GLAST) less than a year away, the GLAST Large Area Telescope (LAT) Collaboration invites cooperative efforts from observers at all wavelengths. Among the many topics where multiwavelength studies will maximize the scientific understanding, three stand out for particular emphasis: (1) Active Galactic Nuclei. The study of AGN gamma-ray jets can help link the accretion processes close to the black hole with the large-scale interaction of the AGN with its environment. Gamma-ray AGN are also important in the study of absorption effects of extragalactic background light at high redshifts; (2) Unidentified Gamma-ray Sources. New gamma-ray sources need first to be identified with known objects by position, spectrum, or time variability, and then multiwavelength studies can be used to explore the astrophysical implications of high-energy radiation from these sources; (3) Pulsar Timing. The LAT will be capable of some blind searches for new gamma-ray pulsars, but the deepest studies of these rotating neutron stars will come from having known timing solutions. The need for long LAT observations calls for timing solutions valid (at least piecewise) over years. Observers interested in providing coordinated observations should contact one of the authors.

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153.04

Gamma-Ray Pulsar Candidates for GLAST

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The Gamma-ray Large Area Space Telescope (GLAST) will be launched less than a year from now, and its Large Area Telescope (LAT) is expected to discover scores to hundreds of gamma-ray pulsars. This poster discusses which of the over 1700 known pulsars, mostly visible only at radio frequencies, are likely to emit >100 MeV gamma rays with intensities detectable by the LAT. The main figure of merit used to select gamma-ray pulsar candidates is sqrt(E-dot)/d^2, where E-dot is the energy loss due to rotational spindown, and d is the distance to the pulsar. The figure of merit incorporates spin-down flux at earth (proportional to E-dot/d^2) times efficiency, assumed proportional to 1/sqrt(E-dot). A few individual objects are cited to illustrate the issues. Since large E-dot pulsars also tend to have large timing noise and occasional glitches, their ephemerides can become inaccurate in weeks to months. To detect and study the gamma-ray emission the photons must be accurately tagged with the pulse phase. With hours to days between gamma-ray photon arrival times from a pulsar and months to years of LAT exposure needed for good detections, GLAST will need timing measurements throughout the continuous gamma-ray observations. The poster will describe efforts to coordinate pulsar timing of the candidate gamma-ray pulsars.

153.05

Studying Gamma-ray Blazars with the GLAST-LAT

Benoit Lott[1], LAT Blazar Science Working Group
[1]SLAC/CENBG.

Thanks to its sensitivity (4 10^{-9} ph (E> 100 MeV) $cm^{-2}s^{-1}$ for one year of observation), the GLAST LAT should detect many more (over a thousand) gamma-ray blazars than currently known. This large blazar sample will enable detailed population studies to be carried out. Moreover, the LAT large field-of-view combined with the scanning mode will provide a very uniform exposure over the sky, allowing a constant monitoring of several tens of blazars and flare alerts to be issued. The poster will present the LAT performance relevant to blazar studies, more particularly related to timing and spectral properties. Major specific issues regarding the blazar phenomenon that the LAT data should shed light on thanks to these capabilities will be discussed, as well as the different approaches foreseen to address them. The associated data required in other bands, to be collected in contemporaneous/simultaneous multiwavelength campaigns will be mentioned as well.

153.06

Prospects for Observations of Microquasars with GLAST

Richard Dubois[1]
[1]Stanford Linear Accelerator Center.

The Gamma-ray Large Area Space Telescope (GLAST) is a next generation high energy gamma-ray observatory due for launch in Fall 2007. The primary instrument is the Large Area Telescope (LAT), which will measure gamma-ray flux and spectra from 20 MeV to > 300 GeV and is a successor to the highly successful EGRET experiment on CGRO. The LAT will have better angular resolution, greater effective area, wider field of view and broader energy coverage than any previous experiment in this energy range. This poster will present performance estimates with particular emphasis on how these apply to studies of microquasars. The LAT's scanning mode will provide unprecedented unformity of sky coverage and permit measurements of light curves for any source. We will show results from recent detailed simulations that illustrate the potential of the LAT to observe microquasar variability and spectra, including source sensitivity and ability to detect orbital modulation.

153.07

Observing GRBs with the GLAST LAT Telescope

Julie E. McEnery[1], GLAST LAT GRB science working group
[1]NASA's GSFC.

The Gamma-ray Large Area Space Telescope (GLAST) is the next generation satellite for high-energy gamma-ray astronomy. The main instrument, the Large Area Telescope (LAT) is a pair conversion telescope built with a high precision silicon tracker, a segmented CsI electromagnetic calorimeter and a plastic anticoincidence shield. The LAT will survey the sky in the energy range between 20 MeV to more than 300 GeV. The huge field of view, large collection area, broard spectral coverage and good angular resolution make the LAT ideally suited to a study of the high energy gamma-ray emission from GRB. Analysis and simulation tools dedicated to the GRB science have been developed, including simulation of the GLAST Burst Monitor (GBM), the second instrument on-board GLAST. In this contribution we show the expected LAT sensitivity obtained with such simulations, and illustrate the results we expect from LAT observations with spectral and temporal analysis of simulated GRB.

153.08

Future GLAST Observations of Supernova Remnants and Pulsar Wind Nebulae

Stefan Funk[1], GLAST LAT Collab. Pulsars, SNR and Plerions group
[1]*SLAC.*

Shell-type Supernova remnants (SNRs) have long been known to harbour a population of ultra-relativistic particles, accelerated in the Supernova shock wave by the mechanism of Diffusive shock acceleration. Experimental evidence for the existence of electrons up to energies of ~100 TeV was first provided by the detection of hard X-ray synchrotron emission as e.g. in the shell of the young SNR SN1006. Furthermore using theoretical arguments shell-type Supernova remnants have long been considered as the main accelerator of protons Cosmic rays in the Galaxy; definite proof of this process is however still missing.

Pulsar Wind Nebulae (PWN) diffuse structures surrounding young pulsars are another class of objects known to be a site of particle acceleration in the Galaxy, again through the detection of hard synchrotron X-rays such as in the Crab Nebula.

Gamma-rays above 100 MeV provide a direct access to acceleration processes. Ultra-relativistic electrons emit gamma-radiation through Inverse Compton scattering in ubiquitous photon fields (such as CMBR, star light and dust emission or local synchrotron radiation), protons emit gamma-radiation through the decay of pi0s, generated in proton-proton interactions with Interstellar material such as gas clouds. Recent advances in ground-based gamma-ray astronomy e.g. made by Cherenkov Telescopes above an energy threshold of 100 GeV have shown, that both shell-type SNRs and PWN are classes of gamma-ray emitting objects in the Galaxy. The upcoming GLAST Large Area Telescope (LAT) will be operating in the energy range between 30 MeV and 300 GeV and will provide excellent sensitivity, angular and energy resolution in a poorly investigated energy band. Shell-type SNRs as well as PWN provide natural targets for GLAST observations and detections and in this poster we will describe prospects for the investigation of these Galactic particle accelerators with GLAST.

153.09

GLAST Large Area Telescope Performance Monitoring and Calibrations

Anders W. Borgland[1]
[1]*SLAC.*

The Large Area Telescope (LAT) is one of the two instruments onboard the Gamma ray Large Area Space Telescope (GLAST), the next generation high energy gamma ray telescope. It contains sixteen identical towers in a four-by-four grid, each tower containing a silicon-strip tracker and a CsI calorimeter that together will give the incident direction and energy of the pair-converting photon. The instrument is covered by an Anti-Coincidence Detector (ACD) to reject charged particle background. Altogether, the LAT contains more than 864k channels in the trackers, 1536 CsI crystals and 97 ACD tiles and ribbons.

The LAT was integrated and tested at the Stanford Linear Accelerator Center (SLAC) in 2005-2006, underwent Thermo-Vacuum (TVAC) testing at the Naval Research Lab (NRL) in the summer of 2006 and is currently being integrated with the Spacecraft at General Dynamics/Spectrum Astro Space Systems in Arizona. GLAST is due to be launched in Fall of 2007.

This poster details some of strategies and methods for calibrating the instrument, including both particle based calibrations, using Galactic Cosmic Rays (GCR) events, and charge injection, that will be necessary to ensure a satisfactory performance of the LAT in its full energy range from 20 MeV to 300 GeV. It will also detail how we are planning to monitor the instrument performance, including both low level detector monitoring and more high level analysis based monitoring using astrophysical sources. Both calibrations and monitoring draws on the extensive experience gained from Integration and Test of the instrument.

153.10

The GLAST LAT Instrument Science Operations Center

Robert A. Cameron[1], GLAST LAT ISOC
[1]*Stanford Univ..*

The Gamma-ray Large Area Space Telescope (GLAST) is scheduled for launch in late 2007. The major science instrument on GLAST is the Large Area Telescope (LAT). Operations support and science data processing for the LAT instrument on GLAST will be performed by the LAT Instrument Science Operations Center (ISOC) at the Stanford Linear Accelerator Center (SLAC). The ISOC supports GLAST mission operations in cooperation with other GLAST mission ground system elements and supports the science research activities of the LAT collaboration.

The ISOC will be responsible for monitoring the health and safety of the LAT, preparing command loads for the LAT, maintaining and updating embedded flight software which controls the LAT detector and data acquisition flight hardware, maintaining the operating configration of the LAT and its calibration, and applying event reconstruction processing to downlinked LAT data to recover information about detected gamma-ray photons. The SLAC computer farm will be used to process the large volume of LAT event data and generate science products to be made available to the LAT collaboration through the ISOC and to the broader scientific community through the GLAST Science Support Center at GSFC. Science operations in the ISOC will optimize the performance of the LAT and oversee automated science processing of LAT data to detect and monitor transient gamma-ray sources. We describe the use of collaboration-wide data challenges and service challenges to test and exercise LAT data processing and science operations before launch.

This work is supported by Stanford University and the Stanford Linear Accelerator Center (SLAC) under DoE contract number DE-AC03-76SFO0515. Non-US sources of funding also support the efforts of GLAST LAT collaborators in France, Italy, Japan, and Sweden.

153.11

GLAST User Support

David L. Band[1], GLAST Science Support Center
[1]*University of Maryland, Baltimore County.*

The Gamma-ray Large Area Space Telescope (GLAST) mission will provide the user community with many scientific opportunities. The mission's interface with the user community is the GLAST Science Support Center (GSSC). Yearly guest investigator (GI) cycles will support research related to GLAST. After the first year GIs may propose pointed observations; however, as a consequence of the large field-of-view of GLAST's instruments, pointed observations will rarely have an advantage over the default survey mode. Data, analysis software and documentation will be provided through the GSSC website (http://glast.gsfc.nasa.gov/ssc/); the website also includes a library of scientific results, and a helpdesk.

153.12

The GLAST Science Support Center

Thomas E. Stephens[1], GLAST Science Support Center
[1]*NASA's GSFC/RSIS.*

The GLAST Science Support Center (GSSC) serves as the mission's primary interface to the scientific community. The GSSC supports the planning and scheduling of science observations and maintains a publicly accessible archive of all GLAST data products. The GSSC also maintains and distributes data analysis software and documentation as well as providing technical and scientific support. In addition, the GSSC will administer the guest investigator program for NASA HQ and provide proposal preparation tools and documentation. We present an overview of our role in each of these activities.

153.13

GLAST Data Access and Analysis Software

Donald J. Horner[1], GLAST Science Support Center
[1]NASA's GSFC.

The scientific community will access the public GLAST data through the website of the GLAST Science Support Center (GSSC). For most data products the GSSC website will link to the NASA High Energy Astrophysics Science Archive Research Center's (HEASARC) Browse interface, which will actually serve the data. For example, data from the GLAST Burst Monitor (GBM) from a given burst will be packaged together and accessible through Browse. However, the photon data produced by the Large Area Telescope (LAT), GLAST's primary instrument, will require a customized GSSC interface. These photons will be detected over the LAT's large field-of-view, usually while the LAT is scanning the sky, and thus cannot be attributed to the observation of a particular object. Users will request all photons detected from a region on the sky over a specified time and energy range. This also means that analyzing data from the LAT will require sophisticated techniques. The GSSC will provide a suite of data analysis tools and libraries for use in analyzing the GLAST data. This software is being developed by the instrument teams with assistance from the GSSC to provide a solid and robust framework for interpreting and analyzing the GLAST data. Here we provide a short overview of the Standard Analysis Environment (SAE) software and the data products that will be served.

153.14

Beyond the Event Horizon: Education with Black Holes

Sarah Silva[1], P. Plait[1], L. Cominsky[1]
[1]Sonoma State Univ. NASA GLAST E/PO.

The Sonoma State University (SSU) NASA Education and Public Outreach group (E/PO), in collaboration with several other groups, has created "The Black Hole Suite": a series of formal and informal education and outreach products based on the science of black holes. The formal (in-class) products which include an educator's guide with activities and an online resource -are closely tied to the informal (museum and television) products, which include the nationally distributed planetarium show "Black Holes: The Other Side of Infinity," the PBS NOVA television program "Monster of the Milky Way," and a black holes fact sheet. All of these products were developed with integrated evaluation and assessment.

To disseminate these materials, the SSU E/PO group has created an educator workshop designed specifically to go along with the planetarium program. When a museum or planetarium leases the program, SSU E/PO staff will travel to that venue and provide a workshop for local educators on the use of the Black Hole Suite. Part of the goal of the workshop is for museum and planetarium staff to participate so that they can hold future workshops for local educators.

153.15

On the Problem of Detecting Quantum-Gravity Based Photon Dispersion in Gamma-ray Bursts

Jeffrey D. Scargle[1], J. P. Norris[2], J. T. Bonnell[3]
[1]NASA/Ames Research Center, [2]University of Denver, [3]NASA/GSFC/USRA.

Gamma-ray bursts at cosmological distances offer a time-varying signal that can be used to search for energy-dependent photon dispersion effects. We show that short bursts with narrow pulse structures at high energies will offer the least ambiguous tests for energy-dependent dispersion effects. We discuss an array of quantitative methods to search for such effects in time-tagged photon data. Utilizing observed gamma-ray burst profiles extrapolated to GeV energies, as may expected to be observed by GLAST, we also demonstrate the extent to which these methods can be used as an empirical exploration of quantum gravity formalisms.

154: Ground-Based Instrumentation III
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

154.01

Pisgah Astronomical Research Institute

J. D. Cline[1], M. Castelaz[1], D. Clavier[1]
[1]Pisgah Astronomical Research Inst..

Pisgah Astronomical Research Institute (PARI) is a not-for-profit public foundation located at a former NASA Tracking Station in Western North Carolina. PARI is a radio and optical observatory engaged in education, research, and public outreach. The 200 acre campus facilities include two 26m radio telescopes, a 4.6m radio telescope, a 12m radio telescope, several optical telescopes, and lab space available to researchers and science educators. We will present improvements made to the infrastructure during 2006 which includes a new 0.4m optical telescope and CCD camera, refinishing of the 26m radio telescope surfaces and cabling to the 26m radio telescope feeds, a new projection system for the PARI portable StarLab planetarium, and a new distance learning center. We will also discuss improvement plans for 2007.

154.02

The Apache Point Observatory Lunar Laser-ranging Operation: Testing General Relativity with Millimeter-precision Measurements of the Earth-Moon Separation.

James B. Battat[1], T. W. Murphy[2], E. G. Adelberger[3], C. D. Hoyle[3], R. J. McMillan[4], E. Michelsen[2], K. Nordtvedt[5], A. Orin[2], C. W. Stubbs[1], H. E. Swanson[3]
[1]Harvard Univ., [2]University of California San Diego, [3]University of Washington, [4]Apache Point Observatory, [5]Northwest Analysis.

Based on the discovery of the accelerating universe and dark energy, along with our inability to unite quantum mechanics and General Relativity, there is a clear need to probe deeper into gravitational physics. The Earth-Moon-Sun system is a natural, fertile laboratory for such tests. The Apache Point Observatory Lunar Laser-ranging Operation (APOLLO) bounces laser light off of man-made retro-reflectors on the lunar surface to measure the Earth-Moon separation with a precision of one millimeter. Such precise measurements of the lunar orbit allow us to improve constraints on gravitational phenomena such as the Weak Equivalence Principle, the Strong Equivalence Principle, de Sitter precession and dG/dt by an order of magnitude or better. I will describe the APOLLO project and its current status, as well as prospects for constraining PPN parameters and the universality of free-fall.

This work was carried out under the financial support of NASA and NSF.

154.03

The McDonald Observatory Skycam Project

Michael A. Gully-Santiago[1]
[1]Boston University.

Preliminary results of the McDonald Observatory Skycam Project are presented. The Skycam Project couples an inexpensive wide field sky camera with the freely available Wolf wide field image analysis software made by the Night Sky Live Network. The robust software drastically enhances the utility of the camera. The inexpensive software and hardware combination provides an effective sky imaging solution with very low investment cost. Applications to remote observatories are discussed. This project was conducted in ten weeks during the McDonald Observatory REU program funded under NSF AST-0243745.

154.04

ALE: Astronomical LIDAR for Extinction

Peter C. Zimmer[1], J. T. McGraw[1], G. Gimmestad[2], D. Roberts[2], J. Stewart[2], M. Dawsey[3], J. Fitch[1], J. Smith[1], A. Townsend[1], B. Black[1]
[1]Univ. of New Mexico, [2]Georgia Tech Research Institute, [3]Univ. of Arizona.

The primary impediment to precision all-sky photometry is the scattering or absorption of incoming starlight by the aerosols suspended in, and the molecules of, the Earth's atmosphere. The University of New Mexico (UNM) and the Georgia Tech Research Institute (GTRI) are currently developing the Astronomical LIDAR (LIght Detection And Ranging) for Extinction (ALE), which is undergoing final integration and initial calibration at UNM. ALE is based upon a 527nm laser operated at a pulse repetition rate of 1500 pps, and rendered eyesafe by expanding its beam through a 32cm diameter transmitter. The alt-az mounted ALE will operate in multiple modes, including mapping the sky to obtain a quantitative measurement of extinction sources, measuring a monochromatic extinction coefficient by producing Langely plots, and monitoring extinction in the direction in which a telescope is observing.

A primary goal is to use the Rayleigh scattered LIDAR return from air above 20km as a quasi-constant illumination source. Air above this altitude is generally free from aerosols and the variations in density are relatively constant over intervals of a few minutes. When measured at several zenith angles, the integrated line-of-sight extinction can be obtained from a simple model fit of these returns. The 69 microjoule exit pulse power and 0.6m aperture receiver will allow ALE to collect approximately one million photons per minute from above 20km, enough to enable measurements of the monochromatic vertical extinction to better than 1% under photometric conditions. Along the way, ALE will also provide a plethora of additional information about the vertical and horizontal distributions of low-lying aerosols, dust or smoke in the free troposphere, and high cirrus, as well as detect the passage of boundary layer atmospheric gravity waves.

This project is funded by NSF Grant 0421087.

154.05

A GRB Optical Afterglow Automatic Response Telescope on Skynet

Adam B. Smith[1], D. B. Caton[1], L. Hawkins[1]
[1]Appalachian State Univ..

We are developing a telescope for automated response observations of Gamma Ray Bursts. The instrument is composed of a Celestron14 on a Paramount, and an Apogee U47 CCD, JMI electronically controlled focuser, and DFM Engineering FW-82 filter wheel containing Omega Optical UBVR filters.

The system will run under the control of the Skynet system developed at UNC-Chapel Hill as part of the PROMPT system. Maxim DL and Software Bisque's The Sky are the interface to the Skynet Terminator program that connects to Skynet.

The Ash dome will be opened for the night on any clear night with power transferred via contactors at the park position. Rotation control will be provided by software control. Weather monitoring is provided by online data from a Davis Vantage Pro weather station, a Boltwood cloud sensor and an SBIG All-sky ("meteor") camera.

In the "idle mode" the telescope may be used by any Skynet user. Much of the idle time will be used in a program to search for transits of exoplanets.

Support for this project was provided by the North Carolina Space Grant, the Appalachian State University Research Council, and the NSF through award AST-0520812.

154.06

A New Sky Brightness Monitor

David L. Crawford[1], D. McKenna[2]
[1]IDA, [2]Vatican Observatory.

A good estimate of sky brightness and its variations throughout the night, the months, and even the years is an essential bit of knowledge both for good observing and especially as a tool in efforts to minimize sky brightness through local action. Hence a stable and accurate monitor can be a valuable and necessary tool. We have developed such a monitor, with the financial help of Vatican Observatory and Walker Management. The device is now undergoing its Beta test in preparation for production. It is simple, accurate, well calibrated, and automatic, sending its data directly to IDA over the internet via E-mail . Approximately 50 such monitors will be ready soon for deployment worldwide including most major observatories. Those interested in having one should enquire of IDA about details.

154.07

Brightness of Clouds at Night over a City

R. H. Garstang[1]
[1]Univ. of Colorado.

I have completed my program of calculations on the brightness of clouds at night over a city. To simplify the calculations I took the simple model of a uniformly illuminated circular city. I took my light pollution model, which was originally designed to calculate the sky brightness at a distant observatory caused by a city, and modified the program to calculate the sky brightness at the zenith as seen from the center of a circular city. I assumed a uniform horizontal cloud layer, described by the height of the cloudbase above the ground and the total optical depth of the cloud layer. Three methods of calculating the reflectivity and transmissivity of the clouds were tried; most of the results were obtained by using the doubling method as implemented by Wiscombe. The reflectivity and transmissivity were incorporated into the light pollution model. The brightness of the clouds at the zenith as seen from the city center was calculated, along with the brightness seen from a satellite in the nadir direction towards the city center. Calculations were performed for various parameter choices to get a feel for the importance of various parameters. The city population, city radius, ground reflectivity, light emission from the city per capita, the extent of light escaping from inadequately shielded lamps, height of the cloudbase, the single scattering coefficient in the clouds, and the total optical depth of the clouds were varies and the brightness calculated. The most critical parameters were the population density of the city and the total optical depth of the cloud layer. The paper has been accepted for publication in *The Observatory* for February 2007.

154.08

Performance of the Visiting Instrument TEXES on Gemini North

Andrew J. Kruger[1], J. H. Lacy[2], D. T. Jaffe[2], M. J. Richter[1], T. K. Greathouse[3], M. Bitner[2], P. Segura[4], W. Moller[4], T. R. Geballe[5], K. Volk[5]
[1]Department of Physics, University of California, [2]Department of Astronomy, University of Texas, [3]Lunar and Planetary Institute, [4]McDonald Observatory, University of Texas, [5]Gemini Observatory.

We report on the use of TEXES as a visiting instrument on Gemini North during 2006. TEXES is a high spectral resolution (3-5 km/s), mid-infrared (4.5 μm to 25 μm) instrument that has been used on the NASA IRTF 3m since 2000. The high spectral resolution makes TEXES well suited for studying the dynamics and composition of gaseous regions using molecular and ionic tracers (e.g. star forming regions or planetary and stellar atmospheres). Based on our results from an engineering run, a science verification run, and a full science campaign (17 nights), we will describe the system performance in anticipation of future availability of TEXES on Gemini. Observations with TEXES are supported by NSF grant AST-0607312. AK is supported by NSF grant AST-0307497.

154.09

bHROS: Year One

Steven J. Margheim[1]
[1]Gemini Observatory, Chile.

The bench-mounted, High-Resolution Optical Spectrograph on the Gemini South telescope completed demonstration science in 2005B and became available for programs in 2006A. Early science-results from the first year of science observations will be highlighted and an overview of instrument capabilities will be presented.

154.10

The Gemini Planet Imager Apodized Pupil Lyot Coronagraph

Remi Soummer[1], A. Sivaramakrishnan[1], B. R. Oppenheimer[1], B. A. Macintosh[2], GPI team
[1]American Museum of Nautral History, [2]LLNL.

The Gemini Planet Imager instrument is a multi-institution project which consists of an Extreme Adaptive Optics system, an Apodized Pupil Lyot Coronagraph, an Integral Field Unit and an active calibration system for speckle suppression. The AMNH group is designing and building the Apodized Pupil Lyot Coronagraph. This type of coronagraph is basically a classical Lyot coronagraph with an upstream pupil apodization, based on mathematical properties of the prolate spheroidal functions. An APLC produces a dramatic improvement over the classical Lyot coronagraph. We have identified appropriate technologies to manufacture the required components. We will present the current status of the design and laboratory infrared testing results.

154.11

A Proposed GLAO System for Gemini

David R. Andersen[1], Gemini GLAO Feasibility Study Team
[1]Herzberg Institute of Astrophysics, Canada.

We show the results of a study commissioned by Gemini Observatory to determine the feasibility of implementing a Ground Layer Adaptive Optics (GLAO) system on one of the Gemini telescopes. Our team, including members from HIA, University of Durham and University of Arizona, produced a detailed estimate of the performance gain of a GLAO system on Gemini through extensive modeling. In particular, we showed that over a large field of view at visible and near-infrared wavelengths, GLAO concentrates light from a point source by significantly decreasing the size of the point spread function (PSF). This improvement can be realized using a single, relatively low-order adaptive secondary mirror (ASM) to correct the wavefront errors from low altitude turbulence. Here we present both these GLAO modeling results and an overview of the GLAO design. GLAO on Gemini will be a telescope facility rather than a separate instrument; the design includes an ASM, a new laser launch facility to produce a 10 arcminute diameter asterism of four Sodium beacons, and wavefront sensors inside the Acquisition & Guide Unit. With such a Gemini GLAO facility, an overall efficiency gain up to 40% can be expected. In addition, the greatest absolute improvements in image quality will actually be realized when the conditions are worst; GLAO can effectively eliminate "bad seeing" nights at Gemini.

154.12

Preliminary Optical and Mechanical Designs for a 2.2 Degree Diameter PrimeFocus Corrector for the Blanco 4 Meter Telescope

Stephen M. Kent[1], R. Bernstein[2], B. Bigelow[2], F. Leger[1], A. Stefanik[1], T. Abbott[3], D. Brooks[4], P. Doel[4], B. Flaugher[1], M. Gladders[5], A. Walker[3], S. Worswick[4]
[1]Fermi Nat'l. Accelerator Lab., [2]U. of Michigan, [3]CTIO/AURA, Chile, [4]University College London, United Kingdom, [5]U. of Chicago.

We describe a five element corrector for the prime focus of the 4 meter Blanco telescope at the Cerro Tololo Inter-American Observatory (CTIO) in Chile that will be used in conjunction with a new mosaic CCD camera as part of the proposed Dark Energy Survey (DES). The corrector is designed to provide a flat focal plane and good images in the SDSS g, r, i, and z filters. The mechanical design allows for full five-axis motion. We describe the performance in conjunction with the scientific requirements of the DES.

154.13

Observating Techniques with the IRMOS MEMS Spectrometer

John W. MacKenty[1], M. A. Greenhouse[2], R. G. Ohl[2], M. Robberto[1]
[1]STScI, [2]NASA/GSFC.

We describe two classes of experiments in the operation and calibration of the Infrared Multi-Object Spectrometer (IRMOS). This instrument employs a novel approach to slit definition with a 848x600 element array of individually controlled mirco-mirrors. Now available as a facility instrument at KPNO, IRMOS provides resolutions of 300, 1000, and 3000 in the J, H, and K near-infrared bands over a 3x2 arc minute field on the Mayall 4m telescope. We have extensively experimented with a ″point and click″ slit definition observing mode in which the observer interactively places and adjusts slits on an image of the field of interest. We discuss observing strategies to improve calibration and background removal. We have also started the exploration of a full integral field mode using Hadamard transform slit masks and will present reconstructed images and extracted spectra from the resulting data cubes.

IRMOS has been supported by NASA's JWST project, NASA/GSFC, STScI Director's Discretionary Research Fund, and KPNO.

154.14

Astrometric Calibration of Digitized Wide-Field Photographic Plates

Peter B. Boyce[1], P. N. Truong[1]
[1]Maria Mitchell Association.

8000 photographic plates originally taken at Maria Mitchell Observatory from 1913 to 1996 were scanned and digitized in 2002-2003. The resulting scans are stored in TIFF format. We have investigated the use of currently existing tools to convert plate coordinates to RA and Dec to ready the scans for inclusion in the National Virtual Observatory. This involves converting the scans to FITS format and adding WCS headers. Five of the digitized images, with slightly different centers, covering 13° x 16° in Cygnus, were calibrated using the CDS Aladin program version 3.6. An initial Tangent Plane fit was produced by entering parameters applicable for the MMO plates. The images were first calibrated by parameters. The calibration was refined by matching stars images with their positions by overlaying the positions from the Bright Star Catalog. Once a reasonably accurate calibration has been determined, additional star catalogs can be used to refine the calibration.

We find that the accuracy of the calibration for a Tangent Plane is not heavily dependent upon the number of stars used. Using a simple Tangent Plane model on these wide-field plates, the coordinates of objects near the edges of the plate often differ from coordinates of objects in the catalog by up to an arcminute. As a check, we also used the WCS Tools programs written by Doug Mink at the Harvard-Smithsonian CfA, and they yield the same results. A satisfactory astrometric calibration which covers the whole field will require the use of higher order polynomials.

This project was supported by the NSF/REU grant AST-0354056, the NASA/AAS Small Research Grant Program and the Nantucket Maria Mitchell Association.

154.15

2.1 meter (82 inch) Slip Ring By-Pass Project

Corby B. Bryan[1]
[1]Texas Tech University.

2.1 meter (82 inch) Slip Ring By-Pass Project

I will describe a project to bypass the old method of getting control communications above the rotation point of the McDonald Observatory 2.1 meter dome. The old method used slip rings that were implemented in the late 1930s. The new system uses wireless serial commands which allow the control lines to be taken off the slip rings, leaving only power and ground. I will describe how the concept was devised so the slip rings could be bypassed, what micro-controller system that was decided on and used, how the wireless units were set up and finally how the system was tested and put in place with only limited tasks to control. (I.E. the opening and closing of the

shutters) We describe the advantages to making this upgrade and how it could benefit any telescope interested in upgrading its communication systems. This project was designed and tested in ten weeks during the McDonald Observatory REU and was supported under NSF AST-0243745. The system was designed so that it could be installed while running side by side with the current method of getting control to the above rotation point. The method is still in place being tested on the 2.1 meter telescope and will soon be fully implemented by the University of Texas McDonald Observatory OS staff.

155: Observations and Models of Extragalactic LMXBs AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

155.01

Low-Mass X-ray Binary Models for NGC3379 and NGC4278

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We present theoretical models for populations of Low-Mass X-Ray Binaries in two elliptical galaxies NGC3379 and NGC4278. The models are calculated with the recently updated StarTrack code (Belczynski et al. 2006) and targeted to modeling and understanding the origin of the shape characteristics of the X-ray luminosity functions (XLF) in these galaxies. For the first time we explore the population XLF down to low luminosities in the range of (5-10)E36 erg/s as probed by the most recent observational results (Kim et al. 2006).

155.02

X-ray Binaries in the Fornax Local Group Dwarf

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Local Group dwarfs offer a unique opportunity to study X-ray populations: their proximity allows the detection of lower luminosity sources than is possible outside the Local Group. In this poster, we describe a 100ks *XMM-Newton* observation of the Fornax Dwarf Spheroidal (dSh) galaxy. The main observational goal is to detect X-ray sources down to a luminosity limit of approximately 3E33 erg/s. Since the Fornax dSh shows very little evidence for recent star formation, we expect most detected sources to be either low mass X-ray binaries (LMXBs) or background sources. This limit is much deeper than has been obtained in any previous X-ray survey of LMXB sources, and enables us to detect LMXBs in quiescence.

Using standard SAS routines, we combined the PN and MOS images and ran the source detection routine *wavedetect*. We detect approximately 130 sources down to a luminosity of 5E33 erg/s in the XMM field of view. The cumulative X-ray luminosity function is a power law with flattening below 6.8E33 ergs/s which may be due to incompleteness. Approximately 40 of the sources lie within the D25 ellipse of the galaxy. Comparison with the Optical Monitor data shows that at least 12 of the detected sources within D25 are coincident with a bright UV source, and hence are likely to be background AGN. This number is consistent with the log(N)-log(S) relationship of Campana et al. (2001, ApJL, 560,19). We therefore have 28 sources that are likely LMXBs in Fornax.

155.03

X-ray Binary Populations in Normal elliptical Galaxies

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We present the preliminary results of deep Chandra monitoring of the LMXB populations of two elliptical galaxies, NGC 3379 and NGC 4278. It is important to study these LMXBs as they provide the only direct fossil evidence of the formation and evolution of binary stars in elliptical galaxies. With 110 and 140 ks Chandra ACIS S3 exposures, we detect 59 and 112 LMXBs within the D25 ellipse of NGC 3379 and NGC 4278, respectively. The spectral and temporal characteristics of these point sources have been investigated with an image analysis pipeline, which we will summarise here. We also present deep images of both galaxies, alongside X-ray color-color diagrams and variability plots, allowing us to constrain the fraction of transients in these galaxies, thus placing important limits on formation mechanisms and binary evolution. Further to this, we will also compare these LMXBs to counterparts, found in both the field and globular clusters.

155.04

Low-Luminosity XLF in Normal Elliptical Galaxies

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We investigate the low luminosity (Lx > 5 10 x 10^{36} erg s-1) X-ray luminosity functions (XLFs) of low-mass X-ray binaries (LMXBs) determined for two typical old elliptical galaxies, NGC 3379 and NGC 4278. Because both galaxies contain little diffuse emission from hot ISM and no recent significant star formation (hence no high-mass X-ray binary contamination), they provide two of the best homogeneous sample of LMXBs. With deep Chandra ACIS S3 exposures, we present well-determined XLFs which are well represented by a single power-law with a slope (in a differential form) of 1.9 +/0.1. In NGC 4278, we can exclude the break at Lx ~ 5 x 10^{37} erg s-1 that was recently suggested to be a general feature of LMXB XLFs. In NGC 3379 instead we find a localized excess over the power law XLF at ~4 x 10^{37} erg s-1, but with a marginal significance of ~1.6sigma. Because of the small number of luminous sources, we cannot constrain the high luminosity break (at 5 x 10^{38} erg s-1) found in a large sample of early type galaxies. For our two galaxies, the ratios of the integrated LMXB X-ray luminosities to the optical luminosity differ by a factor of 4, but it is consistent with the general trend of a positive correlation between the X-ray to optical luminosity ratio and the globular cluster specific frequency.

156: Planetary Nebulae & Supernova Remnants AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

156.01

Discovery of Multiple Coaxial Rings in the Bipolar Nebula Hb12

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A series of two-dimensional rings along a common axis aligned with the bipolar lobes is found in the planetary nebula Hb 12. The rings have separations of about 0.5 arc sec, which can be translated into physical separations of ~1700 AU, or time separations of the order of 100 years. We suggest that the existence of the rings is a manifestation of the interaction between a time-variable, collimated fast outflow with the circumstellar envelope created by the stellar wind of an asymptotic giant branch star.

156.02

Planetary Nebulae and Stellar Kinematics in Interacting Spiral Galaxy M82

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Using an on-band/off-band filter technique, we identify 114 planetary nebulae (PNs) in the edge-on spiral galaxy M82 using the FOCAS instrument at the 8.2m Subaru Telescope. Radial velocities were determined for 100 of these PNs using a method of slitless spectroscopy, from which we obtain a clear picture of the galaxy's rotation. We find evidence for a Keplerian decline in M82's rotation curve, in agreement with results derived by CO(2-1) and HI measurements (Sofue 1998). These results affirm the use of PN as effective, accurate kinematic probes of galaxies. This work was conducted by a Research Experience for Undergraduates (REU) position at the University of Hawaii's Institute for Astronomy and funded by the NSF.

156.03

Balmer Ratios and Molecular Hydrogen in M27

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We present infrared (IR) observations of molecular hydrogen and longslit optical spectroscopy of planetary nebula M27 using the NICFPS and DIS III instruments with the APO 3.5 m telescope. The IR imaging provides $\sim 1''.5$ maps of the nebula in the S(1) (1−0) 2.12 μm and S(1) (2−1) 2.25 μm lines, revealing the detailed structure of the H_2 distribution. The spectra are used to derive $H\alpha/H\beta$, $H\gamma/H\beta$, and $H\delta/H\beta$ ratios as a function of position in the nebula. Balmer ratio maps are constructed from 57 scans, covering the whole nebula. During each 200s scan the $300'' \times 0''.9$ DIS slit was drifted in the spectral direction by $10''$. The $0''.9$ slit provides a spectral resolution of ~4Å. The analysis is supplemented by recent archival Spitzer observations, which give us the possibility of investigating the spatial correlations and clumping of the material observed in the the two datasets. Four-band IRAC photometry is performed on the knots and the contribution of molecular and atomic lines to the total brightness in each band is estimated based on IRS spectra. We compare the infrared imaging to the Balmer ratio maps and estimate the implications for the excitation mechanisms of molecular hydrogen.

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156.04

Planetary Nebulae in the Large Magellanic Cloud: Results from MCELS

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As the ejected atmospheres of more common low to intermediate mass stars, planetary nebulae (PNe) represent an important constituent of the interstellar medium (ISM), reflecting the evolutionary histories of the progenitor giant stars and chemically-enriching the ambient ISM. Large samples of PNe are required for the study of general characteristics and evolutionary trends, especially when trying to determine the breakdown of PNe in terms of excitation class, chemical abundances, and other properties. The Galactic PN sample suffers from incompleteness due to interstellar absorption along the line-of-sight and uncertain distance measurements. The Large Magellanic Cloud (LMC), with its low foreground absorption and relative proximity, offers an ideal laboratory to investigate the physical properties of a large sample of PNe. In this work, we present a flux-calibrated set of planetary nebulae (PNe) candidates over the central 8x8 degrees of the LMC using data from the Magellanic Cloud Emission Line Survey (MCELS). With our data pipeline, we subtract continuum images from the emission-line images ([O III], H-alpha, and [S II]) to obtain accurate measurements of the emission-line intensities without significant contamination by the background stellar continuum. Furthermore, our continuum-subtracted data allow us to map out deeper detail in the faint, diffuse emission, improving our selection process and identification of PNe candidates. We compare our results with those from previous surveys.

156.05

A More Complete Sample of Planetary Nebulae in the Small Magellanic Cloud: Results from MCELS

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We have examined the entire SMC data set from the Magellanic Cloud Emission Line Survey (MCELS) and have identified 34 objects as probable planetary nebulae (PNe). All the candidates show significant emission in both [O III] and H-alpha emission lines, an absence of continuum emission, and are essentially unresolved at the 4-arcsec resolution of the MCELS. Our survey covers an area of 4.5 x 3.5 degrees, over 5 times larger than the deep CCD survey of the central 2.8 sq deg of the SMC by Jacoby & De Marco (2002, AJ, 123, 269). All but three of the new candidates are outside the Jacoby & De Marco survey region. We have measured [O III] 5007 Å fluxes for all the new candidates and for 91 previously cataloged PNe, and we have obtained a planetary nebula luminosity function that should be nearly complete down to at least 5 magnitudes below the bright cut-off. We have also obtained fluxes or upper limits for most of the PNe in H-alpha (partially contaminated by [N II]) and [S II] 6717, 6731 Å, for what is probably the most complete survey of PN line fluxes and flux ratios in any galaxy beyond our own.

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156.06

High-resolution X-ray Imaging and Spectroscopy of the Planetary Nebula BD +30 3639

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Planetary nebulae (PN) are the last stages of evolution of intermediate mass (1-8 M_{solar}) stars. X-ray observations of PNs offer unique insight into the mechanisms that shape the nebulae. In February/March 2006 we observed the X-ray-bright young PN, BD+30 3639, for 150 ks using the Chandra X-ray Observatory's Low Energy Transmission Gratings in combination with its Advanced CCD Imaging Spectrometer (LETG/ACIS). This observation was the first half of our total time allocation with Chandra/LETG/ACIS. The well-resolved emission lines in the dispersed spectrum and the spatial structure in the 0^{th} order image provide constraints on the origin of the X-ray-emitting plasma and the processes responsible for the structure of the nebula, respectively. We have used a combination of Sub-pixel Event Repositioning (SER) and deconvolution to improve the spatial resolution of the 0^{th} order image. We report the preliminary results of spectral analysis and SER/deconvolution, including a comparison of the 0^{th} order LETG/ACIS image with Hubble Space Telescope imaging as well as with an archival Chandra/ACIS image obtained in 2000.

156.07

K-Band Spectroscopy of the Extragalactic Planetary Nebula Hen 2-436

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We present a 2.115 to 2.300 micron spectrum of the extragalactic planetary nebula Hen 2-436, obtained with GNIRS on Gemini South at a resolution of R = 5900. This object has been identified as a member of the Sagittarius dwarf elliptical galaxy, which is being tidally disrupted by the Milky Way, on the basis of its radial velocity and overall metallicity of roughly 0.3 solar (Walsh et al. 1997, ApJ, 487, 651). In addition to H I Brackett gamma, two He I lines, H2 1-0 S(1) 2.121 and 1-0 S(0) 2.223 microns, we detect two lines of trans-iron elements: [Kr III] 2.199 and [Se IV] 2.287 microns (Dinerstein 2001, ApJ, 550, L223). These elements can be self-enriched in the envelopes of thermally-pulsing AGB stars, the progenitors of planetary nebulae, by s-process nucleosynthesis in the H-He intershell region, followed by convective dredge-up. Using ionization correction procedures developed by Sterling, Dinerstein, & Kallman (2006, ApJ, submitted), we find a Se/H abundance of about twice solar, and a Kr/H value of several times solar. Due to the subsolar initial abundances of the progenitor star, the actual Se and Kr enrichment factors are greater than 5 and 10, respectively. These large enrichments are consistent with other evidence that the progenitor star of Hen 2-436 underwent extensive third dredge-up (Dudziak et al. 2000, A&A, 363, 717; Pequignot et al. 2000, A&A, 361, L1). These measurements represent the first detection of s-process enrichments in a planetary nebula from a low-metallicity progenitor. Further observations of planetary nebulae in diverse stellar populations will enable us to study the relationship between s-process enrichment and metallicity. This research was supported by NSF grant AST 04-06809.

156.08

Properties of Planetary Nebulae: NGC2022

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We present, for the planetary nebula NGC 2022, emission line flux mapping extracted from long-slit spectra taken with the 2.56 m Nordic Optical Telescope. Two-dimensional emission-line images for the entire nebula are created using data from only half of the nebula (which is symmetric), and are used to derive fluxes for 19 lines. We also create the Halpha/Hbeta extinction map, the [SII] and [Ar IV] line ratio density maps, and the [OIII] temperature map of the nebula. The total Hbeta flux is compared with values obtained by other authors. With these results we are now ready to begin modelling the nebula with a 3-D photoionization code, which will allow us to determine the 3-D structure, central star properties, and the distance to NGC 2022.

156.09

A Search for Gas-Phase Zirconium in s-process Enriched Planetary Nebulae

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We report results from a search for the ground-state fine-structure line of triply ionized zirconium (Zr) near 8 microns, for several planetary nebulae known to have enhanced abundances of other light neutron-capture elements. The observations were made with the high spectral resolution mid-IR spectrometer TEXES (Lacy et al. 2002, PASP, 114, 153) on the IRTF. Zr, atomic number Z = 40, is part of the "light s-process" peak of nuclei which are synthesized in the region between the H and He-burning shells within AGB stars and mixed into the stellar envelope by dredge-up processes before expulsion of a planetary nebula. The targets included objects for which we have demonstrated that Ge (Z = 32) is enhanced by up to a factor of 5 (Sterling et al. 2005, ApJ, 625, 368), and Kr (Z = 36) is enhanced by factors of up to 10 (Sterling et al. 2006, submitted; Sterling & Dinerstein, in preparation). According to both evolutionary models and observations of Galactic S-type stars, Zr can be even more highly enriched than Ge or Kr, with enrichment factors of up to 20 30 (Busso et al. 2001, ApJ, 557, 802; Vanture & Wallerstein 2002, ApJ, 564, 397). If Zr is present primarily in gaseous form in these planetary nebulae, our failure to detect the mid-IR Zr line sets constraints on a combination of the initial mass of the progenitor stars and the details of the s-process and convective mixing. An alternate interpretation is that much of the Zr, a highly refractory element, is locked up in dust grains that formed in the AGB star's atmosphere before or during envelope ejection.

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156.10

Searching for the Missing Galactic Planetary Nebulae: A Pilot [S III] Imaging Survey

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Current estimates of the total number of Galactic planetary nebulae (GPNe) are highly uncertain; the most inclusive current catalog contains only ~ 1,500 PNe. A complete and minimally contaminated catalog of GPNe is necessary for a variety of ongoing studies, including investigation of the possibility that most or all PNe originate from binary systems. In order to complete current catalogs, a reliable long-wavelength PNe detection method is needed to find those GPNe obscured by dust and so missed by previous surveys using standard PNe signposts--[O III] at 5007Å or Hα at 6563Å. We have employed the method used by Jacoby & Van de Steene, who surveyed the Galactic bulge for [S III] λ9532 emission. They show that the [S III] λ9532 emission line dominates the visible spectrum of most PNe when the visual extinction is between 4 and 12 magnitudes. Thus, narrowband imaging surveys of [S III] emission are a potentially efficient and effective method for finding distant, highly-extincted PNe like those within the Galactic plane. Use of this line should also exclude many of the most troublesome PNe catalog contaminants--ultracompact HII regions. We have used the PRISM wide-field imager and two 20Å bandpass interference filters on the 1.8-m Perkins Telescope at Lowell Observatory to conduct a pilot survey of ~ 1 square degree of the Northern Galactic plane for $|b| \leq 1°$. The survey observations and results from subsequent data analysis will be presented.

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156.11

A Multi-Wavelength Investigation of Newly Discovered Supernova Remnants in the Large Magellanic Cloud

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The Large Magellanic Cloud (LMC), with its low foreground absorption and proximity, offers the ideal site to study a large sample of supernova remnants (SNRs) in detail, both spatially and energetically. It is possible to obtain a relatively complete sample of SNRs in the LMC to examine both global properties and the subclasses of SNRs. Toward this goal, we have identified new SNRs using multi-wavelength data. The newly recognized SNRs are generally fainter than the known sample, and may represent a previously missed population.

We have obtained X-ray images and spectra of three of these recently identified SNRs using the XMM observatory. These data, in conjunction with pre-existing optical emission-line images and spectra and radio continuum data, are used to determine the physical conditions of the warm ionized gas and the hot ionized gas. We compare the morphologies of the SNRs in the different waveband. The physical properties of the warm ionized shell are determined from the Hα surface brightness and the SNR expansion velocity. The X-ray spectra were fit with a Raymond-Smith thermal plasma model and the physical conditions of the hot gas are derived from the model fits. We find that the pressure of the hot gas is greater than that in the warm shell by about an order of magnitude, implying that these remnants are in the pressure-driven expansion stage. We also discuss the ages and classifications of the remnants.

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156.12

Modeling the Crab Synchrotron Nebula by Including Radiative Losses in Flow Dynamics

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Models of the Crab synchrotron nebula include energy losses by radiative and adiabatic expansion, but neglect the effect of radiative losses on the flow itself. The standard model of Kennel and Coroniti (1984), for example, calculates a post-shocked flow and modifies only the energy equation while assuming steady state flow dynamics. Recent efforts at simulating the synchrotron emission from the Crab also take this approach (Shibata et al. 2003 MNRAS, 346, 841, and Del Zanna et al. 2006, A&A, 453, 621). Typically, these authors argue that since the radiated power is only about 10 percent of the pulsar's spin down luminosity, radiative losses should have only negligible effects on flow dynamics. This argument implicitly assumes a spherically symmetric nebula: the estimate can be as high as 20 30 percent for a wedge geometry, for example.

In previous work we have revisited the problem of a steady state adiabatic flow, replacing the semi-analytic treatment of KC with a numerical calculation (Foy & Hester 2005). We present a preliminary time-dependent model that incorporates synchrotron radiative losses into the dynamics of the flow and discuss how such a treatment may reveal dynamical instabilities associated with the observed 'wisps' in the Crab nebula.

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156.13

Spitzer Observations of Supernova Remnant N49 in the LMC

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N49 (SNR 0525-66.1) is the brightest optical supernova remnant (SNR) in the Large Magellanic Cloud, located at the edge of a massive, dense molecular cloud. The environment surrounding the N49 remnant is ideal to study the interaction of the supernova ejecta with the interstellar medium and to ascertain whether this SNe has triggered star formation processes within the adjacent molecular cloud. We present Spitzer Space Telescope infrared imaging and spectroscopy of N49 obtained with the Infrared Array Camera (IRAC) at 3.6, 4.5, 5.8, and 8.0 microns, the Multiband Imaging Photometer (MIPS) at 24 and 70 microns, and three modules of the Infrared Spectrograph (IRS) covering the wavelengths between 5 and 38 microns. The IRAC morphology resembles that evident at visible and x-ray wavelengths. The peak IRAC surface brightness of the SNR is along the southeastern edge, where it encounters the molecular cloud. While the MIPS images exhibit the same enhancement in the southeast, a complete shell structure is detected in the 24 micron image. The IRS spectra show strong ionic emission lines of [Si II], [Fe II], [O IV], [S III], [Ne II], and [Ne III], molecular hydrogen line emission, and no apparent dust features at the selected slit position.

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156.14

The N19 HII Complex in the SMC: Multiple Supernova Remnants Forming a Proto-Superbubble?

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We have analyzed Chandra data for supernova remnants (SNRs) within the N19 HII complex in the Small Magellanic Cloud, supplemented by optical emission-line images and echelle spectroscopy. Our analysis examines the known SNR MCRX J0047.2-7308 (SNR B0045-73.4), confirms the SNR candidate MCRX J0046.6-7308 (SNR B0045-7325), and strengthens the case for a large, extended SNR identified as candidate MCRX J0047.5-7308. We find that the abundances inferred from spectral model fits to the X-ray emission from these SNRs and SNR candidates are consistent in each case with remnants of massive-star progenitors. We observe a possible point source within J0047.2-7308, embedded in a region of hard emission, suggestive of a possible embedded PWN. As these three remnants, all with massive-star origins, appear to be spatially located within the N19 complex, we infer that a small OB association may be the source of these phenomena. To expand on this assessment, we estimate the number of massive stars within N19 and project their energy input to the region. We find that a stellar-wind created superbubble is unlikely to have formed, but that the further expansion of the SNRs in the region may lead to superbubble formation on a timescale of <0.3 Myr from the first supernova. The authors acknowledge support from SAO grant GO3-4094A and NASA LTSA grant NNG05GC97G.

156.15

Balmer-Dominated Supernova Remnants Revisited

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We summarize the results of a new formalism presented in Heng & McCray (2006), which we use to describe the ratios and profiles of emission lines from hydrogen in Balmer-dominated shocks, and to interpret the measured widths and ratios of broad and narrow H-alpha, H-beta and Ly-alpha emission lines in supernova remnants (SNRs). Our model results agree fairly well with those obtained previously by Chevalier, Kirshner & Raymond (1980) and are consistent with observations of several SNRs. The same model fails to account for the ratio of broad to narrow line emission from the reverse shock in SNR 1987A as observed by Heng et al. (2006). We suggest that this discrepancy between theory and observation results from a faulty assumption that Balmer-dominated shocks can be treated as sharp discontinuities. If the spatial structure of the shock transition zone is taken into account, the predicted ratios of broad to narrow line emission in most SNRs will change by modest factors, but the ratio in SNR 1987A will increase substantially. Significantly greater shock velocities will be required to account for the observed full widths at half-maximum of the broad emission lines in most SNRs.

156.16

Expanding Ejecta in the Core-Collapse Supernova Remnant G292.0+1.8, Cas A's Older Cousin

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G292.0+1.8 is an oxygen-rich supernova remnant (SNR)--a member of the same exclusive family as Cas A. It is the *only* Galactic SNR which displays *all* the features expected in the young remnant of a core-collapse supernova: optical (and X-ray) emission from fragments of metal-rich ejecta, an active pulsar and associated pulsar-wind nebula, and evidence for interaction of a blast wave with circumstellar wind material. We report here measurements of proper motions of the ejecta-dominated filaments, based on CCD images in the [O III] 5007 Å line taken from the CTIO 0.9m telescope at epochs from 1999 through 2006. We also use additional images from as early as 1986 for the central region of this 8-arcmin-diameter remnant. Matched narrow-band continuum images at most epochs aid in removing the myriad stars that litter the crowded field, making small, faint filaments of ejecta more apparent. We use a two-dimensional cross-correlation technique to measure the shifts for dozens of individual filaments between multiple epoch pairs. The fastest, most outlying filaments display proper motions as large as 0.15 arcsec/yr. Preliminary results appear consistent with undecelerated expansion from a common center, and suggest a kinematic age slightly younger than the 3000-3400 yr inferred by Ghavamian et al. (2005, ApJ, 635, 365) from Fabry-Perot measurements of the radial velocities for many of the ejecta filaments in G292.

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156.17

A Deep Chandra Observation of Kepler's Supernova Remnant: A Type Ia Supernova with Circumstellar Interaction

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We present initial results of a 750 ks Chandra observation of the remnant of Kepler's supernova of AD 1604. We are able to separate shocked circumstellar medium, identified by O emission below 0.72 keV, and shocked ejecta, identified by Fe L and Si and S K alpha emission. The strength and prominence of iron emission, and the absence of O-rich ejecta, support the longstanding claim that Kepler resulted from a thermonuclear supernova, even though evidence for circumstellar interaction is also strong. We present images with arcsecond resolution demonstrating that the ejecta are stratified with Si and S extending beyond Fe L emission; we also find evidence for ionization of Fe decreasing inward, i.e., increasing with distance behind the reverse shock. This chemical stratification conflicts with the predictions of some Type Ia explosion models, such as sub-Chandrasekhar models or 3-D deflagrations with well-mixed ejecta. Hard continuum emission, almost certainly synchrotron, surrounds the remnant in thin filaments, as seen in other young remnants. Ejecta blobs reach to the outer blast wave in many locations. Fe K alpha emission can be seen in spectra in almost all parts of the remnant. We observe differences in Fe K alpha line centroids and profiles, due both to ionization effects and to Doppler shifts and broadening, and containing important clues to the dynamics of the remnant. We summarize the significant constraints placed on models of Type Ia supernovae, and on the progenitor of Kepler's supernova in particular, by these observations.

156.18

A Deep Chandra Observation of the O-Rich SNR 0540-69.3 in the LMC

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We performed a deep 120 ks Chandra observation of supernova remnant (SNR) 0540-69.3 in the Large Magellanic Cloud (LMC). SNR 0540-69.3 is one of only two members classified as ″oxygen-rich″ SNRs in the LMC. This SNR also contains a 50 ms pulsar and its wind-blown nebula (PWN). We search for the O-rich ejecta material whose presence is known in the optical band, but has been controversial in X-rays. High photon statistics obtained with the deep exposure allow us to characterize the spectral properties of the complex network of the shocked ISM and the faint nonthermal arcs. Using the 1/4 subarray mode of the ACIS, our data are less contaminated by the pile-up than previous observations, which is useful for the spectral study of the PWN. We present the first results of the spectral and imaging analyses. This work was supported in part by the SAO grant GO5-6063X.

156.19

X-Ray Imaging and Spectroscopy of Oxygen-Rich Ejecta in N132D

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The brightest supernova remnant in the Magellanic Clouds, N132D, belongs to a rare class of oxygen-rich remnants, consisting of about a dozen objects which show emission from pure heavy-element ejecta in their optical spectra. They are generally thought to originate in explosions of massive stars which produce large amounts of O, although only a tiny fraction of that O is found to emit at optical wavelengths. We report detection of the ″missing″ O at X-ray wavelengths in a recent deep (100 ksec) Chandra ACIS observation of N132D. Ejecta spectra are dominated by strong lines of He- and H-like O, and Ne and Mg emission enhancements are also apparent. There is a good match between X-rayand optically-emitting ejecta, as shown by comparison between subarcsecond-resolution Chandra and Hubble images. Because optical ejecta are concentrated in a 5 pc radius elliptical expanding shell, most of ejecta X-ray emission also originates in this shell. We interpret these new Chandra observations in a framework of a core-collapse supernova explosion of a massive star within a wind-blown bubble, about 3000 yr ago. We discuss constraints on the initial main-sequence mass of the supernova progenitor posed by detection of large amounts of O in X-rays.

156.20

Investigation of the Vela X Emission

Stephanie M. LaMassa[1], P. Slane[1], O. de Jager[2]
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The Vela supernova remnant (SNR), at a distance of ~ 290 pc is the closest SNR to contain an active pulsar, (PSR) B0833-45. The SNR spans about 8 degrees in diameter and contains regions of nonthermal emission, including Vela X to the south-southwest of the pulsar, thought to be a pulsar-powered wind nebula (PWN). The center of Vela X is offset by about 40' from the pulsar and emits in the radio, X-ray, and gamma ray bands.

ROSAT observations of the Vela SNR reveal a collimated X-ray filament seen predominantly at higher energies extending from the pulsar to the center of Vela X, about 45' in length. This cocoon-like feature was interpreted by Markwardt and Ogelman as an X-ray jet along which the pulsar loses energy. Subsequent Chandra observations show that the pulsar jet actually lies along the northwest-southeast direction, roughly aligned with the pulsar proper motion, leaving unanswered the nature of the extended *ROSAT* structure.

We investigate the properties of this cocoon-like filament using archival XMM-*Newton* data. We find that the spectrum is best-fit by a two-component model: an absorbed non-equilibrium plasma model with a power-law component to accommodate the hard emission. We model the synchrotron radiation responsible for the radio and X-ray emission and fit an inverse compton model to the gamma ray emission. We also investigate the thermal emission, which shows evidence for ejecta that may be have been mixed into the PWN during disruption from the reverse shock of the SNR.

156.21

Optical Imaging and Spectroscopy of the Galactic Supernova Remnant 3C58

Robert A. Fesen[1], G. Rudie[1], A. Hurford[1], A. Soto[1]
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Results from a comprehensive imaging and spectroscopic survey of the optical emission knots associated with the Galactic supernova remnant

3C58 are presented. H-alpha images show hundreds of filaments and knots covering a nearly circular area roughly 400'' in diameter. Measured radial velocities of over 450 knots reveal two distinct kinematic populations; one with a peak expansion velocity of around 1100 km/s and the other expanding at less than 250 km/s. No intermediate velocity material is seen near the center of the remnant. The faster expanding population appears to form a thick shell of knots with an average velocity of 770 km/s and showing strong [N II] 6548,6583 relative to H-alpha suggesting N/H abundances several times that of solar. The slower population of knots shows generally lower

[N II]/H line ratios and likely represents circumstellar mass loss material from the 3C58 progenitor. Proper motion estimates using image data spanning a 28 yr time interval suggest positional shifts of between 0.5'' 2.0'' implying proper motions much less than the 0.2'' per yr expected if 3C58 was associated with SN 1181 as has been suggested.

157: Professional Development for Scientists and Educators
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

157.01

The ASP: Programs to Inspire Educators

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[1]*Astronomical Society of the Pacific.*

The Astronomical Society of the Pacific (ASP) provides educators with new approaches to hands-on astronomy and space science. Through interactive educational programs, our goal is to help more people understand, appreciate, and enjoy astronomy and science. Over the past several years, the ASP has re-dedicated itself to achieving this mission through an ever-expanding portfolio of programs. Our astronomy and education programs target educators of all descriptions classroom teachers, informal science educators (in science museums, planetariums, nature centers, etc.), college astronomy teachers, and amateur astronomers providing them with materials and training to capture the attention of their students and audiences and to introduce them to science via an initial engagement in astronomy.

In this poster we provide an overview of current programs that include partnerships with the National Optical Astronomy Observatory, the Association of Science-Technology Centers, TERC, the Astronomical League, NASA, and the SETI Institute to address this broad range of formal and informal educators.

Additionally, the poster will provide a summary of recently conducted research by the ASP regarding the Project ASTRO program, done in cooperation with our national partners, to gauge whether the program, as perceived by the teachers participating in Project ASTRO, a) assists in correcting common misconceptions in astronomy or science and b) improve students' attitudes towards science.

Additional information regarding the ASP's educational programs can be found at: www.astrosociety.org/education.html

157.02

An Online Hands-On Program for Middle-School Science Teachers

Stephen Schneider[1], K. Davis[1]
[1]*UMass.*

Science Education Online (SEO) is a new program of science and pedagogy courses developed at the University of Massachusetts, Amherst and Lowell campuses, and now offers a Masters Degree in Science Education. The program was developed with NSF support over the last three years and has the goal of reaching in-service teachers, particularly in urban and rural communities. The science content courses have been developed by science and education faculty at UMass, working in collaboration to address Massachusetts and national science frameworks at the middle-school level. The SEO courses take a hands-on approach, with kits of inexpensive materials, cooperative learning strategies, and sharing of digital pictures. We give detailed examples of implementing the online hands-on approach from an astronomy course we developed using many Project STAR materials. One of the more interesting results of the online format is that teachers report that they have found themselves mastering skills that they had avoided in lab group work in college courses. By its nature, the online format also requires the teachers to express their understanding in writing, and we have found that small online groups are effective in helping the teachers to clarify their understanding. The SEO program was developed under National Science Foundation Grant # ESI-0243536.

157.03

Strategies for Professional Development for Educators

Matthew Bobrowsky[1], D. A. Smith[1], B. Eisenhamer[1], NASA Origins E/PO Leads
[1]*STScI.*

Do you want teachers and students to connect your science content to other science topics and to the real world? The Origins Education Forum and its member missions have developed a variety of professional development experiences for middleand high-school level educators that integrate content from multiple space science missions and research programs searching for the origins of galaxies, stars, planets, and life. These thematic experiences provide opportunities for educators to experience science content within a larger context, strengthening understanding of the relationships between science topics, and helping students and teachers to make connections to the real world and to education standards. By making use of the expertise of both scientists and educators, we are able to provide continuity in the learning process and afford the opportunity for audiences to experience successively deeper levels of professional development. Here we provide an overview of the strategies that Forum members have developed for presenting integrated experiences for educators, as well as an in-depth example of a professional development experience that enables educators to share current science discoveries with students. By working as a team, we bring content to a wider range of audiences, and we convey a more coherent message. This educational model is transferable to a variety of programs, which can similarly achieve the synergistic advantage that results from scientists and educators coordinating their efforts toward a common goal.

157.04

Teaching Astronomy Graduate Students About Teaching at the 101 Level

Erika Grundstrom[1], D. R. Gies[1], J. W. Wilson[1]
[1]*Georgia State Univ..*

At Georgia State University, all graduate teaching assistants must have three credits of teaching instruction. For new astronomy graduate students, we have the recently restructured ASTR 6300 and 6310 courses to satisfy this three credit requirement. Our textbook is *Learner-Centered Astronomy Teaching: Strategies For Astro 101* by Slater and Adams and we also utilize video recordings. Herein, we describe our curriculum and format as well as report preliminary results regarding the teaching assistants' post-course impressions and laboratory instruction (as no alumnus has yet graduated).

157.05

The NASA Center for Astronomy Education (CAE): 2007 College Astronomy Teaching Excellence Workshops

Gina Brissenden[1], E. E. Prather[1], T. F. Slater[1], W. M. Greene[2], M. Thaller[3]
[1]*Univ. of Arizona,* [2]*Navigator, JPL,* [3]*Spitzer, Cal Tech.*

Since 2003 the NASA Center for Astronomy Education (CAE) has been devoted to the professional development of introductory *college* astronomy faculty with a special focus on faculty teaching at community colleges. As part of our efforts CAE conducts 2-day and 3-day Teaching Excellence Workshops. In **Tier I (introductory) Workshops**, the overarching goal is for participants to become familiar with *learner-centered* teaching and assessment materials, as well as how to implement them in their college introductory astronomy courses. To accomplish this goal, participants learn how to create productive learning environments by reviewing research on the nature of teaching and learning; setting course goals and objectives; and using interactive lectures, peer instruction, engaging demonstrations, collaborative groups, tutorials, and ranking tasks. Participants also learn how to create more effective multiple-choice tests. In **Tier II (advanced) Workshops**, the overarching goal is to help *past workshop participants* with their obstacles to implementing a learner-centered introductory college astronomy course. Workshop participants work to understand how students learn while engaged in learner-centered activities and what the role of the instructor is in the learner-centered class. CAE regional workshops are held at community colleges around the country, NASA Research Centers, and in conjunction with professional society meetings, such as the American Astronomical Society and the American Association of Physics Teachers, and also through the infrastructure of the National Science Foundation's Summer Chautauqua Workshop program. The NASA Center for Astronomy Education (CAE) is a partnership with the Univ. of Arizona Conceptual Astronomy & Physics Education Research (CAPER) Team. CAE is supported by NASA JPL's

Navigator Public Engagement program (consisting of several space telescopes--including SIM PlanetQuest, the Terrestrial Planet Finder, the Keck Interferometer, and the Large Binocular Telescope Interferometer--whose ultimate mission is to search for extrasolar planets) and the Spitzer Space Telescope Education and Public Outreach Program.

157.06

Impact of the CAE Astronomy Teaching Excellence Workshop Program

Erin F. Dokter[1], E. E. Prather[1], G. Brissenden[1], T. F. Slater[1], W. M. Greene[2], M. Thaller[3]
[1]Univ. of Arizona, [2]JPL Navigator, [3]Caltech, Spitzer.

Since 2003, the faculty from the University of Arizona's Conceptual Astronomy and Physics Education Research (CAPER) Team have conducted teaching excellence workshops for the NASA Center for Astronomy Education. These workshops are designed to help 2and 4-year college and university faculty incorporate learner-centered teaching strategies into their ASTRO 101 courses. These workshops are supported by learner-centered curriculum approaches and instructional strategies reflecting best practices in teaching. In an effort to iteratively improve the workshops, this study evaluated the impact of the workshop on attendees' teaching beliefs and practices using survey data, which was collected before and after the workshops, between December 2004 and August 2006. Content analysis of the surveys has revealed that college and university faculty have only a limited notion of learner-centered teaching strategies before the workshops and a greatly increased awareness after the workshops. In addition, the surveys have indicated the extent to which faculty have implemented the teaching strategies presented in the workshop, perceived barriers to implementing more learner-centered practices, the goals they have in attending the workshop, and that they find the workshop to be very valuable and enjoyable.

The CAE Workshop Series is funded by the NASA JPL Navigator Public Engagement Program, the Spitzer Education and Public Outreach Program, and the NSF Chautauqua Program.

157.07

Deciphering Stars: A Professional Development Workshop for Teachers

Mary Kay Hemenway[1], S. Redfield[1]
[1]U. Texas-Austin.

A workshop for secondary school science teachers was conducted at McDonald Observatory in July 2006. Participants performed activities involving spectroscopy, sizes and colors of stars, solar activity, and binary star systems. They did classroom experiments to detect radiation in the ultraviolet, optical, and infrared regions of the electromagnetic spectrum. These topics were chosen to help them form a conceptual understanding of RS CVns (binary stars whose coronal activity is studied spectroscopically in the UV region by FUSE). Fifteen teachers from California, Kentucky, Louisiana, Oklahoma, South Carolina, Texas, and Virginia performed these standards-aligned activities at the workshop in preparation for using them within their own classrooms. During three scheduled nights of observing, the participants became familiar with the night sky and the operation of small telescopes. The workshop included tours of other observatory facilities and time to reflect on their own teaching practices. Evaluation on the workshop and the use of the instructional materials is continuing.

Support from The National Aeronautics and Space Administration under an Education and Public Outreach supplement to the Far Ultraviolet Spectroscopic Explorer Guest Investigator grant NNG06GA28G issued through the Office of Space Science is gratefully acknowledged.

158: Properties of Hot Stars
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

158.01

Xatlas: An Online Archive of Chandra Hot Star Gratings Observations

Owen Westbrook[1], N. R. Evans[1], S. J. Wolk[1], J. Nichols[1], V. L. Kashyap[1], P. J. Mendygral[2], W. L. Waldron[3]
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Nearly 30 years after the discovery of X-ray emission from OB stars, the exact mechanisms responsible remain a mystery. However, major advances in our understanding of such emission have been made since the launch of the Chandra X-ray Observatory in 1999 and the subsequent availability of high-resolution transmission grating spectra of numerous hot stars. To facilitate the rapid comparison and characterization of hot star spectra, we are compiling a database of all O, B and Wolf-Rayet stars observed with Chandra's High Energy Transmission Grating (HETG). This database, known as Xatlas, will be accessible through a web interface with searching and interactive plotting capabilities. In addition to high-resolution HETG data, Xatlas will also feature simulations of the low-resolution ACIS-S and ACIS-I spectra convolved from the high-resolution spectra for each target, potentially enabling further scientific analysis of the low-resolution spectra of the hot stars in existing Chandra images. Currently slated for release in the first quarter of 2007, Xatlas will initially offer 55 observations of over 25 hot stars and provide a practical and user-friendly resource for the astronomical community.

Funding for this work was provided by Chandra Grants GO5-6006 and GO5-6006A and Chandra X-ray Center NASA Contract NAS8-39073.

158.02

Searching for Hidden Wolf-Rayet Stars in the Galaxy 15 New Wolf-Rayet Stars

Lucy J. Hadfield[1], S. D. van Dyk[2], P. W. Morris[3], J. D. Smith[4], A. P. Marston[5]
[1]The Univerity Of Sheffield, United Kingdom, [2]Spitzer Science Center, IPAC, CALTECH, [3]NASA Herschel Science Center, IPAC, CALTECH, [4]Steward Observatory, [5]ESA/ESAC, Spain.

TUESDAY

Hot, massive stars play a vital role in the working of the ′cosmic cauldron', living life in the fast lane and ending their evolution via some of the most powerful events in the universe. Wolf-Rayet (WR) stars are the evolved descendants of the most massive stars. Believed to represent the bare He-core of their massive star precursor, their spectra are dominated by impressive emission features. This and the short duration of this evolutionary phase make WR stars excellent tracers of recent star formation in the nearby Universe as well as vital tests for stellar evolutionary models. Our Galaxy provides an excellent laboratory for studying massive stars as we can resolve objects on small scales and so hope to achieve sample completeness. To date ~300 WR stars have been observed in our Galaxy but with studies predicting that the Milk Way should host 1000-2500 WR stars, it would appear that a large number of stars are still waiting to be discovered. Here we report the discovery of 15 (11 WN and 4 WC) WR stars found as part of near-mid infrared broad-band study of the Galactic WR population.

158.03

Chandra Spectroscopy of the Hot Star Beta Cru and the Discovery of a Pre-Main Sequence Companion

Michael A. Kuhn[1], D. H. Cohen[1], E. L. Jensen[1], M. Gagne[2]
[1]Swarthmore College, [2]West Chester University.

Using a 75 ks Chandra grating observation, we have studied x-ray emission from the B0.5 III star beta Cru one of the four bright stars in the Southern Cross and a newly discovered companion. The companion is separated from beta Cru by 4″ and it has about 3 times fewer x-ray counts. The flux contrast must be much greater in the optical, though, or the companion would have been discovered earlier. The system is a member of the Sco-Cen association, and is estimated to be 8 to 11 million years old; old enough for the B star primary to have evolved off the main sequence, but young enough that a coeval, late-type companion would still be descending to the main sequence. We marginally resolved individual line profiles of the primary in the grating spectra. The lines show slight broadening, suggesting an origin in a slow stellar wind rather than a corona. The secondary has a harder spectral energy distribution (temperatures $>$ 20 million K) than the primary ($<$ 4 million K), making it a probable pre-main-sequence star. The secondary is also more variable than the primary, consistent with the x-ray flaring seen in pre-main-sequence stars.

We acknowledge grants GO2-3030A and AR5-6003X to Swarthmore College from the Chandra X-ray Center at the Smithsonian Astrophysical Observatory, and also support from Swarthmore College via a Eugene M. Lang Summer Research Fellowship.

159: Pulsars
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

159.01

The Torque-luminosity Relation and Possible Glitches in Three X-ray Binary Systems

Michael J. Stark[1], D. Meral[1], A. Baykal[2], J. H. Swank[3]
[1]Lafayette College, [2]Middle East Technical University, Turkey, [3]NASA's Goddard Space Flight Center.

We have made a detailed study of the pulse-frequency changes during the long outbursts of three transient X-ray binaries observed by RXTE. These sources, GRO J1744-28, KS 1947+300 and SAX J2103.5+4545, all demonstrate a well-determined relationship between their X-ray luminosity and the derivative of the pulse frequency. They also each undergo episodes during which the pulse-frequency derivative is significantly higher than would be predicted from the observed X-ray luminosity. Some of these episodes may be the result of not correctly determining the X-ray luminosity but others may be due to torque not associated with mass accretion, with which the X-ray luminosity is correlated.

159.02

New Pulsars in the Globular Cluster M28

Ingrid H. Stairs[1], S. Begin[1], S. Ransom[2], P. Freire[3], J. Hessels[4], J. Katz[5], V. Kaspi[6], F. Camilo[7]
[1]Univ. of BC, Canada, [2]NRAO, [3]NAIC, [4]University of Amsterdam, The Netherlands, [5]University of Virginia, [6]McGill University, Canada, [7]Columbia University.

We have discovered ten new pulsars in recent observations of the globular cluster M28 (NGC6626) with the Green Bank Telescope. M28 is now the globular cluster with the third largest population of known pulsars, after Terzan 5 and 47 Tucanae. We have obtained phase-coherent timing solutions for most of the new MSPs. Seven new MSPs are in binary systems, of which one shows eclipses, two have very low-mass companions and two have highly eccentric orbits. We have measured the rate of advance of periastron for one of the two highly eccentric binaries (M28C), which yields a total system mass of 1.616+/-0.007 MSun. We use the ensemble of pulsars to investigate the gravitational potential and mass-to-light ratio of M28. One of the new pulsars, M28F, is an isolated MSP far from the center of M28; this may have implications for dynamics in the core of the cluster.

159.03

Discovery and Timing of Eight New Millisecond Pulsars in NGC 6440 and NGC 6441

Paulo Freire[1], S. M. Ransom[2], S. Begin[3], I. H. Stairs[3], J. W. Hessels[4]
[1]Arecibo Observatory, [2]NRAO, [3]University of British Columbia, Canada, [4]McGill University, Canada.

Motivated by the recent discovery of 30 new millisecond pulsars in Terzan 5, made using the Green Bank Telescope's S-band receiver and the Pulsar Spigot, we have set out to use the same system in a systematic search for pulsars in other rich globular clusters. We here report on some of the first results from this survey, the discovery of five new millisecond pulsars in the globular cluster NGC 6440 and three new ones in NGC 6441; each cluster has one previously known pulsar. The pulsar population in these clusters is remarkably diverse, with spin periods between 3.8 and 288 ms; five of these ten pulsars are found in binary systems. We present timing solutions for seven of the eight newly discovered pulsars. One of these, PSR J1748-2021B in NGC 6440, is notable for its eccentric orbit, which has allowed the measurement of the rate of advance of periastron and of the total mass of this system. Another of the new pulsars, NGC 6440D, is an eclipsing binary with a 0.12 solar mass companion, which probably is a main sequence star.

159.04

A New Technique for the Characterization of Radio Pulsar Polarization Profiles

Samuel Rodarte, Jr.[1], W. van Straten[1]
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Since their discovery, radio pulsars have provided a valuable tool in various areas of astrophysics. Radio pulsars are spinning neutron stars emitting electromagnetic radiation from their magnetic poles. Like a distant lighthouse, they are observed by their periodic bursts of radiation; however much is to be learned about their emission mechanism. We present a new method of characterizing radio pulsar polarization profiles using an objective statistic based on all four Stokes parameters. Various properties of this statistic are analyzed and possible applications are discussed.

159.05

Discovery of an Energetic Young Pulsar Candidate Coincident with a TeV Gamma-ray Source.

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[1]Columbia Astrophysics Lab., [2]University of California, Davis, [3]Space Telescope Science Institute.

The HESS TeV gamma-ray source J1813-178 is coincident with a low-surface brightness, small diameter (3.5') radio shell. A hard X-ray source discovered by ASCA also lies within the gamma-ray error circle. We have obtained Chandra observations of this source, and find a hard X-ray point-source centrally located in the radio shell and surrounded by a structured, diffuse source filling the shell which strongly resembles a pulsar wind nebular (PWN). The point-source spectrum is a power law with index 1.1, similar to that of the Vela pulsar; the PWN's spectral slope is sightly steeper 1.3 power law, typical of other young PWNe. For a distance of 8 kpc, consistent with the X-ray absorption, the 0.1-10 keV X-ray luminosity of the source is 2 x 10^{35} erg/s, implying a spin-down power $>10^{37}$ erg/s, marking this as one of the most energetic young pulsars in the Galaxy. The TeV emission can be explained as inverse Compton scattering of CMB and ambient star-light photons off the relativistic electrons in the nebula. The results of a search for radio pulsations will be reported.

This work is supported by a grant from the Chandra Guest Investigator program.

159.06

Timing Pulsars in Globular Cluster NGC6441

Lucille H. Frey[1], S. Ransom[2]
[1]Case Western Reserve University, [2]National Radio Astronomy Observatory.

We present timing solutions for two binary and two isolated millisecond pulsars in globular cluster NGC6441. Pulsar NGC6441A was discovered during a 1.4 GHz search with the Parkes radio telescope and NGC6441B-D were discovered during a 2 GHz search with the Green Bank Telescope. The spin down rate of NGC6441C was used to constrain the mass to light ratio of the cluster and show that the core mass-to-light ratio is typical for a globular cluster. Pulsar NGC6441A is a highly eccentric binary, allowing us to constrain the pulsar masses using relativistic effects. These constraints suggest a system of a 1.6 Msun pulsar and a 0.8 Msun companion with the possibility of a double neutron star within the errors. This project was supported by NRAO and the NSF REU progr

159.07

Population Synthesis of Radio and Gamma-ray Millisecond Pulsars from the Galactic Plane

Sarah A. Story[1], P. L. Gonthier[1], B. D. Clow[1], A. K. Harding[2]
[1]Hope College, [2]NASA Goddard Space Flight Center.

We present results of a population synthesis of millisecond pulsars in the Galactic plane. Excluding globular clusters, we model the spatial distribution of millisecond pulsars by assuming they are born in the Galactic disk with a random kick velocity and evolve them to the present within the Galactic potential. We assume that ordinary and millisecond pulsars are standard candles described with a common radio emission model invoking a new relationship between radio core and cone emission suggested by recent studies. In modeling the radio emission beams, we explore the relativistic effects of time delay, aberration and sweepback of the open field lines. While these effects are essential in understanding pulse profiles, the phase-averaged flux is adequately described without a relativistic model. We use a polar cap acceleration model for the gamma-ray emission. We present the preliminary results of our recent study and the implications for observing millisecond pulsars with GLAST and AGILE.

We express our gratitude for the generous support of the National Science Foundation (REU and AST-0307365), the Michigan Space Grant Consortium and the NASA Astrophysics Theory Program.

159.08

First Results from a Galactic Center Search for Pulsars and Transients:A Rotating Radio Transient Candidate

Julia S. Deneva[1], J. M. Cordes[1], T. J. Lazio[2], R. Bhat[3], S. Chatterjee[4], S. M. Ransom[5], G. Bower[6], W. Vlemmings[7], P. Demorest[6], D. C. Backer[6]
[1]Cornell University, [2]NRL, [3]Swinburne University, Australia, [4]University of Sydney, Australia, [5]NRAO, [6]University of California, Berkeley, [7]Jodrell Bank Observatory, United Kingdom.

We present initial results from an ongoing search for pulsars and transients at 5 and 9 GHz with the Green Bank telescope. Survey targets include Sgr A* and its immediate vicinity, and a few specific sources in the region from the 2LC VLA survey by Cordes & Lazio (in preparation). Our search for dispersed single pulses discovered a Rotating Radio Transient (RRAT) candidate with a dispersion measure of ~750 pc/cm^3 less than 4 arcminutes from Sgr A*. While the candidade's dispersion measure is too low to be associated with Sgr A*, investigating the presence and type of intermittent objects in the inner Galaxy has implications about modelling the neutron star population in the region and estimating the yield of future surveys.

159.09

Updated Timing Parameters of two Massive Binary Pulsars: J0621+1002 and J0751+1807

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Previous observations suggest that the pulsars in the J0621+1002 and J0751+1807 binary systems have large masses; in fact, the pulsar in J0751+1807 has been found to have a mass of 2.1 \pm 0.2 M\odot, making it the largest pulsar mass ever measured. J0621+1002 is an "intermediate-mass" binary system containing a 28.8 ms pulsar in a 8.3-day orbit about a white dwarf companion; J0751+1807 contains a 3.5 ms pulsar in a circular 6-hour orbit about a white dwarf. We have obtained new data from these two binary systems through a recent timing campaign with the Arecibo radio telescope. The new data will help to constrain the spin, astrometric and binary parameters of both systems and to clarify mass measurements. We present preliminary results from our updated timing analysis.

159.10

Circumpulsar Asteroids: Inferences from Nulling Statistics and High Energy Correlations

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We have proposed that some classes of radio pulsar variability are associated with the entry of neutral asteroidal material into the pulsar magnetosphere. The region surrounding neutron stars is polluted with supernova fall-back material, which collapses and condenses into an asteroid-bearing disk that is stable for millions of years. Over time, collisional and radiative processes cause the asteroids to migrate inward until they are heated to the point of ionization. For older and cooler pulsars, asteroids ionize within the large magnetospheres and inject a sufficient amount of charged particles to alter the electrodynamics of the gap regions and modulate emission processes. This extrinsic model unifies many observed phenomena of variability that occur on time scales that are disparate with the much shorter time scales associated with pulsars and their magnetospheres. One such type of variability is nulling, in which certain pulsars exhibit episodes of quiescence that for some objects may be as short as a few pulse periods, but, for others, is longer than days. Here, in the context of this model, we examine the nulling phenomenon. We analyze the relationship between in-falling material and the statistics of nulling. In addition, as motivation for further high energy observations, we consider the relationship between the nulling and other magnetospheric processes.

159.11

Application of Typological Sequencing for the Classification of Radio Pulsar Profiles

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We utilize a technique borrowed from archeology, known as typological sequencing, to look for a relationship between the shape of radio pulsar profiles and pulsar physical observables (period, frequency, distance, age, and pulse width.) If a typological sequence shows a relationship with one or more of the physical observables, then valuable insights into the nature of pulsars could be obtained. Pulse profiles were selected from the European Pulsar Network Database. Low noise profiles at a frequency of 0.400-0.499 GHz were selected. 93 profiles were used in this study. A possible relationship between the sequence and the period was identified. These preliminary results show that further research is needed.

159.12

Population Statistics of Normal Isolated, Radio and Gamma-ray Pulsars from the Galactic Plane

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We present results of a pulsar population synthesis of normal ordinary pulsars in the Galactic plane. Over the past several years, we have developed a program to simulate pulsar birth, evolution, and emission using Monte Carlo techniques. We model the spatial distribution of pulsars by assuming they are born with a random kick velocity and then evolve them within the Galactic potential. We assume that pulsars are standard candles using a new relationship between core and cone emission suggested by recent studies, which we also apply to millisecond pulsars. From our studies

TUESDAY

of radio pulsars that have clearly identifiable core and cone components, in which we fit the polarization sweep as well as the pulse profiles to constrain the viewing geometry, we develop a model describing the ratio of radio core-to-cone peak fluxes. In this model, we find that short period pulsars are more cone-dominated than in our previous studies. We use both a low and high altitude slot gap model for describing the gamma-ray emission. We also include gamma-ray emission from an outer-gap model to compare the statistics of radio-loud and radio-quiet gamma-ray pulsars on the same footing as pulsars from our slot gap, polar cap model. We present the preliminary results of our recent study and the implications for observing these pulsars with GLAST and AGILE.

We express our gratitude for the generous support of the National Science Foundation (REU and AST-0307365), the Michigan Space Grant Consortium and the NASA Astrophysics Theory Program.

159.13

Numerical Simulations of Bulk and Thermal Comptonization in X-Ray Pulsar Accretion Columns

Kenneth D. Wolfram[1], P. A. Becker[2], M. T. Wolff[1]
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Recent work by Becker and Wolff on spectral formation in X-ray pulsar accretion columns has established a novel physical theory from first principles that reproduces the observed X-ray spectra for several well-known sources. In the analytical approach of Becker and Wolff, an approximate velocity profile was employed in order to separate the transport equation. This resulted in a closed-form solution for the emergent photon spectrum describing the reprocessing of seed photons created via bremsstrahlung, cyclotron, and blackbody emission. The good agreement between the analytical solution and the observational data is encouraging, but it is not clear how the utilization of the approximate velocity profile affects the accuracy of the solution. In this paper we employ a numerical approach to solve the transport equation based on the exact velocity profile describing the inflow of the gas in the accretion column. When the exact velocity profile is employed, the transport equation is no longer separable, and therefore we employ a relaxation method to solve for the spectrum of the escaping radiation as a function of energy and altitude in the column. The results are compared with the observational data and also with the spectra computed using the analytical model of Becker and Wolff. We conclude by discussing future enhancements of the simulation code such as including (i) a self-consistent calculation of the electron temperature based on inverse-Compton equilibrium, (ii) the vertical variation of the magnetic field strength and the column cross section, and (iii) the energy and angle dependence of the electron scattering cross section.

159.14

The Radio Properties and Magnetic Field Configuration in Pulsar Wind Nebula G54.1+0.3

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We present multifrqeuency radio observations made with the Very Large Array of the pulsar wind nebula known as SNR G54.1+0.3. Radio spectral index and morphological results provide insight into the energetics of this Crab-like PWN. However, unlike the Crab, the radio and X-ray extents are very similar. We present a discussion of the comparisons between the high-resolution Chandra X-ray image and the radio images. We also present high-resolution (~5″) radio polarimetric results which illustrate the intrinsic magnetic field structure of the PWN. Few such studies have been done for PWNe. The magnetic field in G54.1+0.3 appears to be highly ordered and well organized.

160: SAGE
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

160.01

Dust Processing Near Sites of High-Mass Star Formation in the Large Magellanic Cloud

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We present a study into the properties of the dust and complex molecules in and around selected Hii regions in the Large Magellanic Cloud. The analysis is based on the Spitzer program SAGE (Surveying the Agents of a Galaxy's Evolution). Because of the lower metallicity environment, dust shielding is reduced and the effects of the ultraviolet radiation carry further than in the Milky way. Because of this these Hii regions may well be better representatives of star forming regions in the more distant universe.

We present the mid-IR spectral energy distributions (SEDs) as a function of radial distance to the center of the clusters: LHA 120-N4, N11, N63 and N105. These regions span a wide range in luminosities. The observed variations in SED are interpreted in terms of the varying incident radiation-field and changing abundances of polycyclic aromatic hydrocarbons (PAHs), transiently heated very small grains (VSG) to submicron-sized grains in thermal equilibrium, i.e. in terms of the varying grain-size distribution.

This analysis allows us to quantify the dust destruction and/or processing-rate due to photoevaporation and the typical distance scale on which Hii regions impact their surroundings.

160.02

SST/SAGE and *HST* Study of Stellar Populations and Star Formation around NGC 1850 in the LMC

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Combining the high angular resolution ($< 0.1''$) and deep HST optical images of limited area fields with the SAGE survey observations of the LMC obtained in the NIR/MIR with Spitzer at lower angular resolution ($> 1''$) but with deep exposures, allows one to reach an excellent understanding of the processes governing the formation of moderate to low mass stars (0.8-2 M_{Sun}), which represent the bulk of the stellar mass in galaxies. We have followed this approach to study the properties of the young populations present in the region around the double cluster NGC 1850 and their relationsip with both the diffuse medium and the older stellar populations.

160.03

Mass Loss from Evolved Stars in LMC Clusters

Sean Points[1], K. Olsen[1], R. Blum[2], B. Whitney[3], M. Meade[4], B. Babler[4], R. Indebetouw[5], J. Hora[6], K. Gordon[7], C. Engelbracht[7], B. For[8], M. Block[7], K. Misselt[7], M. Meixner[9], U. Vijh[9], C. Leitherer[9], S. Srinivasan[9]
[1]CTIO/NOAO, Chile, [2]NOAO, [3]Space Science Institute, [4]Univ Wisconsin, [5]Univ Virginia, [6]Harvard-Smithsonian/CfA, [7]Univ Arizona, [8]Univ Texas, [9]STScI.

We present preliminary results of our investigation into the mass-loss from evolved stars in rich, well-studied clusters in the Large Magellanic Cloud (LMC) using data obtained with the Spitzer Space Telescope SAGE (Surveying the Agents of a Galaxy's Evolution) survey. We have obtained the 8 and 24 micron magnitudes of point sources toward ~30 clusters in the LMC with a range of ages from 10^6 to 10^10 years, a spread in metallicity ([Fe/H]) from -2.0 to 0.0, and masses from 10^3 to 10^5 solar masses. Using the 8 and 24 micron fluxes as proxies for stellar mass loss, we calculate the normalized mass loss rates for the clusters in our sample. We use these data to explore the relationships between mass-loss, age, and metallicity, with the aim of developing a cluster mass-loss history for the LMC. Our further goal is to use these results in conjunction with knowledge of the star formation history of the LMC to investigate the LMC's chemical enrichment history.

160.04

Crystalline Silicates around Asymptotic Giant Branch Stars in the Large Magellanic Cloud

Francisca Markwick-Kemper[1], C. Dijkstra[2]
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We present 5-40 micron spectroscopy obtained with the Infrared Spectrograph on board Spitzer of a sample of oxygen-rich Asymptotic Giant Branch stars. The spectra of these dust-enshrouded objects all show the characteristic resonances at 9.7 and 18 micron due to 'amorphous' silicates. In addition, several of the spectra show the finer substructure that is ascribed to crystalline silicates, in particular crystalline forsterite. We will explore the range in physical conditions at which these crystalline silicates are found, and compare those to the crystalline fraction seen in Galactic post-main sequence stars in the same evolutionary stage.

160.05

The Mass Loss Return From Evolved Stars to the LMC: Empirical Relations For Excess Emission at 8 and 24 µm

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We will present empirical relations for excess emission from evolved stars in the Large Magellanic Cloud (LMC) using data from the Spitzer Space Telescope SAGE (Surveying the Agents of a Galaxy's Evolution) survey. Combined with the 2MASS survey and the optical Magellanic Cloud Photometric Survey (MCPS) catalog, these data enable multiband analysis of evolved stars, and can help probe the life cycle of dust in the LMC. Outflows from evolved asymptotic giant branch (AGB) stars and supergiants are the main producers of dust in a galaxy, and the aim of this work is to investigate the mass loss return by AGBs and supergiants to the interstellar medium of the LMC. The spectral energy distributions (SEDs) are compared with plane-parallel (for Carbon-rich AGBs) and spherical (for Oxygen-rich AGBs) atmosphere models to obtain the excess flux in the 8 and 24 micron bands, which is plotted against the total integrated flux. We will show that this excess emission increases with total integrated flux, and the 24 micron flux for heavily obscured AGBs is entirely due to excess emission from dust. The SAGE Project is supported by NASA/Spitzer grant 1275598 and NASA NAG5-12595.

160.06

Variable Sources in Large Magellanic Cloud using the SAGE Survey

Uma P. Vijh[1], M. Meixner[1], S. Srinivasan[2], B. Babler[3], M. Block[4], C. Engelbracht[4], B. -. For[4], K. Gordon[4], J. Hora[5], R. Indebetouw[6], C. Leitherer[1], M. Meade[3], K. Misselt[4], B. Whitney[7]
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We will present results on the population of variable sources in the Large Magellanic Cloud (LMC) detected in the Spitzer Space Telescope (SST) SAGE (Surveying the Agents of a Galaxy's Evolution) survey. The SAGE data consists of 2 epoch photometry, 3 months apart using the IRAC (3.6, 4.5, 5.8 and 8.0 µm) and MIPS (24, 70 and 160 µm) instruments on board the SST. We define a variability index based on the difference of the epoch 1 and 2 fluxes weighted by their combined errors. Stars on the upper asymptotic giant branch (AGB) are known to be pulsating with large amplitudes and long periods based on optical studies. Some classes of YSOs are also expected to be variable. We classify the SAGE variable sources based on their colors and magnitudes. We investigate if variability is correlated with other properties such as the bolometric luminosity and in the case of AGB stars, infrared excess emission/mass-loss rate. Different classes of AGB stars are known to have different luminosity-period relations. We explore if the variability index in the SAGE data can also trace these classifications.

The SAGE Project is supported by NASA/Spitzer grant 1275598 and NASA NAG5-12595.

160.07

Modelling Evolved Stars Detected by the Spitzer LMC Survey (SAGE)

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The Spitzer photometric survey of the Large Magellanic Cloud (SAGE) has the sensitivity to detect all evolved stars of luminosity 1000 L $\odot$ or higher. In order to estimate the global mass return to the interstellar medium for these stars we will need to (a) classify the type of object based upon the available photometry from Spitzer, and 2MASS where available; and (b) estimate the dust shell properties directly from these observations. This will require calculating a grid of dust radiative transfer models to cover the range of parameters suitable for stars in the LMC and having an automatic algorithm for selecting the best fit model for each observed object.

Given the lower metallicity of the LMC compared to the Galaxy we need to study some of the brighter objects in detail including fitting of spectroscopy observations to understand the basic dust properties for both oxygen-rich objects with silicate dust and carbon-rich objects with amorphous carbon and silicon-carbide dust. The dust to gas mass ratio must also be estimated, as it is expected to be somewhat higher than the values derived for galactic objects.

We will show some preliminary results of the modelling work for a small number of the brighter AGB stars or M-type supergiants in the LMC, as well as discussing the identification of groups of objects in the multi-color space defined by the Spitzer IRAC, Spitzer MIPS, and 2MASS observations.

The SAGE Project is supported by NASA/Spitzer grant 1275598 and NASA NAG5-12595.

160.08

Spitzer/SAGE Observations of Planetary Nebulae in the Large Magellanic Cloud

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We present initial results of a program to determine the properties of Planetary Nebulae (PNe) in the Spitzer SAGE survey of the Large Magellanic Cloud (LMC). We have constructed IRAC mosaics of a sample of previously identified PNe in the LMC. Of the 233 PNe in the SAGE survey area, we found 213 that had IRAC sources within 1.5 arcsec of the catalog positions, and 118 had detections in all four IRAC bands. The IRAC colors of the PNe span a similar range as a sample of Galactic PNe. IRS spectra of the LMC PNe reveal several classes of spectral types, including ones dominated by warm dust continuum, PAH features, or emission lines from the ionized gas, including [Ne VI] at 7.65 microns. Several of the PNe are resolved with IRAC, and we compare the images to previous HST imaging at optical wavelengths. We present color-color plots and IRAC images of the detected PNe.

160.09

Star Formation Tracers and Dust Emission in the Large Magellanic Cloud

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We present an analysis of ultraviolet, H-alpha, and infrared images of the Large Magellanic Cloud to study the LMC's star formation and dust emission. The infrared images are the new Spitzer SAGE Legacy IRAC and MIPS images with wavelengths from 3.6 to 160 micron. The ultraviolet image at 0.15 micron is from a rocket flight (Smith et al. 1987) and the H-alpha image is from SHASSA (Gaustad et al. 2001). The ultraviolet, H-alpha, and MIPS 160 micron images have a similiar resolutions of around 40″ allowing for the study of this galaxy at approx. 10 pc resolution. These images allow us to probe the detailed behavior of the dust emission (heating sources and aromatic features) and star formation tracers for both young stars (H-alpha+24 micron, $<$ 10 Myrs) and somewhat older stars (UV+IR, $<$ 100 Myrs). The results of this work have implications for understanding star formation and dust emission in the LMC as well as understanding the same in more distant galaxies.

160.10

Spitzer SAGE Observations of Young Stellar Objects in the Large Magellanic Cloud

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We have identified thousands of new Young Stellar Objects (YSOs) in the Large Magellanic Cloud. The observations were made with the Spitzer Space Telescope as part of the SAGE Legacy project. The YSOs were selected from the SAGE point source catalog by locating regions of color-magnitude space unoccupied by known sources such as galaxies and evolved stars. Our YSO list is not complete, since those with similar colors and magnitudes to other populations are not included. However, our initial goal is to produce a list that is dominated by YSOs. The spatial distribution of the YSOs correlates with CO, H I, and especially 3 cm observations. We will show analysis of the YSOs based on radiation transfer models.

This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

160.11

Star Formation Activity in Giant Molecular Clouds in the LMC

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The formation of stellar clusters is one of the biggest issues in Astronomy. In our Galaxy, the currently formed clusters are only open clusters; no ″young″ globular clusters have been observed. On the other hand, in the LMC, stellar clusters called ″populous clusters″ are found to be forming at present. Comparative studies of young stars as well as the properties of giant molecular clouds both in our Galaxy and LMC are therefore of vital importance. Spizter/SAGE dataset provides most comprehensive and complete knowledge on how and where the YSOs are distributed in the LMCs for the first time. We present here the statistical comparison of the distribution of YSOs with that of CO molecular clouds detected by NANTEN CO survey throughout the entire galaxy. The distribution of SAGE sources with a cold spectrum shows good correlation with that of molecular clouds, indicating that these sources are good candidates for YSOs. Star formation activities in the molecular clouds were estimated, and we found that the star formation activity shows stronger correlation with the cloud mass than in the Galaxy. This may explain active star formation in the most massive clouds and the existence of giant molecular clouds without high-mass star formation, which are rare in the Galaxy.

160.12

Spitzer Spectroscopy of Stellar Feedback on Circumstellar Gas and Dust in 30 Doradus, the Nearest Super-Star Cluster

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The feedback between massive stars and the interstellar medium dominates the evolution of their host galaxies. Therefore, to understand galaxy evolution, we must understand how massive star clusters process local gas and dust (radiatively and mechanically), and how strong stellar winds interact with the HII region. Super-star clusters are the sites of the most energetic star formation in the universe, particularly as one looks further back in time. The nearest super-star cluster, 30 Doradus in the Large Magellanic Cloud, presents an ideal opportunity to observe these interactions in detail.

Using the *Spitzer* infrared space telescope, we have obtained a complete spectral map of 30 Doradus in both the IRS low-resolution modules 5-38 μm) and the MIPS/SED mode (55-95 μm). As a nearby super-star cluster, 30 Doradus is a laboratory for studying the spectra of infrared-emitting species: dust, PAHs, and ionized gas. The spatially and spectrally complete data cube has unprecedented detail, allowing us to analyze conditions which vary dramatically on small spatial scales. The understanding that we gain from 30 Doradus and its circumcluster gas and dust can then be applied to interpret the spectra of distant, unresolved galaxies in the context of star formation. In this poster, we showcase the datacube in the context of a multi-wavelength view of 30 Doradus, and present preliminary results.

160.13

Viewing SAGE selected LMC Star Formation with Hubble Vision

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We present a comparative study of SAGE data with archival Hubble Space Telescope (HST) observations on selected Large Magellanic Cloud (LMC) star formation regions. SAGE (Surveying the Agents of a Galaxy's Evolution) includes a complete survey of the LMC with both the Infrared Array Camera (IRAC) and MIPS, the Multiband Imaging Photometer for Spitzer, aboard the Spitzer Space Telescope. These infrared data allow us to locate and identify young stellar objects (YSOs). IRAC 3.6, 4.5, 5.8, and 8.0 micron observations, coupled with MIPS 24 micron data, facilitate the identification of embedded YSOs and the distinction between various YSO classes. Interstellar dust emission peaks in the longer infrared wavelengths and is well detected by the MIPS 70 and 160 micron bands. These unprecedented infrared data allow the detection of never before seen YSO populations in the LMC. However, confusion of these YSOs with unresolved background galaxy populations makes the complete census of YSOs a challenging task. With the factor of ten better angular resolution of HST, background galaxies become resolved and their distinction from the YSOs becomes straightforward. Our comparative study reveals that the SAGE data highlights the embedded YSO populations of Class 0 and I, while the HST data reveals the more exposed, and fainter, pre-main sequence population.

The SAGE Project is supported by NASA/Spitzer grant 1275598 and NASA NAG5-12595.

160.14

The Spitzer SAGE Survey of the Large Magellanic Cloud: Characteristics of the Epoch 1 IRAC and MIPS-24 Source Lists

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We present the characteristics of the Epoch 1 IRAC and MIPS 24 micron source lists from the Spitzer SAGE survey of the Large Magellanic Cloud (LMC) that involved two epoch of observations separated by 3 months. The IRAC source lists include photometry of the IRAC 3.6, 4.5, 5.8 and 8.0 micron bandpaases that have been band merged with the corresponding 2MASS photometry. The MIPS 24 micron list is a separate list of the 24 micron photometry values. Photometry is listed as Vega magnitudes and in milli-Jy for both lists. The criteria for inclusion in the source lists ensures a high level of reliability. We describe the basic properties of the source lists including: astrometric accuracy, precision of photometry, accuracy of the photometry and an estimate of completeness based on comparison with deeper exposures. The Epoch 1 IRAC processing performed single frame photometry using a modified version of DAOPHot on both the 0.6 and 12 second exposures taking into account cosmic ray and artifact corrections. The point source selection criteria, requiring multiple detections across wavelength bands, mitigates the effects of cosmic rays and other artifacts. The Epoch 1 IRAC catalog has ~4 million point sources. The MIPS Epoch 1 data processing is performed on mosaciked images using StarFinder with a criteria of at least 10 sigma and a confirmation of the source in the draft Epoch 2 source list. The Epoch 1 MIPS 24 micron catalog has ~60,000 sources. Future catalog releases will involve photometry on mosaicked images and will be deeper and more complete. We compare the IRAC, MIPS 24 micron and 2MASS photometry. We find that the SAGE catalog is much deeper than 2MASS and many of the fainter, redder sources have no 2MASS counterparts.

160.15

Molecular Clouds and Star Formation in the Magellanic System by NANTEN

Akiko Kawamura[1], T. Onishi[1], T. Minamidani[1], Y. Mizuno[1], N. Mizuno[1], A. Mizuno[1], Y. Fukui[1], M. Meixner[2], U. Vijh[2], C. Leitherer[2], B. Whitney[3], M. Meade[4], B. Babler[4], R. Indebetouw[5], J. Hora[6], K. Gordon[7], C. Engelbracht[7], B. For[8], M. Block[7], K. Misselt[7], S. Madden[9], J. Bernard[10], R. Paladini[11], W. Reach[11], SAGE team
[1]Nagoya University, Japan, [2]STScI, [3]Space Science Institute, [4]University of Wisconsin, [5]University of Virginia, [6]Harvard-Smithsonian/CfA, [7]University of Arizona, [8]University of Texas, [9]CEA, France, [10]CNRS, France, [11]IPAC.

The Magellanic System offers an ideal laboratory to study how the interstellar medium evolves and how stars are formed at the unrivalled closeness to us. In order to elucidate star formation in the Magellanic System, surveys of the molecular clouds were carried out by NANTEN. In this work, we compare the giant molecular clouds (GMCs) with young clusters and H II regions identified by optical or radio. We find that about 76 % of the GMCs are actively forming stars or clusters, while 24 % show no signs of massive star or cluster formation. Effects of supergiant shells (SGSs) on the formation of GMCs and stars are also studied. The number and surface mass densities of the GMCs are higher by a factor of 1.5-2 at the edge of the SGSs than elsewhere. It is also found that young stellar clusters are more actively formed in the GMCs facing to the center of the SGSs. These results are consistent with the previous studies by Yamaguchi et al. and suggest the formation of the GMCs and the cluster is triggered by dynamical effects of the SGSs. We will also present a result from a comparison of the GMCs with YSO candidates from SAGE.

161: Science from the NDWFS Bootes Field
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

161.01

Mid-Infrared Properties of X-ray Sources

Varoujan Gorjian[1], M. Brodwin[1], C. S. Kochanek[2], S. Murray[3], D. Stern[1], K. Brand[4], P. Eisenhardt[1], M. Ashby[3], P. Barmby[3], M. J. Brown[4], A. Dey[4], W. R. Forman[3], B. T. Jannuzi[4], C. Jones[3], A. Kenter[3], M. A. Pahre[3], J. C. Shields[5], M. W. Werner[1]
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We combine the results of the *Spitzer* IRAC Shallow Survey and the *Chandra* XBootes Survey of the 8.5 square degrees Bootes field of the NOAO Deep Wide-Field Survey to produce the largest comparison of mid-IR and X-ray sources to date. The comparison is limited to sources with X-ray fluxes $>8\times10^{-15}$ erg cm^{-2} s^{-1} in the 0.5-7.0 keV range and mid-IR sources with 3.6 μm fluxes brighter than 18.4 mag (12.3~ μJy). In this most sensitive IRAC band, 85% of the 3086 X-ray sources have mid-IR counterparts at an 80% confidence level based on a Bayesian matching technique. Of the remaining 15%, only 2.5% have no IRAC counterpart at all based on visual inspection. Even for a smaller but a significantly deeper *Chandra* survey in the same field, the IRAC Shallow Survey recovers most of the X-ray sources. A majority (65%) of the *Chandra* sources detected in all four IRAC bands occupy a well-defined region of IRAC [3.6] [4.5] vs [5.8] [8.0] color-color space. These X-ray sources are likely infrared luminous, unobscured *type I* AGN with little mid-infrared flux contributed by the AGN host galaxy. Of the remaining *Chandra* sources, most are lower luminosity *type I* and *type II* AGN whose mid-IR emission is dominated by the host galaxy, while approximately 5% are either Galactic stars or very local galaxies.

161.02

Optical and IR Diagnostics of Radio Sources in the Bootes Field

Steve Croft[1], W. van Breugel[1], W. de Vries[2], IRAC Shallow Survey Team, NDWFS Team

[1]UC Merced / LLNL, [2]UC Davis / LLNL.

By combining our extremely deep maps of the Bootes Field at 325 MHz and 1.4 GHz with data from the IRAC Shallow Survey and the NDWFS, we are investigating the optical and infrared properties of radio sources as a function of radio flux and spectral index. We present deeper IRAC imaging, undertaken for a sample of radio sources unidentified in the existing IRAC data. We also present observations of candidate high-redshift radio galaxies which were followed up with Keck NIRC and LRIS. Some are spectroscopically confirmed at z $\sim$ 2; SED fitting suggests others are at z $\sim$ 5.

161.03

A Large Population of Infrared-Selected, Obscured AGN in the Bootes Field

Christine Jones[1], R. Hickox[1], S. Murray[1], W. Forman[1], M. Brodwin[2], XBootes, IRAC Shallow Survey, NDWFS, AGES Teams
[1]Harvard-Smithsonian, CfA, [2]NASA/JPL.

We analyze an infrared-selected sample of ~1500 active galactic nuclei (AGN) at redshifts 0.7<z<3 from the 9 sq. degree wide-field multiwavelength survey in Bootes. Data are taken from the Spitzer IRAC Shallow Survey, Chandra XBootes survey, NOAO Deep Wide Field Survey, and MMT/AGES survey. We classify the IR-selected AGN as Type 1 (unobscured) and Type 2 (obscured) based on their mid-IR, X-ray and optical luminosities. We find ~700 Type 2 objects, and show that their multiwavelength properties are consistent with AGNs having nH ~ 3E22 cm-2 and bolometric unabsorbed luminosities log L(bol) ~ 44-46 ergs per second. These Type 2 AGN comprise ~40 percent of the infrared-selected AGN in Bootes and are the largest sample to date of distant, obscured AGN.

161.04

IRS Spectroscopy of z=2 Star-forming ULIRGs in the NDWFS Bootes Field

Baruch T. Soifer[1], V. Desai[1], A. Dey[2], B. Jannuzi[2], L. Armus[3], H. Teplitz[3], K. Brand[4], E. Le Floc'h[5], D. Weedman[6], J. Houck[6]
[1]Caltech, [2]NOAO, [3]SSC/Caltech, [4]STScI, [5]IFA/U. Hawaii, [6]Cornell U..

Multiwavelength surveys combining deep groundbased optical imaging and Spitzer MIPS 24 micron mapping have revealed a population of extreme infrared-loud sources. The fraction of such sources increases significantly with decreasing 24 micron flux, indicating that they become a larger fraction of the 24 micron population with increasing redshift. Mid-infrared spectroscopy carried out with Spitzer's Infrared Spectrograph (IRS) has indicated that the brightest (f(24)>0.8 mJy) of these sources lie at z=2 and are powered predominantly by AGN. This mid-infrared spectroscopic classification is consistent with the lack of 1.6 micron stellar photospheric emission in their broadband SEDs. However, the fraction of sources with SEDs that do display this stellar bump increases to fainter 24 micron flux densities, indicating that the bulk of extreme sources may be powered by star formation. To test the SED-based classification of mid-infrared sources, and to study the properties of high-redshift starburst-dominated ULIRGs, we have obtained IRS spectra of 16 extreme IR-loud sources in the NDWFS Bootes field with f(24)=0.5-0.75 mJy and stellar photospheric emission suggesting z=2. The high fraction (14/16) of sources displaying PAH features contrasts with the power-law and absorption-dominated spectra common among extreme sources with brighter 24 micron fluxes. These results are an important verification of the assumptions used to classify sources based on photometry, which is available in far larger quantities than IRS spectroscopy.

161.05

Clusters of Galaxies in the First Half of the Universe from the IRAC Shallow Survey

Peter R. Eisenhardt[1], M. Brodwin[1], A. Gonzalez[2], S. A. Stanford[3], D. Stern[1], P. Barmby[4], A. Dey[5], M. J. Brown[6], J. Huang[4], B. T. Jannuzi[5], M. A. Pahre[4]
[1]JPL/Caltech, [2]U. Florida, [3]IGPP/UC-Davis, [4]Harvard, [5]NOAO, [6]Princeton University.

We use a wavelet algorithm and photometric redshift probability distributions for a 4.5 micron selected sample of objects using data from the 8 square degree Spitzer Infrared Array Camera (IRAC) shallow survey and the NOAO Deep Wide Field Survey in Bootes to search for galaxy clusters to redshift 2. We find 292 high reliability galaxy cluster and group candidates, 93 of which are at z $>$ 1. To date 8 of the z $>$ 1 candidates have been confirmed spectroscopically, at redshifts from 1.06 to 1.41. Color magnitude diagrams in I [3.6] vs. [3.6] are presented for these spectroscopically confirmed clusters. The mean I [3.6] color for cluster galaxies for cluster redshifts out to 1 is well matched by a passively evolving model in which stars are formed in a 0.1 Gyr burst starting at redshift zf = 3. Cluster galaxies brighter than L* are systematically redder. At z $>$ 1, a wider range of formation histories is needed, but for most of the clusters, passive models with zf $>$ 4 match the mean I [3.6] color for cluster galaxies brighter than L*.

161.06

Mid-Infrared Selection of Brown Dwarfs and High-Redshift Quasars

Daniel Stern[1], J. D. Kirkpatrick[2], IRAC Shallow Survey Team
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We discuss color selection of rare objects in a wide-field, multiband survey spanning from the optical to the mid-infrared. Simple color criteria simultaneously identify and distinguish two of the most sought after astrophysical sources: the coolest brown dwarfs and the most distant quasars. We present spectroscopically-confirmed examples of each class identified in the IRAC Shallow Survey of the Bootes field of the NOAO Deep Wide-Field Survey. ISS J142950.9+333012 is a T4.5 brown dwarf at a distance of approximately 42 pc, and ISS J142738.5+331242 is a radio-loud quasar at redshift z=6.12. Our selection criteria identify a total of four candidates over 8 square degrees of the Bootes field. The other two candidates are both confirmed 5.5<z<6 quasars, previously reported by Cool et al. (2006). We discuss the implications of these discoveries and conclude that there are excellent prospects for extending such searches to cooler brown dwarfs and higher redshift quasars.

161.07

Searching for Brown Dwarfs in the Spitzer/IRAC Shallow Survey

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The IRAC Shallow Survey in Bootes, augmented by J and Ks photometry obtained as part of the FLAMINGOS Extragalactic Survey (FLAMEX), provides an ideal dataset for the search of brown dwarfs and other cool objects, as demonstrated by the recent detection of a T4.5 spectral type brown dwarf by Stern et al. (astro-ph/0608603). More brown dwarfs of L and early T type are expected to be found in the Bootes survey area, but an efficient and thorough method is required to complete the search. We present here a statistical technique for the automatic photometric classification of astronomical sources, that aims to satisfy these requirements. Based on the k-Nearest Neighbor method, this technique provides an unbiased tool for selecting brown dwarf candidates by comparing their colors with a set of templates derived from IRAC Guaranteed Time Observations (Patten et al. 2006, astro-ph/0606432), and it has already proved its effectiveness by identifying brown dwarf companions around nearby stars (Luhman et al. 2006, astro-ph/0609464). We describe its application to the search for field brown dwarfs in the Shallow Survey/FLAMEX database.

This work is based in part on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

161.08

X-ray Bright Optically Normal Galaxies (XBONGs) in the XBootes Field

Michael Anderson[1], S. Murray[2], C. Jones[2], A. Kenter[2], B. Forman[2], R. Hickox[2]
[1]University of Michigan, [2]Harvard-Smithsonian Center for Astrophysics.

We analyze a sample of 258 X-ray Bright Optically Normal Galaxies (XBONGs) in the XBootes Field by far the largest sample of XBONGs ever studied. These galaxies show X-ray emission characteristic of accretion onto a supermassive black hole, but lack any detected optical emission lines expected for active galaxies. We examine the sample using X-ray, optical, near-infrared, and radio photometry, comparing the XBONGs to a sample of 218 normal active galaxies in the same field. Both samples extend out to z=1. We find a heterogeneous population of XBONGs comprising the early-type galaxies noted in previous studies as well as a number of blue elliptical, spiral, irregular, and interacting galaxies. We test the observational data against three prominent models of XBONG behavior: obscuration of the nuclear light by dust in the host galaxy, dilution of the emission lines by stellar light in the host galaxy, and a weak ionizing continuum from the accretion disk because of an Advection-Dominated Accretion Flow (ADAF) in the disk. We find evidence for all three of these models in our sample of XBONGs.

161.09

Low Resolution Spectral Templates for Galaxies from 0.2--10 microns

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We built an optimal basis of low resolution templates for galaxies in the wavelength range of 0.2 to 10 microns using a variation of the algorithm presented by Budavari et al. (2000). We used eleven bands of photometry for about 17000 galaxies in the NDWFS Bootes field with spectroscopic redshifts measured by the AGN and Galaxy Evolution Survey. We also developed algorithms to accurately determine photometric redshifts, K corrections and bolometric Luminosities using these optimal spectral templates basis. Our photometric redshifts estimates have an accuracy of dz $=0.04(1+z)$ for the 95% clipped distribution. Finally, we also used this algorithms to study the spectral type distribution of the field and estimate luminosity functions of galaxies as a function of redshift and spectral type.

161.10

An Hα Objective Prism Survey in the NDWFS Boötes Field

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[1]Penn State Univ., [2]Wesleyan University, [3]Harvard-Smithsonian Center for Astrophysics.

We present results of an objective-prism survey for nearby emission-line galaxies (ELGs) in the NOAO Deep Wide Field Survey (NDWFS) Boötes Field. This survey is part of the KPNO International Spectroscopic Survey (KISS) collaboration which has surveyed approximately 150 square degrees for Hα emission line galaxies out to a redshift of 0.1. KISS is the first purely digital objective-prism survey, and it extends previous photographic surveys to much fainter flux limits. We have discovered 130 additional ELG candidates in the NDWFS Boötes field, and have obtained follow-up spectroscopy on this entire sample. We present the magnitude, color, redshift, and spatial distributions of this sample based on the survey data. We also discuss science applications made possible by this sample, in particular improved calibrations of various star-formation rate indicators made possible by the multi-wavelength data available on this field including Spitzer IRAC and MIPS as well as GALEX observations.

162: Search for Variables Through Surveys, Databases and Archives
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

162.01

Combined NSVS/2MASS Database Search For Cool Algols and Eclipsing Subdwarf B Stars

Nicole Kelley[1], J. S. Shaw[2]
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Combining both the Northern Sky Variability Survey (NSVS) and the Two Micron All Sky Survey (2MASS) has allowed us to search for rare types of eclipsing variable stars based upon their light curves and V, J, H and K colors. We have found ten previously unknown cool Algols and 52 new giant star (GS) eclipsing binary systems. In addition, we have found eight possible subdwarf B star (sdB) eclipsing binaries. Six are systems with periods longer than one day and contain a companion star of M2 or later. The two others have short periods and contain an earlier main sequence companion.

This research was funded by a partnership between the National Science Foundation (NSF AST-0552798) Research Experiences for Undergraduates (REU) and the Department of Defense (DoD) ASSURE (Awards to Stimulate and Support Undergraduate Research Experiences) programs.

162.02

LGSAO Imaging of STEPS Astrometric Candidates

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STEPS (STEllar Planet Survey) is a ground-based, optical astrometric survey of ~ 30 nearby M dwarfs from the Hale 5-meter telescope with the goal of discovering extrasolar planets. Since astrometry measures center of light motion about the center of mass, a degeneracy exists between luminous and non-luminous secondaries. This degeneracy can be removed by high-resolution imaging. Using the Keck II laser guide star adaptive optics system (LGSAO), we imaged four candidate binary systems. Stellar companions were discovered for two of the four stars (G 78-28 and GJ 231.1B), but no luminous companions were detected for the remaining two stars. This raises the possibility of substellar companions around these stars. The companion to G 78-28 lies 2.19 $\pm$ 0.10 AU from the 0.370 $\pm$ 0.034 solar mass primary and has a mass of 0.195 $\pm$ 0.021 solar masses. The full orbit of GJ 231.1BC has not been observed, because its $>$ 26 year period is almost three times the temporal baseline of STEPS. Thus, the primary and secondary component masses of 0.25 $\pm$ 0.06 and 0.12 $\pm$ 0.02 solar masses, respectively, are based on mass-luminosity relations in the literature. To calibrate the NIRC2 detector pixel scale and nominal rotation, we imaged the core of M5 and correlated stellar positions against an archival, public image from the Hubble Space Telescope Planetary Camera. We find the pixel scale for the narrow camera mode of 9.970 $\pm$ 0.012 mas/pix is consistent with other values from the literature, and we find that rotation information in image headers is accurate to better than 1 degree.

162.03

Recovering Long-Term Lightcurves from the Harvard Plates: A Search for Eclipsing Binaries in M44

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We search for eclipsing binary stars in M44 using the archival data from the Harvard plates collection. Our group, the DASCH collaboration digitized the images of the Harvard plates pointing at M44 using a custom-built scanner. These plate images provide a look at the past 100 years of the cluster's history. We fit world coordinate systems onto these plates images and, by comparing to the ASAS photometric catalog, fit the nonlinear photometry curve for stars on the plate. We search for stars whose magnitude changed by more than statistical error, conduct a periodicity search on those

candidate lightcurves, and fit those to folded lightcurves We find one candidate binary, GSC1993:2093, which exihibits a nearly three magnitude drop in luminosity

162.04

The American Association of Variable Star Observers (AAVSO)

Travis Searle[1], M. Templeton[1], A. Price[1], A. Henden[1]
[1]*AAVSO.*

Founded in 1911 and headquartered in Cambridge, Massachusetts, the American Association of Variable Star Observers (AAVSO) is a non-profit worldwide scientific and educational organization of professional and amateur astronomers dedicated to the observing and research of variable stars. The AAVSO International Database has over 13 million observations contributed by over 2,500 observers from around the world. The AAVSO receives thousands of data requests per year from the astronomical community. AAVSO observers also contribute to active research programs and community support activities like target-of-opportunity monitoring and coordinated observing campaigns, as well as providing early notification of rare events like novae and supernovae. In 2006, the AAVSO received over 700,000 new observations. Approximately 2/3rds were photometric (UBVRIJH) and about 3/5ths of AAVSO active observers reside outside the United States. The AAVSO is also active in training amateurs in observing techniques, data mining, and data analysis and also runs an active education and public outreach (E/PO) program including the NSF-funded Hands-On Astrophysics Curriculum. AAVSO data is available for download in near real-time at www.aavso.org.

162.05

The AAVSO International Database

Rebecca Turner[1], A. Price[1], M. Templeton[1], E. O. Waagen[1], A. Henden[1]
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The AAVSO International Database contains over 13 million variable star brightness estimates for nearly 10,000 known and suspected variable stars contributed by over 7300 observers since 1911. Data for some stars even date back as far as 1845. The database continues to grow, with over 700,000 new data points added in the last year. The database exists thanks to the dedication of the many tireless amateur and professional observers around the globe. This list of observers includes both well known names of the past and those who will no doubt become the well known names of the future. The AAVSO has a number of systems in place to ensure accuracy, such as: training for observers, standardized AAVSO charts, automated data entry checks, and data validation by AAVSO staff. The AAVSO is also committed to making the database accessible to the public. Raw observations are currently available in near real-time via the online data request form, light curve generator, and quick look file of recent observations. Multiple data formats are supported, including NVO standards.

162.06

The Precision of Visual Estimates of Variable Stars

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Existing records of visual observations of variable stars date back centuries. The largest database of visual variable star observations is the AAVSO International Database with over 11 million visual observations, which for some stars dates back to 1845. The AAVSO receives thousands of requests for this data from the astronomical community per year. We show early results of a project to assign a precision to variable star estimates based on properties such as the star's color index, time resolution, lunar phase, etc.

162.07

A Bright Stellar Variability Survey in the NGC 6811 Region

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We present preliminary results of a BVRI variability survey conducted by the AAVSO in coordination with the BOKS program during the month of September. Stars in a 1.5x0.75 degree field centered on the open cluster NGC 6811 in Cygnus were monitored. Many new variables brighter than V=15 were discovered, and light curves of several existing or suspected variables in the region were created. A description of the observing program, highlights from some of the more prolific amateur contributors, and light-curves of the variables will be presented.

162.08

RR Lyrae Stars in the SDSS-II Supernova Survey

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[1]*Michigan State Univ.,* [2]*Michigan State Univ. & JINA,* [3]*Institute of Astronomy, Cambridge, United Kingdom,* [4]*Univ. of Washington.*

This report details the ongoing search for RR Lyrae stars in the Supernova Survey of the Sloan Digital Sky Survey (SDSS). The SDSS-II SN Survey covers a 2.5 degree equatorial stripe ranging from -60 to +60 degrees in RA. This corresponds to relatively high southern galactic latitudes in the anti-center direction. There are currently over five million detected objects in this survey. Many of these have nearly concurrent observations in all five ugriz filters. The current work contains data from SDSS-I calibration runs and the first year of the three year SN Survey. This represents on average roughly 20 epochs per object.

Using this sample, we explore spatial and period distributions of the RR Lyrae stars in the Galactic Halo. These distributions are compared to other surveys of RR Lyrae stars which concentrate on other components of the Galaxy. We will discuss the results to date and consider further analyses that will be conducted as this survey continues.

We would like to thank the NSF for partial support from grants AST 0607249 and AST 0406784 to Michigan State University.

162.09

GNAT Student Follow-Up Pilot Project

Noll S. Roberts[1], N. Jaggi[1], C. Milne[1]
[1]*Cuesta College.*

The Global Network of Astronomical Telescopes (GNAT) has discovered some 25,000 new variable star candidates along an equatorial strip of the sky with a non-moving (drift scan) telescope. With three closely spaced observations of any given star being made on the order of 100 nights spread over three years, GNAT could not determine the types of variability and periods of the short period, aliased light curve stars in their MG-1 Variable Star Catalog. Such determinations typically require, for each star, hundreds of closely spaced observations over a number of nights with a modest-aperture tracking telescope equipped for CCD photometry. Many college and amateur observatories are capable of making such observation. At Cuesta College we have initiated a GNAT follow-up pilot program to determine how students at small observatories could efficiently make such determinations in a single-semester research course. We used a 10" Meade LX-200 telescope equipped with a SBIG ST-8XE camera to observe nine GNAT candidates, looking for short-term variability. We found two of the nine to be very short-term variables. We obtained 1397 one-minute integrations on the GNAT star GM1-15036 (GSC 13:95) over seven nights. We determined its period to be about 0.16 days. Its sinusoidal waveform has a peak-to-peak amplitude of 0.2 magnitudes. This star is most likely an RR Lyrae pulsating variable. The second short-term variable star is now being repeatedly observed and, in parallel, we are examining a second batch of nine candidates for short-term variability. At the end of the fall 2006 semester, we will summarize what have learned about one-semester GNAT student follow-up

observations. We are pleased to acknowledge the assistance of Eric Craine from GNAT, Russell Genet from Cuesta College and Orion Observatory, and Thomas Smith from Dark Ridge Observatory.

162.10

Revisited The Draco Dwarf Spheroidal Galaxy Variable Star Population

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The Draco dwarf spheroidal galaxy was first mined for variable star by Baade & Swope, which yielded approximately 200 stars. We present an updated census of variable stars found in Draco with an emphasis on the RR Lyrae (RRL) stars. In total, we have found 267 RRL stars. We have calculated updated periods, amplitudes, and mean magnitudes in V and I. We have also performed a Fourier decomposition on the light curves of the ab-type RRL and calculated photometric metallicities. We will discuss our findings with the Blazhko and double-mode RRL as well as the Oosterhoff classification of Draco.

162.11

Light Curves of Newly Discovered Variable Stars from ROTSE-I Observations

Douglas I. Hoffman[1], T. E. Harrison[1], B. J. McNamara[1], T. W. Vestrand[2]
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The Robotic Optical Transient Search Experiment(ROTSE-I) contains multiple-exposure records of roughly 20 million objects taken over year-long baseline. These objects are compiled in the SkyDOT database. We have identified roughly 100,000 objects with at least 30 observations, amplitude variations greater than 0.1 magnitudes, and mean magnitudes brighter than 13.5. Fourier analysis was used to find objects that have periodic behavior. We present light curves of some of these objects that have not previously been documented.

162.12

The FUSE Survey of Algol-Type Interacting Binary Systems

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A survey of Algol binaries at random phases is currently being carried through with the FUSE spacecraft as part of the FUSE survey and supplemental program. A similar program was undertaken in FUSE Cycle 3. Both programs have produced multiple observations of 12 Algol systems with periods ranging from 1.2 37 d and include direct-impact and disk systems. We report on the status of the program. The absence of O VI absorption in the systems observed to date allows us to place an upper limit on the column density and temperature of the High Temperature Accretion Region, HTAR (~100,000 K) confirmed in some Algols from earlier IUE data. The HTAR plasma component appears to be distinct from an O VI-emitting polar plasma discovered in FUSE totality observations of RY Per, V356 Sgr, and TT Hya. New observations of the direct-impact system U Cep have provided more information on the geometry and mass flow (including a splash plasma) in the vicinity of a hot spot at phase 0.90 that was discovered earlier. The extent of disk asymmetries in the long period (~33 d) systems SX Cas and RX Cas is discussed. Models for direct-impact and the disk systems will be presented. The authors appreciate support from NASA grants NAG5-12253, NNG04GL17G, and NAS5-32985.

162.13

An Update on the Radial Velocity Survey in Cygnus OB2

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We conducted a radial velocity survey of the Cygnus OB2 Association over a 7-year (1999 2006) time interval to search for massive close binaries. During this time we obtained ~1400 spectra on 146 OB stars to measure mean systemic radial velocities and radial velocity variations. Of the 120 stars with the most reliable data, 36 are probable and 9 are possible single-lined spectroscopic binaries. We also identify 3 new and 8 candidate double-lined spectroscopic binaries. These data imply a lower limit on the massive binary fraction of 30 42%. The calculated velocity dispersion for Cygnus OB2 is 2.44 +/0.07 km/s, which is typical of open clusters. No runaway OB stars were found.

162.14

Variable Stars in the Lepine List of Nearby Stars

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An analysis of Lepine's list (2005, AJ 130, 1680) of newly identified nearby stars was conducted at the Pisgah Astronomical Research Institute in Rosman, NC in hopes of supporting future searches for potential hosts for nearby, extraterrestrial planets. The celestial coordinates were extracted from Lepine's list and cross-referenced with the Northern Sky Variability Survey to determine which stars among them were variable. The stars deemed variable were then cross referenced with the ROSAT all sky survey to determine if any were X-ray sources. It was determined that roughly half of the list of newly discovered nearby stars coincided to within 3arcseconds of a NSVS variable. The search done with the ROSAT all sky survey is, at this point, being verified. Future work will include statistical studies of the sample and follow-up observations of candidate variable stars. We would like to acknowledge support for this work for one of us (McNutt) through 2006 PARSEC Internship Program, and was supported by NASA Award NNG05GQ66, the North Carolina Space Grant, and the Glaxo-Wellcome Endowment at UNCA.

162.15

Burrell-Optical-Kepler Survey (BOKS) I: Survey Description

John J. Feldmeier[1], S. Howell[2], P. Harding[3], C. Mihos[3], C. Rudick[3], W. Sherry[4], T. Lee[5], C. Knox[3], D. Ciardi[6], K. von Braun[6], M. Everett[7], M. Proctor[8], G. van Belle[6]
[1]Youngstown State Univ., [2]NOAO/WIYN, [3]CWRU, [4]NSO, [5]NOAO, [6]MSC, [7]PSI, [8]LPL.

The Burrell Optical Kepler Survey (BOKS) is a ground-based, high cadence, stellar variability survey over a portion of the planned science field for the Kepler mission. The survey was carried out at the 0.6m Burrell Schmidt telescope, with an observed field size of 1.36 square degrees. Over 60,000 stars were observed within the BOKS field in the SDSS r-band spanning a time period of 39 days, with a ~4.5 minute cadence. We give a basic description of the survey, and calculate the observability function for stellar variablity of different types.

162.16

Burrell-Optical-Kepler Survey (BOKS) II: Early Variability Results

Steve B. Howell[1], J. Feldmeier[2], K. van Braun[3], M. Everett[4], C. Mihos[5], P. Harding[5], C. Knox[5], W. Sherry[6], T. Lee[7], D. Ciardi[3], C. Rudick[5], M. Proctor[8], G. van Belle[3]
[1]WIYN/NOAO, [2]YSU, [3]MSC, [4]PSI, [5]CWRU, [6]NSO, [7]NOAO, [8]LPL.

We present preliminary results for the photometric time-series data obtained with the BOKS survey (see BOKS I poster Feldmeier et al.). The BOKS survey covers about 1 square degree in the constellation of Cygnus. We obtained nearly 2000 SDSS r-band images spanning a total time period of 39 days. Each point source in our BOKS survey is also present in the single epoch, 7-color photometric survey catalogue being produced by the NASA Discovery program Kepler mission. Light curves of approximately 60,000 point sources, spanning r=14 to 20, are examined and discussed. We will present variability demographics for the BOKS survey including characterization of the light curves into variable classes based on type, color, amplitude, and any extra-solar planet transit candidates.

162.17

WIYN Open Cluster Study Long-term Monitoring: NGC 2141

Allison M. Widhalm[1], S. Kafka[2]
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Old open clusters, located in the disk of the galaxy, are useful tools in understanding stars at all stages of evolution. In this work, we present a variability study of the old open cluster NGC 2141. We used the WIYN 0.9m telescope to photometrically monitor the cluster during November 2004 December 2005. Here we present initial results of our study: of the 100 candidate variables two have been confirmed to be Algol eclipsing binaries. Future work includes determining the nature of variability for the rest of the candidates.

162.18

New Close Binary Systems from the SDSS-I (Data Release Five) and the Orbital Periods for a Subset of Close White Dwarf + M Dwarf Systems

Nicole M. Silvestri[1], S. L. Hawley[1], L. C. Dang[2], D. A. Krogsrud[1], K. Smoke[1], M. A. Wolfe[1], L. Mannikko[1]
[1]Univ. of Washington, [2]NASA GSFC.

We present the latest catalog of more than 1200 spectroscopically selected close binary systems observed with the Sloan Digital Sky Survey (SDSS) through the now public Data Release Five. We use the systems from this catalog to study the influence of the binary environment on the evolution of the low-mass (typically an M dwarf) secondary star. We investigate how the properties of the M dwarf are impacted by the presence of the white dwarf primary using a variety of methods. Candidate systems with very active secondaries and/or low-mass primaries are observed using time-series spectroscopy on the ARC 3.5m to find their orbital periods. Preliminary orbital periods from repeat observations from the SDSS are also presented. In addition to the orbital period study, candidates are observed using photometric time-series on the MDM 2.4m to search for variability (eclipses, rotational modulation) and infrared photometry on the ARC 3.5m to search for faint, low-mass companions. We have now compiled a sample of systems with a wide range of spectral types, orbital periods and ages, and will discuss our results on the properties of these systems.

162.19

Discovery of WD+M Binaries in the Sloan Digital Sky Survey

Robert L. da Silva[1]
[1]LBNL.

Type Ia supernovae provide the evidence for the current greatest scientific puzzle, the accelerating expansion of the universe. To better understand this phenomenon it is important to understand the basis for that discovery; the progenitors of these supernovae.

Type Ia supernovae are thought to occur when a white dwarf (WD) reaches the Chandrasekhar limit of approximately 1.44 times the mass of our sun. This can occur when two WDs in a binary system eventually merge due to the loss of rotational energy in the form of gravitational waves. WDs in a binary system can also exceed this limit when the WD accretes enough mass from its companion due to its strong gravitational and magnetic forces.

The Sloan Digital Sky Survey (SDSS) observed approximately 1.2 million objects among which were 9822 that the pipeline designated as WDs. For all objects in the SDSS, multiple exposures were taken that were then co-added to create a higher signal-to-noise composite spectrum. The time between these exposures varied between 15 minutes to several days. Every object has at least 3 of these exposures. While these exposures are often neglected in favor of their higher signal-to-noise co-added spectra, I set out to examine the differences in the spectra of these individual exposures to determine if there were any radial velocity shifts between these exposures. I chose to first examine WDs since they have the capability of being in very short period binary systems that may be Type Ia Supernova progenitors.

This paper presents 2 WD+M binaries (in plate-fiber-mjd format: 2232-584-53827 and 2075-144-53737) as well as a method to determine if a large number of objects in the SDSS database are in short period binary systems.

I would like to thank and acknowledge Lawrence Berkeley National Laboratory for their funding and support.

162.20

Optically Variable RASS X-ray Sources in the Northern Sky Variability Survey

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Optical variability is often associated with high energy emission, allowing for the identification of optical counterparts to x-ray sources. A catalog of over 65,000 previously known optical variables is position-matched to the ROSAT All-Sky Survey, and 1056 variables are identified as x-ray emitters. Using data from SIMBAD where known, variability classes are determined using period and 2MASS colors. A large fraction of these variables are believed to be young stellar objects, some of which fall in the classical T-Tauri period range. Follow-up spectra have been measured for these objects.

162.21

Eclipsing Binaries in the Galactic Bulge from SWEEPS Data

Kailash C. Sahu[1], T. E. Smith[1], W. Clarkson[1]
[1]STScI.

The SWEEPS (Sagittarius Window Eclipsing Extrasolar Planet Search) project used the Advanced Camera for Surveys onboard HST to continuously monitor a rich stellar field in the Galactic bulge for 7 days during Feb 23-29, 2004. The SWEEPS field contains about 245,000 stars down to V ~ 29. The principal aim of this project was to detect transiting planets, but the dataset is also ideal for detecting short-period eclipsing binaries. We detected about 165 eclipsing binaries with periods ranging from ~0.2 to 5 days; the physical properties of these eclipsing binaries will be presented.

162.22

Multicolor Oservations of the Type II Cepheid Prototype W Virginis

Matthew R. Templeton[1], A. A. Henden[1], T. Crawford[1], R. James[1], M. Bonnardeau[1], D. Wells[1]
[1]AAVSO.

We present preliminary results of the AAVSO's six-month photometric campaign on the bright, pulsating variable star W Virginis, class prototype of the Type II Cepheid variables. This campaign was organized in support of separate spectroscopic observations (Wallerstein et al., in preparation), but these photometric data also stand alone as a valuable, recent, multicolor light curve of this object. Observations were obtained by several amateur and professional observers using a variety of equipment; data are primarily in the V filter, but include two complete pulsation cycles in the BVRcIc filters. We present lightand color-curves of this star, and compare our results to previous observational and theoretical results on W Vir and the Type II Cepheids.

163: Extrasolar Planets VI: Observed Systems
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

163.01

Interferometric Observations of the Transiting Planet HD 189733 with the CHARA Array

Ellyn K. Baines[1], G. T. van Belle[2], H. A. McAlister[1], T. A. ten Brummelaar[1], D. H. Berger[3], N. H. Turner[1], P. J. Goldfinger[1]
[1]*Georgia State Univ.,* [2]*Michelson Science Center,* [3]*Univ. of Michigan.*

The star HD 189733 (HIP 98505, GJ 4130, type K2 V) is one of only a handful of extrasolar planetary systems that show photometric variations due planetary transits. Bouchy et al. (A&A, 444, L15, 2005) discovered a hot Jupiter-like planet with an orbital period of 2.219 days and estimated the star's radius to be 0.76±0.01 Rsol. This value, along with a planet-to-star radius ratio of 0.172±0.003, led to a planetary radius of 1.26±0.03 RJup. We observed HD 189733 using the Georgia State University's Center for High Angular Resolution (CHARA) Array, a six-element optical/infrared interferometer located on Mount Wilson, California. The star was observed using the 331-m S1/E1 baseline over eight nights spanning May to August 2006. All observations were obtained with the ″CHARA Classic″ beam combiner using both the K'and H-band infrared wavelengths. We present data taken in order to determine the host star's radius from its angular diameter and parallax and thereby directly calculate a physical radius and density for the planet. This result is significant in that it represents the first extrasolar planetary diameter that has been determined through purely direct means.

163.02

Infrared Phase Variations of Hot Jupiters

Nicolas B. Cowan[1], E. Agol[1], D. Charbonneau[2]
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We present results from Spitzer Space Telescope observations of three close-in giant planets: 51 Peg b, HD 179949 b and HD 209458 b. Such short-period planets are expected to be tidally locked and therefore to have permanent dayand night-sides. They may be nearly isothermal, or exhibit a large day/night temperature contrast, depending on how efficiently their gaseous envelope redistributes incident energy to their night-side. Indeed, the various atmospheric models of hot Jupiters are not in agreement about the value of this redistribution factor. In an attempt to resolve this controversy, IRAC 8.0 micron images were taken at 8 points throughout each planet's orbit. The phase variability of the systems was used to constrain the diurnal flux difference of the planets. By making suitable assumptions about their albedo, we were able to constrain these planets' day/night temperature contrast.

163.03

Eccentricities of Extrasolar Planets and Implications for Planet Formation Theory

Eric B. Ford[1]
[1]*Harvard-Smithsonian Center for Astrophysics.*

The discovery of ~200 extrasolar planets around solar-like stars has revealed an unexpected diversity of planets that continues to challenge theories of planet formation. In particular, most known extrasolar planets have significant eccentricities, including many massive giant planets. In this poster, we present a Bayesian analysis of the radial velocity observations taken by the California and Carnegie Planet Search at Keck and recently published by Butler et al. (2006). We investigate the observational constraints for the eccentricity distribution of giant extrasolar planets and discuss the implications for theories of planet formation. We outline how future radial velocity observations can test models of planet formation.

Support for E.B.F. was provided by NASA through Hubble Fellowship grant HST-HF-01195.01A awarded by the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., for NASA, under contract NAS 5-26555.

163.04

A Possible Planet Around a White Dwarf

Fergal Mullally[1], D. Winget[1]
[1]*Univ. of Texas, Austin.*

We present evidence for a possible planetary companion to a pulsating white dwarf star. A subset of pulsating white dwarf stars exhibit extreme stability in the period and phase of their pulsations. This allows the motion of the star due to an orbiting planet around the center of mass of the system to be detected as a change in the observed arrival time of pulsations. Our best fit orbital solution gives a period of 4 years, a semi-major axis of 2 AU and an mass of 2/sin(i) Jupiter masses.

This work is supported by a grant from the NASA Origins program, NAG5-13094 and in part under contract with the Jet Propulsion Laboratory (JPL) funded by NASA through the Michelson Fellowship Program. JPL is managed for NASA by the California Institute of Technology.

163.05

MOST Spacebased Photometry of Transiting Exoplanet Systems

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We present photometry of the transiting exoplanetary systems HD 209458, HD 189733 and HAT-P1-b obtained during 2004 2006 by the MOST (Microvariablity and Oscillations of STars) satellite. The advantageous vantage point of MOST allows continuous coverage of certain stars for up to 8 weeks. This results in unique datasets we have used to investigate stellar activity and rotation of the host stars, the albedos of the hot Jupiters, searches for transits at other periods by planets approaching Earth radius, and timing measurements of the known transits to search for planets of Earth mass and less.

164: Space-Based Instrumentation I
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

164.01

Steps Toward a UV/Optical Interferometer in Space: FIT & SIFFT

Kenneth G. Carpenter[1], R. G. Lyon[1], A. Liu[1], P. Dogoda[2], P. Petrone[2], D. Mozurkewich[3], D. Miller[4], S. Mohan[4], P. Stahl[5]
[1]*NASA's GSFC,* [2]*Sigma Space,* [3]*Seabrook Eng.,* [4]*MIT,* [5]*NASA's MSFC.*

We summarize the goals and result-to-date of a ROSES/APRA-sponsored program to develop two of the major technologies needed to enable the design and construction of future large baseline, space-based Interferometric and Sparse Aperture Telescope missions (e.g., Stellar Imager, Life Finder, Black Hole Imager, and Planet Imager). The Fizeau Interferometer Testbed (FIT) is being used to develop and demonstrate nm-level, closed-loop optical control of mirrors (i.e., control of tip, tilt, piston, translation of array elements) and the overall system to keep multiple beams in phase and optimize imaging of a Fizeau interferometric system and to assess various image reconstruction algorithms (phase diversity, clean, maximum entropy method, etc.) for utility and accuracy. The Synthetic Imaging Formation Flying Testbed (SIFFT) is, in parallel, being used to develop and demonstrate algorithms for autonomous cm-level precision formation flying, which can be combined in the future with the higher precision optical control systems (e.g., those developed on the FIT) to fully enable synthetic aperture imaging systems. The ultimate goal of this research is the demonstration of closed-loop performance of a unified system which combines formation flying and nm-level optical control systems (based on analysis of the science

data stream) to maintain phasing of a large array of space-borne mirrors, as needed for missions like those listed above, as well as smaller baseline Precursor missions that may pave the path to the larger strategic missions.

164.02

CALISTO: A Far-Infrared Observatory for the Next Decade

Harold W. Yorke[1], P. F. Goldsmith[1], C. M. Bradford[1], J. Zmuidzinas[1], C. Paine[1], M. Dragovan[1], C. M. Satter[1], A. E. Nash III[1], R. A. Lee[1], B. Khayatian[1], A. R. Girerd[1], S. J. MacLellan[1]
[1]*Jet Propulsion Laboratory, California Institute of Technology.*

We present a design for a far-infrared space-based observatory, based on existing instrument and telescope technologies and launchable within the next decade for an estimated cost under $1.3B. The Cryogenic Aperture Large Infrared Space Telescope Observatory (CALISTO) utilizes a 4 m x 6 m monolithic off-axis telescope cooled to 4 K, with far-infrared cameras and moderate-resolution spectrographs operating in the critical 30-300 micron wavelength range. This wavelength range is crucial for charting the history of galaxies, yet is inaccessible from terrestrial platforms due to the opacity of the Earth's atmosphere at these wavelengths. CALISTO would also fill in the observation wavelength gap between the Atacama Large Millimeter Array (ALMA) and the James Webb Space Telescope (JWST). CALISTO's excellent sensitivity in this band would enable detailed studies of the production of the cosmic far-IR background light, the repository of half the energy ever released in stars and black hole accretion. The galaxies which produced this background are now being revealed in surveys by the Spitzer Space Telescope. They appear to be Luminous and Ultraluminous Infrared Galaxies (LIRGs and ULIRGs) at redshifts of 1 to 4. Their study requires capabilities beyond what Herschel will provide: deep imaging and sensitive spectroscopy from a large cryogenic aperture. CALISTO offers these capabilities on a reasonable timescale and budget.

164.03

Cryogenic Telescope, Scanner, and Imaging Optics for the Wide-field Imaging Survey Explorer (WISE)

Mark Schwalm[1], A. Akerstrom[1], M. Barry[1], J. Guregian[1], F. LaMalva[1], P. Laquidara[1], G. Perron[1], D. Sampath[1], V. Ugolini[1]
[1]*L-3 Communications SSG-Tinsley.*

NASA's Wide-field Infrared Survey Explorer (WISE) instrument includes a cryogenic telescope, scanner, and imaging optics module. Component fabrication, mirror polishing, and prototype scanner cryogenic testing are complete for these subassemblies, and assembly is in process. The telescope is a 40 cm aperture reflecting five-mirror imager/collimator relay that provides 8X demagnification, a 47 x 86 arcminute field of regard, and a real exit pupil for scanning. It also provides distortion control to better than one part in a thousand to prevent image blur during internal scanning. A single-axis scan mirror at the exit pupil scans the detectors' field of view across the telescope field of regard, countering the orbital motion and freezing the line of sight during the multi-second exposure period. The imaging optics module is a five-mirror re-imager with dichroic beamsplitters that separate the energy into four infrared channels between 2.8 and 26 microns. All modules operate below 17 Kelvin. The all-reflective system uses aluminum mirrors and metering structures. L-3 Communications SSG-Tinsley is designing and building the telescope, scanner, and imaging optics module under contract to the Space Dynamics Laboratory. WISE is a MIDEX mission within NASA's Explorers Program.

164.04

Scientific Promise and Instrument Concepts for a Background-Limited Infrared-Submillimeter Spectrograph (BLISS) for SPICA

Charles Bradford[1], BLISS and SPICA teams
[1]*Caltech/ JPL.*

The far-IR component of the cosmic background light is the product of dust-enshrouded energy release integrated over the history of stars and galaxies. The fact that the energy in this dust component is comparable to that in the optical / near-IR component means that on average in the universe, interstellar dust has absorbed and reradiated half of the total energy ever generated by stars and black-hole accretion. The first high-redshift dusty galaxies discovered offer a clue: they have properties similar to those of the local luminous and ultraluminous IR galaxies (LIRGs and ULIRGs). The next generation continuum surveys will discover tens of thousands of similar galaxies at various post-reionization redshifts as the bulk of the background is resolved into its constituent sources.

The key to studying these galaxies will be spectroscopy in the mid-IR through millimeter range. Gas-phase and solid-state spectral features in this band provide redshifts, gas masses, and physical conditions from which luminosities, stellar populations, and star formation histories are derived independent of dust extinction. Unfortunately, such measurements in galaxies to redshift 5 are not possible with currently-planned far-IR instrumentation -they require a large ($>$ 1 meter), actively-cooled telescope, and a zodiacal-light-limited spectrograph.

Given recent technological advances, we can now anticipate this opportunity for the first time. We present a far-IR spectrograph concept for the Japanese SPICA mission. The background-limited infrared-submillimeter spectrograph (BLISS) is a suite of broadband, moderate resolution (RËœ1000) spectrograph modules covering 40-600 microns, with excellent sensitivity to take advantage of the cold telescope. BLISS will utilize the world's most sensitive far-IR/submillimeter detectors as well as novel sub-K cooler and multiplexer technologies. The combination of BLISS with SPICA will offer broadband coverage and sensitivities at or better than 1e-20 W/m^2 in modest integrations, enabling spectral studies throughout the era of peak activity in galaxies.

164.05

CASTER A Concept for a Black Hole Finder Probe based on the Use of New Scintillator Technologies

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The primary scientific mission of the Black Hole Finder Probe (BHFP), part of the NASA Beyond Einstein program, is to survey the local Universe for black holes over a wide range of mass and accretion rate. One approach to such a survey is a hard X-ray coded aperture imaging mission operating in the 10-600 keV energy band, a spectral range that is considered to be especially useful in the detection of black hole sources. The development of new inorganic scintillator materials provides improved scintillator performance (for example, with regards to energy resolution and timing) that is well suited to the BHFP science requirements. Detection planes formed with these materials coupled with a new generation of readout devices represent a major advancement in the performance capabilities of scintillator-based gamma cameras. Here, we discuss the Coded Aperture Survey Telescope for Energetic Radiation (CASTER), a concept that represents a BHFP based on the use of the latest scintillator technology. We report on recent work with Lanthanum Halide scintillators, including recent radiation hardness testing and event location capabilities. We also discuss how these scintillators might best be incorporated into a BHFP design and how they can be expected to provide improved sensitivity at higher energies.

164.06

New Worlds Observer: Mission Overview

Charles F. Lillie[1], J. W. Arenberg[1], W. C. Cash[2], R. P. Samuele[1], A. S. Lo[1]
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New Worlds Observer is an external occulter concept designed to detect optical wavelength light from Earth-like planets around solar neighborhood stars. Here we describe a multi-occulter mission scenario operating in conjunction with a UV-Optical telescope. We describe the expected NWO exoplanet detection performance, and the system architecture, and delineate the limits of the NWO system. 50% of the telescope time is devoted to exoplanet hunting, and 50% is open to general astrophysics. We include a brief discussion of the baseline, 4-meter class UV-Optical telescope and other possible astrophysics with NWO.

164.07

Absolute Time Calibration for the Chandra X-ray Observatory

Arnold H. Rots[1]
[1]Harvard-Smithsonian CfA.

We performed an absolute time calibration of the Chandra clock through simultaneous observations by Chandra and the Rossi X-ray Timing Explorer (RXTE) of the millisecond pulsar PSR B1821-24. Using an updated clock correlation file, we find that the error in the Chandra clock, with respect to the RXTE clock, is 4±3 μs. Considering that the uncertainty in the RXTE times is typically 2 μs and taking into account other sources of error, we conclude that Chandra time is off by 4±4 μs. We add two caveats to this. First, this is only a single snapshot measurement; although we feel confident about the stability of the Chandra clock, we cannot entirely exclude the possibility of random or systematic variations in this offset. Second, first-version standard production data are typically run by CXC with an extrapolated clock correlation; in this particular case the error in the extrapolated clock correlation was 3±1 μs, but that is not necessarily a typical value. The final conclusion is that with careful processing we may reasonably have confidence that Chandra absolute time can achieve an accuracy of 4 μs.

164.08

Design and Lab Demonstration of the PIAA/Binary-Mask Hybrid Coronagraph

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[1]Subaru Telescope.

The PIAA (phase-induced amplitude apodization, Guyon 2003) coronagraph uses two mirrors to realize the apodization needed to for high contrast (~10^{10}) imaging for extrasolar planet searches. It achieves a very high throughput and a very small inner working angle (IWA) simultaneously, without being affected too much by resolved stellar disks.

However, the PIAA designed to give a 10^{10} contrast by itself would suffer from optics shapes that are difficult to polish, as well as the reduced bandwidth because of chromatic diffraction (Pluzhnik et al. 2006). This problem can be solved through combining classical pupil apodization (CPA) with a PIAA producing more moderate apodization. Binary-mask solutions as the CPA are especially attractive because they can make a practically achromatic coronagraph that is not hard to manufacture.

We have designed a concentric ring mask that is optimized to give an IWA of 1.2 lambda/D (in the sky) with a 75 % total throughput (as the hybrid system) for out first lab demonstration. The contrast of 10^6 has been achieved at a sepation of 1.5 lambda/D up to now, with a focal plane wavefront control.

164.09

Experimental Demonstration of Wavefront Estimation in a Shaped-Pupil Coronagraph

Ruslan Belikov[1], A. Give'on[2], E. Cady[1], J. Kay[1], L. Pueyo[1], N. J. Kasdin[1]
[1]Princeton Univ., [2]Caltech University.

Direct imaging of extrasolar planets, and terrestrial planets in particular, is an exciting but difficult problem requiring a telescope imaging system with unprecedented levels of contrast. One promising design is the Shaped Pupil Coronagraph (SPC), pioneered by our lab over the past several years. The SPC was designed to achieve 10^{10} contrast at an inner working angle of 4 lamdba/D, based on the requirements of NASA's space-based Terrestrial Planet Finder Coronagraph (TPF-C) mission. However, it has long been recognized that a key problem in achieving these requirements in practice is estimation and control of wavefront aberrations in the optics of the telescope. Furthermore, it is crucial to correct as fast as possible because of finite mission lifetime as well as due to the non-static nature of some aberrations. In earlier work, we have used the so-called speckle nulling algorithm to achieve 10^6 contrast at 4 lambda/D in air on the Princeton testbed, as well as almost 10^8 contrast in vacuum on JPL's testbed. However, the speckle nulling algorithm does not fully estimate the wavefront, and is therefore quite slow, requiring hundreds or even thousands of iterations. In this work, we present experimental results of wavefront correction using wavefront-estimation based techniques, which lead to much better performance and speed. In particular, we use a variant of the ″peak-a-boo″ algorithm as well as the Borde-Traub algorithm, both of which work with image-plane data and use different patterns on the DM to introduce diversity. Finally, we study the performance at different wavelengths and in broadband light.

164.10

Wavefront Compensation for High Contrast Imaging in the Presence of Fresnel Effects

Laurent A. Pueyo[1], J. Kasdin[1]
[1]Princeton University.

Recent progress in static wavefront compensation has both numerically and experimentally proven the feasibity of wavefront flattening very close to a level that would enable direct space based observation of exo-planets. This poster reports a novel semi-analytic approach to the influence of Fresnel propagation in pupil apodised coronagraphs and introduces a methodology to compensate for propagated wavefront aberrations under broadband illumination. We start from the Fresnel integral and derive an analytical closed form of the propagated field at an arbitrary distance from a pupil. Then we use this result in order to provide an analytical bound to the influence of propagation of the apodisation on the overall contrast level and thus quantify the required performance level of the optics . Next, we use this result to predict the wavelength dependence of an aberration that is not located at a conjugate of a pupil and use this a priori model to develop a multi-wavelength wavefront sensing scheme that takes into account Fresnel effects. Lastly, we present a series of wavefront actuators based on multiple deformable mirrors that possess the adequate chromatic behavior to correct for these aberrations.

164.11

STARCaL: A Tunable Laser in Space for Telescope Calibration and Atmospheric Studies

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We propose a tunable laser-based satellite-mounted spectrophotometric and absolute flux calibration system, to be utilized by groundand space-based telescopes. As uncertainties on the photometry, due to imperfect knowledge of both telescope optics and the atmosphere, will in the near future begin to dominate the uncertainties on fundamental cosmological parameters such as Ω_Λ (Omega_Lambda) and w in measurements from SNIa, weak gravitational lensing, and baryon oscillations, a method for reducing such uncertainties is needed. We propose to improve spectrophotometric calibration, currently obtained using standard stars, by placing a tunable laser and a wide-angle light source on a satellite by early next decade (perhaps included in the upgrade to the GPS satellite network) to improve absolute flux calibration to the 0.02% level and relative spectrophotometric calibration to better than 0.001% across the visible and near-infrared spectrum. As well as fundamental astrophysical applications, the system proposed here potentially has broad utility for atmospheric physics, as well as for defense and national security applications such as ground target illumination, space situational awareness, and space communication.

For further details please see http://www.starcal.org/ and http://www.arxiv.org/abs/astro-ph/0604339.

164.12

Selective Deposition of Thin Films for Future X-ray Optics

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X-ray telescopes help provide a view of the universe that cannot be seen in optical wavelengths. These telescopes provide observations of high energy processes that emit x-rays, processes that are not visible in optical light. Astrophysicists will benefit from new telescopes that can allow insight into the early universe which will create a better understanding of how the universe became what we see today, in terms of its composition and overall structure. However, optics such as those of the Chandra X-ray Observatory are no longer feasible due to practical limitations. Selective deposition via DC magnetron sputtering can provide an alternative to the traditional grinding and polishing technique that was used to create Chandra's x-ray optics. This method can also correct the figure of a thermally formed optic such as those currently being developed for the Constellation-X mission. Advantages to this technique include the ability to fabricate a larger and lighter optic which is more cost efficient.

Keywords: Selective Deposition, DC Magnetron Sputtering, X-ray Optics, X-ray telescopes

164.13

Dynamics of an Occulter Based Planet Finding Telescope

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Recently, the idea of using a large occulter with a conventional telescope in space has resurfaced and is gaining attention as an alternative approach to imaging extrasolar earthlike planets. One such concept involves the formation flying of a telescope on the order of 2 to 4 meter diameter with a large occulter, roughly 30 m across and 50,000 km away. The recent progress in optimal shaped pupil apodization has made the manufacture of such a starshade feasible. This approach to planet imaging eliminates all of the precision optical requirements that exist in the alternative coronagraphic or interferometric approaches. However, it introduces the difficult problem of controlling and realigning the satellite formation. In this poster, we outline various approaches to the trajectory design of the satellite and occulter to minimize fuel consumption throughout the mission. Using optimal control techniques, we find feasible mission scenarios that allow a full planet finding mission with acceptable cost.

164.14

The Lost Flux Method: A New Algorithm for Improving the Precision of Space-Based Near-Infrared Stellar Photometry with Lossy Detectors

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The combination of undersampling stellar images with detectors that have non-uniform pixel response functions is currently diminishing the science return of some near-infrared imagers onboard the Hubble Space Telescope and the Spitzer Space Telescope. Although the recorded flux of point sources may vary significantly by using detectors with large effective intrapixel quantum efficiency variations, it is still possible to achieve excellent stellar photometry -if the image formation process inside the detector is accurately modeled. A new analysis technique called the Lost Flux Method is described and used to demonstrate how the precision of stellar photometry from an existing space-based near-infrared camera with a lossy detector can be significantly improved. A detailed analysis of multiple observations of a single bright isolated star obtained with Channel 1 of the Spitzer Space Telescope Infrared Array Camera (IRAC) instrument yields an improvement in photometric precision of more than 100% over the best results obtained with aperture photometry. This work has been supported by a grant from the National Aeronautics and Space Administration (NASA), Interagency Order No. NNG06EC81I, which was awarded by the Applied Information Systems Research (AISR) Program of NASA's Science Mission Directorate.

164.15

Closed-loop Wavefront Correction for High-contrast Imaging: The ″Peak-A-Boo″ Algorithm.

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High contrast imaging from space must overcome photon noise of the diffracted star light and scattered light from optical components defects. The very high contrast required (up to 10^-10 for terrestrial planets) puts severe requirements on the wavefront control system, as the achievable contrast is limited by the quality of the wavefront. The "Peak-a-boo" correction algorithm, presented here, is a closed loop correction method for the shaped pupil coronagraph to minimize the energy in a pre-defined region in the image where terrestrial planets would be found. The reconstruction part uses three intensity measurements in the image plane with a pinhole added to the shaped pupil for diversity. This method has been shown in simulations to converge to the nominal contrast in 2-3 iterations. In addition, the "peak-a-boo" has shown to be effective in broadband conditions.

165: Star Clusters III
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

165.01

Using Open Clusters to Trace the Local Milky Way Rotation Curve and Velocity Field

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Establishing the rotation curve of the Milky Way is one of the fundamental contributions needed to understand the Galaxy and its mass distribution. We have undertaken a systematic spectroscopic survey of open star clusters which can serve as tracers of Galactic disk dynamics. We report on our initial sample of 67 clusters for which the Hydra multi-fiber spectrographs on the WIYN and Blanco telescopes have delivered ~1-2 km/s radial velocities (RVs) of many dozens of stars in the fields of each cluster, which are used to derive cluster membership and bulk cluster kinematics when combined with Tycho-2 proper motions. The clusters selected for study have a broad spatial distribution in order to be sensitive to the disk velocity field in all Galactic quadrants and across a Galactocentric radius range as much as 3.0 kpc from the solar circle. Through analysis of the cluster sample, we find (1) the rotation velocity of the LSR is 221 (+2,-4) km/s, (2) the local rotation curve is declining with radius having a slope of -9.0 km/s/kpc, (3) we find (using R_0 = 8.5 kpc) the following Galactic parameters: A = 17.0 km/s/kpc and B = -8.9 km/s/kpc, which yields a Galaxy mass within of 1.5 R_0 of M = 0.9 ± 0.2 x 10^11 solar masses and a M/L of 5.9 in solar units. We also explore the distribution of the local velocity field and find evidence for non-circular motion due to the sprial arms.

165.02

WIYN Tip-Tilt Module Observations of the Old Open Cluster NGC 1193

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We present the analysis of new photometric data in the *BVI* system of the old Galactic open cluster NGC 1193 obtained at the WIYN 3.5 m on Kitt Peak with the WIYN Tip-Tilt Module. CCD image reductions were performed using IRAF's CCDRED package and final photometry was obtained with IRAF's DAOPHOT package. Our preliminary results from the analysis

of five color-magnitude diagrams with the 2004 Yonsei-Yale isochrones give an age estimate of 5 Gyr for NGC 1193 which is 3 Gyr younger than the original estimate of Kaluzny in 1988 and the reanalysis of the same data by Tadross in 2004. Although our metallicity estimate for NGC 1193 is [Fe/H]=-0.30 is in agreement with those of Kaluzny and Tadross, we find that the cluster has a significantly higher apparent distance modulus in V of (m-M)_V = 14.12 mag due to our larger reddening estimate of E(B-V)=0.20 mag which is in agreement with the E(B-V)=0.21 mag estimate of Schlegel, Finkbeiner, and Davis that was based on their analysis of infrared dust maps. We discuss the impact this new analysis of NGC 1193 has on our understanding of Galactic open clusters.

Myra Stone's research was supported by the NOAO/KPNO Research Experiences for Undergraduates (REU) Program which is funded by the National Science Foundation through Scientific Program Order No. 3 (AST-0243875) of the Cooperative Agreement No. AST-0132798 between the Association of Universities for Research in Astronomy (AURA) and the NSF.

165.03

WIYN Open Cluster Study: Precision UBVRI CCD Photometry of the Open Cluster NGC 2420

Aaron J. Steinhauer[1], N. Lauffenburger[1], J. Hughto[1], C. P. Deliyannis[2], K. Croxall[2], A. Sarajedini[3]
[1]SUNY Geneseo, [2]Indiana University, [3]University of Florida.

We present UBVRI photometry of the metal-poor open cluster NGC 2420. Data were taken using the WIYN 0.9m telescope over one photometric night. Point Spread Function photometry was performed and data were standardized using Landolt fields observed on the same night. We present revised parameters for NGC 2420 of reddening, metallicity, distance, and age. This study is a part of an ongoing photometric study of this cluster, and our results provide an independent calibration of the magnitude scale, reducing the systematic errors in the cluster parameters.

165.04

WIYN Open Cluster Study: Precision UBVRI CCD Photometry of the Open Cluster NGC 2506

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We present UBVRI CCD photometry of the metal-poor open cluster NGC 2506. Data were taken with the WIYN 0.9m telescope on a photometric night and were calibrated using Landolt fields taken on the same night. We present revised parameters for NGC 2506 of reddening, metallicity, distance and age. This is part of the ongoing WOCS photometric survey of this cluster and our results provide an independent calibration of the magnitude scale which reduces the systematic errors in the cluster parameters.

165.05

The Red Buttes Observatory's Wide-Field Telescope's ZAMS Project

Ronald W. Canterna[1], M. MacDonald[1], D. Allen[1], E. Hausel[1], M. Pierce[1], C. T. Rodgers[1]
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We have started a photometric program to obtain Sloan u'g'r'i'z' data of large field, nearby clusters to define the Zero Age Main Sequence. Historically these clusters have been used to define the UBVRI ZAMS and includeCluster Name, Diameter (arc min): (h Per 18'), (x Per 18'),(a Per, 300'),(Pleiades 120'),(Hyades 330'), (NGC 2244 29'),NGC 2264 39'), (NGC 2420 5'), (M 67 25'),(Coma Berenices 120'),(NGC 6611 6″), (III Cep 66'). To obtain the data we use a 203mm F/4.9 Orion reflector, which is piggy-backed to the RBO 60-cm telescope. A field of view of 45 arc minutes is achieved with our Apogee Alta U47-UV coated, back-illuminated Marconi CCD. Initial observations start in Fall 2006 and preliminary result will be presented.

165.06

The Dolidze 27 and Alessi 10 Open Star Clusters

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New information was obtained for the open star clusters Dolidze 27 (Dolidze, M.V. 1961, Astron. Cir., 223, 11) and Alessi 10 (Alessi B. S., Moitinho A., Dias W.S. 2003, A&A, 410, 565). Two 20-minute exposure objective prism plates were selected from the collection of Michigan Blue Sky Objective Prism Plates in the North American Astronomical Photographic Plate Center located at the Pisgah Astronomical Research Institute. The plates were used to determine the spectral types for the stars in the two clusters. Alessi 10 consists primarily of late B and early A type stars, whereas Dolidze 27 has primarily K-type stars. Magnitudes of all stars in approximately 45 arcminute diameter areas centered on the clusters were measured from B and V images. The images were taken in July 2006 using the 40 cm Panchromatic Robotic Optical Monitoring and Polarimetry Telescopes (PROMPT; Reichart et al. 2005, Il Nuovo Cimento C, vol. 28, Issue 4, p.767). Color magnitude diagrams (CMD) from the B and V magnitudes were used to analyze the membership of the clusters and to determine the reddening, distanced modulus, and distances to the probable members of the clusters. E(B-V) = 0.55 +/0.02 mag, the distance modulus is 9.0 mag +/0.1 mag, and distance is 290 +/100 pc for Dolidze 27. Alessi 10 is reddened by 0.22 +/0.01 mag, and has a distance modulus of 9.4 +/0.1 magnitudes, and a distance of 550 +/100 pc. Known proper motions from Hipparchos for the brighter stars in the regions were also used to determine cluster membership. The stars of Dolidze 27 had average proper motions of $\mu\alpha$ = -7.50 mas and $\mu\delta$ = -13.94 mas, and the stars of Alessi 10 had $\mu\alpha$ = 3.06 mas and $\mu\delta$ = -6.84 mas.

165.07

WIYN Open Cluster Study: Binary Orbits and Tidal Circularization in NGC 6819

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We are conducting a comprehensive stellar radial-velocity survey in NGC 6819, a rich, intermediate age (~2.4 Gyr) open cluster with [Fe/H]~-0.05. As of October 2006, we have obtained 7065 radial-velocity measurements of 1409 stars using the WIYN Hydra Multi-Object Spectrograph, with typical velocity measurement precisions of ~0.4 km/s. Using an E/I criterion of 3, we have identified 282 velocity variables. In the past year we have expanded the number of final orbital solutions by 45 to a total of more than 80 solutions.

In coeval stellar populations, circular binaries tend to have the shortest orbital periods, while longer period binaries show a distribution of non-zero eccentricities. The circularization of the shortest period orbits is the result of an exchange of stellar and orbital angular momentum due to tidal interactions. We defined a population's *tidal circularization period* as the longest orbital period at which a binary of typical initial eccentricity has become circularized (e.g., has evolved to an eccentricity $e = 0.01$) over the lifetime of the cluster (Meibom & Mathieu, 2005, ApJ, 620, 970). We are studying the trend of increasing tidal circularization periods with population age. Preliminary results in NGC 6819 indicate a tidal circularization period of ~7.5 days, which is consistent with this overall trend. We will recalculate the tidal circularization period in order to include the latest sample of orbital solutions.

This comprehensive survey also allows us to investigate the relative spatial distributions of spectroscopic binaries and other constant-velocity cluster members of similar mass. We find the spectroscopic binaries to be more centrally concentrated at a statistically significant level, which we attribute to energy equipartition processes.

MM was supported by REU NSF grant AST-0453442. RDM, SK, KTH, and SM were supported by NSF grant AST-0406615.

165.08

WIYN Open Cluster Study: Signature(s) of Main Sequence Lithium Depletion Mechanism(s) from Subgiants of the Old (6-7Gyr) Open Cluster NGC 188

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We present Li abundances in subgiants of the old (6-7Gyr) open cluster NGC 188, derived from high signal-to-noise, high resolution (R~15,000) spectra obtained with the Hydra multi-fiber spectrograph on the WIYN 3.5m telescope. These data multiply by a large factor the number of Li observations reported for this cluster. Membership and binarity were evaluated on photometric, proper motion, and radial velocity data. A variety of physical mechanisms have been proposed to explain the Li depletion that occurs in F dwarfs during the main sequence. Each mechanism leaves a distinct signature in the profile of the Li preservation region (abundance of Li vs. stellar depth). As surface convection zones deepen during subgiant evolution, they can reveal the signature(s) of the dominant main sequence Li depletion mechanism(s). Data from our previous work on the slightly younger (4-5 Gyr) M67 open cluster argued against models with diffusion and mass loss and in favor of models with rotationally induced (slow) mixing. Subgiants in NGC 188 have slightly lower mass than those in M67 (and come from a slightly cooler portion of the late F dwarf main sequence). Our conclusions from our NGC 188 data are compared and contrasted to those from our M67 data. See also our poster on NGC 188 dwarfs (Gill et al.) This work is supported by the National Science Foundation grant AST-04-52975 via the REU program at Indiana University.

165.09

WIYN Open Cluster Study: Lithium Abundances in Dwarf Stars of the Old (6-7Gyr) Open Cluster NGC 188

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[1]Indiana University and Brown University, [2]Indiana University, [3]Clemson University.

We present Li abundances in dwarfs of the old (6-7Gyr) open cluster NGC 188, derived from high signal-to-noise, high resolution (R~15,000) spectra obtained with the Hydra multi-fiber spectrograph on the WIYN 3.5m telescope. These data multiply by a large factor the number of Li observations reported for this cluster. Membership and binarity were evaluated on photometric, proper motion, and radial velocity data. NGC 188 is possibly the oldest open cluster for which Li data exist. A variety of physical mechanisms have been proposed to explain the Li depletion that occurs in F dwarfs during the main sequence. We compare our Li data to various model predictions, and to other star clusters. See also our poster on NGC 188 subgiants (Trentadue et al.). This work is supported by the National Science Foundation grant AST-04-52975 via the REU program at Indiana University.

165.10

WIYN Open Cluster Study: Lithium in the Young and Metal-Poor Cluster M36

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We present Li abundances in 154 late A, F, G, K, and early M dwarfs that are photometric candidate members of M36 (NGC 1960), derived from high resolution (R~13,000) spectra obtained with the Hydra multi-fiber spectrograph on the WIYN 3.5m telescope. Radial velocity measurements from our data show that a majority of these stars are also radial velocity members. M36 is a young (~40 Myr) and metal-poor ([Fe/H] ~ -0.3) open cluster; this makes it an interesting comparison cluster for the young and near solar-metallicity ([Fe/H] = -0.034 +/0.024 [Boesgaard & Friel, 1990]) Pleiades cluster. The A, F, G, and early K dwarfs in M36 show a rather flat plateau with little Li dispersion, at a Li level that is marginally below that of the Pleiades Li plateau. We interpret this M36 Li plateau as reflecting the undepleted M36 initial cluster Li abundance, and its level is consistent with the hypothesis that Galactic Li production resulted in a higher level for the (undepleted) Pleiades Li plateau. We also find that: a) the coolest dwarf are depleted relative to the plateau level and b) they have nonetheless suffered significantly less Li depletion than Pleiades dwarfs of the same Teff. This supports the robust prediction, from standard stellar evolution theory, that pre-main sequence depletion of the surface Li abundance in K and M dwarfs depends on metallicity: higher metallicity should result in greater Li depletion. This work is supported by the National Science Foundation through grant AST-0206202.

165.11

The Composition of the Old, Metal-Rich Open Cluster, NGC 6791

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The populous open cluster, NGC 6791, has presented an anomaly as it appears to be very old (8-10 Gyr), yet metal-rich. We have made high resolution (45,000) spectroscopic observations of two turn-off stars (V = 17.4) with HIRES on the Keck I telescope on Mauna Kea. We have determined the stellar parameters for these two stars spectroscopically. The high metallicity of NGC 6791 is confirmed by our results, [Fe/H] = +0.40. In addition we have found elemental abundances for Na, Si, Ca, Ti, Ni, Cr and Y. We compare our results with those of field star samples that are both old and metal-rich: a) six dwarf stars with [Fe/H] > +0.01 and age > 8.5 Gyr from Edvardsson et al. (1993), b) nine old dwarf stars with [Fe/H] from +0.05 to +0.39 from Chen et al. (2003), and c) four old dwarf stars with [Fe/H] from +0.15 to +0.47 from Feltzing & Gonzalez (2001). The abundances of these elements are in agreement in the field and in the cluster with the possible exception of Ti which appears higher in the cluster stars; it is not clear why Ti would be enhanced when Si and Ca are not. We discuss the possible interpretations of the cluster peculiarities.

This research was supported by NSF through the REU program to the Institute for Astronomy, AST04-53395, and by a grant to AMB, AST05-05899.

165.12

The Search for Low Amplitude Pulsational Variable Stars in Six Open Clusters

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We have used the Robust Median Statistic (RoMS) to examine a set of six open clusters to look for low amplitude pulsating variable stars. The clusters examined were NGC 225, NGC 559, NGC 6811, NGC 6940, NGC 7142, and NGC 7160. Two pieces of information will be presented. First we will discuss the effectiveness of the RoMS in providing a probability of variability for stars in our sample. In addition, we will present light curves and other information for the new variable stars and suspected variable stars found in each cluster. Data for this project were collected with the 0.4-m David Derrick Telescope of the Orson Pratt Observatory on the BYU campus and with the 1.85-m Plaskett Telescope of the Dominion Astrophysical Observatory in Victoria, Canada.

165.13

Variable Star Search in the Open Cluster NGC 6659

William Gray[1], E. G. Hintz[2]
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As part of a wider program to examine characteristics of open clusters we examined the sparse open cluster NGC 6659 to look for short to medium period variable stars. NGC 6659 was selected since it has received very little attention and to test previously designed reduction techniques on a sparse field. Data was acquired on the 0.4-m David Derrick Telescope of the Orson Pratt Observatory on the campus of BYU. From the data set one solid candidate for variability was found. We will present results on the entire cluster and give a description of the candidate variable star.

This research was conducted as part of a summer Research Experience for Undergraduates program held at BYU. We would like to acknowledge NSF grant PHY-0552795.

165.14

A Search for Variable Stars in the Field of NGC 7092 (M39)

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The open cluster NGC 7092 (M39) was observed for 8 nights during the years 2004-2006. Five nights were taken from the 0.4-m David Derrick Telescope of the Orson Pratt Observatory at Brigham Young University in Provo, Utah. Three others employed the 0.3 and 0.4-m telescopes at the BYU West Mountain Observatory. All frames were taken using B, V, or R filters; data were analyzed using standard aperture photometry techniques. Series of short and long exposures were taken for comparison of surface as well as deep-field study. A total of 228 stars were studied and differential photometry techniques applied to determine variability. Of these, 10 are suspected short-period variables which will be presented.

166: Tests of Gravity, and Alternative Theories of Gravity
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

166.01

The Implication of MOND for Dark Haloes

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It is always interesting that how much implication that Milgrom's relation could provide, even phenomenologically. With just one assumption that the gravitational acceleration goes like 1/r instead of Newton's law, $1/r^2$, when the acceleration is smaller than the value $\$10^{-10}m/sec^2$, it is well known that MOND can give a better description of the rotational curves in spiral galaxies. In this research, we explore the configuration of the parameter space for the dark haloes by fitting the rotation curves of halo profiles with the exponential disk for stellar mass to that of MOND. In addition, we find that the baryon mass to the halo mass ratio is lower than the primordial ratio which gives that the total baryon mass is about 15% of the dark matter, and which is consistent with what we generally expect today.

166.02

Solar System tests DO rule out 1/R gravity

Tristan L. Smith[1], A. L. Erickcek[1], M. Kamionkowski[1]
[1]*Caltech.*

Shortly after the addition of a 1/R term to the Einstein-Hilbert action was proposed as a solution to the cosmic-acceleration puzzle, Chiba showed that such a theory violates Solar System tests of gravity. A flurry of recent papers have called Chiba's result into question. They argue that the spherically-symmetric vacuum spacetime in this theory is the Schwarzschild-de Sitter solution, making this theory consistent with Solar System tests. We point out that although the Schwarzschild-de Sitter solution exists in this theory, it is not the unique spherically-symmetric vacuum solution, and it is not the solution that describes the spacetime in the Solar System. The solution that correctly matches onto the stellar-interior solution differs from Schwarzschild-de Sitter in a way consistent with Chiba's claims. Thus, 1/R gravity is ruled out by Solar System tests.

166.03

Testing Alternative Theories of Gravity with Long Term Pulsar Timing

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Long-term pulsar timing offers a unique opportunity to test alternative theories of gravity. As it turns out, pulsar timing is extremely sensitive to longitudinal gravitational wave modes. We place upper limits on the strain amplitude of longitudinal modes and discuss the theoretical implications of this result.

166.04

21st Century Gravity

Tom Van Flandern[1]
[1]*Meta Research.*

The strongest of six experiments showing without ambiguity that gravity is faster than the speed of light (*c*) sets a lower limit to the propagation speed of gravitational force of 20 billion *c*. Such speeds are allowed and are causal in Lorentzian relativity. Meanwhile, changes in gravitational potential account for the relativistic effects of gravitation such as light-bending, and they propagate at speed *c*. This dichotomy of speeds strongly favors the Le Sage model for the physical interpretation of relativistic gravitation over the now-dubious geometric interpretation. In the former, space is filled with a flux of ultra-fast, ultra-small "gravitons". Then the apple falls from the tree, not because of a force originating within the Earth, but because Earth blocks part of an otherwise isotropic flux striking the apple. These concepts are now extensively developed in the references below.

** "Possible new properties of gravity", Astrophys.&SpaceSci. 244:249-261 (1996)

** "The speed of gravity What the experiments say", Phys.Lett.A 250:1-11 (1998)

** "Reply to comments on 'The speed of gravity'", Phys.Lett.A 262:261-263 (1999)

** "Experimental Repeal of the Speed Limit¼", Found.Phys. 32:1031-1068 (2002)

** *Pushing Gravity*, M. Edwards, ed., Apeiron Press, Montreal, 93-122

** Meta Research "Gravity" CD, http://metaresearch.org/ (available at meeting)

167: Stars, Gas and their Motions in Dwarfs and Irregulars
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

167.01

Magnetic Fields in Irregular Galaxies: NGC 4214

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Magnetic fields are an important component of the interstellar medium of galaxies. They provide support, transfer energy from supernovae, provide a possible heating mechanism, and channel gas flows (Beck 2004). Despite the importance of magnetic fields in the ISM, it is not well known what generates and sustains galactic magnetic fields or how magnetic fields, gas, and stars interact in galaxies. The magnetic fields may be especially important in low-mass galaxies like irregulars where the magnetic pressure may be great enough for the field to be dynamically important. However, only four irregular galaxies besides the LMC and the SMC have observed magnetic field structures. The goal of our project is to significantly increase the number of irregular galaxies with observed magnetic field structure. Here

we present preliminary results for one of the galaxies in our sample: NGC 4214. Using the VLA and the GBT, we have obtained 3cm, 6cm, and 20cm radio continuum polarization observations of this well-studied galaxy. Our observations allow us to investigate the effects of NGC 4214's high star formation rate, slow rotation rate, and weak bar on the structure of its magnetic field. We find that NGC 4214's magnetic field has an S-shaped structure, with the central field following the bar and the outer edges curving to follow the shape of the arms. The mechanism for generating these fields is still uncertain.

A. Kepley is funded by an NSF Graduate Research Fellowship.

167.02

Evidence for Tidal Heating in the Dynamics of LMC Carbon Stars and Red Supergiants

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We present an analysis of the kinematics of the HI gas, carbon stars, and red supergiants of the Large Magellanic Cloud. After correcting the line-of-sight velocities for the recent accurate measurement of the LMC's space motion, we find that each kinematic tracer clearly defines a flat rotation curve with similar shape but different amplitude for each tracer: 61 km s^{-1} for the carbon stars, 80 km s^{-1} for the HI gas, and 107 km s^{-1} for the red supergiants. We suggest that noncircular motions of the stars and gas in the LMC can at least in part explain the different rotation amplitudes. A significant fraction, 7-15%, of the total sample of carbon stars appears to be associated with previously identified tidal HI streamers. In addition, although the local velocity dispersion of the red supergiants is small, ~8 km s^{-1}, their velocity dispersion about the carbon star rotation solution is 17 km s^{-1}, equal to the velocity dispersion of the carbon stars themselves. We thus appear to be witnessing the tidal heating of the LMC's stellar populations.

167.03

Kinematics of the dE Galaxy IC 225

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We present the preliminary findings of a kinematic study of the low luminosity elliptical galaxy IC 225. This object is of considerable interest as it contains two bright nuclei which could give credence to the theory of dwarf elliptical (dE) formation through mergers. We present Integral Field Unit (IFU) data of the dE from the Gemini-North Multi Object Spectrograph (GMOS) Integral Field Unit (IFU) taken December of 2005. We present a new comprehensive reduction plan for data of this sort. From the reduced IFU data, we present several 2D maps of the region including higher order Balmer lines and the [OIII] doublet at λλ4959, 5007. From these images we conclude that within IC 225, the off-center nucleus is almost certainly associated with a large cloud of gas. There is evidence that the gas is rotating about the geometrical center of the galaxy but that the stellar velocity of the young star cluster, or off-center nucleus, is distinct from the velocities of the stars in the main body of the galaxy.

167.04

An Examination of Kinematic Properties of Dwarf Irregular Galaxies

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We present an investigation of the kinematic properties of twenty-eight dwarf irregular galaxies using spatially resolved neutral hydrogen maps from the Very Large Array. We explore several scaling relations, including both the classical and baryonic Tully-Fisher relations, mass relations, and metallicity-luminosity relations and offer comparisons to gas rich late-type spirals. In addition, we examine correlations between dark and luminous matter (stellar and gaseous) for the dwarf irregular galaxies with both optical and neutral hydrogen images. While it is known that dwarf irregular galaxies fall off the classical Tully-Fisher relation, further support is offered for the baryonic Tully-Fisher relation being the underlying relation for both spiral and dwarf irregular galaxies. We discuss these results in the context of downsizing and galaxy evolution.

167.05

Outer Disks of Dwarf Irregular Galaxies: Stars and Gas

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We compare deep optical images and HI interferometric maps of two dwarf irregular galaxies in order to explore the relationship between stars and gas in their outer disks. The V-band surface photometry extends to 29 mag/arcsec^2. Between R_{25} and $R_{\rm H}$ the stellar exponential profiles in both galaxies sharply change slopes, becoming steeper in the outer parts. This change in the stellar density suggests a change in the star formation process at that radius. We explore the reasons for that change by comparing the optical profiles with those of the HI, the material from which star-forming clouds develop. From the HI maps we measure azimuthally-averaged gas surface densities and gas velocity dispersions. We also compute the ratio of gas surface density to the critical density for large-scale gravitational instabilities that would allow the formation of clouds. We compare the gas density and kinematic profiles with the surface brightness profiles of the stars before and after the break. We also compare the gas surface density profiles of these galaxies with dwarf irregulars of similar luminosity that do not have breaks in their stellar exponential disk profiles.

This research has been funded by the Lowell Research Fund.

167.06

An Interaction Induced Transformation of I Zw 18? New Results from A-Array VLA Observations

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We present the results of high spatial resolution neutral hydrogen synthesis observations of the extremely metal-poor starbursting dwarf galaxy I Zw 18. Examination of neutral hydrogen maps made from the combination of data obtained in the A, B, C, and D configurations of the Very Large Array yields a peak HI column density of 2.4 ξ 10^{22} atoms cm^{-2} at 1.6″ spatial resolution (~120 pc linear resolution, assuming a distance of 15 Mpc). As expected, the peak gas column densities are associated with the intense starburst regions in the southeast and northwest. At this linear resolution, the gas distribution is clumpy and irregular. As seen in previous low resolution maps, there is a significant velocity gradient across the main body of I Zw 18. Further, the linear and clumpy nature of the extended gas distribution south of the main body is suggestive of a tidal tail. We examine the gas distribution and kinematics of I Zw 18 in the context of a possible dwarf-dwarf galaxy interaction and tidal stirring.

167.07

Investigation of Star Formation in Dwarf Iffedular Galaxies Using Ultra-violet Photometry

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[1]James Madison University, [2]Lowell Observatory.

Ultra-violet photometry is added to a multi-wavelength investigation of star formation in dwarf irregular (dIm) galaxies. We obtained FUV (1516 Angstrom) and NUV (2267 Angstrom) images of 13 dIm galaxies from the GALEX (Galaxy Evolution Explorer) satellite archives, and combined them with UBVJHK and Halpha images. Halpha may not be an effective tracer of recent star formation in the outer parts of galaxies, but UV photometry has the potential to trace star formation to large radii. We found that the UV does reveal recent star formation beyond where Halpha nebular emission ends in about half of the galaxies. The UV colors are consistent with star formation in the outer parts of these galaxies being either constant or having occurred in 10-200 Myr old bursts. Surface brightness profiles show that the

UV light decreases in brightness faster with radius than visual light in most of the galaxies, suggesting that the density of the young stars drops off faster than that of the older stars.

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167.08

Oxygen Abundances in Starbursting Transition Dwarfs

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We present HII region oxygen abundances for five starbursting low-luminosity galaxies. The sample was selected to have central starbursts with transition dwarf morphologies, i.e. the starbursts are embedded in smooth stellar envelopes resembling dE-like systems. We further selected our sample to have low MHI/LB < 0.1. Objects in this sample are candidates for being near the end of their star forming careers, as gas exhaustion timescales are < 1 Gyr. These systems have surprisingly high oxygen abundances, with values near solar. Evidently the starburst came from internal gas and a significant fraction of the synthesized metals are retained. We propose that these objects are a subclass of low-gas content blue compact dwarfs (BCDs), which have retained their metals and are now nearing the end of their starburst phase.

This research is supported in part by NSF grant AST 98-03018 and the University of Wisconsin Graduate School.

167.09

A Spitzer/IRAC Census of the Asymptotic Giant Branch Populations in Local Group Dwarfs

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We present a Spitzer/IRAC near-IR imaging census of the AGB stars in the three Local Group dwarf irregular galaxies IC 1613, WLM, and Sextans A. By combining our IR data with optical imaging of these galaxies we find that 39-55% of the AGB stars detected in the IR are not detected in the optical and an additional 4-11% of the AGB stars are misidentified as sub-TRGB red giants in the optical, presumably due to extinction by circumstellar dust. We compare our IR photometry of IC 1613 and WLM with narrow-band optical data and find that only 18-19% of the AGB stars detected in the IR are seen in these studies. We detect a number of sources in each galaxy that have IR fluxes consistent with them being mass-losing AGB stars, and derive total present day mass-loss rates of 2-4 x 10^-4 solar masses per year. In all three galaxies the distribution of mass-loss rates and bolometric luminosities of AGB stars, as well as the empirical maximum mass-loss rates are in excellent agreement with those found in the LMC and SMC.

This work is supported by NASA JPL/SSC-1256406, 1215746).

167.10

Diffraction Limited Imaging of the Stellar Population of IC 10 with Laser Guide Star Adaptive Optics and the Hubble Space Telescope

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We present near-infrared Keck laser guide star adaptive optics (AO) images of the central starburst region of the Local Group dwarf irregular IC 10. The field is centered on the putative Wolf-Rayet (W-R) object [MAC92] 24. We compare these H and K' band data with an F814W image obtained with the Hubble Space Telescope. Because systematic error in AO photometry is potentially large due to uncertainties in the point spread function (PSF), we have used the Fourier power spectrum method of Sheehy, McCrady and Graham (ApJ, 647, 1517) to reduce it to 0.04 mag., or less. The W-R object [MAC92] 24 is resolved into at least six blue stars. Four of these components have near-IR colors and luminosities that make them robust WN star candidates. By comparing the K' versus [F814W]-K' color-magnitude diagram we find that the stellar population is best represented by two distinct periods of star formation, one ~ 10 Myr ago and one significantly older (150-500 Myr). We derived reddening and distance estimates by matching the location of Carbon stars in the IC10 color-magnitude diagram (CMD) with that in the SMC CMD, as well as by locating the tip of the giant branch in the IC10 F814W, H, and K' luminosity functions. We find from the Carbon stars a distance modulus for IC 10 of about 24.5 mag., and from the tip of the giant branch a weighted mean distance modulus of (m-M) = 24.48 +/0.08 with a systematic error of +/0.16 mag due to possible mismatches between the RGB populations of IC 10 and the SMC.

167.11

High Resolution Mapping of Expanding Shells in IC10

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We present the results of an investigation of the effects of massive star formation on the neutral hydrogen (HI) gas in the interstellar medium of the dwarf starburst galaxy IC10. Studies suggest that energy output from star formation has a significant impact on the dynamics of the ISM, contributing to further star formation and galactic evolution. However, due to interactions between structures in the ISM, only a small fraction of the energy put out by the massive stars in IC10 seems to be transferred to the gas.

Using high-resolution (~2") 21-cm wavelength radio telescope data collected at the Very Large Array, we estimate the mass and velocity of the HI gas in these shells and determine its kinetic energy. Using optical data from the Hubble Space Telescope, we locate stars within the shells and obtain their energy output. Comparing these data sets allows us to determine how much of the stars' energy output goes into the kinetic energy of the ISM.

This work was supported by the National Science Foundation's REU program and the Department of Defense's ASSURE program through NSF Award AST-0453442.

168: Stellar Populations II
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

168.01

Hafnium and the R-Process in the Sun and Metal-Poor Stars

Christopher Sneden[1], J. E. Lawler[2], E. A. Den Hartog[2], Z. E. Labby[2], J. J. Cowan[3], I. Ivans[4]
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New laboratory radiative lifetimes accurate to about $\pm 5\%$ for 41 odd-parity levels of Hf II have been combined with FTS-based emission-line branching fractions to determine transition probabilities for 150 lines of Hf II. Approximately half of these new transition probabilities overlap and are in excellent agreement with recent independent measurements by Lundqvist et al. (2006). Our new laboratory data include all known strong Hf II transitions in wavelength regimes accessible to ground-based spectroscopy of cool stars. These gf-values are applied to refine the hafnium photospheric solar abundance and to determine hafnium abundances in 10 metal-poor giant stars with enhanced r-process abundances (those with[Fe/H] +0.5). For the Sun we derive log ε(Hf) = 0.88 $\pm$ 0.08 from four lines; the uncertainty is due to the intrinsic weakness of the Hf II lines, and their usually significant blending by other spectral features. We find that the r-process-rich stars exhibit constant Hf/La and Hf/Eu abundance ratios, log ε(Hf/La) = -0.13 $\pm$ 0.02 (σ = 0.06) and log ε(Hf/Eu) = +0.04 $\pm$ 0.02 (σ = 0.06). The observed average stellar abundance ratio of Hf/Eu and La/Eu is larger than previous estimates of the solar system r-process-only value, arguing for a larger r-process contribution to Hf and La abundances. The newly determined Hf values could be employed as part of the chronometer pair, Th/Hf, to determine radioactive stellar ages.

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168.02

Isotopic Abundances of Eu, Ba, and Sm in Metal-Poor Stars

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We have examined the isotopic mix of the heavy neutron (n)-capture elements Eu, Ba, and Sm in three metal-poor stars with different enrichment histories. Isotopic abundances are more fundamental than elemental abundances as probes of the contributions from the rapid (r) and slow (s) nucleosynthesis reactions. We use our isotopic abundances in conjunction with elemental abundances of many heavy n-capture elements to constrain the nucleosynthetic history of these metal-poor stars. HD 122563 is a very metal-poor giant that has a clear underabundance of n-capture elements ([Fe/H]=-2.7, [Eu/Fe]=-0.5, [Ba/Fe]=-1.0). HD 175305 is a metal-poor giant that is enriched in r-process material ([Fe/H]=-1.5, [Eu/Fe]=+0.5). HD 196944 is a very metal-poor giant star that is enriched in s-process material ([Fe/H]=-2.3, [Ba/Fe]=+1.1). We have acquired new high-resolution (R~130,000) and high-S/N (S/N~160-1000) observations of these three stars with the 2.7m Harlan J. Smith Telescope at McDonald Observatory using the 2dcoude spectrograph. We present our measurements of the isotopic abundances of Eu, Ba, and Sm in these three stars. This research has been supported by U.S. National Science Foundation grants AST 03-07495 and AST 06-07708.

168.03

Revisiting Zirconium: New Abundance Determinations with Improved Oscillator Strengths

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The element Zirconium is produced via neutron capture (n-capture). It resides in the mass range where there is uncertainty about the production mechanism at early time. The rapid n-capture process (r-process) was believed to be responsible for the production, but no study (Burris et al 2000, Gilroy et al 1988 and others) has been able to successfully use the r-process to reproduce the abundance signature for elements in this mass range for metal-poor halo stars. It has been suggested (Sneden and Cowan 2003) that there may be an undiscovered component to the r-process. New transition probabilities for Zr II have been reported by Malcheva et al (2006). We utilize these values to make new abundance determinations for Zr in the Sun and the metal-poor halo star BD +17 3248.

This work is supported in part by the AAS Small Grant Program, the Arkansas Space Grant Consortium and the UCA Undergraduate Research Council.

168.04

Lanthanum and Europium Abundances in a Large Sample of Galactic Disk Dwarf Stars

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Elemental abundance trends within the thin and thick disk stellar populations of the Milky Way argue for distinct large-scale evolution within those populations. Recent studies of the abundance trends of thin and thick disk stars have found that the run of [alpha/Fe] with [Fe/H] differs significantly, indicating unique star formation histories (Reddy et al. 2006, Brewer & Carney 2006, Bensby et al. 2003). The heavy element contributions are also different in the two populations, such that the r-process element [Eu/Fe] is higher at a given [Fe/H] in thick disk stars. In the thick disk, the s-process/r-process ratio may be lower overall (Mashonkina & Gehren 2001, Bensby et al. 2005). This evidence of the varying contributions of low and high mass stars is of particular interest in light of the possibility of chemical substructure in the Galactic disk. Based on high resolution (R~40,000) and high signal-to-noise (S/N~100) spectra of 600 nearby dwarf stars, we will present the s-/r-process ratio in the local disk population as traced by the abundace ratio La/Eu. Stellar parameters have been derived from photometry. The sample covers 800 K in effective temperature (5400 K $<$ Teff $<$ 6200 K) and 0.7 dex in metallicity (-0.5 dex $<$ [Fe/H] $<$ +0.2 dex). For such a large number of spectra we employ an abundance measurement technique based on minimizing the Chi-squared fit to synthetic template spectra. Stellar kinematics and population assignments have been calculated for the entire sample, which is composed primarily of thin disk stars.

168.05

Lithium Production in Asymptotic Giant Branch Stars

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When stars undergo helium shell burning, they are subject to many different mixing processes which contribute to unusual elemental abundances found in these stars. ^{7}Lithium burns at relatively low temperatures; however, it is found in these asymptotic giant branch (AGB) stars. This should not be possible, except through the production of lithium via hot bottom burning and the Cameron-Fowler mechanism. In this study, 122 AGB candidates were analyzed for possible lithium production. Lithium abundances (or upper limits) were determined for these stars using MOOG, as well as [Fe/H], radial velocity, and rotational velocity estimates. This project was conducted in ten weeks during the McDonald Observatory REU program funded under NSF AST-0243745

168.06

Beryllium in Extremely Metal Deficient Stars

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The very low metal stars ([Fe/H] $<$ -3.0) were formed in the earliest days of the galaxy. Spallation reactions, the main progenitor of Be, are tied to the rate of supernovae. Therefore, the abundance of Be in low metal, older stars is a tracer of massive star formation within our galaxy. There is also evidence of a primordial Be plateau at very low metallicities, a result of some inhmogeneous Big-Bang models. We analyze high S/N HIRES spectra (resolution of ~45,000) of several very low metal stars taken with the Keck I telescope on Mauna Kea in order to determine the history of Be abundance and explore the possible Be plateau.

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168.07

Metallicity in the Solar Neighborhood Out to 60pc

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We present an overview and early results on a continuing large-scale project to examine spectra of solar-type stars in the solar neighborhood out to 60pc. Physical parameters for approximately 4,000 stars have been determined and these are used to generate synthetic spectra. We have developed computer programs to help automate the process from synthetic spectrum generation to metallicity determination. Initial metallicity estimates for almost 3,000 stars have been calculated based on low resolution spectra. Results from this project will be useful in answering questions about chemical homogeneity in the solar neighborhood and developing age-metallicity relationships. We gratefully aknowledge the support of the NSF through grants AST 00-86576 and AST 02-39518.

168.08

The Most Metal-Poor Candidates in SDSS-I DR-5

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There are some 194,000 R = 2000 stellar spectra reported in the final public release of the Sloan Digital Sky Survey (SDSS-I), known as DR-5. Setting aside the stars observed during the course of early tests for the Sloan Extension for Galactic Understanding and Exploration (SEGUE), which will be considered in the future, this leaves a total of about 168,000 stellar spectra. The stars in this sample were targeted for a wide variety of reasons, and hence do not represent a

sample from which an unbiased metallicity distribution function (MDF) of stars in the halo or thick-disk populations may be drawn. However, there exist some 6500 stars with estimated metallicities [Fe/H] < -2.0 and effective temperatures in the range 5000K < Teff < 7000K among this sample, based on application of the SDSS/SEGUE spectroscopic analysis pipeline described in other contributions at this meeting.

This sample represents, by a factor of more than three, the largest database of very metal-poor stars yet assembled. A least 1000 of these stars have $g < 16.5$, and hence are amenable to high-resolution spectroscopic studies with presently available large-aperture telescopes. We report on the catalog of these stars, and consider the shape of the low-metallicity tail of the halo MDF derived from these data.

Funding for the SDSS and SDSS-II has been provided by the Alfred P. Sloan Foundation, the Participating Institutions, the National Science Foundation, the U.S. Department of Energy, the National Aeronautics and Space Administration, the Japanese Monbukagakusho, the Max Planck Society, and the Higher Education Funding Council for England. The SDSS Web Site is http://www.sdss.org/.

168.09

A Search for Evidence of an Abundance Gradient in the Galactic Halo Based on Stars from SDSS-I DR-5

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One of the classical tests of the early dynamical evolution of the Milky Way is the prediction of the monolithic collapse model (e.g., Eggen, Lynden-Bell, & Sandage 1962) of a decline in the mean stellar abundance of the halo population as one proceeds to stars at greater distances, or equivalently, with higher local space velocities in the solar neighborhood. This stands in contrast to the prediction of galaxy formation within the Cold Dark Matter paradigm, where assembly from multiple fragments (e.g., Searle & Zinn 1978) would not be expected to produce an abundance gradient in the halo. Although several attempts have been made in the past to test this idea, all such efforts have been limited by small sample sizes, concerns about selection biases, or both. We are presently analyzing a very large sample of over 24,000 stars selected as calibration objects (used for providing checks on the spectrophotometric flux and reddening corrections) from SDSS-I DR-5. These stars are primarily F (and early G-type) turnoff stars in the thick-disk and halo populations of the Galaxy. The color-based selection ensures that an adequate number (several thousand) of very low-metallicity ([Fe/H] < -2.0) stars exist in order to search for the presence (or not) of a halo abundance gradient. Accurate estimates of radial velocity, metallicity, temperature, surface gravity, and distance are obtained for all of these stars by application of the (still evolving) SDSS/SEGUE spectroscopic analysis pipeline discussed in other contributions at this meeting. This information is combined with proper motions derived from the recalibrated USNOB-2 catalog, as discussed by Munn et al. (2004), in order to obtain estimates of their full space motions. Results on the search for a halo abundance gradient, based on these data, will be reported.

168.10

High-Resolution Calibration of the SDSS/SEGUE Spectroscopic Analysis Pipeline

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We present a discussion of efforts to obtain external validation of the estimated atmospheric parameters (Teff, log g, [Fe/H]) obtained from medium-resolution (R = 2000) SDSS spectroscopy and ugriz photometry, which are being employed for both the completed SDSS-I and the ongoing SEGUE survey. The SDSS/SEGUE spectroscopic pipeline makes use of a number of methods for the estimation of each parameter, with estimated internal errors on the order of σ(Teff) = 150~K, σ(log g) = 0.4 dex, and σ([Fe/H]) = 0.3 dex. Over the course of the past two years, we have obtained over 100 high-resolution optical spectra of SDSS/SEGUE stars using the HET, KECK and SUBARU telescopes. For the KECK/HIRES spectra, which have R = 40000, we have performed standard high-resolution analyses to estimate the stellar parameters. For the HET and KECK-ESI data, which have R = 15000 and R = 5000, respectively, we have performed synthetic spectra matching in order to to estimate the stellar parameters. We find that the derived stellar parameters agree well with the SDSS/SEGUE pipeline estimates for the temperature range 5000~K < Teff < 6500K; the errors are of the order of the internal errors expected from the SDSS/SEGUE pipeline. For effective temperatures in the range 4000~K to 5000~K the estimated parameters from the high-resolution spectroscopy exhibit offsets relative to the SDSS/SEGUE pipeline values on the order of ΔTeff = 200~K, Δlogg = 0.8 dex, and Δ[Fe/H] = 0.4 dex. Similar offsets exist for stars with T > 6500~K. The main reason for these offsets appears to arise due to varying microturbulence, for which the medium-resolution SDSS spectra are not sensitive. We also have performed external checks on pipline radial velocities. We find that the errors in radial velocities are on the order of 7 km/s for stars, which is at the expected level.

168.11

A New Calibration of [Fe/H] and [C/Fe] Estimates for Medium-Resolution Spectra of Carbon-Enhanced Metal-Poor Stars

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In recent years it has become clear that a significant fraction (on the order of at least 20%) of Galactic halo stars with [Fe/H] < -2.0 exhibit strong enhancements of carbon, with [C/Fe] > +1.0. The availability of many thousands of medium-resolution spectra from previous (and ongoing) surveys such as the HK survey of Beers and colleagues, and the Hamburg/ESO Survey of Christlieb and collaborators, provide the opportunity to identify and quantify the distribution of [C/Fe] over a wide range of [Fe/H] and stellar evolutionary states. In order to quickly obtain this information, previous attempts have been made to develop a calibration of line index estimates of [Fe/H] and [C/Fe] based on the observed strengths of the CaII K line and the CH G-band feature. The methodology developed by Rossi et al. (2005) relied on a sample of some 120 stars with available high-resolution spectroscopic estimates of [Fe/H] and [C/Fe], as well as 2MASS J-K colors, to carry out such a calibration. Unfortunately, the sample of calibration objects did not include numerous stars with effective temperatures (and carbon abundances) over the full range that is required for some applications. Recently the numbers of potential calibration objects has increased dramatically, to over 500 stars, due to the completion of several large high-resolution spectroscopic studies (e.g., Barklem et al. 2005, Cohen et al.

2005, Spite et al. 2005, and Aoki et al. 2006). In addition, new carbon-enhanced model atmospheres from which synthetic spectra and colors can be estimated have become available. We explore the use of these new data and tools and develop a revised calibration that is expected to be superior in many respects to previous attempts.

168.12

Evidence that R Coronae Borealis Stars Evolve from a White Dwarf Merger rather than a Final Helium Shell Flash

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We have discovered, mainly using Gemini/GNIRS, that several hydrogen-deficient carbon (HdC) and R Coronae Borealis (RCB) stars, have 18O/16O ratios close to and sometimes exceeding unity, a value orders of magnitude greater than measured in other known stars (the Solar value is 1/500). This discovery is an important step in determining the evolutionary pathway of HdC and RCB stars in general, for which two models have been proposed: double degenerate (white dwarf (WD) merger), and the final helium-shell flash (FF). The FF model for producing RCB stars has been discredited recently due to a mismatch of abundances and timescales needed to produce the RCB stars. We have explored the idea that HdC and RCB stars originate in the merger of COand He-WDs in the light of the new observations. Understanding the RCB and HdC stars is a key test for any theory that aims to explain hydrogen deficiency in post-AGB stars. These new results on the 18O/16O ratio and our work on the FF star V605 Aql represent an opportunity for a huge breakthrough. Confirmation of the WD merger scenario, which is suggested, by both the models and these observations, will allow the use of RCB and HdC stars as probes for WD merger simulations. The ability to model the rates of these low-mass WD mergers will help us to understand the rates of more massive mergers that may make some type Ia supernovae.

168.13

Dust at Low Metallicity: Spitzer Observations of AGB Stars in NGC 6822

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Dust condensation may depend heavily on the metallicity, although the effect is poorly known. The total condensed dust mass from stars at low metallicity could be lower, there could be more simple oxides and fewer silicates, and the degree of silicate crystallinity could be lower. We have obtained mid-infrared spectra with the Spitzer Space Telescope of a sample of 20 Cand O-rich asymptotic giant branch (AGB) stars in the Local Group dwarf galaxy NGC 6822. To our knowledge this is the first time such evolved stars have been spectroscopically observed in this galaxy. We compare our results to those for AGB stars in the Galaxy and in the Magellanic Clouds. We intend to contribute to an improved understanding of dust formation in general and to provide the ability to use grain properties and dust composition as a tool to trace physical conditions in nearby galaxies. This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

168.14

Infrared Identification of Herbig AeBe stars in the Small Magellanic Cloud

Sweta Shah[1], L. D. Keller[1], N. Chitrakar[1]
[1]Ithaca College.

Observations of Herbig Ae/Be (HAeBe) stars in the Small Magellanic Cloud (SMC) can help us gain insight into how proto-planetary disk evolution and subsequent planet formation proceed in a chemically metal poor environment relative to the Milky Way Galaxy. Several research groups have used the EROS microlensing survey to identify erratically variable A and B type stars that also have H-alpha emission. We have searched the Spitzer Space Telescope archive at the coordinates of these candidate HAeBe stars and found mid-infrared fluxes (5.8, 8.0, and 24 micron) for three of them. This may indicate thermal emission from circumstellar dust and adds new evidence for the HAeBe classification. In advance of a detailed mid-IR spectroscopic study, we present the optical, near-infrared, and mid-infrared photometry for these three candidates

and an analysis of their HAeBe classification. We will also present an analysis and classification of the HAeBe candidates that were not detected in the Spitzer surveys of the Magellanic clouds.

168.15

The SDSS-II/SEGUE Spectroscopic Parameter Pipeline

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The Sloan Extension for Galactic Understanding and Exploration (SEGUE) is one of three key projects in SDSS-II. SEGUE is in the process of obtaining ugriz imaging of some 3500 square degrees of sky outside of the SDSS-I footprint, with special attention being given to scans of lower galactic latitudes in order to better probe the disk/halo interface in the Galaxy. Over one-third of the imaging has already been completed. SEGUE is also obtaining R = 2000 sectroscopy over the wavelenth range 380 900 nm for 250,000 stars in 200 selected areas over the sky available from Apache Point, New Mexico. The spectroscopic candidates are selected on the basis of ugriz photometry to populate some 16 target categories of stars chosen to explore the nature of the stellar populations in the Galaxy as a function of distance from the Sun (from 0.5 kpc to over 100 kpc).

The SEGUE data clearly require automated analysis tools in order to extract the maximum amount of useful information. In this contribution we describe the development and execution of the SEGUE spectroscopic analysis pipeline, which makes use of multiple approaches (including spectral matching, neural network analysis, line index calculations, etc.) in order to estimate the fundamental stellar atmospheric parameters (effective temperature, surface gravity, and [Fe/H]). These approaches are in the process of being extended to include determinations of other elemental abundances (e.g., C, Na, Mg) that the SDSS spectra probe.

Funding for the SDSS and SDSS-II has been provided by the Alfred P. Sloan Foundation, the Participating Institutions, the National Science Foundation, the U.S. Department of Energy, the National Aeronautics and Space Administration, the Japanese Monbukagakusho, the Max Planck Society, and the Higher Education Funding Council for England. The SDSS Web Site is http://www.sdss.org/.

169: Extrasolar Planets VII: Surveys
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

169.01

Observation of Transiting Extrasolar Planets and Gamma-ray Bursts with Robotic Telescopes

Jay Fisher[1], T. R. Young[1]
[1]Univ. Of North Dakota.

Using UND's TOAST observatory to search for extrasolar planets using the transit method and pinpointing the optical afterglows associated with Gamma-ray Bursts in conjunction with NASA's SWIFT satellite. Refining the current system to reduce systematic errors and reduce the detection

margin. Developing a new system, namely the CRUST observatory, to overcome the limitations of the current operation. A positive detection of a known transiting planet TrES-1 proved the viability of the system to continue to detect known and unknown extrasolar transiting planets. Small telescope projects, like this one, thus have the potential to continue to make contributions to observations of transiting extrasolar planets. This research was made possible by the North Dakota EPSCoR-AURA Program.

169.02

An Extrasolar Planet Transit Search in NGC 188

Laura Portscheller[1], B. Kelly[1], K. Kinemuchi[1], C. Kobulnicky[1]
[1]*University of Wyoming.*

We present early results from an ongoing observational undergraduate research project aimed at locating extrasolar planets in the inner 8' of the open cluster NGC 188 by means of the transit detection method. Beginning in the summer of 2006 to the present, weather permitting, we have gathered optical CCD data two nights a week at the 0.9 m Red Buttes Observatory telescope located near Laramie, Wyoming. To date, we have accumulated 20 nights of data. Additionally, we are developing the final stages of our data reduction process which incorporates psf fitting and a relative photometry correction. We will be forming light curves of the stars in our field and expect to find many eclipsing binary star systems or other variable-type stars. Due to instrumentation restrictions, the only probable planetary transit candidate we will be ale to resolve is of the giant Jovian type. We anticipate having preliminary results by spring 2007. This research is supported by Wyoming NASA Space Grand Consortium.

169.03

Planet Detection and Simulations from Multi-Object Spectrograph Surveys

Stephen R. Kane[1], D. P. Schneider[2], J. Ge[1]
[1]*University of Florida,* [2]*Pennsylvania State University.*

The development of multi-object spectrographs for use in radial velocity surveys is expected to increase the detection rate of extra-solar planets by at least an order of magnitude. The dramatic increase in data acquisition requires that a robust method be developed which is able to adequately screen the data for planet candidates. We present simulations of the expected results from a generic multi-object survey based on calculated noise models and sensitivity for the instrument and the known distribution of exoplanetary system parameters. This is applied to a survey of several fields using the W.M. Keck Exoplanet Tracker instrument, the design of which utilises a dispersed fixed-delay interferometer, which is currently being used on the Sloan Digital Sky Survey 2.5m telescope. We have developed code for automatically sifting and fitting the planet candidates produced by the survey to allow for fast follow-up observations to be conducted. The techniques presented here may be applied to a wide range of multi-object planet surveys.

169.04

Exoplanet Tracker Observations with a Monolithic Fixed-Delay Interferometer: First Steps Towards Long-term Stability

Scott W. Fleming[1], S. Mahadevan[1], X. Wan[1], C. Dewitt[1], A. Hariharan[1], D. McDavitt[1], J. van Eyken[1], J. Ge[1]
[1]*University of Florida.*

We present initial results from observations of a set of standard stars using the Exoplanet Tracker (ET) instrument at Kitt Peak National Observatory with a monolithic fixed-delay interferometer. By using a monolithic fixed-delay interferometer we eliminate any moving components associated with the actively-controlled interferometer that is currently used by the ET instrument. We observe stars with known short-period planets as well as RV-stable reference stars. We obtain an estimated RMS of 10 m/s on the RV stable star 36 Uma as well as estimated RMS values of 11.1 and 12.5 m/s for the known planetary systems rho Crb and 55 Cnc, respectively. Use of a monolithic fixed-delay interferometer, combined with a temperature and pressure controlled environment, could produce a long-term stable ET instrument capable of performing an all-sky survey for long-period planets, including those in the Habitability Zone of their parent star.

169.05

Monitoring the Long-term Radial Velocity Stability of the New Generation Multi-object Keck Exoplanet Tracker at the Sloan Telescope

Kaike Pan[1], S. Snedden[1], J. Ge[2], J. van Eyken[2], S. W. Fleming[2], S. Kane[2], C. Warner[2]
[1]*APO-NMSU,* [2]*UF.*

We present early results of a four-month monitoring campaign (Sept.-Dec. 2006) of radial velocity long-term stability for sixty fibers on a new generation fiber-fed multi-object Doppler instrument, called the W. M. Keck Exoplanet Tracker(Keck ET). This instrument with 60 object capability, has been commissioned at the Sloan Digital Sky Survey (SDSS) 2.5-m telescope at Apache Point Observatory. Since its commissioning, the instrument has been used for a trial planet survey in May and June 2006. After the August engineering run, the instrument performance (throughput, image quality and Doppler precision) has been substantially improved. The Keck ET along with several clones will be used to conduct an All Sky Extrasolar Planet Survey (ASEPS) in 2006-2020 (Ge et al 2006, SPIE, 6269, 75).

169.06

Latest Results from the Multi-Object Keck Exoplanet Tracker

Julian C. Van Eyken[1], J. Ge[1], X. Wan[1], B. Zhao[1], A. Hariharan[1], S. Mahadevan[1], C. DeWitt[1], P. Guo[1], R. Cohen[1], S. W. Fleming[1], J. Crepp[1], C. Warner[1], S. Kane[1], F. Leger[2], K. Pan[3]
[1]*Univ. of Florida,* [2]*Fermilab,* [3]*Apache Point Observatory.*

The W. M. Keck Exoplanet Tracker is a precision Doppler radial velocity instrument based on dispersed fixed-delay interferometry (DFDI) which takes advantage of the new technique to allow multi-object RV surveying. Installed at the 2.5m Sloan telescope at Apache Point Observatory, the combination of Michelson interferometer and medium resolution spectrograph allows design for simultaneous Doppler measurements of up to 60 targets, while maintaining high instrument throughput.

Using a single-object prototype of the instrument at the Kitt Peak National Observatory 2.1m telescope, we previously discovered a 0.49MJup planet, HD 102195b (ET-1), orbiting with a 4.11d period, and other interesting targets are being followed up. From recent trial observations, the Keck Exoplanet Tracker now yields 59 usable simultaneous fringing stellar spectra, of a quality sufficient to attempt to detect short period hot-Jupiter type planets. Recent engineering improvements reduced errors by a factor of ~2, and typical photon limits for stellar data are now at the 30m/s level for magnitude V~10.5 (depending on spectral type and v sin i), with a best value of 6.9m/s at V=7.6. Preliminary RMS precisions from solar data (daytime sky) are around 10m/s over a few days, with some spectra reaching close to their photon limit of ~6-7m/s on the short term (~1 hour). A number of targets showing interesting RV variability are currently being followed up independently. Additional engineering work is planned which should make for further significant gains in Doppler precision.

Here we present the latest results and updates from the most recent engineering and observing runs with the Keck ET.

TUESDAY

169.07

Measuring Precise Stellar Barycentric Radial Velocities with a Dispersed Fixed-Delay Interferometer: Implications for a Multi-Object Survey

Suvrath Mahadevan[1], J. van Eyken[1], J. Ge[1], C. Dewitt[1], S. Fleming[1], R. Cohen[1], J. Crepp[1], A. vanden Heuvel[1]
[1]*University of Florida.*

We demonstrate the ability to measure precise barycentric stellar radial velocities using the Exoplanet Tracker (ET), a new instrument primarily designed for precision differential Doppler velocity measurements. Our barycentric radial velocities, derived from observations taken at the KPNO 2.1 meter telescope, differ from those of Nidever et al. by 0.047 km/s (RMS) when simultaneous iodine calibration is used, and by 0.120 km/s (RMS) without simultaneous calibration. Our results effectively show that a Michelson interferometer coupled to a spectrograph allows precise measurements of barycentric radial velocities even at a modest spectral resolution of R ~5000-6000. A large multi-object survey to find extrasolar planets using an instrument based on the ET prototype is already underway at the Sloan 2.5 meter telescope and can observe up to 500 stars per night in the magnitude range 7.6<V<13. An All Sky Exoplanet Survey (ASEPS) using this instrument and its clones will be able to observe ~3000 stars per night. Over the next 12 years the ASEPS survey will observe hundreds of thousands of stars in an effort to discover a large number of extrasolar planets. This survey will also produce precise barycentric radial velocities for all these stars using the data analysis techniques reported here. Such a large kinematic survey at high velocity precision will be useful in identifying the signature of accretion events in the Milky Way and understanding local stellar kinematics.

169.08

Eclipse Mapping of Hot Jupiters

Emily Rauscher[1], K. Menou[1], S. Seager[2], D. Deming[3]
[1]Columbia University, [2]Carnegie Institution of Washington, [3]NASA Goddard Space Flight Center.

In principle, the photospheric temperature structure of an extrasolar planet can be resolved by measuring the shape of the infrared light curve as the planet passes into secondary eclipse behind its parent star. We consider the feasibility of using this method to constrain current atmospheric models of tidally-locked hot Jupiters, which experience extreme heating on their permanent daysides. We find that the Spitzer Space Telescope lacks the sensitivity necessary to differentiate between even the most disparate models in a reasonable number of eclipse measurements. However, the upcoming James Webb Space Telescope will be an incredible asset, with enough sensitivity to distinguish detailed temperature structure in one or a few eclipses. This work was supported by NASA grant NNG06GF55G.

169.09

Simulations of Exoplanet Spectroscopy with JWST

Matthew Johnson[1], J. Valenti[2]
[1]Wesleyan Univ., [2]STScI.

We conducted several simulations to investigate the feasibility of obtaining spectroscopy of extrasolar planets using the Near-Infrared Spectrograph (NIRSpec) on the James Webb Space Telescope (JWST). NASA's Kepler Mission, which is scheduled for launch in 2008, expects to find a wealth of both Jupiter-mass and Earth-mass planets transiting their host stars which could serve as candidates for NIRSpec observations when JWST launches. Using current published specifications of NIRSpec and models of star and planet spectra, we determined lower magnitude bounds for which spectral features can be resolved for planets around host stars of various spectral classes. We also investigated other parameters, such as transit length and orbital period, and their effects on the signal to noise and quality of the simulated spectra. We acknowledge the Space Telescope Science Institute summer student program for funding this project.

169.10

New Worlds Observer: Optical Simulation

Tiffany M. Glassman[1], A. Lo[1], W. Cash[2]
[1]Northrop Grumman Space Technology, [2]University of Colorado.

New Worlds Observer is an external occulter concept designed to detect optical wavelength light from Earth-like planets around solar neighborhood stars. The telescope spacecraft operates in the "shadow" cast by the occulter spacecraft, which suppresses the central starlight by a factor of greater than 10^{10}. The geometric and optical characteristics of this shadow are described here with respect to the occulter size, occulter shape, and telescope to occulter separation. Imaging of the exo-planet is discussed, and the effective point spread function of the occulter is given, with a discussion on the expected exo-planet throughput. We also give a brief discussion of the spectroscopy that might be done with the occulter, including possible instrument configurations and the expected spectroscopic signal to noise as a function of integration time, for various absorption lines of interest.

169.11

New Worlds Observer: Orbit and Sky Coverage

Amy Lo[1], R. Malmstrom[1], T. Guilmette[1]
[1]Northrop Grumman Corporation.

New Worlds Observer is an external occulter concept designed to detect optical wavelength light from Earth-like planets around solar neighborhood stars. NWO uses a multi-petal external occulter situated tens of thousands of kilometers away from a telescope to suppress the central starlight by a factor of greater than 10^{10} to allow direct exo-planet observation. Due to the large separation, the occulter needs to move large distances off orbit. We discuss possible orbits for NWO which achieves 4π steradian sky coverage during mission lifetime. In particular, we focus on an L_2 Lissajous orbit which achieves full coverage every year, with an instantaneous 1.6π steradian viewing zone. We discuss the fuel requirements of slewing, alignment, and stationkeeping.

169.12

On the Feasibility of Detecting UV Auroral Emission from Extrasolar Giant Planets (EGPs)

Michele Cash[1], E. Agol[1]
[1]University of Washington.

We present an analysis of the expected ultraviolet auroral emission strengths from extrasolar giant planets and the feasibility of detecting such exoplanetary aurora. Searching for and studying the ultraviolet auroral emission generated by extrasolar giant planets has unique advantages not offered by other methods. First, UV auroral emission is a means of detecting a planet directly as opposed to the indirect methods employed to date, such as radial velocity and pulsar timing. Second, the detection of an auroral signature would provide evidence of the presence of a planetary magnetic field. No other detection method can provide such evidence. Third, UV auroral emission could play a role in characterizing the near space environment around these planets, providing information about basic atmospheric composition and the deposition energies of the impacting particles. Fourth, ultraviolet wavelengths provide observational advantages compared to the optical. For instance, more favorable contrast ratios can be achieved and the UV diffraction limit allows planets to be detected at smaller angular separations to their host stars. Using Jupiter as a template and taking into account some basic properties involved in auroral production, possible emission fluxes were estimated for a given set of planetary system parameters. Potential candidate planets for UV observations are identified and the possibility of detecting UV auroral emissions with current and future technology is explored.

This research has been supported by NSF IGERT Grant No. DGE-9870713 through the Astrobiology Program at the University of Washington, Seattle.

169.13

Spectral Bandwidth: A Key TPF Challenge for Achieving Adequate SNR

Martin C. Noecker[1], S. Kilston[1]
[1]Ball Aerospace & Tech. Corp..

The two essential tasks for direct observation of terrestrial extrasolar planets, the goal of the visible-light Terrestrial Planet Finder (TPF), are (1) suppressing noise contributed by host-star photons while simultaneously (2) collecting enough signal photons from the billion-times fainter planet. Of

the concepts proposed to accomplish the first task, most require exquisite optical quality and stability, including extremely precise wavefront control (with a deformable mirror, or DM). This compensates the initial wavefront imperfections, to keep the stellar photons away from the detector pixels at the planet location. However, practical wavefront control generally achieves adequate starlight suppression only over a narrow spectral bandwidth, typically less than 20%. We describe and summarize here the kinds of spectral bandwidth performance limitations expected for the following candidate concepts for TPF: (a) the classical Lyot coronagraph; (b) the phase-induced amplitude apodization coronagraph; (c) the shaped pupil coronagraph; (d) the optical vortex coronagraph; (e) the visible nulling coronagraph; and (f) the external occulter coronagraph. The driving issues include wavelength scaling in Fraunhofer diffraction, spectral dispersion of optics, Fresnel propagation effects, and wavelength dependence of actuators. We will comment on the difficulty and prospects for each challenge.

169.14

Characterization of Exoplanet Orbits Using a Monte Carlo Bayesian Analysis

Jonathan Arenberg[1], T. Schuman[1], A. Lo[1]
[1]*Northrop Grumman.*

This poster discusses the problem of “recovery” of an exo-planet. Recovery refers to observations of exo-planets after the initial look. Previously introduced Monte Carlo models are used to calculate all of the probable positions of an exo-planet after an initial observation. During this initial look, the exo-planet may either be detected or not detected. We present the probable positions of the exo-planet as a function of time between the first and second observations, for both the detected and not-detected cases. This set is used to generate the following information: probability of exo-planet residency in its stellar habitable zone; likelihood of exo-planet detection if not detected during the initial look; completeness as a function of recovery time; and optimal time intervals between successive observations. We include our top 20 list of stars that may harbor terrestrial planets.

169.15

The PIAA Coronagraph Prototype: First Laboratory Results.

Eugene Pluzhnik[1], O. Guyon[1], S. Colley[1], B. Gallet[1], S. Ridgway[2], R. Woodruff[3], S. Tanaka[1], M. Warren[4]
[1]*Subaru Telescope, NAOJ,* [2]*NOAO,* [3]*Lockheed Martin Space Corporation,* [4]*Axsys Technologies, Inc.*

The phase-induced amplitude apodization (PIAA) coronagraph combines the main advantages of classical pupil apodization with high throughput (~100%), high angular resolution (~2λ/D) and low chromaticity. These advantages can allow direct imaging of nearby extrasolar planets with a 4-meter telescope. The PIAA coronagraph laboratory prototype has been successfully manufactured and starts to operate at the Subary Telescope facility. We present here our first laboratory results with this prototype where we have achieved $2x10^{-6}$ contrast within 2 λ/D. We also discuss the main constrains limiting the contrast and describe our future efforts.

This work was carried out under JPL contract numbers 1254445 and 1257767 for Development of Technologies for the Terrestrial Planet Finder Mission, with the support and hospitality of the National Astronomical Observatory of Japan.

170: The Undergraduate Astronomy Course for Non-Majors
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

170.01

How Are Students’ Interests in Astronomy Affected by Doing Projects in ASTR 101 at a Two Year College?

Noella L. D’Cruz[1]
[1]*Joliet Junior College.*

We teach introductory astronomy to non-science majors at a two year college in suburban Chicago. In the Fall 2006 semester, to promote awareness of the transit of Mercury amongst the college community, about 175 students have been asked to do projects related to this event or to the solar system. Groups of 3 or 4 students work on one project. The projects are being presented as posters that will be on display for the entire college to view. In addition to creating the posters, students will individually report on a project other than their own. We are studying how doing such projects affects the non-science major students’ interest in astronomical events and astronomy in general.

170.02

For a Better Grade in Astronomy, Write About It

Ana M. Larson[1], N. Kool[1], C. Beyer[1]
[1]*Univ. Of Washington.*

The goal of the interdisciplinary writing program (IWP) at the University of Washington is to help students learn about writing in a particular discipline. A writing link with Astronomy 101 was begun Spring Quarter, 2002. Almost immediately the instructors involved noticed a secondary effect: as a group, those students enrolled in the IWP link did better overall in the Astronomy 101 course. We investigate this trend for almost all quarters since then. We also address the statistics that show the backgrounds of the students in the IWP link do not differ significantly from the general astronomy population, leaving other possibilities for their doing better in all aspects of the introductory course.

170.03

Is the Promise of Space Worth the Price? College Students Weigh In

Jo Eliza Pitesky[1], J. Turner[2]
[1]*JPL,* [2]*UCLA Department of Physics and Astronomy.*

For the past two years, we have offered an undergraduate science seminar as part of the Fiat Lux program at UCLA. Entitled ″To Boldly Go: NASA, Your Money in Space″, the course is aimed at non-science majors, and designed with the ″concerned voter″ in mind. The course reviews the many activities of NASA, its accomplishments, and their costs, including a study of the federal budget and general consumer spending. The course focuses on the local NASA center, the Jet Propulsion Laboratory. The students summarize their findings with a paper on the topic ″Are current NASA funding priorities correct: What I would do if I were the NASA Administrator″, followed by a tour of JPL. By the end of the course, most of the students display a much more informed and nuanced view of government-sponsored science and engineering programs.

170.04

Use of Clickers in Introductory Astronomy Courses at California State University Sacramento

Christopher L. Taylor[1]
[1]*California State University, Sacramento.*

The use of clickers in introductory Astronomy classes was begun at California State University, Sacramento in the 2005-2006 academic year. One year later we describe the integration of this technology into the large lecture hall setting. The most challenging aspect has been the design of non-trivial activities that are suited to the multiple choice format of the clicker systems that are able to provoke the students into active participation in their own learning. Activities are designed to 1) test student comprehension of basic facts; 2) reiterate conceptual material discussed in lecture; and 3) get the students to apply the concepts in ways not explicity discussed in lecture. Examples of successful and non-successful activities will be discussed. The effect of the use of clickers on student learning outcomes will also be discussed.

170.05

The Story of Astronomy: An Activities-Based, Historical Approach to Classroom Instruction

Alan W. Hirshfeld[1]
[1]*Univ. of Mass., Dartmouth.*

Missing from the standard introductory astronomy course is the essential "story line" that tells how astronomers came to know so much about the universe. Without such context, students find it hard to engage with the presentation of scientific principles and knowledge, no matter how logically organized. Through a series of in-class, modestly mathematical, paper-and-pencil activities, coupled with brief lectures and available online simulations, non-science students can recapitulate the epic advancement of astronomical thought, from the rudimentary observations of prehistoric skywatchers to the development of modern astrophysics. Examples of the activities are presented. The new approach was implemented during the Fall 2006 semester in the introductory astronomy course at UMass Dartmouth, to a total of 250 students. As structured, the course can serve both as a standalone, one-semester introduction to science and an effective lead-in to a "standard" introductory astronomy course.

170.06

A Spectrum is Worth a Thousand Pictures

Richard F. Gelderman[1]
[1]*Western Kentucky Univ..*

A wise astronomer once pointed out that if a picture is worth a thousand words, then a spectrum is worth a thousand pictures. Unfortunately, spectra are rarely emphasized in the introductory astronomy courses and few students exit such a course with any meaningful understanding or appreciation of spectroscopy. Part of the problem is lack of background knowledge; the typical introductory astronomy student has little experience with spectroscopy or atomic physics. Another issue is that spectra are not pretty pictures and are not intuitively understandable.

We present and discuss a series of "minds-on" exercises and activities built into a college-level "stars, galaxies, and cosmology" intro astronomy course. The lessons are structured to help students improve their ability to recognize patterns and improve their ability to really see the details in front of them. Another goal is for students to realize there is "more than meets the eye"; to learn how to discover "hidden" diagnostics, such as different sources of light their eyes see as white light. A curriculum that emphasizes spectroscopy also provides the opportunity to stress the story of the "Harvard Women," a tale that bridges gender gaps and often humanizes scientists in the eyes of non-science majors. Finally, with a solid foundation in spectroscopy, students are better prepared to understand exciting topics such as Hubble's Law and the importance of primordial nucleosynthesis.

170.07

The Astronomy Workshop: Computer Assisted Learning Tools with Instructor Support Materials and Student Activities

Grace Deming[1], D. Hamilton[1], M. Hayes-Gehrke[1]
[1]*Univ. of Maryland.*

The Astronomy Workshop (http://janus.astro.umd.edu) is a collection of interactive World Wide Web tools that were developed under the direction of Doug Hamilton for use in undergraduate classes, as supplementary materials appropriate for grades 9-12, and by the general public. The philosophy of the website is to foster student and public interest in astronomy by capitalizing on their fascination with computers and the internet. Many of the tools were developed by graduate and undergraduate students at UMD. This website contains over 20 tools on topics including scientific notation, giant impacts, extrasolar planets, astronomical distances, planets, moons, comets, and asteroids. Educators around the country at universities, colleges, and secondary schools have used the Astronomy Workshop's tools and activities as homework assignments, in-class demos, or extra credit. Since 2005, Grace Deming has assessed several of the Astronomy Workshop's tools for clarity and effectiveness by interviewing students as they used tools on the website. Based on these interviews, Deming wrote student activities and instructor support materials and posted them to the website. Over the next three years, we will continue to interview students, develop web materials, and field-test activities. We are targeting classes in introductory undergraduate astronomy courses and grades 11-12 for our Spring 2007 field tests. We are interested in hearing your ideas on how we can make the Astronomy Workshop more appealing to educators, museum directors, specialty programs, and professors. This research is funded by NASA EPO grants NNG04GM18G and NNG06GGF99G.

170.08

Calibrated Peer Review Essays Increase Confidence in Self-assessment

Lauren Likkel[1]
[1]*Univ. of Wisconsin -Eau Claire.*

We studied the effect of the web-based tool "Calibrated Peer Review" ™ on student confidence in their ability to recognize the quality of their own work. CPR can be used in large enrollment classes to allow a controlled peer review of moderate length student essays. We expected that teaching students how to grade an essay and having them grade their own work would increase confidence in assessing the quality of their own essays, and the results support this.

Three introductory astronomy classes participated in this study during 2005 at the University of Wisconsin Eau Claire, a four year university. Four essays were assigned in both the experimental class (104 students) and the control classes (34 students). In the comparison classes, the student was given a score on the essay and perhaps a few written comments. The experimental group used the CPR tool, in which they are taught how to evaluate the essay, evaluate assignments written by peers, and evaluate their own essay.

Three survey questions were used to characterize the change in confidence level in ability to assess their own work. The survey results from a survey at the end of the semester were compared to results from the same survey administered at the beginning of the semester. A measurable effect on the average confidence level of the experimental class was found. By the final survey, significantly more of the CPR students had changed to a more positive statement in indicating their confidence in evaluating their own written work. There was no effect seen on the classes that wrote essays but did not use the CPR system, showing that this result is due to using the CPR system for the essays, not just writing essays or becoming more confident during the course of the semester.

170.09

Astro 001 through an Interactive, Multimedia Science Fiction Story

Christopher Palma[1], J. C. Charlton[1], N. Tr'Ehnl[1], K. A. Herrmann[1], A. Narayanan[1]
[1]*Penn State Univ..*

We present a preview of a new, fully on-line astronomy course for undergraduate non-science majors at Penn State, to be offered for the first time in Spring 2007, with an expected enrollment of 300-600 students. The entire course content is conveyed through an interactive story, capitalizing on the many multimedia astronomy resources publically available on the WWW. The four units of the course, basic astronomy and the nighttime sky, our solar system, stars and the Milky Way Galaxy, and extragalactic astronomy and cosmology deliver the same content as a traditional Astro 001 course. The story for our first unit involves a student abducted by aliens and taken to another planet. There the student is confronted with puzzles involving a different stellar system configuration. The final unit involves a student's quest for a career, aided by visits to alien civilizations in which they explain their varied views of life which is shaped by cosmological findings. The four units are united by a character, the Riddler, who poses riddles about various aspects of the course, and whose identity and purpose is revealed gradually as a reward for completion of various subtopics. This initial offering of the course will be entirely web-based except for traditional evening in-class exams. Our own exams and a standardized preand post-assessment will be used to benchmark our students' performance against those from our traditional course.

We gratefully acknowledge funding from an STScI IDEAS award.

170.10

Course Components for Large Astronomy Lectures

Michael Stage[1], S. Schneider[1]
[1]*Univ. of Massachusetts.*

Large sized introductory astronomy classes (100-300+) pose unique problems to instructors because of the wide range of student background and ability. We present some of the techniques we are using in the astronomy survey course at UMass to help that wide audience develop an appreciation of the methods of science and some of the key concepts in astronomy and physics. We also present and invite discussion about the methods we have used for assessment: in-class response (″clickers″--see also related special session), online homework, surveys, and exams. In particular, we have found that classes respond best to physical demonstrations, and we comment on some ways to focus the students' attention during them. In particular, even for live demonstration the video camera is an extremely important tool. We also describe how we try introduce a sense of ″experiment″ rather than just ″demonstration″ to concepts of the tilt of the Earth, gravity, brightness, and spectroscopy. Ultimately, we are able to create a package of demonstration, lecture material, and assessment questions, that becomes a course ″component.″

170.11

CAPER Team Innovations in Teaching and Learning in ASTRO 101

Timothy F. Slater[1], E. E. Prather[1], J. M. Bailey[2], E. Bardar[3], G. Brissenden[1], E. F. Dokter[1], D. Hudgins[4], J. Keller[5]
[1]*Univ. of Arizona,* [2]*Univ. of Nevada Las Vegas,* [3]*Boston Univ.,* [4]*Rockhurst Univ.,* [5]*Cal Poly.*

The *Conceptual Astronomy and Physics Education Research* (CAPER) Team, based at the University of Arizona but drawing on the collective expertise of astronomy educators around the world, is conducting scholarly research and developing instructional strategies in an effort to support high-quality astronomy teaching. One avenue of research is focused on creating and validating conceptual inventories that instructors can use to measure the effectiveness of their instructional interventions. We have recently completed new inventories in the topic areas of (1) light and spectra; (2) stars and stellar formation; and (3) planetary atmospheres and the greenhouse effect. In addition, we are using results from research on students' naive beliefs and reasoning difficulties to development instructional strategies that promote a learner centered classroom. Our research into the effectiveness of two such curriculum projects (*Lecture-Tutorials for Introductory Astronomy* and *Ranking Tasks for Introductory Astronomy*) show that these curriculum result in statistically significant gains in student understanding across a broad range of topics, much greater than lecture alone. A third avenue of research centers on improving how ASTRO 101 is taught on a national level. Informed by our continual evaluation and fine tuning of different forms of collaborative group learning and peer instruction teaching strategies, we have developed a multi-day series of workshops that are designed to help faculty better implement innovative teaching strategies that promote a learner-centered teaching environment in the ASTO 101 large lecture course. The workshops are being assessed and iteratively improved through formative evaluation approaches aimed at determining to what extent they have a positive impact on classroom practice.

171: UDF and DEEP2
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

171.01

Lyman-alpha Emitters in the HUDF: A Population of Low Mass, Star Forming Galaxies

Norbert Pirzkal[1], S. Malhotra[2], J. E. Rhoads[2], C. Xu[1]
[1]*STScI,* [2]*Arizona State University.*

We present observations of the Ly-alpha galaxies at reshifts $4<z<5.5$ detected in the Hubble Ultra Deep Field. We show that these objects are young, low mass objects with characteristic ages of a few 10^6 Myr and masses $< 10^8$ $M_{\odot}$. These objects were identified based on the presence of strong Lyman-alpha emission in their low resolution ACS slitless spectra.

We present both our morphological analysis of these sources as well as our estimates of their masses, ages, and metalicities. The latter estimates are based on a thorough SED fitting of the broad band photometry that is available for these objects and using an extensive number of models. We have combined extremely deep HST/ACS, HST/NICMOS, VLT/ISAAC, and Spitzer/IRAC observations of these objects to provide us with a continuum rest-frame wavelength coverage ranging from the UV to the optical.

We observe that the color of these objects is extremely blue, and consistent with being dominated by a population of very young stars. The IRAC infrared observations, corresponding to the rest-frame optical, furthermore allow us to set upper limits on the amount of older stars present in these objects. We conclude that the Lyman-alpha emitters that we identified in the HUDF, and which should constitute a nearly complete sample between the redshifts of $4<z<5.5$, are smaller, and sometimes significantly smaller, than 10^8 $M_{\odot}$. We further discuss the implications of having detected such low mass objects at these redshifts.

171.02

Surface Brightness Properties of z~4-6 Galaxies in the HUDF

Nimish P. Hathi[1], R. A. Jansen[1], S. H. Cohen[1], R. A. Windhorst[1], S. Malhotra[1], J. Rhoads[1]
[1]*Arizona State Univ..*

The Hubble Ultra-Deep Field (HUDF) provides imaging deep enough that we can study surface brightness properties for a representative sample of high redshift galaxies at z=4-6. By separately coadding V, i' and z'-band HUDF images of sets of z~4,5,6 objects, pre-selected to have nearly identical sizes and shapes, we are able to study the averaged radial structure of these objects at much higher signal-to-noise. We observe evolution of the radial surface brightness profiles with redshift, and place the observed differences within the context of galaxy formation scenarios.

Additionally, a comparison of the UV surface brightness from z=0-6 shows little evolution in the surface density of star-formation in star-forming galaxies. We use this as a Tolman test to confirm the cosmological surface brightness dimming expected under standard cosmological models.

This work was supported by HST grant GO 10530.

171.03

The Unresolved Stellar Populations of Galaxies in the HUDF

Russell E. Ryan, Jr.[1], R. A. Jansen[1], S. H. Cohen[1], R. A. Windhorst[1]
[1]*Arizona State Univ..*

We present preliminary results of a pixel-by-pixel stellar population study of well-resolved, intermediate redshift (z~1) galaxies in the Hubble Ultra-Deep Field. We fit the publicly available HST images from ACS and NICMOS with stellar population synthesis models (Bruzual & Charlot 2003) at each pixel for galaxies with measured spectroscopic redshifts. This allows us to simultaneously estimate the stellar mass, star formation rate, age, and extinction from the best-fit model SED at each pixel. Given the NICMOS pixel size (0.09 ″/pix) and the typical galaxy redshift (z~1), we estimate these parameters on sub-kiloparsec linear scales in each galaxy.

Support for this work was provided by NASA through grant number AR-10974.01A from the Space Telescope Science Institute, which is operated by AURA, Inc., under NASA contract NAS 5-26555.

171.04

Emission Line Galaxies in PEARS: A 2-D Detection Method

Amber Straughn[1], G. Meurer[2], J. Gardner[3], S. Malhotra[1], N. Pirzkal[4], N. Hathi[1], S. Cohen[1], R. A. Windhorst[1], J. Rhoads[1], C. Xu[4], C. Gronwall[5], PEARS Team
[1]*Arizona State University,* [2]*Johns Hopkins University,* [3]*Goddard Space Flight Center,* [4]*Space Telescope Science Institute,* [5]*Pennsylvania State University.*

The PEARS (Probing Evolution And Reionization Spectroscopically) project provides an enormous dataset of low-resolution spectra from thousands of galaxies in the GOODS North and South fields. Here we present results of a search for emission line galaxies in PEARS using a unique 2D detection method that utilizes the observation that many emission lines originate from clumpy knots within galaxies (Meurer 2005). This 2D line-finding method proves to be useful in detecting emission lines from compact knots within galaxies that might not otherwise be detected using more traditional 1D line-finding techniques. Preliminary results in the Hubble Ultra Deep Field indicate that ~5% of galaxies--79 in total--to 27 mag display prominant emission lines. ~14% of these 79 galaxies display a merging/interacting morphology. Completion of the remaining ACS fields will result in a catalog of 600-900 emission line sources. From these line emitters we can derive the luminosity function of [OII] and [OIII] lines at z= 0.5-1.

This research was supported by the NASA Harriett G. Jenkins Predoctoral Fellowship Program and HST Grant 10530.

171.05

The Luminosity Function of Lyα Emitters at z=3.1

Robin Ciardullo[1], C. Gronwall[1], T. Hickey[1], E. Gawiser[2], J. J. Feldmeier[3], MUSYC Collaboration
[1]*Penn State Univ.,* [2]*Yale Univ.,* [3]*Youngstown State Univ..*

We describe the results of an extremely deep, wide-field (0.28 deg^2) survey for z=3.1 Lyα emitting galaxies (LAEs) in the Extended Chandra Deep Field South. Using a complete sample of 162 objects with observed equivalent widths greater than 80 Å and monochromatic line fluxes brighter than 1.5 x 10^{-17} ergs-cm^{-2}-s^{-1}, we show that a) the Lyα emission-line luminosity function has a faint-end slope of α = -1.7 $\pm$ 0.3, b) the bright-end break in this function is near log L*/$L_\odot$ ~ 9.3, but is only detected at the 2 σ level, and c) the space density of LAEs above our detection threshold is 1.47 $\pm$ 0.13 x 10^{-3} $h_{0.7}{}^{-3}$ galaxies Mpc^{-3}. The space density of LAEs implies that Lyα emitters at z = 3.1 are more numerous and/or more luminous than their z = 5.7 counterparts. Moreover, the equivalent width distribution of the galaxies demonstrates that fewer than ~ 10% have the extremely high (> 240 Å) rest-frame values suggestive of Pop III star formation. By translating our fluxes into star-formation rates, we show that typical LAEs form stars at rates between 1 and 10 $h_{0.7}{}^{-2}$ $M_\odot$ yr^{-1} and that the integral star-formation rate of these objects is 1.2 x 10^{-2} $h_{0.7}$ $M_\odot$ yr^{-1} Mpc^{-3}. We show that these rates are several times less than those implied from the galaxies' UV continua, and attribute this discrepancy to the presence of a small amount of dust in the systems. These data, along with the scatter in the galaxies' rest-frame m_{1060} m_{1570} colors, suggest that Lyα emitters at z = 3.1 are not primordial Pop III objects.

This work was supported by NSF grants 00-71238 and 01-37927 and HST AR10324.01A. JF and EG acknowledge the support of NSF Astronomy & Astrophysics Postdoctoral Fellowships.

171.06

Evolutionary Behaviour in the HOD from the VVDS Data

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In the standard halo model, galaxy clustering can be explained in terms of the halo occupation model (HOD). The observed clustering of galaxies at different redshifts exhibits a 'break' in the traditional power-law slope. Using the language of the halo model, this departure from a power law can be succinctly described in terms of the one-halo and two-halo terms. We present the best fit HOD parameters of the clustering of galaxies in the Vimos-VLT Deep Survey (VVDS) upto redshift 1.5.

171.07

A GALEX Imaging Search for Lyman Continuum Emission at z~1 in the EGS

Peter G. Friedman[1], T. A. Small[1], J. M. Deharveng[2], B. Milliard[2], GALEX Science Team
[1]*Caltech,* [2]*Laboratoire d'Astrophysique de Marseille, France.*

We are using GALEX imaging data in the Extended Groth Strip (EGS) to search for Lyman continuum emission from galaxies at z ~ 1. Our method is to sum FUV image flux at locations of DEEP2 catalog galaxies in the redshift range ~1 < z < ~1.5, for which the GALEX FUV band (1350-1800A) is sensitive only to rest wavelengths below 912 A. We subtract sky flux using control locations near each catalog galaxy. Using photometric catalogs we veto galaxy and control locations near sources that might add spurious FUV flux. We normalize FUV flux using NUV flux to derive the Lyman continuum emission escape fraction. We use various galaxy attributes from DEEP2 spectra and other data to bin galaxies to search for galaxy populations with higher escape fractions. Such a finding might shed light on differences in escape fraction measurements in the literature.

GALEX is a NASA Small Explorer mission with contributions from France and South Korea.

This work uses data from the AEGIS collaboration, which is supported by grants from the National Science Foundation, NASA, and the Keck Observatory.

171.08

Measuring the Star Formation Rate of the Universe at z~1 from H-alpha with Multi-Object Near-Infrared Spectroscopy

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We have demonstrated the first near-infrared multi-object spectrograph ,CIRPASS, on the 4.2-m William Herschel Telescope (WHT) and the 3.9-m Anglo-Australian Telescope. We have conducted an Hα survey of 38 0.77 $<z<$1 galaxies over ~100 arcmin^2 of the Hubble Deep Field North and Flanking Fields, to determine star formation rates (SFRs) using CIRPASS on the WHT. This represents the first successful application of this technique to observing high redshift galaxies (Doherty et al. 2004, MNRAS 354, L7). Stacking the spectra in the rest-frame, we find a lower limit (uncorrected for dust reddening) on the star formation rate density at redshift z = 1 of 0.04M_{Sun}/yr/Mpc^3 (Doherty et al. 2006, MNRAS 370, 331). This implies rapid evolution in the star formation rate density from z = 0 to z = 1 which is proportional to $(1+z)^{3.1}$. We intend to extend our work with FMOS on Subaru as the *evolSMURF* project (the Evolution of Star-formation and Metallicity in the Universe at high Redshift with FMOS). This will represent nearly two orders-of-magnitude improvement on previous work, and for the first time will provide a sample of sufficient size to measure accurately the Hα luminosity function, and so determine the global star formation rate using the same indicator as used in local surveys. Using [O II] 3727 Å, Hβ , [O III] 5007Å and Hα redshifted into the z , J & H bands, we can chart the star formation history over 70% of the age of the Universe, affording complete coverage up to z = 1.6 with the same well-understood diagnostics. The line ratios will also allow the extinction and metallicity to be measured at z > 1. This will resolve one of the long-standing puzzles in extragalactic astrophysics the true evolution of the Madau-Lilly diagram of star formation density.

171.09

Constraining the Interaction History of Galaxies Over 4 Gyr

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[1]*University of Texas at Austin.*

The prevailing model of galaxy assembly predicts that present-day galaxies grew via successive mergers of smaller systems. Thanks to the Galaxy Evolution from Morphology and SEDS (GEMS) survey, a recent, ultra-wide, deep survey conducted with two filters on the Advanced Camera for Surveys aboard the Hubble Space Telescope, we have ~8500 high resolution images to use for investigating the merger history of the Universe. We present preliminary results of visual and quantitative classification of ~2500 GEMS galaxies across a lookback time of 3.7 Gyr, a time interval spanning 27% of the age of the Universe. We find that the fraction of galaxies with strong morphological distortions, likely resulting from tidal interactions and mergers, changes significantly with lookback time. We also illustrate the critical importance of avoiding bandpass shifting (from rest-frame optical to rest-frame UV) in the classification process. Finally, we discuss the implications of our results for the hierarchical Lambda-CDM model of galaxy evolution.

171.10

Conditional Density Analysis of The Hubble Deep Field

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The Hubble Deep Field galaxy data set is reanalyzed using conditional density methods which are more suitable for distributions of unknown correlation structure than n-point correlation statistics or the related power spectrum analyses. The large scale distribution of galaxies is known to exhibit power-law correlation on small scales (perhaps up to tens of megaparsecs) and is thought to become uncorrelated (homogeneous) on large enough scales. This sample is used to probe much larger scales and the initial angular analysis presented here shows no evidence for a change in correlation structure. This implies that the large scale distribution of luminous matter may in fact be power-law correlated on all scales. This has strong implications for current cosmological models based on the Robertson-Walker metric which describes a homogeneous space of constant curvature.

Support for this work has been provided by the NSF through the Research Experience for Undergraduates, which was hosted by the University of Hawai'i at Manoa and the Institute for Astronomy.

172: The Milky Way
AAS Poster, Tuesday, 9:20am-6:30pm, Exhibit Hall 4

172.01

A Wide Area Map of The Galactic Center at 1.1 mm

Elisabeth A. Mills[1], J. E. Aguirre[2], J. Bally[3], J. Glenn[3], M. L. Enoch[4], N. J. Evans, II[5], J. Walawender[6]
[1]*Indiana Univ.,* [2]*NRAO Jansky Fellow, CASA-University of Colorado,* [3]*CASA-University of Colorado,* [4]*Caltech,* [5]*University of Texas,* [6]*IfA-University of Hawaii.*

We present new images of two squares degrees towards the Galactic Center at 1.1 millimeters obtained with Bolocam at the CSO as a part of the Bolocam Galactic Plane Survey. Emission at this wavelength is compared with additional images from SHARC 2 at 350 microns and SCUBA at 450 and 850 microns as well as archival data from MSX and 2MASS. Infrared dark clouds observed in the MSX and 2MASS images are seen to be associated with strong emission at 1.1 mm. Dust emission spectra of several of these giant molecular clouds derived from their submillimeter and millimeter fluxes are also presented. In addition, we examine the circumnuclear disk of Sgr A* in detail.

This work was partially supported by the NRAO Research Experience for Undergraduates (REU) program which is funded by the National Science Foundation.

172.02

Modeling the Galactic Center Magnetic Field Using Synchrotron Flux Density Maps

Benjamin J. Cowin[1], M. Morris[2]
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Within the central few hundred parsecs of our Galaxy, a large-scale, diffuse non-thermal radio source (DNS) has been observed at several radio wavelengths. We have used the brightness distribution of this synchrotron source to model the strength and geometry of the large-scale magnetic field in the Galactic center region. A previous investigation of 330 and 74 MHz imaging data (LaRosa et al. 2005, ApJ 626, L23) concluded that the large-scale magnetic field in the region is relatively weak, only about 10 microgauss. However, their assumption that the magnetic field and cosmic rays are in a minimum-energy state across this region is unlikely to be valid because the ordered magnetic field implied by the vertical orientation of most of the nonthermal radio filaments observed there is inconsistent with the minimum-energy requirement that there be a substantial energy exchange between the cosmic rays and the magnetic field on time scales short compared to the energy loss time of the relativistic particles. Our new analysis of the existing DNS data abandons the minimum energy assumption, and instead assumes a cosmic ray propagation model that places the origin of the cosmic ray electrons in the Galactic disk, and invokes Liouville's theorem to yield a constant electron energy distribution function across the Galaxy, assuming that the cosmic ray electrons diffuse along the initially vertical magnetic field lines that connect the Galactic center to the disk. By tailoring the magnetic field geometry to reproduce the observed shape and intensity of the 330 MHz synchrotron emission, we find that the average field predicted by this model is at least 100 microgauss on a scale of several hundred parsecs, and the field peaks at approximately 500 microgauss at the center of the DNS.

This work was supported by an NSF/REU grant to UCLA.

172.03

New Hot Stars in the Galactic Center

Jon Mauerhan[1], M. Muno[2], M. Morris[1]
[1]*UCLA,* [2]*Space Radiation Lab, Caltech.*

We report the discovery of 3 massive post-main-sequence stars in the Galactic center region (GCR). Using K-band spectroscopy, we have identified 2 of them as nitrogen-type Wolf-Rayet (WR) stars of WN6 and WN9 subtype, and the other a B2 Ia supergiant. The WR stars both have an X-ray counterpart in the Chandra catalog, and were found as part of an ongoing X-ray-guided search for young massive stars and high-mass X-ray binaries in the GCR. The B supergiant was identified within a cavity of a warm dust structure, as revealed by the Spitzer Space Telescope. None of these stars have an obvious association with a stellar cluster. We briefly discuss the implications that these stars have for the history and mode of star formation in the GCR, and for the fate of stellar clusters evolving in the GCR tidal field.

172.04

Is the Vertical Velocity Distruibution of the Milky Way's Thick Disk Isothermal?

Constance M. Rockosi[1]
[1]*UCO/Lick Observatory.*

The vertical velocities of stars in our Galaxy's thin disk, as defined by the local metal-rich population, follow an isothermal distribution. The likely origin of the metal-rich thin disk population is star formation in the plane of the Milky Way. In contrast, the older, more metal-poor thick disk component of the Milky is most likely a relic from a merger event or events earlier in the Galaxy's history. A significant deviation from isothermality in the verti-

cal velocity distribution of the thick disk may be additional evidence in favor of a merger origin, as opposed to steady heating of an older thin disk through many local encounters. A measurement of the vertical velocity distribution of the thick disk requires a sample of many hundreds of stars with accurate radial velocities. The SEGUE survey will provide such a sample of thick disk stars at high Galactic latitude 2-3 kpc above the Galactic plane, where contamination from the thin disk should be minimal. The sample will have radial velocities accurate to 7 km/s at g=18.2, and will total several thousand stars by the end of the survey. We will also have metallicity estimates and proper motion information from the recalibrated USNOB catalog to provide further thick/thin disk and thick disk/halo discrimination and allow us to examine the velocity distribution for metallicity-selected subsets of the population. We report on our current best estimate for the vertical velocity distribution of the thick disk using this sample, and our parallel efforts to verify that we achieve the required accuracy and precision in our velocity measurements. We also discuss the prospects for interpreting a deviation from isothermality in order to use such a measurement to understand thick disk formation.

172.05

Studying the Intergalactic Medium via OVI absorption in the spectra of SDSS Quasars

Stephan Frank[1], S. Mathur[1]
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We report the results of a systematic search for signatures of the Intergalactic Medium (IGM) in Quasar spectra of the Sloan Digital Sky Survey (SDSS), focusing on finding intervening absorbers via detection of their OVI doublet.

Here we present the search algorithm, and criteria for distinguishing candidates from spurious Lyman alpha forest lines. In addition, we compare our findings with simulations of the Lyman alpha forest in order to estimate the detectability of OVI doublets over various redshift intervals.

We have obtained a sample of 125 OVI doublet candidates in 112 AGN spectra (out of 3804 objects with redshifts in the accessible range for OVI detection). This sample is further subdivided into 3 groups according to the potential for follow-up of these candidates : we propose to obtain observations of 7 of the candidates with the cleanest signatures for OVI doublets with high signal-to-noise and high resolution in order to better constrain the physical state of the warm/hot component of the IGM at high redshift.

172.06

A High Precision Radial Velocity Survey of the Galactic Bulge

Christian D. Howard[1], D. B. Reitzel[1], R. M. Rich[1]
[1]UC, Los Angeles.

We are undertaking a large scale radial velocity survey of the Galactic bulge, using M giant stars selected from the 2MASS catalog as radial velocity probes. Here we report 29 fields with Galactic longitudes from -10 degrees to +10 degrees and Galactic latitudes +5 degrees to -5 degrees, with each field containing ~100 stars. We find a bulge rotation of +/-50 km/sec out to +/-10 degrees Galactic longitude, slower than that predicted by the dynamical model of Zhao (1996). However, our velocity dispersion profile is in agreement with the Zhao model. The high precision of our survey (~5km/s) has produced an unexpected result: cold kinematic features are seen in a number of the radial velocity distributions.

172.07

43 GHz SiO Masers for Phase Calibration with VERA in the Galactic Center

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[1]University of New Mexico, [2]NRAO.

We present 9 epochs of Very Large Array (VLA) observations of 24 relatively strong 43 GHz SiO (*J*=1-->0, v=1 and v=2) maser emission in a sample of late-type stars located between 0.3 deg and 2.2 deg from the Galactic Center. The aim was to find suitable Galactic Center phase calibrators for the Japanese "VLBI Exploration of Radio Astrometry" (VERA) network, which will perform sub-milli-arcsecond astrometry in the Galaxy and the Galactic Center. From our VLA monitoring we have found two sources with consistently strong emission. These will be suitable VERA 43 GHz phase calibrators if their emission is unresolved also on VERA baselines. This is currently being investigated with VLBA observations.

172.08

Sagittarius Debris, the Virgo Stellar Stream, and the new stream near the Galactic Plane

Heidi J. Newberg[1], B. Yanny[2], N. Cole[1], T. Beers[3]
[1]Rensselaer Polytechnic Inst., [2]Fermilab, [3]Michigan State University.

We present spatial positions of stars in the leading and trailing tidal tails of the Sagittarius dwarf galaxy debris. We show that the Sgr tidal tails do not explain the overdensity of stars in the direction of what has been named the Virgo Stellar Stream. The Virgo Stellar Stream is probably gravitationally unbound debris from another dwarf galaxy disruption. It covers 300 sq. deg. of sky, with a diameter of ~10 kpc and a stellar mass of roughly 5 x 10^5 M_{Sun}. We demonstrate a new technique of using the color of a stellar population's turnoff to distinguish between structures which may overlap in space. This technique allowed us to clearly separate a new tidal debris stream that is slightly closer, has a bluer turnoff, and is much smaller than the Monoceros stream in the Galactic plane. Funding from the National Science Foundation AST 03-07571, AST 06-07618, and the NASA Space Grant.

172.10

Contour Map for the Gravitational Potential of the Milky Way

David F. Bartlett[1]
[1]Univ. of Colorado.

One usually does not draw a 2D contour plot for the gravitational potential of an astronomical system. It is too boring. For the solar system, the plot of equipotentials is simply a nest of circles about the sun as the center. Replace the sun with a black hole, squash the inner contours towards the x-y plane, and voila, the Milky Way. The situation is entirely different with the non-Newtonian sinusoidal potential. Here φ = -GM cos($2\pi r/\lambda$)/r, $\lambda = R_o/20$, and R_o is the distance from the sun to the center of the Galaxy.[1] Now the contour plot for the Milky Way has an infinite number of minima and *maxima*.

In this poster I show the contours for a disk galaxy having about 20 equal-spaced rings of mass $m_i = a_i \exp[-a_i/5\lambda]$, $a_i = (i+1/4)\lambda$, i=0,1,..19. The λ /4 offset is essential if this toy galaxy is to model the Milky Way that has, I predict, a physical bar in its center. (Other choices for the offset can model M31 or M33). Close to the center this model generates a dynamical disk of λ /4 = 100 pc half-thickness that is separate from the bulge. Evidence of this separation is clearly seen in CO (Fukui et al 2006). Near the solar circle, there are strong radial tidal forces. These forces appear in the data on long-period comets (Matese & Whitmire 1996) and on the position and kinematics of stars in the Gould Belt (Elias et al 2006). Finally the model accommodates the 3 evenly spaced stellar arcs at the periphery of the Milky Way (Grillmair 2006).

I thank Peter Bender for suggesting this plot and John Cumulat for continual support. [1] D. F. Bartlett, "Analogies between Electricity and Gravity", Metrologia 41, 2004, S115-S124.

172.11

Abundacne Patterns in High-Velocity RAVE Stars

Jon P. Fulbright[1], G. Ruchti[1], R. Wyse[1], RAVE Collaboration
[1]Johns Hopkins Univ..

We present abundance results for a sample of high velocity stars selected from the RAVE survey. Previous studies with smaller samples have shown that high velocity stars from the outer halo have lower [alpha/Fe] ratios than local halo stars. The expanded sample includes stars selected purely by their galactocentric radial velocities. At this point, the sample includes at least one new low-alpha star, a s-process element-enhanced C-rich giant and an [Fe/H] = -2.8 giant with a lithium abundance about a factor of 30 above the Spite Plateau.

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through AST-0508996, is gratefully acknowledged.

172.12

Gravitational Lensing and the Distance to the Galactic Center

Erin L. Gutbrod[1], S. Levine[2]
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Combining recent determinations of the mass of the black hole at the center of our galaxy with the formalism of gravitational lensing, we show how to derive an estimate for the distance to the center of our galaxy. The formal error on this distance estimate is competitive with those of other recent determinations, and will suffer from a different set of systematic errors. This research was funded by the National Science Foundation, grant number AST-0453611.

172.13

Smith's Cloud (HVC) in 21 cm HI emission

A. J. Heroux[1]
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In studying the continuing formation of the Milky Way, we have used the Green Bank Telescope (GBT) of the NRAO to measure the 21 cm HI emission from a specific high velocity cloud known as "Smith's Cloud". This cloud is likely within the bounds of the galaxy and appears to be actively plunging into the disk. Our map covers an area about 10x14 degrees, with data taken every 3' over this range. Most of the emission is concentrated into a single large structure with an unusual cometary morphology, which displays signs of interaction between the cloud and the Galactic halo.

We will present an analysis of the cloud, along with information on possible FIR emission with information gained from the IRAS data, kinematics and likely orbits and paths for the origin and future of the cloud. This research was funded through an NSF REU Grant.

172.14

Exploring the Local Milky Way: M Dwarfs as Tracers of Galactic Populations

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[1]Univ. of Washington, [2]US Naval Observatory, [3]Harvard-Smithsonian Center for Astrophysics, [4]Univ. of California.

We utilize Sloan Digital Sky Survey observations of over 8,000 low-mass dwarfs to examine Galactic structure and kinematics in the Southern (b ~ -60 deg) Milky Way. Combining medium-resolution (R ~1,800) spectroscopy, five band (ugriz) photometry and proper motion measurements, this dataset represents a powerful tool for examining the local structure and kinematics of the thin and thick disks. For each star, we have measured the activity (using the H-alpha luminosity) and UVW velocities. These measurements, as functions of distance from the Galactic Plane, offer a glimpse into the mean structural and kinematic properties of the thin and thick disk populations.

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172.15

Galactic Structure Across the Sky with AAOmega

Rosemary F. Wyse[1], G. Gilmore[2], J. E. Norris[3]
[1]Johns Hopkins Univ., [2]Institute of Astronomy, Univ. of Cambridge, United Kingdom, [3]RSAA, ANU, Australia.

As more photometric, kinematic and metallicity data are accumulated the Galaxy appears to be more complex and we are in danger of missing the wood for the trees. The need for wide-area systematic surveys in well-motivated lines-of-sight is apparent. We have undertaken a survey with the new 2-degree field multi-fibre spectrograph on the AAT, AAOmega, that addresses the scientifically important questions of spatial gradients in structure, kinematics and metallicity, focusing on the thick disk -halo interface. We have obtained radial velocities to better than 10km/s, and metallicities to 0.2 dex, for some 10,000 faint (V ~ 19) F/G dwarf stars in intermediate-latitude fields, across the equatorial stripe covered by SDSS DR4. The data allow the determination of small-scale (~ 300pc) and large-scale (several kpc) variations and correlations between kinematics and metallicity. Our results will quantify the relative importances of dissipational (slow settling to equilibrium) and dissipationless (stellar mergers and accretion) physics in the formation of the oldest components of the Galaxy.

172.16

A High-resolution Polarimetric Survey of the Central 200 pc of the Galaxy

Thomas M. Freismuth[1], C. C. Lang[1], T. J. Lazio[2], K. Golap[3]
[1]Univ. of Iowa, [2]NRL, [3]NRAO.

We present a 4.9 GHz continuum survey of the central 200 pc of the Galaxy. The Very Large Array (VLA) was used to obtain 90 pointings toward the central degree of the Galaxy in its D-array configuration. The multi-scale CLEAN algorithm was used in AIPS++ to construct a full-Stokes mosaic with a resolution of ~25″. This is the first large-scale, high-sensitivity mosaic of polarized intensity made toward the Galactic Center (GC) and our primary goal is to search for low-brightness large-scale polarized features which may be associated with the 50-100 known non-thermal filaments (NTFs) which populate this unique region. The survey data will also be used to study the diffuse radio emission in conjunction with Spitzer and new Chandra X-ray observations of the central 200 pc of the GC and also to begin to idenfity the point source distribution in the Galactic center. Follow-up C-array observations with the VLA of this region are underway to improve the spatial resolution to ~10″, which will enhance our sensitivity to point-like features.

TUESDAY

172.17

The Line of Sight Velocity Distribution of the Galactic Bulge

David B. Reitzel[1], C. Howard[1], R. M. Rich[1], H. Zhao[2], Y. Wang[3]
[1]UCLA, [2]University of St. Andrews, United Kingdom, [3]National Astronomical Observatory, China.

We are undertaking a large scale radial velocity survey of the Galactic bulge, using M giant stars selected from the 2MASS catalog as radial velocity probes. Here we report on the line of sight velocity distribution of 29 fields fields from -10 < l <+10 degrees and -6 < b < 5 degrees. We compare directly to theoretical predictions from the models of Zhao (1996). These comparisons indicate the presence of cold kinematic features, a somewhat unexpected result. The persistence from field to field of these features is investigated as well as comparisons to the well knows merger remnant, the Sagittarius dwarf galaxy.

172.18

Deep Astrometry of the Galactic Bulge with the HST ACS-WFC

Will Clarkson[1], K. Sahu[1], E. Smith[1], S. Casertano[1]
[1]STSCI.

We report our HST determination of proper motions in the Galactic Bulge and foreground disk populations. At over 890 ks integration time in F814W, the SWEEPS transiting exoplanet search of Sahu et al. (2006) has produced the deepest image ever taken of the galactic field, allowing stellar positions to be constrained to high accuracy at unprecedented depth. With a second epoch two years later with HST/ACS with full overlap, and a third seven years earlier with WFPC2 at 60% overlap, we are able to measure the proper-motions of diskand bulge-objects, with the aim of providing better kinematic population diagnostics than has previously been possible. We discuss the techniques used to robustly measure proper-motions from our datasets, meeting the challenges of (i) high crowding, (ii) high intrinsic velocity dispersion about a small centroid offset (unlike globular cluster studies), and (iii) significant relative distortion between the ACS-WFC and WFPC2 instruments.

172.19

An Arecibo HI 21-cm Absorption Survey of X-ray Rich Clusters

Hector Hernandez[1], T. Ghosh[1], C. J. Salter[1], E. Momjian[1]
[1]*Arecibo Observatory.*

We present the results of a search for cold neutral hydrogen in intra-cluster media of 90 rich, X-ray bright clusters of galaxies. The spectra were taken towards radio-loud galaxies near the cluster center using the 305-m Arecibo Radio Telescope, and utilizing the wide-band spectrometer to ensure that the entire velocity ranges of the infall regions are covered in the observed spectra (i.e., ± 5000 km/s). To minimize the effect of self-generated bandpass ripples, the sources were observed in double-position-switching mode. We have detected several absorption and emission features. Implications of these (and the non detections) will be discussed vis-a-vis CHANDRA and XMM-Newton observations of these clusters. The Arecibo Observatory is part of the National Astronomy and Ionosphere Center, which is operated by Cornell University under a cooperative agreement with the National Science Foundation.

172.20

A New Distance Calibration for Blue Stars in the Direction of Galactic High-Velocity Clouds

Ronald J. Wilhelm[1], J. Barentine[2], T. C. Beers[3], B. P. Wakker[4], D. G. York[5]
[1]*Texas Tech Univ.,* [2]*University of Texas,* [3]*Michigan State University,* [4]*University of Wisconsin,* [5]*University of Chicago.*

The High-Velocity Clouds (HVC) found in the Galactic halo hold many clues about galactic evolution. Specifically, they can be used to determine, the rate of infall of low-metallicity gas, the potential of the dark matter halo, the rate of circulation between the disk and halo and the number of ionizing photons escaping the Galactic disk. In all of these cases, the usefulness of the HVC depends critically on the determination of distance to the clouds. The most straight-forward method for computing HVC distances is to determine the distances to fore-ground and back-ground blue stars which show the absence/presence of interstellar absorption lines superimposed on their stellar spectra, thus bracketing the distance to the HVC.

We present a new stellar distance calibration for blue stars, based on absolute magnitudes determined from the fit of theoretical isochrones in the Teff-Logg plane. This distance calibration depends critically on the determination of accurate stellar parameters, Teff, Log g and [Fe/H] for the blue horizontal branch, blue straggler and RR Lyrae variable stars. We will present external calibration results for our stellar parameter determination using well studied stars in these luminosity classes and present a balmer-line width/color-index method for determining likely variable stars within the sample. Finally, we will present results for the new distance calibration, through direct comparison to the standard stars and stars in the galactic globular clusters, and use these results to constrain the error in distance measurements to the HVC.

172.21

Elemental Abundances of Metal-Poor Thick Disk Stars from the RAVE Survey

Gregory R. Ruchti[1], J. Fulbright[1], R. F. Wyse[1], RAVE Collaboration
[1]*Johns Hopkins Univ..*

Theories of thick disk formation can be differentiated by observable abundance ratios. Old metal-poor stars in a thick disk made during the accretion of satellite galaxies may show abundance ratio variations as a function of galactic radius. If the thick disk formed during a slow dissipational collapse, abundance ratio gradients may exist in the metal-poor stars in the vertical direction. Conversely, a thick disk made in a burst of high star formation should have a more uniform abundance ratio distribution, but have very few metal-poor stars. We have begun observations of a sample of candidate metal-poor thick disk stars selected from the RAVE survey. These stars cover a range of positions within the Galaxy in order to test whether the distribution of their abundance ratios are consistent with any of the present theories of thick disk formation.

Funding for this research, provided by the National Science Foundation through AST-0508996 as well as the Keck and Moore Foundations, is gratefully acknowledged.

172.22

The Identification of the Microlens in Event MACHO-LMC-20

Michael W. Werner[1], N. Kallivayalil[2], B. M. Patten[2], M. Marengo[2], C. Alcock[2], G. Fazio[2]
[1]*JPL/Caltech,* [2]*CfA.*

We report on the identification of the lens responsible for microlensing event MACHO-LMC-20. As part of a Spitzer/IRAC program conducting mid-infrared follow-up of the MACHO Large Magellanic Cloud microlensing fields, we discovered a significant flux excess at the position of the source star for this event. These data, in combination with high resolution near-infrared Magellan/PANIC data, have allowed us to classify the lens as an early M dwarf in the thick disk of the Milky Way, at a distance of ~2 kpc. This is only the second microlens to have been identified, the first, the lens of MACHO-LMC-5 (Nguyen et al, ApJS, v.154, p.266 {2004}) also being a M dwarf star in the disk. Together, these two events are still consistent with the expected frequency of nearby stars in the Milky Way thin and thick disks acting as lenses.

This work is based [in part] on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA through an award issued by JPL/Caltech.

172.23

GPIPS: Season One

Dan P. Clemens[1], A. Pinnick[1], M. Pavel[1], B. Taylor[1], K. Jameson[1]
[1]*Institute for Astrophysical Research, Boston Univ..*

The Galactic Plane Infrared Polarization Survey (GPIPS) has completed its initial season of H-band (1.6 microns) data collection using the Mimir near-infrared instrument in linear imaging polarimetry mode on the 1.8m Perkins Telescope outside Flagstaff, Arizona. This key project for the Perking Telescope seeks to answer key questions about the nature of the magnetic field and the aligned dust grains used to trace the field for small-scale star-forming regions, medium scale molecular and atomic cloud regions, and large-scale spiral arm and interarm regions. The GPIPS survey goals are to survey about 48 square degrees of the northern galactic disk to H=12th magnitude with polarimetric sensitivity to 0.1-0.2 percent, and create publically available polarimetric and photometric catalogs from the survey data. GPIPS observations were conducted during the June/July and September months of 2006. These first observations covered about 150 of the 3,200 9x9 arcmin spaced grid of field centers slated for polarimetry using the 10x10 arcmin FOV of the Mimir instrument. The field centers were chosen to cover all known inner galaxy stellar clusters within 1 degree latitude of the midplane as well as a couple of nearby molecular clouds already surveyed in 13CO by the Galactic Ring Survey. A sampling of the images and polarimetry drawn from these initial observations will be highlighted in this poster.

GPIPS is partially supported by a grant from the NSF (AST 06-07500) and by Boston University's continuing partnership agreement with Lowell Observatory.

172.24

An HI Absorption Survey of the Central 250 pc of the Galactic Center: Distance Constraints & Understanding the Complex ISM

Kelsey I. Clubb[1], C. C. Lang[1], W. M. Goss[2]
[1]University of Iowa, [2]National Radio Astronomy Observatory.

Using the Very Large Array (VLA), we have carried out a complete study of the HI absorption toward the central 250 pc of the Galactic Center (GC). The spatial resolution of 15″ and velocity resolution of 2.5 km/s are a big improvement over the previous HI absorption study toward the central 50 pc of the GC by Lasenby et al. (1989). Here, we present (1) distance constraints to 40 well-known GC sources, (2) kinematics of the HI component toward many well-known GC sources, and (3) information on the line-of-sight arrangment of the ISM in the SgrA, SgrB and SgrC complexes. We have also created a website for the astronomical community which includes continuum images, HI absorption profiles, and HI data of all major regions of interest in the Galactic Center.

172.25

Spectroscopic Observations of the Galactic Center with OSIRIS

Tuan Do[1], A. Ghez[1], J. Lu[1], K. Matthews[2], M. Morris[1], A. Stolte[1], E. Becklin[1], J. Larkin[1], S. Wright[1]
[1]UC, Los Angeles, [2]Caltech.

We present the results from laser guide star adaptive optics observations of the galactic center with the integral-field spectrometer OSIRIS at ~2 microns on the Keck II telescope. The observations of the 2″ x 3″ field centered on Sgr A* resulted in spectral line detections of over 30 stars. Of the stars detected, five are newly spectroscopically confirmed massive young B type stars. Twelve late type stars are also newly spectroscopically identified in this field. Combining these results with astrometry obtained by our group at the Keck Observatory over the last 12 years, we have: (1) improved our estimates of the black hole properties (eg. mass and distance); (2) obtained the orbital parameters for additional young stars, which tests current ideas of how stars might form in this particularly inhospitable environment; (3) obtained limits for the line of sight distances to many late-type stars, which allows us to test previous claims of a drop in the number density of late type stars close to the supermassive black hole.

172.26

A Comparison of Spitzer, WIYN 0.9m, and Chandra Point Source Populations in the Inner Galaxy

Luis C. Vargas[1], R. A. Benjamin[2]
[1]University of Kansas, [2]University of Wisconsin-Whitewater.

We present a study of the galactic plane region l~28.5, b~0.0 from mid-infrared to X-ray wavelengths. We have produced a source list for a combination of Chandra X-ray (Ebisawa et al. 2005), optical BVR (WIYN 0.9-m), near-IR JHK (2MASS), and mid-IR [3.6],[4.5],[5.8],[8.0] (Spitzer/GLIMPSE) data. Forty-four sources have X-ray, optical and infrared information, and 83 have at least infrared and x-ray fluxes. We present information on the nature of these sources by comparing the infrared SEDs to a extensive grid of stellar and YSO models using a library and fitting algorithm of Robitaille et al. (2006). Out of 12122 IR sources evaluated by the fitter, 479 sources have SED's consistent with young stellar objects (YSOs). We find that only three X-ray sources have SEDs consistent with YSOs. We also note that only 2 hard X-ray sources are detected in the optical bands.

This work was supported by the National Science Foundation's REU program and the Department of Defense's ASSURE program through NSF Award AST-0453442.

172.28

Probing the Interstellar Medium using the Vela Pulsar

Shauna Sallmen[1], D. C. Backer[2], L. Marschke[3]
[1]Univ. of Wisconsin, La Crosse, [2]Univ. of California at Berkeley, [3]Univ. of Northern Colorado.

One tool for investigating turbulent interstellar material on small length-scales is to monitor changes over time in radio waves originating from pulsars. As pulsar signals propagate through the ionized interstellar medium (ISM), scattering, scintillation, and dispersion effects change the pulse shape, flux, and time of arrival. As the Earth and the source move relative to one another, the radio waves will pass through (and be affected by) different parcels of gas in the ISM. In particular, the flux, scattering time scale (τ) and dispersion measure (DM a measure of the electron column density), will all vary with time.

We present measurements of variations in the pulse flux, scattering timescale, and dispersion measure using observations of the Vela Pulsar (PSR B0833-45) at 327 MHz and 610 MHz. This particularly strong pulsar rotates once every 89.9 milliseconds, and lies in the Vela supernova remnant. The data were collected over a period of approximately 6 years via remote monitoring observations using the 85-foot telescope of the National Radio Astronomy Observatory in Green Bank, WV. By investigating the dispersion measure, interstellar scintillation, and scattering properties of the pulsed radiation, we will be able to constrain the properties of the intervening interstellar medium. Our dispersion-measure observations show a clear continuation of the decrease in intervening electron density seen by Hamilton *et al* (1985), interpreted as a wedge of plasma exiting the line of sight. A structure-function analysis of the small-scale flux and dispersion variations is also presented, and compared with various interstellar models.

172.29

VERITAS Observations of LSI +61 303

Andrew W. Smith[1]
[1]Harvard-Smithsonian CfA.

The galactic microquasar LSI +61 303 has been a source of interest for many years due to its periodic X-ray and radio emission which are seemingly tied to its ~26.5 day orbital cycle and its association with the EGRET UID source J0214+6103. The recent MAGIC detection of the source in > 200 GeV gamma rays also places the system among a new class of galactic gamma-ray emitters. Along with LS 5039 (detected by HESS) the MAGIC detection opens up a new window on galactic accretion/emission processes as well as standing to contribute to our understanding of similar emission processes in AGN. In this paper we report on the observations of LSI +61 303 undertaken this Fall by the VERITAS collaboration using the partially completed VERITAS array and with the Whipple 10m gamma-ray telescope. As it is currently constituted, the VERITAS array is sensitive in the range of 0.1->20 TeV. LSI +61 303 was observed from September until November 2006 as a part of a multi-wavelength campaign on the source utilizing X-ray data from RXTE and IR data from the PAIRITEL observatory. A search for correlation of emission across the bands is performed as well as a comparison of the TeV observations with the MAGIC detection.

173: Instrumentation and Community Analysis
AAS Poster, Tuesday, 9:20am-4:00pm, Exhibit Hall 4

173.01

Evaluation of a Novel Design for an Electrostatic Quadrupole Triplet Ion Beam Lens

L. R. Burns[1], J. D. Bouas[1], S. Matteson[1], D. L. Weathers[1]
[1]Ion Beam Modification and Analysis Laboratory (IBMAL) — University of North Texas.

We describe the design and evaluation of an electrostatic quadrupole triplet lens constructed to focus ion beams of up to 200 keV in energy. The lens was built to be used in an apparatus for fundamental sputtering studies. These studies are motivated in part by a desire to understand the influence of low-energy physiochemical processes on surfaces and atmospheres exposed to the solar wind in the inner Solar System. The lens is very compact and incorporates a feature to induce octupole fields that can correct for spherical and other octupole-order aberrations. Two methods were used to evaluate the lens: observation of the focused beam spot on a specially fabricated target while systematically varying lens voltages, and the grid-shadow technique. The latter demonstrated that octupole-order aberrations were completely corrected in one direction when the lens quadrupoles were operated individually with appropriate octupole excitations. This research was made possible by a grant from the National Science Foundation through the Physics Research Experience for Undergraduates (REU) Program at the University of North Texas. Additionally, funding was provided by the Ronald E. McNair Post-baccalaureate Achievement Program at the University of North Texas.

173.02

Finding Astronomical Communities Through Co-readership Analysis

Edwin A. Henneken[1], M. J. Kurtz[1], G. Eichhorn[1], A. Accomazzi[1], C. Grant[1], D. Thompson[1], E. Bohlen[1], S. S. Murray[1]
[1]Smithsonian Astrophysical Obs..

Whenever a large group of people are engaged in an activity, communities will form. The nature of these communities depends on the relationship considered. In the group of people who regularly use scholarly literature, a relationship like ″person i and person j have cited the same paper″ might reveal communities of people working in a particular field. On this poster, we will investigate the relationship ″person i and person j have read the same paper″. Using the data logs of the NASA/Smithsonian Astrophysics Data System (ADS), we first determine the population that will participate by requiring that a user queries the ADS at a certain rate. Next, we apply the relationship to this population. The result of this will be an abstract ″relationship space″, which we will describe in terms of various ″representations″. Examples of such ″representations″ are the projection of coread vectors onto Pincipal Components and the spectral density of the coread network. We will show that the coread relationship results in structure, we will describe this structure and we will provide a first attempt in the classification of this structure in terms of astronomical communities.

173.03

Single Baseline Phases in Optical Interferometry

Anders M. Jorgensen[1], D. Mozurkewich[2], H. Schmitt[3], C. Tycner[4], R. Hindsley[3], T. A. Pauls[3], J. T. Armstrong[3], D. Peterson[5]
[1]NMT and LANL, [2]Seabrook Engineering, [3]Naval Research Laboratory, [4]US Naval Observatory, [5]Stony Brook University.

One of the critical tasks ahead for optical interferometry is to improve the determination of parameters for astronomical objects. The SNR of the squared visibilities in marginal data can be greatly improved with coherent integration, but this helps only to a point: once the SNR exceeds some threshold, the accuracy is limited by calibration uncertainties rather than by photon statistics. The phase normally used in optical interferometry is the sum of the phases of the complex visibilities (the baseline phases) around a triangle of baselines. This closure phase is immune to all non-source effects, including the calibration effects that normally affect squared visibilities. However, only one closure phase is produced from the three baseline phases, and its uncertainty is worse than the uncertainty on the baseline phases. Additionally, the closure phase is only one phase determination whereas the corresponding baseline phases represent three separate phase measurements. We propose using the baseline phases to circumvent the limitations of squared visibilities and closure phases. Baseline phases are also immune to the normal calibration effects, so their SNR is entirely determined by photon statistics. Our approach is to coherently integrate [e.g., Jorgensen SPIE 2004, 2006, AJ 2005 (submitted)] to improve the SNR of the complex visibilities, and then to extract phases for single baselines. This technique depends on spectrally dispersing the fringes so the group delays can be determined. Unlike closure phases, baseline phases contain effects of the atmosphere, fringe-tracking errors, and internal instrument dispersion. We have shown that these effects can be measured and subtracted, leaving only the source phase. In this presentation we will demonstrate how to work with baseline phases and how they can used to model different sources and extract high-precision parameters.

174: Impact of Intelligent Design and Responses to It
AAS Special, Tuesday, 10:00-11:30am, 204

174.01

Overview of the Nature of Intelligent Design as a Pseudoscience

Matthew Bobrowsky[1]
[1]STScI.

There is a very strong anti-science movement in the U.S., which is the result of a number of factors, including poor science education resulting in inadequate public understanding of the process of science. It is therefore not surprising that large numbers of people accept various types of pseudoscience and reject other, very well-established, correct science.

One of the most frequently heard attacks on science deals with ″alternatives to evolution″ (intelligent design and various forms of creationism). While one might suppose this is a matter with which only biologists need to be concerned, some of the same arguments used against biological evolution are invoked to argue against our understanding of the age of the earth and the age of the universe. Attacks on evolution ripple through all the sciences and, in fact, the AAS passed a resolution on teaching evolution in schools. It is a unifying principle just like Big Bang cosmology, with overwhelming supporting evidence. Since many of the most recent attacks against science involved the promotion of Intelligent Design, it is appropriate to provide some background on Intelligent Design, why it is not science, and why astronomers should be concerned about it.

174.02

The AAS Resolution on Teaching Evolution

George D. Nelson[1]
[1]Western Washington University.

In September 2005 the AAS adopted a resolution supporting the teaching of evolution, and against the insertion of non-scientific ″alternatives to evolution″ in the nation’s pre-college science classes. I will discuss the process that the Society followed in writing this resolution while I was Education Officer.

174.03

Francis Slakey[1]
[1]American Physical Society.

174.04

Science and Faith: Discussing Astronomy Research with Religious Audiences

Anton M. Koekemoer[1]
[1]*STScI.*

An important component of our outreach as research astronomers involves interaction with the religious community. From my personal perspective, being an active research astronomer who is also a practicing Christian, I am sometimes invited to present the latest astronomical research to church audiences and other religious groups; belonging to both communities thereby provides a valuable means of contributing to the dialogue between science and religion. These opportunities can be used to explain that science and religion are not necessarily in conflict but can be considered to be quite complementary. For instance, an important aspect of religion deals with the purpose of our existence, while science is more focussed on providing physical explanations for what we observe in the world, using a well-defined scientific process. Hence, religious believers need not necessarily abandon their faith in order to accept mainstream scientific research; these address very different and complementary aspects of our existence. Recent ideas such as Intelligent Design attempt to address the scientific method, but do not address the ultimate religious question of purpose and do not contribute towards reconciling science and religion in this sense. Ultimately, every individual arrives at their own understanding of this rather complex interplay; I will present some personal reflections on general approaches for discussing mainstream astronomical research with religious audiences, aimed at helping to advance the dialogue between religion and science in general.

175: Observations and Models of Extragalactic LMXBs AAS Special, Tuesday, 10:00-11:30am, 201

Chair

Stephen E. Zepf[1]
[1]*Michigan State Univ..*

175.01

Deep Chandra Studies of LMXB Populations in Elliptical Galaxies

Giuseppina Fabbiano[1]
[1]*Harvard-Smithsonian Center for Astrophysics.*

The study of Low Mass X-ray Binary (LMXB) populations in early type galaxies is flourishing thanks to the sub-arcsecond resolution *Chandra* images, that make these faint and crowded X-ray sources visible outside of the Milky Way. The properties of these LMXB populations (spatial distribution, spectra and X-ray colors, time variability and X-ray luminosity function) are a useful tool for understanding their nature, relation to the underlying stellar population, and evolution. In this talk I will review what we have learned from these *Chandra* observations. In particular, I will report on the most recent results of our on-going very large program of deep monitoring *Chandra* observations of the two nearby elliptical galaxies NGC 3379 and NGC 4278.

175.02

The Low Mass X-Ray Binary Globular Cluster Connection and its Implications

Arunav Kundu[1]
[1]*Michigan State University.*

High resolution images from the Chandra X-ray Telescope have discovered large populations of low mass X-ray binaries (LMXBs) in nearby galaxies. Elliptical and S0 galaxies are ideal for studying these bright, close binaries that are also tracers of past high mass star formation, because there is no confusion from ongoing star formation. Early type galaxies are also particularly rich in globular clusters. Recent studies have showed remarkably, that half the LMXBs in these galaxies are associated with globular clusters. The specific characteristics of individual globular clusters, such as metallicity and age, and the wide range of globular cluster properties in these galaxies, provide a unique window into the formation and evolutionary histories of LMXBs. I review recent studies of the LMXB-globular cluster connection in early type galaxies and their implications. These studies have uncovered some expected correlations between LMXBs and globular cluster properties such as the mass, a surprisingly strong correlation with metallicity, and varying claims for other factors such as galactocentric distance, cluster size, age and the interaction rate. Although it has been suggested that a possible solution to the tricky dynamical problem of creating LMXBs in the field is that is that they are an ejected globular cluster population, recent studies using a variety of techniques appear to be reaching a consensus that the majority of field LMXBs are in fact formed in situ.

175.03

Theoretical Models of LMXBs in Elliptical Galaxies

Vicky Kalogera[1]
[1]*Northwestern University.*

Elliptical Galaxies have revealed a large number of point X-ray sources that are thought to be Low-Mass X-Ray Binaries, particularly given the old age of the galactic population. A large fraction of them have been shown to be associated with globular clusters and the rest populate the galactic field. In this talk I will review our current understanding for the nature and evolutionary history of these sources and the open questions and puzzles facing us that could be addressed with theoretical X-ray binary models.

176: GLAST Science and Opportunities at All Wavelengths HEAD Special, Tuesday, 10:00-11:30am, 611-12

176.01

GLAST Science Across Wavelengths

R. D. Blandford[1]
[1]*SLAC.*

The GLAST satellites is almost guaranteed to revolutionize GeV gamma ray astronomy because of the great discoveries that are being made at hard X-ray energy by the Suzaku and Swift satellites and in the TeV range using the H.E.S.S. and Magic telescopes. Unidentified EGRET sources are likely to be identified and new and fainter sources will be found. Known classes of sources blazars, pulsars, gamma ray bursts, supernova remnants, binary X-ray sources and so on will be monitored in much greater detail. Finally, there is the need to limit or even detect dark matter through its annihilation signature. The science that will emerge from GLAST will be determined in large measure by the effort that is put into multiwavelength observing. This will require significant commitments of observing time for monitoring pulsar arrival times, measuring faint galaxy spectra, detecting GeV gamma rays gamma ray bursts and so on. In this talk I will attempt to summarize current thinking on the GLAST multi-wavelength observing program and propose some new approaches.

176.02

Enhancing GLAST Science Through Complementary Radio Observations

James S. Ulvestad[1]
[1]*NRAO.*

Radio astronomical observations with state-of-the-art instrumentation will be critical for achieving the maximum science return from the GLAST mission. Radio nterferometers with baselines of thousands of kilometers, such as the Very Long Baseline Array (VLBA), will provide sub-milliarcsecond imaging of GLAST blazars. High-frequency VLBA imaging, repeatable at intervals of days to weeks, will image the region where gamma-ray flares occur in blazars and help determine the location of the gamma-ray emission. Multi-frequency arcsecond-scale imaging with interferometers having baselines of one to tens of kilometers, particularly the Very Large Array, will provide efficient discrimination among the candidates for unidentified gamma-ray sources. Pulsar timing with single-dish radio telescopes such as the Green Bank Telescope will enable accurate registration of gamma-ray photons with pulsar ephemerides for studies of the pulsar emission mechanisms. Along with these contemporaneous radio/GLAST observing programs, we will discuss briefly some of the recent radio programs that have been conducted in preparation for GLAST launch.

The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

176.03

Galaxy Formation, Cold Dark Matter Substructure, and GLAST

Piero Madau[1]
[1]UC, Santa Cruz.

Many of today's ″observables″ within the Milky Way and nearby galaxies relate to events occurring at early cosmic epochs. It is a clear, unique prediction of LCDM that galaxies are embedded in massive, extended dark matter halos teeming with self-bound substructure or ″subhalos.″ I will discuss how the amount and spatial distribution of subhalos around their host provide unique information and clues on the galaxy assembly process during and after the reionization era, and on the nature of the dark matter. While most dark matter subhalos in the Milky Way appear to have no optically luminous counterparts, the substructure population has been shown to be detectable via flux ratio anomalies in strong gravitational lenses, through its effects on stellar streams, or via gamma-rays from dark matter annihilation in their cores. Surviving nearby subhalos are among the brightest sources of annihilation radiation and could be observed by GLAST.

176.04

GLAST Mission Overview and Science Opportunities

Julie E. McEnery[1]
[1]NASA's GSFC.

The Gamma-ray Large Area Space Telescope (GLAST), scheduled for launch in late 2007, is a satellite-based observatory to study the sky in high-energy gamma-rays. There are two instruments on GLAST: the Large Area Telescope (LAT), which provides coverage from 20 MeV to over 300 GeV, and the GLAST Burst Monitor (GBM), which provides context observations of transients from 8 keV to 30 MeV. The LAT will provide dramatic improvements in sensitivity, angular resolution, and energy range relative to the highly-successful EGRET instrument on the Compton Gamma-Ray Observatory (1991-2000). In addition, the solid-state technology of the LAT will allow vastly improved sensitivity to bright high-energy transients. The very large field of view will contain ~20% of the sky at any instant and the LAT will obtain essentially complete sky coverage every 3 hours. This talk includes descriptions of the instruments and their performance characteristics, the opportunities for guest investigators, and the current status of the mission.

177: Andromeda All the Time
AAS Oral, Tuesday, 10:00-11:30am, 6B

177.01

The Surface Brightness Profile of the Bulge and Halo of the Andromeda Spiral Galaxy (M31) from R = 10 to 165 kiloparsecs

Puragra Guhathakurta[1], K. Gilbert[1], J. Kalirai[1], J. Ostheimer[2], S. Majewski[2], R. Patterson[2], M. Geha[3], M. Cooper[4], D. Reitzel[5], R. Rich[5]
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Understanding the formation of galaxies and their structural subcomponents is a key goal of modern cosmology. Large spiral galaxies like our own consist of a flattened rotating disk, a centrally concentrated bulge whose density decreases exponentially with increasing radius, and an extended halo whose density scales as an inverse power law in radius. Our internal vantage point is disadvantageous for investigating the structure of our own Galaxy. By contrast, the Andromeda spiral galaxy (M31), the Milky Ways neighbour, offers us a global external perspective and yet is close enough for individual stars to be resolved. Over several decades, structural studies of M31 have generally concluded that its outer spheroid is an extension of its inner bulge, displaying the characteristic exponential cut-off out to a distance of about 20 kpc from the center, and/or that its halo is undetected or absent. We report here on the discovery of a halo of red giant stars in M31 extending beyond a radius of 150 kpc. Our finding shows that previous studies of the spheroid of M31 spanning the last few decades have been sampling its extended bulge instead of the pristine metal-poor halo. Characterizing the dynamics, metallicity, substructure, and age of M31's halo will provide unique tests of galaxy formation theories.

This research was supported by funds from the NSF and NASA/STScI.

177.02

New Substructure in the Spheroid of the Andromeda Spiral Galaxy

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The presence of significant amounts of substructure in the spheroids of spiral galaxies is a common prediction of hierarchical galaxy formation in Lambda-CDM cosmology. We present the discovery of kinematically-cold substructure in a few fields within the spheroid of the Andromeda Galaxy (M31). This discovery is part of an on-going large spectroscopic survey of red giant branch stars in M31 using the DEIMOS instrument on the Keck II telescope. We use a likelihood-based method that utilizes photometric and spectroscopic diagnostics to isolate M31 red giant stars from foreground Milky Way dwarf stars. This method yields a clean sample of M31 red giant stars that is essentially unbiased in radial velocity. We discuss the kinematics and metallicity of these cold components in comparison to the smooth spheroid of M31. We explore the physical origin of these substructures in the context of Fardal et al.'s (2006) recent determination of the orbit of the giant southern stream and make statistical comparisons between the observed substructures in M31 and numerical simulations of galactic halo formation.

This research was funded by grants from NSF and NASA/STScI.

177.03

Unraveling NGC 205's Interaction with Andromeda (M31)

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NGC 205 is our nearest example of a dwarf elliptical (dE) galaxy, lying a projected 37 arcminutes from Andromeda (M31). Its proximity provides the means for understanding the role of dEs in hierarchical galaxy formation. Detailed photometric observations by Choi et al (2002) and kinematic observations by Geha et al (2006) suggest that NGC 205 is currently undergoing tidal disruption from its interaction with M31. Although attempts have been made to carefully understand the properties of NGC205, such as its mass and distance from M31, they are still not well known. We attempt to resolve these uncertainties by exploring the interaction between NGC 205 with M31 using a restricted N-body approach to investigate the mass and orbital parameters of NGC 205. We define our system using 10 parameters and use the tidally distorted photometric and kinematic observations as constraints. Since our constrained parameter space contains approximately 10^22 possible orbits, a genetic algorithm is employed for optimization. These simulations provide tighter constraints on the orbit and internal structure/dynamics of NGC 205. This research was supported by funds from NSF and NASA/STScI.

177.04

Reconstructing a Recent Collision in Andromeda

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[1]UMass, [2]UCO/Lick, [3]UVic, Canada, [4]Smith.

The nearby Andromeda Galaxy (M31) shows multiple signs of recent disturbances, including a star-forming ring, a giant stellar stream to the south, and multiple shell-like structures and other density and kinematic irregularities seen in maps of red giant counts. We use N-body simulations to show that many of these features could be due to a single event: the collision between M31 and a large satellite galaxy on a nearly radial orbit. In our simulations, the southern stream is merely the tail of a giant structure which wraps around the center of M31, and is formed from the debris of the satellite. The structure has a distinctive spatial and kinematic signature, which is consistent with features seen in multiple types of observations. These include a triangular signature in R_{proj} V_{los} space in several regions identifiable as radial shells of stars; at least two and probably three such shells are visible in current data. The collision also leaves its imprint on the face of M31. Our simulations show that the sharp NE edge of the southern stream and its gradual falloff to the SW can be reproduced with an initially rotating satellite, with its angular momentum vector pointed toward M31's center at its closest approach. We use the surface density of the radial shells and southern stream to estimate the initial mass of the satellite as ~2×10^9 solar masses. This would make it one of the most massive galaxies in the Local Group, before its violent destruction a mere ~0.7 Gyr ago.

177.05

Constraints on the Chemical Evolution of the M31 Spheroid

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We construct a set of simple parametrized models of the chemical evolution of a stellar population. The models include the following generic features: (1) monotonically increasing mean metallicity with time, (2) a star-formation history with one peak, (3) instantaneous recycling, and (4) homogenous mixing of the chemical elements. These features encapsulate nearly all classical chemical evolution models for the stellar populations of galaxies. Within this general framework we test a wide variety of models against deep HST color-magnitude diagrams of the M31 spheroid, disk and tidal stream. We find that such constrained models provide significantly worse fits to the data than models where some of these assumptions are broken.

177.07

Characterizing the Metallicity Distribution of the Extended Bulge of the Andromeda Spiral Galaxy (M31).

Jedidah C. Isler[1], J. Kalirai[2], K. Gilbert[2], P. Guhathakurta[2], M. Geha[3], S. Majewski[4], J. Ostheimer[4], R. Patterson[4], D. Reitzel[5], R. Rich[5]
[1]Fisk U, Vanderbilt U, UC, Santa Cruz (Visiting Student), [2]UCO/Lick Obs., [3]DAO/HIA/NRC, Canada, [4]U Virginia, [5]UCLA.

We characterize the metallicity [Fe/H] distribution of red giant branch (RGB) stars in the extended bulge of Andromeda spiral galaxy (M31) using spectroscopic and photometric data acquired with the Keck II 10-m telescope/DEIMOS spectrograph, CFHT 3.6-m telescope/ MegaCam camera, and the KPNO 4-m telescope/Mosaic camera. Our study is based on several hundred spectroscopically confirmed M31 RGB stars located in fields that lie in the projected distance range R = 10 30 kpc from M31's center along the minor axis. We measure the [Fe/H] distribution of M31's extended Sersic (n = 2) bulge by statistically subtracting the contribution of the underlying $R^{-2.6}$ power-law metal-poor stellar halo that extends out to R = 165 kpc. This study extends the initial finding by Kalirai et al. (2006) of a radial metallicity gradient in M31's bulge + halo. The derived [Fe/H] distribution of M31's extended bulge is compared to chemical evolution models.

This study is funded by grants from QEM, CfAO, NSF, and NASA/STScI.

177.08

Keck/Deimos Spectroscopy of Distant M31 fields with Deep HST Imaging

Robert M. Rich[1], T. M. Brown[2], D. B. Reitzel[1], H. Ferguson[2], A. Koch[1], E. Smith[2], P. Guhathakurta[3], J. Kalirai[4], A. Renzini[5], R. Kimble[6], A. Sweigart[6], K. Gilbert[4], M. Chiba[7], M. Iye[7], Y. Komiyama[7], M. Tanaka[7]
[1]UCLA, [2]STScI, [3]Lick Observatory/UCSC, [4]UCSC, [5]INAF-Padova, Italy, [6]GSFC, [7]NAOJ, Japan.

We are undertaking a program to obtain the radial velocities and abundances of red giants in the vicinity of M31 fields with deep HST imaging. Our goal is to obtain complementary spectroscopy for fields at 22 and 35 kpc on the minor axis, where the M31 halo may be in a transition in metallicity and surface brightness from relatively metal rich and intermediate age, to metal poor and old. We will describe existing deep M31 fields with Keck spectroscopy and HST imaging and compare our findings with observations in other M31 deep fields.

178: Dwarf Galaxies: Don't Let Their Size Fool You
AAS Oral, Tuesday, 10:00-11:30am, 3B

178.01

Environment and the Gas Content of Dwarf Galaxies

Marla C. Geha[1], M. Blanton[2], A. A. West[3]
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We present results from a survey of low mass dwarf galaxies selected from the Sloan Digital Sky Survey. These data represent the largest homogeneous sample of dwarf galaxies fainter than Mr > -16 with well-measured radio and optical properties. The sample spans a range of environments, from dense groups to truly isolated galaxies. The neutral gas fractions are on average significantly higher for these galaxies as compared to those of typical gas-rich galaxies at higher luminosities. Dwarf galaxies are therefore less efficient at turning gas into stars over their lifetimes. The strong environmental dependence of the gas fraction distribution in these dwarfs demonstrates that while internal processes can reduce gas fractions, external processes are required to fully remove gas from a dwarf galaxy. For a subset of this sample, we present VLA HI synthesis mapping in which we have measured the spatial extent of the HI gas and the two-dimensional gas dynamics. The VLA observations allow us to isolate and study environment-driven processes, such as ram pressure stripping, in these low mass galaxies.

178.02

Spitzer Mid-Infrared Observations of Blue Compact Dwarf Galaxies

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Blue Compact Dwarf Galaxies (BCDs) are galaxies that are characterized by their blue optical colors, low luminosities and small sizes. BCDs are found to typically have have low, subsolar, metallicities. IZw18, the archytype of BCDs, is one of the most metal-poor galaxies in the local universe, only recently losing the record of the lowest metallicity galaxy, and may represent a truly young galaxy. It has now has been observed with all three instruments on Spitzer. We will present our detailed analysis on the dust and star formation properties based on the new mid-infrared imaging and spectroscopic data.

We will also expand the discussion to a larger sample of BCDs, ranging in metallicity from 1/50 to half solar. A number of ionic line emission detected in their high-resolution mid-infraredspectra, consistent with a hard radiation field from massive young stars. We explore their extinction, excitation and abundances in this study and present results of our findings within the context of other star forming galaxies.

*The IRS was a collaborative venture between Cornell University and Ball Aerospace Corporation funded by NASA through the Jet Propulsion Laboratory and the Ames Research Center.

178.03D

Mass and Substructure in Dwarf Spheroidal Galaxies

Matthew G. Walker[1]
[1]Univ. of Michigan.

I present results from a large spectroscopic survey of individual stars in dwarf spheroidal (dSph) galaxies, conducted using the Michigan/MIKE Fiber System (MMFS) at the Magellan Telescopes. dSph galaxies have come under intense scrutiny because they represent the lower extreme of the galaxy mass function, and thereby provide important constraints on models of structure formation. The proximity of the Milky Way's (MW's) dSph satellites allows us to study the resolved stellar populations of these systems in detail. Toward this end I have acquired MMFS spectra (5140-5180 Angstroms at resolution 20000) for more than 5000 stars in the MW dSphs Carina, Fornax, Sculptor, and Sextans. The spectra yield measurements of both radial velocity (median precision $\pm$ 1.8 km/s) and [Fe/H] metallicity ($\pm$ 0.2 dex). I present radial velocity dispersion profiles for each dSph, as well as halo mass profiles derived using a variety of models and nonparametric estimation techniques. In some cases, the bulk stellar component is separable into populations following distinct distributions in position, kinematics, and chemistry, indicating a surprising level of complexity in these diminutive galaxies. Taking advantage of the fine spatial sampling of the MMFS data, I identify regions showing tentative evidence of localized chemo-dynamical substructure.

This work is supported by grants from the National Science Foundation and the University of Michigan.

178.04

Compact Elliptical Galaxies and Ultracompact Dwarfs in the Sloan Digital Sky Survey

Ronald O. Marzke[1], P. Pellegrini[2], L. da Costa[2], M. Maia[2], D. Burstein[3]
[1]San Francisco State University, [2]ON/CNPq, Brazil, [3]Arizona State University.

We present results of a search for compact elliptical galaxies and ultracompact dwarfs in the field. Compact elliptical galaxies like M32, NGC 4486B and NGC 5846A are thought to be generated by tidal stripping of more massive galaxies, but for reasons that are not well understood, they are extremely rare. At distances beyond the Virgo cluster, faint compact ellipticals are difficult to resolve under typical ground-based seeing conditions and are often missed by wide-field spectroscopic surveys. Fortunately, their *ugriz* colors identify them as composite stellar populations and thus distinguish them from the vast majority of foreground stars. We have obtained spectra of a sample of compact elliptical candidates identified in this way using photometry from the Sloan Digital Sky Survey. Several of these sources are compact, red galaxies with luminosities between those of the prototypical compact ellipticals and the much fainter ultracompact dwarfs. We will discuss the structure, stellar populations, and kinematics of these galaxies.

178.05

A New Population of Ultra-faint Local Group Galaxies

Daniel B. Zucker[1], V. Belokurov[1], N. W. Evans[1], G. Gilmore[1], M. I. Wilkinson[1]
[1]University Of Cambridge, United Kingdom.

Dwarf spheroidal galaxies (dSphs) are the smallest stellar systems showing evidence of substantial dark matter. They are also vivid reminders of the discrepancy between the numerous surviving dark matter subhalos predicted by cold dark matter (CDM) and the relatively few dwarf satellites observed in the Local Group (the ″missing satellite″ problem). Between 1938 and 1994, nine dSph satellites were discovered around the Milky Way. However, in the past two years alone, Sloan Digital Sky Survey (SDSS) data have yielded eight new dwarf satellites around the Milky Way and two around M31, in a new regime of extremely low luminosities ($-7.9 \leq M_V \leq -3.8$) and surface brightnesses ($\mu_V > 27$ mag arcsec^{-2}). We present here the physical properties of these new galaxies -their sizes, luminosities, morphologies, and abundances, as well as preliminary velocity dispersions and mass estimates -derived from SDSS data and follow-up observations on Subaru, Keck, the AAT and other telescopes, and discuss the implications of these properties for understanding dark matter and galaxy formation on the smallest scales.

178.06

The Dwarf Galaxy Leo A: A Survivor From the Epoch of Reionization

Andrew A. Cole[1], E. D. Skillman[1], A. E. Dolphin[2], J. S. Gallagher, III[3], E. Tolstoy[4], C. Gallart[5], D. Weisz[1], S. L. Hidalgo[1], A. Saha[6], P. B. Stetson[7], A. Aparicio[5]
[1]U. Minnesota, [2]U. Arizona, [3]U. Wisconsin, [4]Kapteyn Inst., The Netherlands, [5]IAC, Spain, [6]NOAO, [7]DAO, Canada.

We present the results of a program to derive the complete star-formation history of the Local Group dwarf irregular galaxy Leo A (DDO 69). Leo A is a low-luminosity (Mv = -11.7), very gas-rich (M(HI)/LB = 1.6) galaxy. Our analysis is based on color-magnitude diagrams derived from deep HST/ACS imaging; the CMDs reach well below the oldest main-sequence turnoff of Leo A, at I $\approx$ 28. Over 80% of all the stars ever created in Leo A were born more recently than 7.7 Gyr ago (redshift z = 1 in a flat ΛCDM universe). The star-formation rate from 8-12 Gyr ago is formally consistent with zero, but stars as old as the oldest globular clusters are present. These results are discussed in the context of the predicted effects of cosmological reionization on the evolution of dwarf galaxies.

178.07

Spitzer Observations of the Far-Infrared Radio Continuum Correlation in the Small Magellanic Cloud

Karin M. Sandstrom[1], A. Bolatto[1], A. Leroy[2], S. Stanimirovic[3], J. D. Simon[4], L. Staveley-Smith[5], J. R. Dickel[6], R. Shah[7], P. F. Winkler[8], R. C. Smith[9], N. Mizuno[10]
[1]University of California, Berkeley, [2]Max Planck Institute for Astronomy, Germany, [3]University of Wisconsin, Madison, [4]California Institute of Technology, [5]Australia Telescope National Facility, CSIRO, Australia, [6]University of New Mexico, [7]Institute for Astrophysical Research, Boston University, [8]Middlebury College, [9]NOAO, [10]Department of Astrophysics, Nagoya University, Japan.

We present a study of the far-IR radio continuum correlation within the Small Magellanic Cloud using MIPS far-infrared maps obtained as part of the Spitzer Survey of the SMC (S3MC) and radio continuum maps from a combined ATCA-Parkes survey. With these high resolution data, we can study the correlation within the SMC down to scales of about 35 parsecs. We find that there is a correlation even on these small linear scales. In general, the slope of the correlation is approximately unity, except in H II regions where we see an excess of radio continuum relative to the far-IR. Using the MCELS H-alpha image we decompose the radio continuum maps into thermal and non-thermal components and show that the excess corresponds to a higher thermal fraction in H II regions. We also find that regions with molecular gas (as determined by CO) have an excess of far-IR emission relative to radio continuum. We examine these behaviors at various resolutions and discuss their origins and relation to the global far-IR radio continuum correlation.

This work is based on observations made with the Spitzer Space Telescope (NASA-JPL Spitzer grant 1264151 awarded to Cycle 1 project 3316). K. S. is supported by the NSF Graduate Research Fellowship.

179: Extrasolar Planets I
AAS Oral, Tuesday, 10:00-11:30am, 605-07

179.01

The Migration of Giant Planets

Richard G. Edgar[1]
[1]*University of Rochester.*

Giant planets are thought to open gaps in their nascent discs, and then undergo Type II migration. According to Type II theory, the migration rate should be determined only by the disc viscosity. We have performed a systematic test of this prediction, and found it to be false. Our observed migration rates varied with the disc surface density as well as the viscosity. This implies that Type II migration theory is not sufficient to explain giant planet migration. The reason for the discrepancy is almost certainly the gas which remains in the gap. The deviation from Type II behaviour has profound implications for the formation of the 'hot Jupiters.'

179.02

Behavior of Apsidal Orientations in Planetary Systems

Rory Barnes[1], R. Greenberg[1]
[1]*Univ. Of Arizona.*

A widely considered characteristic of extra-solar planetary systems has been a seeming tendency for major axes of adjacent orbits to librate in stable configurations. Based on a new catalog of extra-solar planets (Butler et al. 2006) and our numerical integrations, we find that such small amplitude oscillations are actually not common, but in fact quite rare; most pairs of planets' major axes are consistenet with circulating relative to one another. However, the new results are consistent with studies that find that two-planet systems tend to lie near a separatrix between libration and circulation. Similarly, in systems of more than two planets, many adjacent orbits lie near a separatrix that divides modes of circulation.

179.03D

Turbulent Torques on Protoplanets in a Dead Zone

Jeffrey S. Oishi[1], M. Mac Low[2], K. Menou[3]
[1]*AMNH/UVa,* [2]*AMNH,* [3]*Columbia University.*

Dynamical migration of protoplanets seems likely to explain the observed distribution of extrasolar planets. Previous work on laminar disks predicts short migration times (less than the disk lifetime). This is a significant problem for the "core accretion" scenario, in which giant planets are thought to form from small, rocky protoplanetary cores in the disk. However, there have been recent suggestions that the turbulence providing accretion in protoplanetary disks might enhance migration by turning laminar migration into a random walk, possibly providing a solution to the short migration timescale.

I will report the results of local, 3D simulations of MHD turbulence with quiescent "dead zones" of varying sizes at the midplane. I demonstrate that turbulent torques on a massless protoplanet at the midplane are strongly affected by the presence of dead zones, which considerably decrease the total turbulent torque on the planet. In all cases, the torques have a finite correlation time and are dominated by gas close to the planet. These results can be incorporated into statistical models for the survival of a population of protoplanets in a disk, allowing a better understanding of the nature of planet migration and survival.

179.04D

Stellar Magnetic Activity and the Detection of Exoplanets

Jason Wright[1]
[1]*UC, Berkeley.*

I have characterized the orbits of over 100 exoplanets using precision radial velocity (RV) measurements from the California & Carnegie and Anglo-Australian Planet Searches. I have measured stellar magnetic activity in 1200 Planet Search program stars using the chromospheric Ca II H and K emission cores from the same spectra used to make precision RV measurements. I have reduced these data to Mount Wilson S indices and used the canonical age-activity relation to derive ages for these stars.

I find that this age-activity relation breaks down for very inactive and slightly evolved stars, and yields erroneously large ages for subgiants because it ignores the effects of evolution and abundance. This miscalibration has resulted in some confusion over the nature of some evolved stars, leading to their misclassification in the literature as examples of stars in extraordinary states of inactivity analogous to the solar Maunder Minimum.

I have analyzed the Keck RV data to determine the magnitude of astrophysical and instrumental RV noise, ''jitter'', as a function of color, activity level, and evolution. I quantify the increase in jitter with activity and decrease in B-V.

I have used this jitter estimate to recalculate the orbits of 100 previously known exoplanets, updating their orbital parameters and error estimates. I have combined this with data on all other known nearby exoplanets to create the Catalog of Nearby Exoplanets, containing stellar properties, orbital parameters, RV, and references for all 172 known exoplanets, including 5 previously unreported planets.

I have also used the jitter formula to measure false alarm probabilities for the existence of additional companions orbiting planet-bearing stars, and discuss constraining the orbital parameters of planets with incomplete orbits.

179.05D

A Survey of Close, Young Stars with SDI at the VLT and MMT

Beth A. Biller[1], L. Close[1], E. Masciadri[2], R. Lenzen[3], W. Brandner[3], D. McCarthy[1], T. Henning[3], E. Nielsen[1], M. Hartung[4]
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[3]*MPIA-Heidelberg, Germany,* [4]*European Southern Observatory, Chile.*

We discuss the results of a survey of young (<300 Myr), close (<50 pc) stars with the Simultaneous Differential Extrasolar Planet Imager (SDI) implemented at the VLT and the MMT. SDI uses a double Wollaston prism and a quad filter to take images simultaneously at 3 wavelengths surrounding the 1.62 um methane bandhead found in the spectrum of cool brown dwarfs and gas giants. By performing a difference of images in these filters, speckle noise from the primary can be significantly attenuated, resulting in photon and flat-field noise limited data. In our survey data, we achieved H band contrasts > 25000 (5sigma Delta F1(1.575 um) > 10 mag, Delta H > 10.6 mag for a T6 spectral type) at a separation of 0.5 arcsec from the primary star. With this degree of attenuation, we can image (5 sigma detection) a 2-4 Jupiter mass planet at 5 AU around a 30 Myr star at 10 pc. We have obtained complete datasets for ~50 stars. We believe that our SDI images are the highest contrast astronomical images ever made from ground or space for methane rich companions.

179.06

Planets Formed in Habitable Zones of M Dwarf Stars Probably Lack Volatiles

Jack J. Lissauer[1], E. V. Quintana[1]
[1]NASA/Ames Research Center.

Dynamical considerations, presented herein via analytic scalings and numerical experiments, imply that Earth-mass planets accreting in regions that become habitable zones of M dwarf stars form within several million years. Collision velocities during and after the prime accretionary epoch are somewhat larger than for Earth. Temperatures in protoplanetary disks and during the star's pre-main sequence evolution are higher than those encountered by Earth. These factors suggest that planets orbiting low mass main sequence stars are likely to be either too distant (and thus too cold) for carbon/water based life on their surfaces or lacking in the required volatiles.

180: Galaxy Clusters III
AAS Oral, Tuesday, 10:00-11:30am, 613-14

180.01

Projected 3pt Correlation Function in the Sloan Digital Sky Survey

Cameron McBride[1], R. Scranton[1], A. Connolly[1], J. Gardner[2]
[1]University of Pittsburgh, [2]Pittsburgh Supercomputing Center.

We present measurements of the projected three-point correlation function (3PCF) from the Sloan Digital Sky Survey's (SDSS) main galaxy sample. The 3PCF provides statistical information on the non-Gaussianity of large scale structure (LSS). This is naively an N-cubed calculation, which makes the runtime intractable for large datasets (such as the SDSS). To address this, we have been developing a parallel framework that leverages a tree-based approach to aid in an efficient computation. Utilizing volume-limited samples constructed from the most recent data release (DR5 consisting of over 600,000 galaxies), we probe the scale and configuration dependence of the projected 3PCF. As a complement to bispectrum and redshift-space analyses, the projected 3PCF sidesteps redshift distortions in the SDSS data by integrating out the effect of peculiar velocities. With proper binning, measurements on both weakly and strongly non-linear scales are consistent with expectations. On large scales (weakly non-linear), the 3PCF configuration dependence exhibits the V-shape from filamentary structure and measurements converge between redshift-space and projected-space. On small scales, the U-shape is prevalent in redshift-space and (properly) absent in the projected 3PCF. Comparisons with mass evolution in Hubble Volume simulations (Virgo Consortium) are used to investigate the bias between galaxy and mass clustering. Because the 3PCF contains higher order information than a two point correlation function, both the linear and quadratic bias terms are constrained.

180.02D

High-Redshift Clusters in the SpARCS Survey

Adam Muzzin[1], H. Yee[1], G. Wilson[2], SpARCS Collaboration
[1]Univ. of Toronto, Canada, [2]Spitzer Science Center.

As the densest regions in the universe, galaxy clusters are vital to our understanding of the role that environment plays in galaxy formation and evolution. Unfortunately, the current lack of spectroscopically-confirmed clusters at $z > 1$ prevents a large systematic study of the early stages of cluster galaxy evolution. In this talk I will discuss a new survey for clusters at $z > 1$, the Spitzer Adaptation of the Red-sequence Cluster Survey (SpARCS). SpARCS is a 50 sq deg z-band imaging survey in the Spitzer SWIRE fields designed to detect galaxy clusters at $1 < z < 2$ using the red-sequence technique. When complete in 2007, SpARCS will have discovered ~200 clusters at $z > 1$, significantly increasing the total number of clusters in this redshift range. I will present some of the first rich, high-redshift candidates from the survey as well as preliminary results from Gemini, Magellan and HST followup of cluster candidates.

180.03D

AGN Heating and the Growth of Black Holes and Bulges in Cluster Cores

David A. Rafferty[1], B. R. McNamara[2], P. E. Nulsen[3], M. W. Wise[4]
[1]Ohio University, [2]University of Waterloo, Canada, [3]CfA, [4]University of Amsterdam, The Netherlands.

Many central cluster galaxies (cDs) in cooling flows are growing rapidly through gas accretion and star formation. At the same time, AGN outbursts fueled by accretion onto supermassive black holes are generating X-ray cavity systems and driving outflows that exceed those in powerful quasars. We show that the resulting bulge and black hole growth follows a trend that is roughly consistent with the slope of the local (Magorrian) relation between bulge and black hole mass for nearby quiescent ellipticals. However, a large scatter suggests that cD bulges and black holes do not always grow in lock-step. Recent measurements made with XMM, Chandra, and FUSE of the condensation rates in cooling flows are now approaching or are comparable to the star formation rates, alleviating the need for an invisible sink of cold matter. We show that the remaining radiation losses can be offset by AGN outbursts in most of the systems in our sample, indicating that the level of cooling is regulated by AGN feedback. Lastly, we use optical observations to investigate whether the presence of active star formation is related to the presence of a cooling flow.

180.04

Simulating the Universe: Large Area Synthetic Galaxy Cluster Surveys

Eric J. Hallman[1], B. O'Shea[2], M. Norman[3], R. Wagner[3], J. Burns[1]
[1]University of Colorado, [2]Los Alamos National Laboratory, [3]University of California-San Diego.

We show results from a synthetic Sunyaev-Zeldovich effect (SZE) galaxy cluster survey generated from a very large adaptive mesh refinement cosmological calculation performed with the Enzo code. This calculation simulates a $(512h^{-1}\mathrm{Mpc})^3$ comoving volume with 512^3 root grid zones and 7 levels of dynamic refinement. The simulated volume and grid resolution enables SZE, X-ray and weak lensing synthetic surveys with both large sky coverage (~100 deg^2), and high angular resolution (5-10''). We present expected cluster survey yields for upcoming SZE sky surveys, including estimates of selection effects due to finite beam size and sensitivity limits. The significant new result from this simulation is that fully half the SZE flux in the survey images comes from objects with $M < 5.0\mathrm{x}\ 10^{13} M_{solar}$ and filamentary structures made up of gas in the Warm Hot Intergalactic Medium (WHIM) phase.

180.05D

Galaxy Populations in Clusters and the Estimation of Cluster Optical Richness in Wide-Field Surveys

Ben Koester[1]
[1]University of Michigan.

Using the recently published maxBCG cluster catalog and the imaging survey of the SDSS, we make background-subtracted measurements of the color, spatial, and luminosity distributions of cluster galaxies at $z < 0.3$. The accuracy of the photometric redshifts and the mass proxies of maxBCG allow reliable measurements of these observables as a function of richness and redshift.

The resulting radial, color, and luminosity profiles are converted into filters that are closely matched to observed cluster properties. These filters are then used to remeasure the richnesses of maxBCG clusters. Because the filters contain statistical information about observed cluster galaxy populations, they should generate a more informative mass proxy. Dynamical mass estimates confirm that this new richness measurement indeed contains more mass information than the basic N_{gals}^{r200} richness provided with the max-

BCG catalog. Techniques such as this will likely be a key component of future wide-field optical cluster surveys.

180.06

Probing Structure Formation Physics with the Evolution of Galaxy Cluster Properties

Douglas J. Burke[1], M. Arnaud[2], H. Boehringer[3], S. Borgani[4], C. Collins[5], C. Mullis[6], R. Nichol[7], E. Pointecouteau[8], G. Pratt[3], K. Romer[9], S. Sabirli[10], P. Viana[11], A. Vikhlihnin[1], M. Voit[12]
[1]SAO, [2]CEA Service d'Astrophysique, France, [3]MPE, Germany, [4]Osservatorio Astronomico di Trieste, Italy, [5]Liverpool John Moores University, United Kingdom, [6]University of Michigan, [7]University of Portsmouth, United Kingdom, [8]Centre d'Etude Spatiale des Rayonnements, France, [9]University of Sussex, United Kingdom, [10]Carnegie Mellon University, [11]Universidade do Porto, Portugal, [12]MSU.

XMM-Newton and Chandra observations show that the dark-matter profile of local galaxy clusters is universal, with a central cusp, as predicted by numerical simulations. In contrast, the physics governing the baryonic component remains far from being understood: the gas properties of local clusters do scale self-similarly down to low masses (around 2 keV), but the scaling laws differ from the simplest expectations. It appears that the gas history depends not only on gravitational effects but also on the interplay between cooling and various galaxy feedback mechanisms, none of which are well understood.

Recent evolution studies confirm that clusters follow scaling laws up to high redshifts, but the amount of evolution remains uncertain. We were awarded a XMM-Newton Large Programme in AO4 to assess the evolution of the structural and scaling properties of an unbiased sample of 23 clusters at a redshift of 0.5, covering a large mass range (2.5 to 12 keV). In this contribution we describe the initial results of the full sample and compare the cluster properties to local samples.

We acknowledge support from NASA grant NNG0-5GL94G and NASA Contract NAS8-39073.

181: Galaxy Evolution with DEEP2
AAS Oral, Tuesday, 10:00-11:30am, 608-10

181.01D

The DEEP2 Galaxy Redshift Survey: the Formation of the Red Sequence

Michael C. Cooper[1]
[1]University of California at Berkeley.

By obtaining a data set comparable in size and nature to recent generations of local surveys, the DEEP2 Galaxy Redshift Survey has made possible the study of the relationships between galaxy properties and local environment at z ~ 1. I will present results from DEEP2 focusing on the evolution of the color-density relation at intermediate redshift ($0.4 < z < 1.3$); we find strong evidence that the build-up of galaxies on the red sequence occurred preferentially in overdense environments over that period. I will show that massive clusters of galaxies do not drive these results; rather, it is group-like environments which dominate. If time permits, I will discuss the physical mechanisms responsible for the quenching of star formation at z ~ 1, including the role of AGN activity and quasar feedback. Lastly, I will present the discovery of a population of bright, blue galaxies in dense environments seen at z ~ 1 but not locally. These objects are likely to be precursors of some of the massive, red galaxies seen today.

181.02

Are Massive Galaxies Formed by z~1?

Christopher Conselice[1], AEGIS Team
[1]Univ. of Nottingham, United Kingdom.

The stellar mass function for galaxies has been measured out to redshift z~1.5, and it appears that the most massive galaxies are formed by then. However, it is not yet known if massive galaxies, those larger than log M > 11, evolve in anyway since the universe was about half its current age. To address this point we present results from the Palomar Observatory Wide-Field Infrared Survey which contains over 1.5 sq. degrees of K-band and J-band imaging to K =20.5-21 and J=23-23.5. We use this imaging, as well as DEEP2 spectroscopy and other AEGIS data sets to locate these massive galaxies out to z~1.5 and to trace their: 1. number densities and mass densities, 2. their morphological evolution and merging properties, including dry mergers, 3. their star formation rate and 4. their X-ray emission from Chandra imaging. It appears that while within the errors the most massive galaxies appear to be formed by z~1.5 there is still significant evolution for most of the population, both morphologically, in their merger rates, as well as their AGN properties. This suggests that the idea that massive galaxies are already formed by z~1 and evolve passively thereafter may need revision.

181.03D

The Evolution of the Blue Galaxy Fraction in DEEP2 Groups and Isolated Galaxies

Brian Gerke[1]
[1]UC-Berkeley.

Groups and clusters of galaxies, as the largest, most recently formed objects in the universe, carry much information about the recent history of the cosmos. By studying these systems at a variety of epochs, it is possible to reconstruct the evolution of clusters and their luminous contents, providing important constraints on theories of galaxy formation. With the recent completion of the DEEP2 Galaxy Redshift Survey at z~1, it is now possible to perform detailed studies of galaxy groups and clusters over a wider redshift range than ever before. In this talk I will present recent results suggesting that, at the DEEP2 epoch, galaxy groups had only recently become suitable environments for shutting off star formation in galaxies. I will comment on the implications of this result for models of galaxy formation.

181.04

Redshift Identification of Single-Line Emission Galaxies in the DEEP2 Survey

Evan Kirby[1], P. Guhathakurta[1], S. M. Faber[1], B. J. Weiner[2]
[1]UC Santa Cruz, [2]University of Maryland.

We present two methods for determining spectroscopic redshifts of galaxies in the DEEP2 survey which display only one emission line. Both methods rely on broadband BRI photometry. The first calculates the distance of a single-line galaxy to galaxies of known redshift in (B-R), (R-I), R parameter space. The second is an artificial neural network. Both methods are nearly perfect at identifying blended [OII] $\lambda\lambda$3726, 3729 doublets, and respectively 92% and 90% accurate at identifying Hα. Although they cannot discriminate between [OIII] λ4959 and Hβ, they can identify a single line as one or the other. From a sample of of 648 single-line spectra, the methods determine the identities of 287 and 316 single lines, respectively. This work is supported by NSF and NASA/STScI grants, and ENK is supported by a NSF Graduate Research Fellowship.

181.05D

Galaxies in Transition: AGN Activity and Environments of Post-starburst Galaxies

Renbin Yan[1], DEEP2 Team
[1]UC, Berkeley.

Post-starburst (K+A) galaxies are galaxies that have had their star formation quenched recently and are on their way to become red sequence galaxies. The nature of the quenching mechanism in K+As is uncertain, but resolving it is critical to understanding the build-up of the red sequence population. With two large redshift survey datasets from SDSS (z~0.1) and DEEP2 (z~1), we have studied the K+A population at both low-z and high-z with identical methods. From the SDSS sample, we have discovered that the emission line commonly used to define K+A galaxies at high z, [OII] 3727, is heavily contaminated by LINER emission in many cases, complicating interpretation. Using selection techniques that avoid this problem, we find that at both low and high redshift, a large fraction of both red sequence and K+A galaxies have substantial [OII] and other line emission originating from AGN activity. K+A galaxies are preferentially found in underdense environments, which resembles their progenitors --star-forming galaxies. The implications from these studies for the quenching mechanisms of star formation will be discussed.

Funding for this work is provided by NSF through grants AST05-07428 and AST05-07483.

181.06

The Stellar Mass Tully-Fisher Relation to z=1.2

Susan A. Kassin[1], B. Weiner[2], S. Faber[1], D. Koo[1], J. Lotz[2], DEEP2 Team
[1]UC Santa Cruz, [2]Steward Observatory.

For a sample of 544 galaxies of a large range of morphologies at 0.1 < z < 1.2, Hubble Space Telescope images and resolved spectra from Keck are used to create a stellar mass Tully-Fisher relation (correlating stellar mass with rotation velocity). The resulting relation is found to have large scatter to low rotation velocity (~1 dex) dominated by disturbed, compact, and major merger galaxies. However, when a Tully-Fisher relation for a kinematic estimator that incorporates both rotation velocity and an integrated velocity dispersion is created, a remarkable regularity is found. This new Tully-Fisher relation has scatter that is consistent with measurement errors, is independent of morphology, and is non-evolving to z=1.2 It is also consistent with the stellar mass Faber-Jackson relation for elliptical galaxies which correlates stellar mass with central velocity dispersion. The implications of this relation for galaxy formation models will be discussed.

We would like to thank NSF grants AST0071198 and AST0507483. Support for GO program 10134 was provided by NASA through NASA grant HST-G0-10134.13-A from the Space Telescope Science Institute.

182: Novae/Cataclysmic Variables
AAS Oral, Tuesday, 10:00-11:30am, 6A

182.01

Radio Imaging of the Recurrent Nova RS Ophiuchus

Michael P. Rupen[1], A. J. Mioduszewski[1], J. L. Sokoloski[2], C. R. Kaiser[3], C. Brocksopp[4]
[1]NRAO, [2]Columbia University, [3]University of Southampton, United Kingdom, [4]Mullard Space Science Laboratory, Univ. College London, United Kingdom.

We present high-resolution Very Long Baseline Array radio images of the recurrent nova RS Oph, beginning three weeks after the outburst. We report the evolution of the expanding and decelerating radio shell, and compare our results with observations at other wavelengths.

The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

182.02

Hubble Space Telescope Observations of the 2006 Outburst of RS Ophiuchi

Michael F. Bode[1], D. Harman[1], T. J. O'Brien[2], H. E. Bond[3], S. Starrfield[4], M. Shara[5], S. Eyres[6], A. Evans[7]
[1]Liverpool John Moores University, United Kingdom, [2]Jodrell Bank Observatory, United Kingdom, [3]STScI, [4]Arizona State University, [5]American Museum of Natural History, [6]University of Central Lancashire, United Kingdom, [7]Keele University, United Kingdom.

The latest outburst of the recurrent nova RS Ophiuchi has been followed in unprecedented detail across the electromagnetic spectrum. The central system is known to contain a red giant in orbit with a high mass white dwarf. At outburst,high velocity ejecta from the white dwarf impact the red giant wind setting up shock systems whose evolution has been followed particularly in X-rays,infrared and the radio. Here we report HST observations which for the first time provide direct imaging in the optical of the circumstellar environment following an outburst. Structures are evident that are broadly consistent with those derived in the radio and have some similarities to those seen in SN 1987A.

182.03

The Metallicity and Lithium Abundances in the Repeating Novae, RS Oph and T CrB

George Wallerstein[1], T. Harrison[1], U. Munari[2]
[1]Univ. of Washington, [2]Osservatorio Asiago, Italy.

The subclass of symbiotic stars that has been suggested to be one of the sources of supernovae of type Ia is the repeating novae. Spectroscopic orbits of TCrB and RS Oph indicate that the white dwarfs in those systems have masses close to 1.4 MSun and hence they are vulnerable to catastrophic collapse if they accumulate additional mass from their red giant companions.

To investigate the nature of their companions we obtained high res (35,000) spectra of both RS Oph and TCrB in 2004 with the echelle spectrograph of the Apache Point 3.5-m telescope. The purpose was to derive as much information about the red giant component that has been losing mass, some of which has probably been captured by the white dwarf. Of particular interest is the possibility that the red giant has lost much of its hydrogen envelope which might indicate that the mass-transfer process had reached the point that a supernova outburst (rather than just a repeat of the nova outburst) is imminent. Standard methods were used to derive the effective temperature and gravity of the cool star. Using model atmospheres we have been able to derive the metallicity of the stars. Using lines of Si, Ti, Fe and Ni we found RS Oph to show small metal excess. A small metal deficiency was found for TCrB. Within the uncertainties a solar metallicity is possible for both stars. Both stars show a strong Li line. For 41 other symbiotic stars observed at the Asiago Observatory, 28 showed no Li line and 13 were too severely blended to make a judgment. It is not clear if the lithium in the two repeating nova systems is due to processes within the red giant or to capture by the red giant of Li produced in the nova explosions.

182.04D

Mass Transfer and Evolution of Compact Binaries

Vayujeet Gokhale[1]
[1]Louisiana State Univ..

We present a study of key aspects of the evolution of binary stars with emphasis on binaries consisting of two white dwarf stars obeying the zero temperature mass radius relationship. The evolution of such systems is driven by the loss of angular momentum by gravitational wave radiation. Effects like mass transfer and other modes of angular momentum loss and redistribution influence the evolutionary fate of the binary, and can lead to a merger, the tidal disruption of one of the components or its survival as a long-lived AM Canum Venaticorum (AM CVn) type system. Our study takes into account some of these effects; like mass loss due to super-Eddington accretion, tides, accretion disk formation and direct impact accretion. We find that under some circumstances, the tidal coupling between the spin of the components and the orbit of the binary leads to oscillations in the orbital separation and the mass transfer rate. We also find that as compared to previous studies, a larger fraction of the systems should survive to form AM CVn type systems. Unless the donor star has a finite entropy such that the effective mass-radius relationship deviates significantly from that of a zero temperature white dwarf, we expect our results to be valid. Much of the formalism developed in this work would also apply to other mass-transferring binaries, such as cataclysmic variables and Algol systems.

182.05

Hubble Space Telescope Observations of Thirteen Novae Candidates in the Core of M87

Juan P. Madrid[1], W. B. Sparks[1], H. Ferguson[1], M. Livio[1], D. Macchetto[2]
[1]STScI, [2]STScI/ESA.

A new technique using near ultraviolet imaging to detect transient sources was implemented with the Space Telescope Imaging Spectrograph (STIS) in the core of M87, an area of this galaxy left unexplored by previous studies due to crowding. With HST's unique resolution and sensitivity we detected thirteen novae candidates within less than one kiloparsec from the nucleus. Our findings indicate that the frequency of nova events in the core of M87 is considerably higher than in the rest of the galaxy. This effect may be due to mass segregation of white dwarfs or to the presence of the nearby AGN. These novae candidates do not show a conspicuous orientation or alignment with respect to the prominent jet of M87 as previously thought.

182.06

X-ray Ne/O Ratio in Cataclysmic Variables

Eric M. Schlegel[1], V. Rana[2], K. Singh[2], V. Girish[2], P. Barrett[3]
[1]Univ. of Texas, San Antonio, [2]Tata Inst. of Fundamental Research, India, [3]US Naval Observatory.

The Ne/O ratio has recently become a topic of considerable debate given the difficulties and discrepancies in recent measures of the Ne abundance in the Sun. We describe the results of an analysis of the permitted branches of the X-ray triplet transitions of Ne and O using the available spectra from the Chandra X-ray Observatory's High Energy Transmission Grating observations of cataclysmic variables. We compare our results with those obtained from the Sun and nearby stars.

182.07

Accreting Pulsating White Dwarfs: Hotter than Single DAVs

Paula Szkody[1], A. Mukadam[1], B. T. Gaensicke[2], P. A. Woudt[3], J. Solheim[4], E. M. Sion[5], A. Nitta[6], B. Warner[3], D. K. Sahu[7], T. Prabhu[7], A. Henden[8]
[1]Univ. of Washington, [2]Univ. of Warwick, United Kingdom, [3]Univ. of Cape Town, South Africa, [4]Institute of Theoretical Astrophysics, Norway, [5]Villanova University, [6]Gemini Observatory, [7]Indian Institute of Theoretical Astrophysics, India, [8]AAVSO.

Single DAV pulsating white dwarfs are known to show non-radial g-mode pulsations with periods around 50-1400s and have temperatures in the specific range of 11,000-12,500K. With the discovery of several pulsating white dwarfs in the accreting close binary systems of cataclysmic variables, it is possible to probe the effects of mass transfer and accretion, external heat input, He enriched envelopes and fast rotation on the location of the instability strip. Our UV observations of three pulsating accreting white dwarfs in the cataclysmic variables SDSSJ013132-0901, SDSSJ161033-0102 and SDSSJ220553+1155 with the Solar Blind Channel on HST show enhanced pulsation amplitudes over the optical and white dwarf temperatures near 15,000K. Combined with temperatures of two other known accreting pulsators (GW Lib and HS2331+3905), it appears that there is a wide range in the instability strip for accreting pulsators. This range may be due to different white dwarf masses or compositions compared to single DAVs. This research was supported by NASA grant GO-10233.01A from STScI.

183: SDSS and GALEX
AAS Oral, Tuesday, 10:00-11:30am, 3A

183.01

The Intrinsic Properties of SDSS Galaxies: Taking off the Rose Tinted Glasses

Ariyed Maller[1], A. Berlind[2], M. Blanton[2], D. Hogg[2]
[1]New York City College of Technology, [2]CCPP, NYU.

It is well known that most galaxies contain dust. Dust reddens galaxies and does so as an increasing function of the galaxies observed inclination. Therefore when one looks at the properties of observed galaxies, such as the luminosity function, the correlation function or the color magnitude-diagram, one gets a distorted view of the properties of galaxies. This effect can be corrected for in a large galaxy sample such as the Sloan Digital Sky Survey. The procedure is to identify inclination dependence in an observed galaxy property, color being the most obvious choice, and then to solve for the function of inclination that will remove this observed dependence. In this way we can determine the intrinsic properties of galaxies, properties that are independent of their inclination. The distribution of these intrinsic properties give us an undistorted view into the nature of galaxies and are thus more useful for determining evolutionary effects and comparing to theoretical models.

183.02D

Dependence of Merger Rates and Ram Pressure Stripping on Environment and Galaxy Mass

Janice Hester[1]
[1]Princeton Univ..

In order to disentangle the effects of different, potentially important, mechanisms in the process of galaxy evolution, it is important to understand how they depend on both environment and on galaxy mass and morphology. Galaxy morphology can be separated into two classes of parameters; those that describe star formation or color and those that describe structure. Both depend on environment, but they do so in somewhat subtly different ways. I examine how two different processes depend on environment and galaxy mass. First, an analytic model of ram pressure stripping is developed and its predictions compared to g-r colors and SFRs in groups and clusters in the SDSS. The observed dependence of color on group mass and satellite luminosity in the groups can be understood using the model. Second, a set of merger trees, built from a large N-body simulation, are used to examine the dependence of merger rates on environment, halo mass, and red shift. The results of this study can be applied both to galaxy evolution and to the clustering of luminous AGN. This work was funded by a NASA grant.

183.03D

Reflections of Cluster Assembly in the Stellar Populations and Dynamics of Member Galaxies

Sean Moran[1], R. S. Ellis[1], T. Treu[2], G. P. Smith[3], N. Miller[4]
[1]Caltech, [2]University of California, [3]University of Birmingham, United Kingdom, [4]Caltech/UC Santa Cruz.

We combine space-based optical (HST) and UV (GALEX) imaging of two intermediate redshift galaxy clusters with ground-based (Keck) spectroscopy of member galaxies, to study the relation between the formation history of cluster galaxies and the assembly history of the cluster structure itself. We examine galaxy morphologies, dynamics, and stellar populations as a function of several measures of environment.

We find that galaxies in the cluster MS0451-03 (z=0.54) exhibit a markedly lower incidence of recent star formation activity than galaxies in the cluster Cl0024+17 (z=0.39), despite the higher redshift of MS0451. This effect is significant even in the cluster outskirts, more than 2.5 Mpc from each cluster's core. We find a corresponding increase in the fraction of ″passive″, non-star forming spiral galaxies in MS0451, as compared to

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Cl0024. These passive spirals show signs that their star formation has recently been quenched. Without further star formation, they will likely evolve into S0 galaxies.

The comparatively evolved state of MS0451, with look back time more than 1 Gyr higher than Cl 0024, implies a large cosmic variance in the properties of massive galaxy clusters, and underscores the role of environment in galaxy formation. Specifically, we quantify the roles of assembling substructure and the ICM in governing the star formation histories of cluster galaxies.

183.04

The Star Formation and Extinction Evolution of UV-Selected Galaxies over 0<z<1.25

Christopher D. Martin[1], GALEX Science Team, Spitzer-MIPS Science Team
[1]*Caltech.*

We study the co-evolution of extinction and star formation rate in galaxies over $0<z<1.25$ in the Chandra Deep Field South (CDFS) field. We use a new stacking technique to obtain mean mid IR and far IR to Far UV flux ratios over the rest near-UV/near-IR color-magnitude diagram. We employ COMBO-17 redshifts and COMBO-17 optical, GALEX far and near UV, Spitzer IRAC and MIPS Mid IR photometry. This technique permits us to probe infrared excess (IRX) ratios and their evolution over almost two orders of magnitude. We use the derived IRX to correct extinction in all bands, and then use rest-frame extinction-corrected H-band and NUV-H colors to derive the specific star formation rate and the stellar mass. We confirm some well known trends and discover a number of interesting new ones. At a given redshift the specific star formation rate is a flat distribution up to a critical mass. For higher masses the specific star formation rate falls steeply. The critical mass increases with redshift. The specific star formation rate increases with redshift. At any given epoch, IRX is a strongly increasing function of mass up to the critical mass. Above this mass the IRX falls. The rise in the total star formation density in higher extinction galaxies is directly tied to the increasing characteristic mass of star forming galaxies. Finally, the IRX at a given mass may increase with decreasing redshift. We interpret these trends using a simple evolutionary model that relates extinction, mass, metallicity, and star formation rate.

183.05D

How Special are Brightest Cluster Galaxies?

Anja Von Der Linden[1], P. N. Best[2], G. Kauffmann[1], S. D. White[1]
[1]*Max-Planck-Institut fuer Astrophysik, Germany,* [2]*Institute for Astronomy, Royal Observatory Edinburgh, United Kingdom.*

Using a sample of 625 brightest cluster galaxies (BCGs) in the Sloan Digital Sky Survey (SDSS) at redshifts $z<0.1$, we attempt to disentangle the roles of their typically large stellar masses and their location in the center of a cluster in determining their properties.

The basis of our cluster catalog is the C4 catalog, but we refine this catalog by placing particular emphasis on correctly identifying the BCG, and determining accurate velocity dispersions for the clusters.

We find that BCGs are more likely to host radio--loud active galactic nuclei than other galaxies of the same mass.

Concerning their structural parameters, we find that BCGs are larger and have higher velocity dispersions than non-BCGs of the same stellar mass. Combined, these findings indicate a higher dark matter fractions in BCGs, attributable to the dark matter halo of the parent cluster. This higher dark matter fraction is less variable with luminous mass than for non-BCGs, which causes early-type BCGs to lie on a different fundamental plane than ordinary early-type galaxies. BCGs also follow a steeper Faber--Jackson relation than non-BCGs, and we find tentative evidence that the steepening is stronger in more massive clusters.

183.06

Star Formation and Attenuation in SDSS Galaxies from GALEX and Spitzer: Exploring the Links

Benjamin D. Johnson[1], D. Schiminovich[1], GALEX Science Team
[1]*Columbia University.*

With deep GALEX and Spitzer observations of 1000 galaxies spectroscopically observed by SDSS we can measure both the obscured and unobscured star formation In these galaxies. We present an empirical relation between various measures of star formation history (including a measure based on 8 micron PAH emission), broadband color, and dust attenuation (as measured by the infrared to UV ratio). This relation can be used to infer the attenuation in high redshift galaxies. We explore the implications of this relation for the star formation history of galaxies by comparison with models of galaxy spectra and dust attenuation. Finally, we will present the average 1300 angstrom through 70 micron spectral energy distributions as a function of stellar mass, star formation history, and attenuation.

184: Helping Faculty/Teachers Become More Adept at Working with Under-represented Groups
AAPT Panel, Tuesday, 10:00-11:30am, 615

Chair

Juan R. Burciaga[1]
[1]*Whitman College.*

184.01

Stalking the Anti-Racist Atom: Engaging Educational Equity and Diversity in Physics Teaching

Apriel K. Hodari[1]
[1]*The CNA Corporation.*

One of the first articles I ever read on diversity in physics education stated, “There’s no such thing as an anti-racist atom.” This perspective, that the science of physics is itself inherently unbiased, illustrates the difficulty of engaging our intellectual community on this topic. We genuinely believe that our science is devoid of the complications of the human condition, and therefore we need not worry about these things. It is clear however, as people competing for scarce resources in a non-equitable society, we engage in all of the same behaviors everyone else does, include those that work against equity and diversity. Over the last several years, my colleagues and I have held workshops aimed at addressing educational equity and diversity in physics teaching. In this discussion, I will present some of the questions we have posed, along with lessons learned and ideas about what we can do next.

184.02

Practical Ways to Improve Physics Education

Daryao S. Khatri[1]
[1]*University of the District of Columbia.*

Research shows that the single most important factor contributing to the general decrease in the number of students entering physics in general and those of minority groups in particular is the way we teach physics at both the high school and college levels. When College faculty and high school teachers try to seek practical assistance in their teaching, they are bombarded with theoretical models of student learning rather than being provided with proven and effective teaching techniques. Moreover, these models remain that way in the minds of both the presenters and the conference attendees. No wonder then that nothing ever improves.

Almost everyone in the field of education research has put the blame on the lecture method used by most college faculty and high school teachers, but nothing workable is offered in its place.

We at the University of the District of Columbia have researched, documented and tested a model in faculty/teacher training with phenomenal success. We will share with conference participants the *practical* pedagogical tactics that have worked and had profound impact on the teaching of a faculty member once these tactics are demonstrated by the trainer(s) and habituated by the faculty.

184.03

Labels Matter: Changing the Conversation From "-isms" to Privilege

Melissa H. Dancy[1]
[1]*UNC-Charlotte.*

Whites typically view racism as discrimination and unfair judgment based on skin color. This view inhibits an end to race-based oppression because it names the issue in terms of the oppressed. A more accurate label is White Privilege. The concept of White privilege is very different from the concept of racism because it includes all Whites, not just those who hold explicit racist views. Acknowledging privilege can be threatening for those who hold a privileged status. However, it is necessary for those who are advantaged to have clarity about their status if the "isms" are to be overcome. In this talk I will discuss my personal struggle to acknowledge my own privileged status (White, American, straight, etc.) and will offer suggestions based on my own experiences for working with advantaged populations committed to overcoming all forms of oppression.

184.04

Designing a Workshop for Change in the Community of Physics

Juan R. Burciaga[1]
[1]*Whitman College.*

The problem of under-represented groups in physics continues to be both monolithic and implacable. And to the individual teacher/faculty member the scope of the problem seems so pervasive and far-reaching that there seems to be little that any one person can do. Yet perhaps because of this, the individual instructor is the most sure path to effective and long-term change.

But what can an instructor do to make learning physics more open, more inclusive? How can we establish programs that can make a permanent and sustained change to the way physics is practiced?

In an attempt to answer these questions, the author has developed a workshop called "Reaching, Teaching and Keeping Under-represented Groups in Physics." The paper will highlight the design of the workshop, the model for change upon which the workshop is built, and the lessons learned while leading this workshop.

185: NAEP Science 2009: Why Should Physics Teachers Care?
AAPT Panel, Tuesday, 10:00-11:30am, 310

Chair

Paul Hickman[1]
[1]*Science Education Consultant.*

186: 1957: the Legacy of Sputnik
AAPT Special, Tuesday, 10:00-11:30am, 303

Chair

Richard Jacob[1]
[1]*Arizona State U..*

186.01

Eisenhower, Scientists, and Sputnik

John S. Rigden[1]
[1]*Washington University.*

On October 4, 1957, the Russians launched a 184-pound satellite into Earth orbit. This event had a tremendous impact on Americans as it called into question the capability of U. S. science v*s-a-v*s that of the Russians. On October 15, President Dwight D. Eisenhower called ″his scientists″ to the Oval Office and a meeting took place that Hans Bethe has called an ″unforgettable hour.″ At this meeting, I. I. Rabi, Chairman of the Science Advisory Committee, made several proposals to President Eisenhower that the President accepted immediately. We are still living with the legacy of the proposals that Eisenhower adopted that day.

186.02

The Influence of Sputnik on U.S. Science Education and Research

Leon M. Lederman[1]
[1]*Illinois Institute of Technology and Illinois Mathematics and Science Academy.*

A commonly heard cry which echoes in the corridors of our schools and colleges is: ″Oh! If only we had a Sputnik!″ The need for a motivation as strong as the Soviet satellite which shocked America 50 years ago is felt strongly as we observe our current status of STEM education in decline. I will review the effect of Sputnik on U.S. science education and on the funding of research. What was there about Sputnik that so alarmed both decision makers and citizens? And what actually was the response of the alarmed population to this satellite beeping over us every 90 minutes? Finally, what happened to the resulting initiatives so that, by 1980, we were ″A Nation at Risk″?

187: Virtual Observatories
AAPT Special, Tuesday, 10:00-11:30am, 618

Chair

Jordan Raddick[1]
[1]*Johns Hopkins University.*

187.01

The Science and Technology of the National Virtual Observatory

Alex Szalay[1]
[1]*Johns Hopkins University.*

Astronomy today faces a data avalanche. Breakthroughs in telescope, detector, and computer technology allow sky surveys to produce terabytes of data. These datasets cover the sky in different wavebands, from gamma rays to radio. With new inexpensive storage technologies and high-speed networks, the possibility of combining data from multi-terabyte online databases has become real.

These developments are changing the way astronomy is done. In August 2001, the National Science Foundation awarded five-year funding to a collaboration "Framework for the National Virtual Observatory," under its Information Technology Research program.

The NVO project is now providing simple services for astronomers. The services answer some of the most common questions that astronomers today "where do I find data that is relevant to me," "which surveys have information on my favorite objects," and so on. These services form the building blocks of other, higher level applications. The NVO has developed, and will continue to develop, some of these applications but it also offers the possibility for users to develop their own applications.

The NVO project is working closely with similar development efforts worldwide. We have jointly formed the International Virtual Observatory Alliance, bringing together the leaders from all such efforts, and have agreed upon on common roadmap for development.

In this talk, I will explain the science and technology of virtual observatories in the context of modern astronomy research, discuss some of the NVO's services and applications, and describe the directions in which the virtual observatory concept is evolving.

187.02

Education Potential of the National Virtual Observatory

Carol Christian[1]
[1]STScI.

Research in astronomy is blossoming with the availability of sophisticated instrumentation and tools aimed at breakthroughs in our understanding of the physical universe. Researchers can take advantage of the astronomical infrastructure, the National Virtual Observatory (NVO), for their investigations. . As well, data and tools available to the public are increasing through the distributed resources of observatories, academic institutions, computing facilities and educational organizations. Because Astronomy holds the public interest through engaging content and striking a cord with fundamental questions of human interest, it is a perfect context for science and technical education. Through partnerships we are cultivating, the NVO can be tuned for educational purposes.

187.03

The Challenges of Using Virtual Observatories in the Classroom

Robert T. Sparks[1]
[1]National Optical Astronomy Observatory.

The Internet has made data that was previously available only to professional astronomers available to anyone with an Internet connection. Several programs have developed over the years to attempt to bring this data into the classroom.

There are many challenges to introducing astronomy data in the classroom. These can include issues of computer use, finding the correct data analysis tools, the learning curve associated with your tools, and time constraints. I will discuss how to bring astronomy data into the classroom and how to address some of the common challenges teachers face.

187.04

Discover an Asteroid Using SDSS

Elizabeth A. Ramseyer[1]
[1]Niles West High School.

Every Fall, the Apache Point Observatory repeatedly images the skies near declination 0 degrees in a quest to see first light from distant supernovae. The Sloan Digital Sky Survey (SDSS) uses the data from these images to map the Universe. These data are made available on the internet for use by the public. While analyzing these images, we discovered the presence of a transient light source that subsequent analysis showed our ?mystery object? to be an asteroid. We present here the details of the analysis that allowed us to determine the identity of our ?mystery object.? Learn how you can access the SDSS database and make your own discovery!

188: PER: Student Understanding and Student Reasoning
AAPT Oral, Tuesday, 10:00-11:30am, 307-08

Chair

Marina M. Milner-Bolotin[1]
[1]University of British Columbia, Canada.

188.01

Techniques and Tools for Teaching the Photoelectric Effect

S. B. McKagan[1], W. Handley[1], K. K. Perkins[1], C. E. Wieman[1]
[1]University of Colorado.

Understanding the photoelectric effect is a crucial step in understanding the particle nature of light, one of the foundations of quantum mechanics. The photoelectric effect is a powerful tool to help students build an understanding of the photon model of light, and to probe their understanding of the photon model. This topic, which may seem straightforward to physics professors, is treated only superficially in many courses in modern physics and quantum mechanics. However, research shows that students have serious difficulties understanding even the most basic aspects of the photoelectric effect, such as the experimental set-up, experimental results, and implications about the nature of light [1]. As part of a reformed modern physics course for engineering majors [2], we have created a research-based instructional unit on the photoelectric effect. This unit includes an interactive computer simulation [3], interactive lectures with peer instruction, and conceptual homework problems. Using common exam questions, we have found that our instruction leads to better student understanding than either traditional instruction or previous reformed instruction. [4]

1. R. N. Steinberg, G. E. Oberem, and L. C. McDermott, Am. J. Phys. 64, 1370 (1996).

2. S. B. McKagan, K. K. Perkins, and C. E. Wieman, PERC Proceedings 2006, in press; preprint available at http://arxiv.org/abs/physics/0608239

3. http://phet.colorado.edu/simulations/photoelectric/photoelectric.jnlp

4. This work was supported by NSF, The Kavli Institute, The Hewlett Foundation, and the University of Colorado.

188.02

Examining Student Understanding of Quantum Wavefunctions

Homeyra R. Sadaghiani[1], P. S. Shaffer[1], L. C. McDermott[1]
[1]University of Washington.

As part of an ongoing research and curriculum development effort, the Physics Education Group at the University of Washington is examining student understanding of introductory quantum mechanics. The investigation includes data from four different classes at two large research universities. Specific research questions will be used to illustrate some common problems students have in applying and interpreting basic quantum mechanical principles.

This work has been supported in part by the National Science Foundation.

188.03

Pedagogical Landscape in Upper-Level Thermal Physics *

David E. Meltzer[1], W. M. Christensen[2]
[1]University of Washington, [2]Iowa State University.

We have been engaged in a long-term investigation of student learning of thermal physics at the introductory through advanced-undergraduate level. At the same time, we have drawn from our research to develop and test new instructional materials and strategies to address students' learning difficulties. Based on this work, we will present a brief overview of the initial state of students' knowledge as they begin their upper-level courses, along with a preliminary assessment of their response to particular instructional strate-

gies. This overview incorporates an assessment of the evolution of students' thinking on thermal-physics concepts during the transition from introductory to upper-level studies.

*Supported in part by NSF DUE-9981140, PHY-0406724, and PHY-0604703

188.04

"Is Entropy Conserved?" Student Understanding of Entropy in Introductory Physics

Warren M. Christensen[1], D. E. Meltzer[2]
[1]Iowa State University, [2]University of Washington.

As part of our continuing investigation into student learning of thermal physics in an introductory calculus-based course, we are probing student ideas regarding entropy and the second law of thermodynamics. We will present free-response and multiple-choice data collected both preand post-instruction from the previous five semesters. These data suggest that many key concepts are challenging for students. For example, as many as 75% of students, both before and after instruction, incorrectly claim that the total entropy of a system plus its surroundings must stay the same during a spontaneous process. Many of these students base their claim by asserting some sort of conservation principle for entropy. Early indications are that use of modified instruction with research-based materials may have yielded significant learning gains with some of these concepts. However, many student ideas remain resistant to change despite the modified instruction.

*Supported in part by NSF DUE-9981140, PHY-0406724, and PHY-0604703

188.05

Longitudinal Standing Waves in a Tutorial Environment

Jack Dostal[1]
[1]Montana State University.

Standing waves in introductory college physics courses are commonly introduced in the transverse case where visualization is easier. Longitudinal standing waves, such as resonating air columns, are then treated as an extension. Using this approach, student understanding of longitudinal standing waves frequently amounts to pattern-matching with little conceptual understanding of the underlying physical processes. It also contributes to poor interpretations of the typical representations used to describe longitudinal standing waves. In this talk I will present a new research-based tutorial designed to teach the basics of longitudinal standing waves in the context of sound. The tutorial involves using a hands-on demonstration to give explicit meaning to nodes and antinodes in the longitudinal context, using pipes and tuning forks to create standing waves and advance understanding of particle motion and pressure within the pipe, and investigating the meaning of the representations of longitudinal standing waves commonly used in textbooks.

188.06

Investigating Student Understanding of Wave Behavior at Boundaries*

Mila Kryjevskaia[1], M. R. Stetzer[1], P. R. Heron[1], L. C. McDermott[1]
[1]University of Washington.

The Physics Education Group at the University of Washington has been developing and modifying research-based instructional materials on waves and physical optics.[1] In particular, we continue to assess the persistence of certain student difficulties regarding wave behavior at the boundary between different media. New research questions have helped us examine the effect of providing students with additional practice in applying boundary conditions in the more advanced context of thin-film interference.

* This work has been supported in part by the National Science Foundation.

[1] *Tutorials in Introductory Physics*, L.C. McDermott, P.S. Shaffer and the Physics Education Group at the University of Washington, Prentice Hall (2002).

188.07

Investigating Student Understanding of Control of Variables

Andrew Boudreaux[1], P. R. Heron[2], P. S. Shaffer[2]
[1]Western Washington University, [2]University of Washington.

The concept of control of variables is fundamental to science. A practical understanding is especially important for science teachers, who must help students design experiments and learn to interpret the results. Findings from an extended study of student and teacher facility with the reasoning underlying control of variables will be reported. This research has involved pre-college science teachers, liberal arts physics students, calculus-based introductory physics students, and college science faculty. The results suggest that while most participants are familiar with the idea of controlled experiments, many lack functional skill with the underlying reasoning. Results from interviews and written questions will be used to illustrate specific difficulties.

188.08

Modeling Student Thinking about Motion in Tutorial

Brian W. Frank[1], R. E. Scherr[1]
[1]University of Maryland.

In an ongoing study, we are analyzing students' conceptual resources for understanding motion. Previous work used results of surveys, written questions, and interviews to infer the nature of students' ideas. Video of students working together in tutorial groups now allows us to access the details of their reasoning as they express themselves to their peers. We present examples of students in the algebra-based introductory physics course at the University of Maryland analyzing segments of ticker tape to develop an understanding of constant, instantaneous, and average speeds. The most commonly observed resources involve direct and indirect relationships among speed, distance, and time. Various constructions of ideas built from these resources led to both correct and incorrect accounts of the physical phenomena. We characterize the nature of these various constructions based on a model of student thinking as arising from the activation of conceptual resources, analyze shifts in student reasoning, and discuss the strengths and weaknesses of the resources model in accounting for student performance.

188.09

Sensemaking: Conceptualizing and Coding for "Good" Student Reasoning

Andrew Elby[1], R. Scherr[1], T. Bing[1]
[1]University of Maryland.

Physics instructors' goals often go beyond improving students' conceptual understanding and problem solving. Instructors also want students to engage in inquiry, become scientific/critical thinkers, understand the scientific process, and so on. We see two problems with these "non-content" goals. First, notions such as inquiry and scientific thinking are often defined vaguely or inconsistently across the literature. Second, even when like-minded instructors share a vision of what we'd love to see our students do, descriptions of that vision are often too squishy to communicate, debate, or assess: "We know it when we see it!" In this talk and poster, we address these problems by introducing *sensemaking* vs. *answermaking*, two mindsets with which students can approach physics. Our definitions of those notions benefit from a theoretical base, and our coding scheme for sensemaking vs. answermaking displays high interrater reliability and rests upon a list of specific indicators.

189: Techniques in Introductory Physics Teaching AAPT Oral, Tuesday, 10:00-11:30am, 616

Chair

Frieda Stahl[1]
[1]*California State Univ., Los Angeles.*

189.01

Aesthetic Physics Education: A Symmetry Based, Physics and Fine Arts Curriculum

Jatila van der Veen[1], P. M. Lubin[2], J. Cook-Gumperz[3], J. D. Raley[3], E. Mazur[4]
[1]*Gevirtz Graduate School of Education and Physics Dept., University of California, Santa Barbara,* [2]*Physics Dept. UCSB,* [3]*Gevirtz Graduate School of Education, UCSB,* [4]*Physics Dept, Harvard University.*

Physics education research in the past two decades has focused almost entirely on pedagogical methods, but the curriculum content remains unchanged. In a recent editorial in *Physics Today* (July, 2006, p. 10) the ability of physicists to “imagine new realities” is correlated with what are traditionally considered non-scientific skills, including imagination and creativity, qualities which are usually associated with fine arts. In view of the new developments in physics of the 21st Century, the importance of developing creativity and imagination through education is gaining recognition.

We are investigating the effectiveness of teaching introductory physics from the viewpoint of symmetry, including the foundations of General Relativity and modern cosmology, without the need for the full tensor treatment. We will pilot a new course at UCSB in Winter Quarter, 2007 entitled Symmetry and Aesthetics in Introductory Physics. Our pedagogical model is based on three premises: that the introductory curriculum needs to be modernized; that mathematics should be presented as a *language*; and that theoretical physics has, at its core, a great deal in common with music, art, and dance. In this talk we will present the contents of our new course, and the means by which we plan to evaluate it in comparison to “regular” introductory courses. It is our hope that this modernized and integrated approach to introductory physics can also serve as a course for future teachers of primary and secondary school.

This work is supported by NASA grant #20070268 and the Planck Explorer Mission.

189.02

Science One: An Interdisciplinary First-year Science Program

Domingo J. Louis-Martinez[1], N. Dryden[1], M. Maclean[1]
[1]*University of British Columbia, Canada.*

The Science One Program at the University of British Columbia is a team-taught first-year course in which the traditional subjects of mathematics, physics, chemistry and biology are presented with an emphasis on their integration. The goal of the program is that the students achieve a deep conceptual understanding of the topics covered as part of the curriculum and to transform the students into independent learners. The students complete two scientific research projects as part of the course. In this talk a general presentation of the main features of the program will be given.

189.03

Curbing ″Math Anxiety″ with Galileo While Teaching Physicists, too

Brian P. Schwartz[1]
[1]*Carthage College.*

Carthage College’s introductory physics course caters to both freshmen in our program and students in general education. While ″Understandings of Physics″ is a conceptual overview of our discipline, physical science is necessarily quantitative. Galileo’s ″*Dialogue Concerning the Two New Sciences*″ provides us with a novel way to teach the fundamentals of motion both to students who ″fear″ mathematics, as well as those who are adept at solving algebraic equations.

189.04

Using Whole Vector Force Representations for ″Friction Problems″

Daniel H. Phelps[1]
[1]*Columbia College (Retired), Canada.*

The use of ″whole vector forces″ and force components to describe and ″solve″ some typical friction problems will be compared. Although the results are identical for these two representations, using whole vector forces provides a more clear and direct representation and method for getting ″answers″. Examples will include: (1) an object on a tipped surface, (2) an object pulled or pushed on a surface, (3) minimizing the applied force for (2), and (4) an automobile on a banked surface.

189.05

Teaching Physics for Conceptual Understanding Exemplified for Einstein’s Special Relativity

Lucian M. Undreiu[1]
[1]*UVA’s College at Wise.*

In most liberal arts colleges the prerequisites for College Physics, Introductory or Calculus based, are strictly related to Mathematics. As a state of fact, the majorities of the students perceive Physics as a conglomerate of mathematical equations, a collection of facts to be memorized and they regard Physics as one of the most difficult subjects.

A change of this attitude towards Physics, and Science in general, is intrinsically connected with the promotion of conceptual understanding and stimulation of critical thinking. In such an environment, the educators are facilitators, rather than the source of knowledge. One good way of doing this is to challenge the students to think about what they see around them and to connect physics with the real world. Motivation occurs when students realize that what was learned is interesting and relevant.

Visual teaching aids such as educational videos or computer simulations, as well as computer-assisted experiments, can greatly enhance the effectiveness of a science lecture or laboratory. Difficult topics can be discussed through animated analogies. Special Relativity is recognized as a challenging topic and is probably one of the most misunderstood theories of Physics. While understanding Special Relativity requires a detachment from ordinary perception and every day life notions, animated analogies can prove to be very successful in making difficult topics accessible.

189.06

Student Reported Learning Gains From Pre-Class Questions

David T. Kagan[1]
[1]*California State University, Chico.*

Students in my first semester calculus based mechanics class are required to submit by email the answer to a conceptually oriented question by midnight the night before each class meeting. A distinct pre-class question is posted on the class web site for each class meeting. This question and its answer are addressed during class. At least one similar question appears on each exam as well. The students were surveyed regarding improvements to their study habits and increases in their learning that they attribute to these pre-class questions. Since I won’t be giving this survey until December, the results will be as informative for me as I hope they will be for you!

189.07

High School Physics Experience and Learning Outcomes in Introductory Physics Courses

Tetyana Antimirova[1]
[1]*Ryerson University, Canada.*

Although strongly recommended, high school physics or an equivalent course is not listed as a requirement to enter the science programs at Ryerson University where all students are required to complete a common first year. As a result, the single introductory physics course combines the students who took high school physics, and those who did not, with an approximate split of 60% *versus* 40%, respectively. The presence of these two distinctive groups in same class allows exploring the question of how the previous exposure to high school physics influences the learning outcomes in the university introductory physics courses, as measured by the standard tests (FCI) and by the final course grades. The challenges of having two student groups with very different needs in one class and the measures to close the gap will be discussed as well.

189.08

The Impact of Teaching Technologies in the Introductory Physics Classroom

William W. McNairy[1]
[1]*Duke University.*

This talk will cover present and past applications of teaching technologies to the Introductory Physics classroom. I will review student evaluations of various online homework systems including the University of Texas Homework System, WebAssign, Brownstone EDU and Mastering Physics. Use of online homework has varied according to the strengths and weaknesses of each platform. Additionally, I will present evaluations of classroom polling using PRS IR polling devices. The polling has provided formative feedback for lectures, demonstrations, and development of conceptual understanding by students. Finally, I will comment on the use of the BlackBoard online course system for delivery of course content and end-of-semester surveys.

189.09

Examples from Research on the Learning and Teaching of Quantum Mechanics

Andrew D. Crouse[1], P. S. Shaffer[1], L. C. McDermott[1]
[1]*Univ. of Washington.*

For the past several years, the Physics Education Group at the University of Washington has been engaged in an investigation of the learning and teaching of quantum mechanics. This study has been conducted primarily in the junior-level undergraduate quantum mechanics class at the University of Washington. It has focused on student understanding of many topics including, but not limited to: probability, stationary states, time-dependence, angular momentum, identical particles, and perturbation theory. Results from some selected research questions will be presented.

190: Heineman Prize Lecture
Plenary, Tuesday, 11:40am-12:30pm, Ballroom 6

190.01

The DEEP2 Redshift Survey: From Galaxies to Large-Scale Structure

Marc Davis[1]
[1]*UC, Berkeley.*

Over the last few years, I have worked with my collaborators to use the Keck II telescope in a large-scale redshift survey called DEEP2. The DEEP2 galaxy redshift survey has now covered ~2.5 degrees^2 of sky and obtained ~40,000 spectra; it is now finished, and two thirds of the data has been released. One of our fields is the Extended Groth Strip (EGS), a region where deep imaging has been obtained with Chandra, Spitzer, GALEX, the VLA, and HST/ACS to make this field truly panchromatic. We will provide approximately 10,000 redshifts in this field. In three other regions, we have used three-color imaging to efficiently select galaxies with magnitude R_{AB} $<$24.1 and redshifts in the range 0.7$<$z$<$1.4, but the EGS does not have the preselection. Our survey, the All-wavelength Extended Groth strip International Survey (AEGIS), is intended to study the physical properties and evolutionary processes of galaxies at z ~1. The dense sampling at high redshift allows us to study galaxies as a function of their environment. In this talk I shall show a few of the studies made possible by the sample: a measurement of the dark energy w parameter, a constraint on the time evolution of alpha, the fine structure constant, the beginning of the transformation of blue luminous galaxies to red at z ~ 1.3, the quenching of star formation from active galactic nuclei, resulting in a migration from the blue cloud to the red sequence of galaxies. This is of course only a selection of the possibilities for further study.

191: Next Generation Radial Velocity Planet Surveys
AAS Special, Tuesday, 2:00-3:30pm, 3B

191.01

N2K and Beyond

Greg Laughlin[1]
[1]*UC Santa Cruz.*

N2K is a quick-look Doppler velocity survey that inspects metal-rich, 8$<$V$<$10 dwarf stars for the presence of short-period, hot-Jupiter class planets. I will describe how the N2K pipeline works, including an overview of our broadband selection calibrations, the Doppler observation strategy, and the photometric follow-up campaigns. N2K has discovered a number of new planets, including the unique high-density transiting planet HD 149026b. In the talk, I will show and discuss some of our more interesting new detections.

191.02

Status of the All Sky Extrasolar Planet Survey and Early Results

Jian Ge[1]
[1]*University of Florida.*

The ASEPS program will survey hundreds of thousands of stars with V ~8-13 in the solar neighborhood using the wide-field Sloan 2.5 meter telescope. Following up all the candidate planetary systems with visible and near infrared radial velocity instruments could result in detecting thousands of planets, including rare planetary systems such as transit planets, ′′super-Earth’’ mass planets, and interacting multiple planetary systems, during 2006-2020. ASEPS will provide a valuable statistical sample for studying many aspects of the formation and evolution of planetary systems. The overall ASEPS program has four major phases: a feasibility study and demonstration in 2004-2005 (phase I), a trial survey and a pilot program in 2005-2008 (phase II), a full-scale planet survey in 2008-2013 (phase III) and an extended survey from 2013-2020 (phase IV). During 2006, we commissioned a full-scale multi-object W.M. Keck Exoplanet Tracker (Keck ET) with 60 object capability and began a trial planet survey of ~400 stars at the Sloan telescope. Since August 2006, we have substantially improved the instrument performance (throughput, image quality, Doppler precision and long term stability. In fall 2006, we began searching additional stars. I will summarize the status of ASEPS, early results, and the project’s future prospects.

191.03

Spectroscopic Follow-Up Observations of Transiting Planet Candidates Identified by the Kepler Mission

David Latham[1], D. D. Sasselov[1], A. H. Szentgyorgyi[1]
[1]*Harvard-Smithsonian Center for Astrophysics.*

NASA's Kepler Mission is expected to identify many hundreds of transiting planet candidates in four years of continuous photometric monitoring of 100 square degrees in Cygnus and Lyra. To sort out true planets from eclipsing stellar systems that are masquerading as transiting planets, a variety of follow-up observations are planned. High resolution ground-based spectroscopy at modest signal-to-noise ratio will be used to detect orbital motion induced by stellar companions, for example by small M dwarf secondaries eclipsing solar-type primaries. The most challenging stellar imposters are blends of eclipsing binaries with nearby bright stars; even high-quality spectra may have difficulty resolving such systems. A workhorse for this initial phase of spectroscopic follow up will be TRES, a new fiber-fed echelle spectrograph on the 1.5-m Tillinghast Reflector at the Whipple Observatory. Ultimate confirmation of a transiting planet comes with the solution for a spectroscopic orbit and the derivation of an actual mass of the planet compared to the parent star. A primary goal of the Kepler Mission is to find earth-sized planets in or near the habitable zones of their host stars. The radial-velocity precision needed to derive spectroscopic orbits for the most interesting cases will require considerable improvement beyond 1 m/s. The Geneva Observatory and Harvard University have joined in a collaboration to develop such a capability at a northern site with access to the Kepler field of view. A version of the HARPS spectrograph, now in highly successful operation on the 3.6-m telescope at ESO on La Silla, is being built. Negotiations are underway to site HARPS North at the William Herschel Telescope operated by the Isaac Newton Group of Telescopes on La Palma. The goal is to achieve velocity performance at the level of 20 cm/s and to push the determination of planetary masses into the terrestrial planet regime.

191.04

An Infrared Precision Radial Velocity Spectrograph for Gemini

John Rayner[1]
[1]University of Hawaii Institute for Astronomy.

We discuss the scientific motivation and design of the Precision Radial Velocity Spectrograph (PRVS), a potential next generation near-infrared instrument for the Gemini Observatory. PRVS is a fiber-fed, white-pupil, cooled echelle (R=70,000) spectrograph working in the Y, J and H bands. Using the simultaneous arc-line calibration method, long-term instrumental radial velocity precisions of less than 1 m/s can be achieved. In effect, PRVS is an infrared version of the very successful optical precision radial velocity spectrograph, HARPS, but for an 8 m telescope. Through modelling and simululation of the fundamental Doppler information in the spectra of stars and the effects of telluric contamination, we conclude that the best place to search for earth-mass planets in the habitable zone using their radial velocity signatures is around midto late-M dwarf stars at wavelengths of ~1-2 microns. This conclusion is also supported by experimental observations made with a PRVS ″pathfinder″ spectrograph. Pathfinder is the subject of a separate presentation by Larry Ramsey at this session. Mock surveys show that PRVS can survey several hundred stars for planets in the range 1-10 earth-mass over a period of five years and provide an important test of planet

formation models.

191.05

Big Questions About Planet Formation That Can Be Addressed By Next-Generation Radial Velocity Planet Searches

Eric B. Ford[1], E. Agol[2]
[1]Harvard-Smithsonian Center for Astrophysics, [2]U. Washington.

For centuries, humanity's understanding of planet formation was based on observations of only a single planetary system. Over the past twelve years, the discovery of ~200 extrasolar planets around solar-like stars has revealed an unexpected diversity of planets and revolutionized theories of planet formation. Given this dramatic increase in the amount of observational data, some have questioned whether searching for more planets is still important. In this talk, I will highlight some of the big questions in planet formation theory and outline how future observations can address these challenges. In particular, I will discuss how both wide and deep planet searches can provide important and complementary information that will improve our understanding of the origins of planetary systems in general, potentially habitable exoplanets, and our Earth.

192: SAGE: Surveying the Agents of a Galaxy's Evolution
AAS Special, Tuesday, 2:00-3:30pm, 201

Chair

Alexander G. Tielens[1]
[1]NASA Ames Research Center.

192.01

The Large Magellanic Cloud as a Galaxy

John (Jay) Gallagher[1], M. Meixner[2], J. Bernard[3], R. Blum[4], K. Gordon[5], R. Indebetouw[6], W. Reach[7], B. Whitney[8], B. Babler[1], M. Block[5], E. Churchwell[1], C. Engelbracht[5], B. For[9], J. Hora[10], C. Leitherer[2], M. Meade[1], K. Misselt[5], A. Tielens[11], U. Vijh[2], SAGE Team
[1]University of Wisconsin-Madison, [2]Space Telescope Science Institute, [3]CESR, France, [4]NOAO, [5]University of Arizona, [6]University of Virginia, [7]Caltech, [8]Space Science Institute, [9]University of Texas, [10]Harvard/CfA, [11]NASA/Ames.

The LMC is unusual in that its history and properties have been affected by its close proximity to the Milky Way and interactions with the SMC. Yet in many ways, such as the structure of its main stellar body and chemical abundance patterns, the LMC also is a fairly normal example of a moderate luminosity disk galaxy. Because the LMC is nearby with little extinction and a low inclination, it remains the best studied galaxy other than the Milky Way. In the spirit of our program, Surveying the Agents of a Galaxy's Evolution (SAGE), this talk charts the locations and parameters of major baryonic components of the LMC, ISM and stars, and briefly summarizes the history of star formation in the LMC. The state of the LMC's interstellar medium in relationship to the global structure of the galaxy and populations of recently formed stars is one of the primary topics of SAGE, and will be discussed with an emphasis on differences between conditions in the LMC and those in the Milky Way.

The SAGE Project is supported by NASA/Spitzer grant 1275598 and NASA NAG5-12595

192.02

Spitzer SAGE Survey of the Large Magellanic Cloud: Project Overview

Margaret Meixner[1], B. Babler[2], J. Bernard[3], M. Block[4], R. Blum[5], C. Engelbracht[4], B. For[6], K. Gordon[4], J. Hora[7], R. Indebetouw[8], C. Leitherer[1], M. Meade[2], K. Misselt[4], W. Reach[9], A. G. Tielens[10], U. Vijh[1], B. Whitney[11], S. Team[1]
[1]STScI, [2]University of Wisconsin, [3]CESR, France, [4]University of Arizona, [5]NOAO, [6]University of Texas, [7]Harvard/CfA, [8]University of Virginia, [9]SSC/Caltech, [10]NASA/Ames, [11]Space Science Institute.

We are performing a uniform and unbiased imaging survey of the Large Magellanic Cloud (LMC, ~77), using the IRAC (3.6, 4.5, 5.8 and 8 m) and MIPS (24, 70, and 160 m) instruments on board the Spitzer Space Telescope (Spitzer) in order to survey the agents of a galaxy's evolution (SAGE), through the interaction between the interstellar medium (ISM) and stars in the LMC. This presentation provides an overview of the SAGE legacy project including observing strategy, data processing and initial results. Three key science goals determined the coverage and depth of the survey. The detection of diffuse ISM with column densities >1.2x10^21 H cm-2 permits detailed studies of dust processes in the ISM. SAGE's point source sensitivity enables a complete census of newly formed stars with masses >3 solar masses that will determine the current star formation rate in the LMC. SAGE's detection of evolved stars with mass loss rates >1x10^-8 M/yr will quantify the rate at which evolved stars inject mass into the ISM of the

LMC. The observing strategy includes two epochs in 2005, separated by three months, that both mitigate instrumental artifacts and constrain source variability. The SAGE data are non-proprietary and point source lists will be released to the community in support of Spitzer proposal cycles 4 and 5. The SAGE epoch 1 point source catalog has ~4x10^6 sources and a measured point source sensitivity for the epoch 1 data is consistent with expectations for the survey. We will briefly review the characteristics of this catalog that has been released to the community.

The SAGE Project is supported by NASA/Spitzer grant 1275598 and NASA NAG5-12595.

192.03

The Spitzer/SAGE View of Star Formation in the LMC

Remy Indebetouw[1], B. Whitney[2], M. Sewilo[3], T. Robitaille[4], M. Meade[3], B. Babler[3], J. Hora[5], K. Gordon[6], C. Engelbracht[6], B. For[7], M. Block[6], K. Misselt[6], M. Meixner[8], U. Vijh[8], K. Leitherer[8], SAGE Team
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The Magellanic Clouds are unique laboratories to understand star formation in the distant universe. The physics of star formation processes in molecular clouds and the evolution of young stellar objects (YSOs) is expected to depend on metallicity; the Clouds and outer reaches of our Galaxy are the only places that individual YSOs with subsolar metallicity can be isolated. The Magellanic Clouds are also the only place that a full census of individual YSOs in an external galaxy can be studied. We present the first results on star formation in the LMC using SAGE data: We show how luminous YSOs can be selected from the point source catalogs and classified. We discuss their distribution in space and time (evolutionary state), relative to large structures in the interstellar medium. We also discuss the properties of compact HII regions and small clusters in the LMC. These topics are only the beginning of the rich studies which will be enabled by the SAGE dataset.

The SAGE Project is supported by NASA/Spitzer grant 1275598 and NASA NAG5-12595.

192.04

Dust and gas in the Interstellar Medium of the LMC

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We derive the properties of dust and gas in the Large Magellanic Cloud using observations with the Spitzer Space Telescope in 7 broad filters from 3.6-160 μm. Two regions with different types of interstellar gas (atomic and molecular) were investigated first. In the atomic-gas-dominated region, the dust-to-gas ratio was measured using the optical depth at 160 μm per unit HI column density (from the ATCA 21-cm survey). The resulting dust-to-gas is lower than observed using similar techniques for dust in the solar neighborhood, and very similar to that derived for the average LMC extinction. In the molecular region, the dust is somewhat colder, and there is more emission per unit HI column density. This excess infrared emission is attributed to dust in the molecular cloud, for which we constrain the combination of dust abundance and H2 column density per unit CO line brightness (from the NANTEN survey). Finally, we compare the integrated emission from the LMC to that derived for the individual regions.

192.05

Mass Loss from Evolved Stars in the LMC: A Spitzer SAGE View

Robert D. Blum[1], K. Volk[2], S. Srinivasan[3], F. Markwick-Kemper[4], M. Meixner[5], S. Points[6], K. Olsen[6], K. Gordon[7], C. Engelbracht[7], B. For[8], M. Block[7], K. Misselt[7], B. Whitney[9], M. Meade[10], B. Babler[10], R. Indebetouw[11], J. Hora[12], U. Vijh[5], C. Leitherer[5], J. Mould[1], SAGE Team
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I will present preliminary results for Evolved Star properties and their mass--loss contribution to the Large Magellanic Cloud (LMC) as viewed from color--magnitude diagrams (CMDs) obtained with the Spitzer space telescope SAGE (Surveying the Agents of a Galaxy's Evolution) survey. These data represent the deepest, widest mid--infrared CMDs of their kind ever produced in the LMC. Combined with the 2MASS survey, the diagrams are used to delineate the evolved stellar populations in the LMC from which we can deduce the relative contributions to the complete mass--loss budget. I will show initial fits to the spectral energy distributions of the LMC stars using dust radiative transfer models and assumptions about the evolved star envelopes guided by existing observations of luminous stars. Owing to the high angular resolution and sensitivity of Spitzer, we can identify essentially all the important mass--loss sources in the galaxy. Indeed, there is strong evidence from the 24 micron channel of Spitzer that previously unexplored, lower luminosity oxygen--rich AGB stars contribute significantly to the mass loss budget.

This work has been funded by generous grants from the NASA SST program.

192.06

Spitzer Spectroscopy of Evolved Stars in the LMC

Joel H. Kastner[1]
[1]RIT Center for Imaging Science.

In the era of Spitzer, rapidly mass-losing asymptotic giant branch (AGB) and red supergiant (RSG) stars are readily detectable throughout the Local Group. Such stars dominate the rate of return of nuclear-processed material to the interstellar medium (ISM) and, hence, play crucial roles in the chemical evolution of galaxies. I describe recent results from Spitzer Infrared Spectrograph (IRS) surveys of IR-luminous AGB stars and RSGs in the Large Magellanic Cloud (LMC). These results provide new insight into the composition of the dust and gas injected into the ISM by an evolved star population in a subsolar-metallicity environment, and offer new constraints on stellar evolution theory. Spitzer IRS spectroscopy of LMC evolved stars also provides the basis on which to reliably identify and classify mass-losing evolved stars detected in SAGE and other broad-band infrared imaging surveys.

Spitzer data analysis at RIT is supported by JPL/Caltech award NMO710076.

193: Science from the NDWFS Bootes Field AAS Special, Tuesday, 2:00-3:30pm, 3A

Chair

Daniel Stern[1]
[1]JPL/ Caltech.

193.01

The NOAO Deep Wide-Field Survey An Introduction

Buell Jannuzi[1]
[1]NOAO.

The NOAO Deep Wide-Field Survey (NDWFS), a deep optical (B_WRI) and near IR imaging survey of 18 square degrees of the sky, has the primary goal of studying the evolution of large-scale structure between redshift 4 to 1. The survey also enables the investigation of the formation, assembly and evolution of galaxies and the detection of powerful quasars and star-forming galaxies, including obscured examples of these populations. The 9.3 square degree Boötes sub-field of the survey is of particular interest because of the extensive multi-wavelength observations now publicly available. These include imaging with Chandra (X-rays), GALEX (UV), Spitzer (near, mid,

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and far IR), the VLA, and Westerbork (radio). Selected science results based primarily on the optical and near-IR imaging data sets will be highlighted. For example, we have recently used the galaxy luminosity and correlation functions to trace the assembly history of red galaxies since z=1. The stellar mass contained within the red galaxy population doubles between z=1 and z=0, as blue star-forming galaxies are transformed into red galaxies. We find there is ongoing assembly of the most massive red galaxies at z<1, albeit at a rate that does not lead to rapid growth of red galaxy stellar masses.

Updates on the status and results of the NDWFS can be found at http://www.noao.edu/noao/noaodeep/.

Our research is supported by the National Optical Astronomy Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., (AURA), under a cooperative agreement with the National Science Foundation.

193.02

The Flamingos Extragalactic Survey

S A. Stanford[1], A. Gonzalez[2], P. Eisenhardt[3], M. Brodwin[3], D. Stern[3], E. McKenzie[2], R. Elston[2]
[1]UC, Davis, [2]UF, [3]JPL.

Using the Florida Multi-object Imaging Near-IR grism Observational Spectrometer (FLAMINGOS), we have conducted the FLAMINGOS Extragalactic Survey (FLAMEX), a deep imaging survey covering 7.1 square degrees within the 18.6 sq. deg NOAO Deep Wide-Field Survey (NDWFS) regions. FLAMEX is the first deep, wide-area near-infrared survey to image in both the J and Ks filters, and is larger than any previous NIR surveys of comparable depth. I will present recent results from efforts to use this survey to find and study high redshift galaxy clusters.

193.03

The IRAC Shallow Survey

Peter R. Eisenhardt[1]
[1]JPL/Caltech.

The Spitzer Infrared Array Camera (IRAC) shallow survey covers 8.5 square degrees in the NDWFS Bootes field with 3 or more 30 second exposures per position. The survey reaches 5 sigma limits of 6.4, 8.8, 51, and 50 microJy at 3.6, 4.5, 5.8, and 8 microns respectively. The availability of deep optical imaging and extensive spectroscopy for the field have enabled reliable photometric redshifts to be fit to a 4.5 micron selected sample. The photometric redshifts have been used to find almost 300 galaxy clusters and groups, 93 of which are beyond redshift one (eight of which have been spectroscopically confirmed). Other results include an IRAC color selection technique for identifying AGN, the identification of quasars with redshifts up to 6.1, and the identification of the first isolated brown dwarf discovered by Spitzer.

193.04

A Spitzer Far-infrared Look at the NOAO-Deep Wide Field Survey

Emeric LeFloc'h[1]
[1]Institute for Astronomy, University of Hawaii.

The NDFWS was imaged and spectroscopically followed-up in the mid- and far-IR (5-35mic, 70mic, 160mic) with the MIPS and IRS instruments on-board the Spitzer Space Telescope. I will discuss the main results that have been obtained so far from the combination of these observations with other wavelength data (X-ray, optical, radio) available across the field. This includes the IR characterization of the spectral energy distribution of IR/radio/Ly-alpha selected starburst galaxies and AGNs at high redshift, the study of AGN/starburst diagnostics based on mid-IR properties, the redshift distribution of mid-IR selected sources and the mid-IR luminosity function of quasars up to z~5. In particular, I will also emphasize the discovery of a population of 2<z<3 optically-faint and dust-enshrouded sources with extremely high mid-IR luminosities mostly powered by accretion of material around AGNs. I will describe the properties of this population and discuss its potential role in the context of a coeval growth of bulges and super massive black holes. Other aspects of these sources to be explored in the near future will be briefly mentioned.

193.05

XBootes Chandra Shallow Survey of the Bootes Region

Stephen S. Murray[1], XBootes Team
[1]SAO.

We used the Chandra X-ray Observatory to survey a 9.3 square degree patch of sky, overlapping with NDWFS on Bootes and similar surveys with the Spitzer Space Telescope and others. The initial Chandra survey consisted of a mosaic of 126 ACIS-I observations of 5 ksec each. In addition for about one half of the region a second set of 5 ksec observations has been obtained for a total of almost 1 million Chandra observing seconds. In the first set of observations, over 4600 sources have been detected, of which about 3500 have 4 or more counts (and no more than 30 are expected to be spurious). We have high probability optical candidates for virtually all of the 4 count or brighter sources, and, for about half of these, we have obtained moderate resolution spectra using the MMT/Hectospec.

The X-ray population of sources is dominated by broad line AGN with a mean redshift of about 1.25. The IRAC infrared colors of the X-ray selected AGN are typical of IR selected AGN. The XBootes catalog contains 36 AGN at high redshift (>3), making it one of the larger samples of these rare, high luminosity objects. We also have detected a large population (about 260, all at redshift <1.0, and the largest sample to date) of X-ray Bright, Optically Normal Galaxies (XBONGS) which fall into four primary classes red ellipticals, blue ellipticals, star forming/interacting systems, and IR-selected AGN.

The spatial distribution of X-ray selected AGN at redshifts below 0.7 match very well the spatial distribution of galaxies. At higher redshifts, voids and filaments continue to be seen in the X-ray data suggesting that X-ray selected AGN are excellent tracers of dark matter halos at high redshifts and can be used to study the evolution of large scale structure with cosmic time.

193.06

AGES: The AGN and Galaxy Evolution Survey

Richard J. Cool[1]
[1]Univ. of Arizona.

AGES, the AGN and Galaxy Evolution Survey, is a spectroscopic survey of the NOAO Deep Wide-Field Survey Bootes field. We have obtained redshifts of roughly 17,000 galaxies and 3,000 AGN over the nine square-degree field using the Hectospec multi-object spectrograph on the MMT. The AGES galaxy sample consists of a highly-complete set of galaxies with I<20 selected based on their optical or infrared properties using the NDWFS and Spitzer IRAC and MIPS imaging of the field. AGES is senstive to L* galaxies to z=0.5 and provides a complementary data set to DEEP-2 which did not target galaxies at z<0.7 over most of their survey area. Active galaxies were selected in AGES based on their X-ray flux, 24 micron flux, or red mid-infrared colors and results in 1250 objects at z>1, 208 at z>2.5, and 3 objects with z>5. In this talk, I will provide an introduction to the survey and discuss several scientific applications of the AGES spectra.

194: Short Gamma-Ray Bursts
HEAD Special, Tuesday, 2:00-3:30pm, 618

Chair

Neil Gehrels[1]
[1]NASA's GSFC.

194.01

On the Prompt Gamma-ray Emission Properties of Short GRBs

Chryssa Kouveliotou[1]
[1]*MSFC.*

Short Gamma-Ray Bursts have been identified as a separate class of events with distinct spectral and temporal properties from their long (>2 seconds) counterparts. Although multi-wavelength transients and their host galaxies had been found for the latter, it was only after the launch of the Swift satellite that short GRB counterparts and hosts were discovered and studied in detail. Currently, over a dozen short events have been detected with less than half having a measured redshift. Since 1991, GRB durations were established using BATSE gamma-ray light-curves; it is becoming, however, gradually evident from the Swift/BAT data, that we now need to fold spectral dependence, in particular prompt gamma-ray emission spectral time lags, into a multi-parameter GRB classification scheme. I will discuss here the properties of the prompt gamma-rays of all Swift short GRBs, compare them to those detected with BATSE and other missions and comment on the implications of the different subclass population each mission is probing.

194.02

X-ray Afterglows of Short Gamma-Ray Bursts

David N. Burrows[1]
[1]*Penn State Univ..*

The Swift Burst Alert Telescope (BAT) has discovered about 20 short GRBs in its first two years of operation. The Swift X-ray Telescope (XRT) has detected X-ray afterglows for roughly 75% of these, allowing host galaxies, redshifts and source characteristics to be studied for the first time. As a result, our knowledge of the properties of short GRBs and their afterglows has increased tremendously in the past year and a half. I will discuss the X-ray afterglows of short GRBs as observed by the Swift XRT and by Chandra. These afterglows are generally much fainter than those of long GRBs, and therefore fade rapidly below detection thresholds. However, some brighter, long-lived afterglows provide intriguing insights into the properties of the progenitors and their environments.

194.03

The Host Galaxies and Host Clusters of Short Gamma Ray Bursts: Constraints on the Progenitor Age Distribution

Edo Berger[1]
[1]*Carnegie Observatories.*

The progenitors of short GRBs are now known to be related to an old stellar population, possibly NS-NS or NS-BH binaries. However, due to the lack of direct observations (gravitational waves, chemical abundances), a more detailed understanding of the progenitor population has to rely on statistical studies. In this talk I will review recent observations and theoretical work focused on the use of host galaxy and cluster associations to assess the age distribution of the progenitors. Of particular promise is the ratio of short GRBs in cluster and field early-type galaxies, since this method overcomes any systematic differences between progenitors in earlyand late-type galaxies. I will summarize the results of recent multi-object spectroscopy and X-ray observations aimed at applying this approach, as well as the discovery of a redshift 1.8 cluster associated with a short GRB.

194.04

Theoretical Interpretation of Short GRB Observations

Ehud Nakar[1]
[1]*Caltech.*

The detection of short GRB afterglows, and the following host galaxy identifications, confirmed that the two observationally defined sub-classes, long and short GRBs, are distinctive physical phenomena. Following this observational breakthrough, the study of short GRBs progressed rapidly during the last year. I discuss theoretical conclusions that can be drawn from these recent observations on the relativistic emission source, such as constraints on its Lorentz factor and on the efficiency in which it produces gamma-rays. I also review the constraints on the nature of short GRB progenitors that can be derived using environmental properties (host galaxy types, redshift distribution, circum-burst medium density, etc.).

195: AGN, Starbursts and Sub-mm Galaxies
AAS Oral, Tuesday, 2:00-3:30pm, 6C

195.01

Millimeter Detection of Spitzer-selected High Redshift Hyperluminus Starburst Galaxies

Carol J. Lonsdale[1], A. Omont[2], M. del Carmen Polletta[3], R. Zylka[4], D. Shupe[1], H. E. Smith, Jr[3], S. Berta[5], N. Bavouzet[6], G. Lagache[6], D. Farrah[7], F. Bertoldi[8], P. Cox[4], C. de Breuck[9], H. Dole[6], D. Lutz[10], L. Tacconi[10], I. Perez-Fournon[11], H. Aussel[12], H. McCracken[13], D. Clements[14], M. Rowan-Robinson[14], A. Franceschini[5], D. Frayer[1], J. Surace[1], B. Siana[1]
[1]*IPAC, Caltech,* [2]*Institut d'Astrophysique de Paris, France,* [3]*UCSD,* [4]*IRAM, France,* [5]*University of Padova, Italy,* [6]*IAS, France,* [7]*Cornell,* [8]*University of Bonn, Germany,* [9]*ESO, France,* [10]*MPIE, Germany,* [11]*Instituto Astrofisica, Spain,* [12]*Service d'Astrpphysique, CEA, France,* [13]*Service d'Astrophysique, CEA, France,* [14]*Imperial College, United Kingdom.*

We have used the Mambo instrument on the IRAM 30m telescope to observe at 1.2mm 63 Spitzer-selected z>1 hyperluminous infrared galaxy candidates (HLIRGs) with starburst-dominated mid-infrared (MIR) spectral energy distributions from the SWIRE Legacy survey. The primary selection criteria are a peak in the IRAC 5.8μm band due to the rest frame near-infrared spectrum of evolved stars, a bright detection at 24μm, and very faint optical counterparts. The detection rate with Mambo is very high at 45%, and both the detection rate and the average 1.2mm/24μm flux ratio are much higher than found for previous Spitzer MIR-selected samples, due to the fact that earlier samples favored systems with AGN-dominated MIR emission. Our sample, on the other hand, shows systematically lower 1.2mm/24μm ratios than a sample of Spitzer-detected submillimeter-selected galaxies (SMGs) in a similar redshift range. Thus Spitzer MIR selection complements submillimeter selection of high redshift starburst-dominated HLIRGs, finding a population with substantially different SED shapes. The large MIR/submillimeter flux ratios probably indicate exceptionally luminous 7.7μm PAH emission, based on Spitzer IRS spectra for a subset of these objects (Weedman et al. 2007).

195.02D

The Masses and Luminosities of Submillimeter-Selected Galaxies

Laura J. Hainline[1]
[1]*Caltech.*

The observed far-infrared SEDs of the population of high-redshift galaxies revealed through deep submillimeter surveys suggest that the population is characterized by large bolometric luminosities, mostly emitted at infrared wavelengths. As X-ray observations indicate that this luminosity is dominated by reprocessed emission from obscured star formation, star formation rates of ~1000 M_{sol} yr^{-1} are required to account for the enormous IR emission inferred from the SEDs, leading to the hypothesis that submillimeter-selected galaxies represent the formation epoch of the massive bulges and ellipticals observed locally. However, our knowledge of the SEDs of submillimeter-selected galaxies in the near and mid-IR and their total mass has until recently been limited by the faintness of the galaxy population; thus, our estimates of the IR luminosity of the galaxies, their stellar content, and the mass of gas available for conversion into stars have been poorly constrained. The mid-IR windows opened up by the Spitzer Space Tele-

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scope, together with its unprecedented sensitivity, allow us to fill in the gaps in the IR SEDs of submillimeter-selected galaxies and determine the relative contributions to their luminosities from stars, dust, and AGN, while the wide-bandwidth spectrometer and 18-40 GHz receivers at the GBT permit us to measure their total molecular gas masses. We have exploited the unique capabilities of both Spitzer and the GBT by obtaining IRAC and MIPS imaging of a sample of ~ 100 submillimeter-selected galaxies with redshifts confirmed through optical spectroscopy, and GBT spectroscopy of a subsample of these objects. We present here new estimates of stellar mass and age derived from IRAC data and IR luminosity from MIPS data, plus estimates of molecular hydrogen mass in galaxies with GBT observations.

195.03

Mid-Infrared Spectral Diagnostics of Submillimetre Galaxies

Alexandra Pope[1], R. Chary[2], M. Dickinson[3], D. Scott[1]
[1]Univ. of British Columbia, Canada, [2]Spitzer Science Center, [3]National Optical Astronomy Observatory.

Submillimetre (submm) galaxies have very high infrared (IR) luminosities and are orders of magnitudes more numerous at z~2 than local ultraluminous IR galaxies. They therefore represent a key phase in galaxy evolution which can be missed in optical surveys. Determining their contribution to the global star formation rate requires dissecting their IR emission into contributions from starbursts (SB) and active galactic nuclei (AGN). There are several examples of AGN systems which masquerade as SBs in either the IR or X-ray, and SBs can often look like AGN in some wavebands. A combination of SB and AGN emission is not unreasonable, given models of merger-driven evolution. To assess in details what powers the intense IR luminosity of submm galaxies it is important to obtain a complete multi-wavelength picture. Mid-IR spectroscopy is a particularly good probe of where the intense IR luminosity is coming from. We present the results from a program to obtain IRS spectroscopy of a sample of high redshift galaxies in GOODS-N, a large fraction of which are submm galaxies. This field is already home to the deepest X-ray, optical, IR and radio data. We compare the IRS spectra from the submm galaxies with those from other high redshift galaxies and, by comparing the features and line-continuum ratios, we can separate the AGN and SB components in the mid-IR. Combined with the submm and X-ray data, we are able to quantify the contribution to the bolometric luminosity from the AGN and SB components.

195.04

The Redshift Distribution of 24 micron sources in the NDWFS Bootes Field

Vandana Desai[1]
[1]Caltech.

The 9 square degree Bootes field of the NOAO Deep Wide-Field Survey (NDWFS) has been mapped with both the IRAC and MIPS instruments on board the Spitzer Space Telescope, complementing deep groundbased optical imaging. I will present the results of an optical spectroscopic survey of 24 micron sources in Bootes carried out with the DEIMOS and LRIS instruments on the Keck telescope. The approximately 550 targets represent an unbiased sample of 24 micron sources down to 0.3 mJy. We obtained redshifts for 70% of the targets, the remainder being optically faint (R>23 mag). The peak of the resulting redshift distribution occurs at z = 0.8 and is dominated by LIRGs, with the number of ULIRGs growing rapidly at z>1. Existing models of the evolution of infrared sources based on number counts and the infrared background differ on the nature of the optically faint targets without redshifts, predicting they are predominantly either LIRGs at z=1 or ULIRGs at z=2.

195.05

History and Modes of Star Formation since z~1 in Field Galaxies: A New Picture from the AEGIS Collaboration

Kai Noeske[1], AEGIS collaboration
[1]UC, Santa Cruz.

We present a comprehensive view of star formation since z~1 in massive field galaxies. For ~3000 galaxies in the All Wavelength Extended Groth Strip Survey″ (AEGIS), we combine UV-to-IR star formation rate tracers, stellar masses, quantitative HST morphologies and rest-frame photometry.

Star-forming galaxies form a distinct ″Main Sequence″, with a narrow range of star formation rates at a given mass and redshift. The range of star formation (1) limits the amplitude of episodic star formation; (2) constrains the effect of major mergers; (3) shows that a gradual decrease of star formation in most galaxies dominated since z~1, not a decrease of strong starbursts; (4) shows Luminous Infrared galaxies at z~1 to be mostly normal star-forming galaxies, not strong bursts.

This gradual decrease of star formation can be reproduced by a model of gas exhaustion with timescales increasing to less massive galaxies, quantifying mass depencencies of star formation histories. The data and models also indicate a new picture of ″staged galaxy formation″, where the onset of major star formation shifts to lower redshifts for less massive galaxies.

195.06D

The Molecular ISM of Quasar Host Galaxies in the Early Universe

Dominik A. Riechers[1]
[1]Max-Planck Institut fuer Astronomie, Germany.

Detailed studies of the molecular gas phase in the host galaxies of the highest redshift quasars are important for our understanding of the formation and evolution of quasars and their bulges, since it is the molecular gas out of which stars form. I will discuss recent observations in the radio/millimeter wavelength regime that have concentrated on adressing three main questions: 1) How massive are the molecular gas reservoirs of distant quasars? 2) What is the structure and dynamical mass of their host galaxies? 3) What are the composition and excitation conditions of the molecular ISM in these early systems? Observational highlights within this framework include 1) high velocity resolution (up to 25 kms^{-1}) CO(1-0) spectroscopy in z>4 QSOs with the NRAO Green Bank Telescope (GBT) and the MPIfR Effelsberg 100m telescope, leading to typical molecular gas masses of $M(H_2)$ $=4x10^{10}$ $M_\odot$ 2) high spatial resolution (up to 0.15″, or 1 kpc at z=4) CO imaging with the NRAO Very Large Array (VLA), revealing spatially and dynamically resolved molecular structures in the targeted systems; and 3) the first high-z detections of emission from HCO^+, CN, and CS with the VLA and the IRAM Interferometer (PdBI), raising the total number of detected molecules in emission at high z from 2 (CO/HCN) to 5. All these observations uniquely constrain the properties of the molecular environments in key targets among the earliest galaxies currently observable, and thus provide an important foundation for future studies with the Atacama Large Millimeter Array (ALMA).

195.07

The Hard X-ray 20-40 keV AGN Luminosity Function

Volker Beckmann[1], S. Soldi[2], C. R. Shrader[1], N. Gehrels[1], N. Produit[2]
[1]NASA's GSFC, [2]INTEGRAL Science Data Centre, Switzerland.

The INTEGRAL mission has been operational in the hard X-ray band since October 2002. Up to now more than 70 AGN have been detected by the imager IBIS/ISGRI.

We have compiled a complete, significance limited sample based on ~25,000 square degrees to a limiting flux of 3E-11 ergs/cm**2/sec (~7,000 square degrees to a

flux limit of 1E-11 ergs/cm**2/sec) in the 20-40 keV band with INTEGRAL. We have constructed a detailed exposure map to compensate for effects of non-uniform exposure. The flux-number relation is best described by a power-law with a slope of 1.66 $\pm$ 0.11.

We present the first luminosity function of AGN in the 20-40 keV energy range, based on 38 extragalactic objects detected by the imager IBIS/ISGRI on-board INTEGRAL. The luminosity function shows a smoothly connected two power-law form, with an index of γ_1 = 0.9 below, and γ_2 = 2.2 above the turn-over luminosity of Lx = 4.6E43 ergs/sec. The emissivity of all INTEGRAL AGNs per unit volume is W(> 1E41 ergs/sec) = 2.8E38 ergs/sec/Mpc**3. These results are consistent with those derived in the 2 20 keV energy band and do not show a significant contribution by Compton-

thick objects. Because the sample used in this study is truly local (z = 0.022), only limited conclusions can be drawn for the evolution of AGNs in this energy band. But the objects explaining the peak in the cosmic X-ray background are likely to be either low luminosity AGN (Lx < 1E41 ergs/sec) or of other type, such as intermediate mass black holes, clusters, and star forming regions.

196: Extrasolar Planets III
AAS Oral, Tuesday, 2:00-3:30pm, 605-07

196.01

MIPS Lightcurves for Extrasolar Planets

Bradley M. Hansen[1], J. Harrington[2], S. Luszcz[3], D. Deming[4], S. Seager[5], K. Menou[6], J. Cho[7], J. Richardson[4]
[1]UC, Los Angeles, [2]U. Central Florida, [3]UC, Berkeley, [4]GSFC, [5]OCIW, [6]Columbia, [7]QMUL, United Kingdom.

We present the results of a Spitzer campaign to measure the day-night temperature differences of planets in the brightest known 'Hot Jupiter' systems. We use the MIPS instrument at 24 microns, making use of the zodiacal background as a flux reference. Initial results suggest the presence of significant day-night temperature differences on these planets. We will also discuss some of the preliminary implications of these measurements.

196.02

Infrared Spectrocopy of the Transiting Extrasolar Planet HD209458b

Lee J. Richardson[1], D. Deming[1], K. Horning[2], S. Seager[3], J. Harrington[4]
[1]NASA's GSFC, [2]Florida Institute of Technology, [3]Carnegie Institution of Washington, [4]University of Central Florida.

We have used the Spitzer Space Telescope to observe the transiting extrasolar planet system HD 209458 at the time of secondary eclipse, when the planet disappears behind the star and later reappears. Using the Infrared Spectrograph (IRS), our technique subtracts the spectrum of the star (when the planet is eclipsed) from the combined light spectrum (when the planet is out of eclipse), to isolate the 7-14 micron spectrum of the planet. This process has required decorrelation of systematic effects, due to detector response drift and telescope pointing jitter. The observations, spanning two secondary eclipse events, have sufficient signal-to-noise to reveal spectral structure. We discuss the implications for the structure and composition of the planet's atmosphere.

This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA. K.H. acknowledges support from the Summer Undergraduate Internship program of the Goddard Center for Astrobiology. L.J.R. acknowledges support as a NASA Postdoctoral Fellow.

196.03

The Thermal Flux of the Extrasolar Planet HD 209458b at 7-14 Microns

Drake Deming[1], S. Seager[2], L. J. Richardson[1], K. Horning[3], J. Harrington[4]
[1]NASA's GSFC, [2]CIW/MIT, [3]FIT, [4]UCF.

We used Spitzer/IRS to measure two secondary eclipses of the extrasolar planet HD 209458b. The primary goal of these observations was to isolate the 7-14 micron spectrum of the planet (Richardson et al., this meeting). However, it is also possible to extract photometry from the spectra, and measure the thermal flux from the planet, averaged over wavelength. Summing the spectra over wavelength, several instrument-related systematic effects are seen. These include a baseline drift, and an oscillation in intensity due to telescope pointing jitter. However, the secondary eclipse of the planet is clearly detected in spite of the instrument systematic effects. We will discuss the eclipse amplitude, and the implications for models of the planet.
This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Support for this work was provided by NASA. K. Horning acknowledges support from the Summer Undergraduate Internship program of the Goddard Center for Astrobiology. LJR acknowledges support of the NASA Postdoctoral Program at GSFC.

196.04

High Precision Differential Photometry of the Transit and Secondary Eclipse of HD209458b

Daniel E. Potter[1]
[1]Univ. of Arizona.

Differential photmetric observations of HD209458 obtained at the Steward 2.3 m Bok telescope during the transit and secondary eclipse of the known planet HD209458b are presented. The instrument used in the observations, PEPPER (a Polarization Encoding differential Photometer and PolarimetER) achieves near photon-noise limited differential photometric accuracies using a novel optical design. These observations were carried out through narrow band filters centered on the 770 nm potassium line and a continuum region centered at 800 nm. Using the normalized difference of the photometric measurements through these filters, accuracies of 3 parts in 10e5 were obtained in 20 minute observation intervals which was sufficient to observe the photometric signature of the HD209458b in both the transit and secondary eclipse events.

196.05

First High-Contrast Science with an IFU: The Sub-Stellar Companion to GQ Lup

Stanimir A. Metchev[1], M. McElwain[1], J. Larkin[1]
[1]UCLA.

We present high-contrast integral field spectroscopy with Keck AO +OSIRIS of the young star GQ Lup and its close-in sub-stellar companion claimed to be the first, and only, planet directly imaged around a hydrogen-burning star. By allowing simultaneous two-dimensional sampling of the bright halo of the primary, OSIRIS enables us to accurately estimate the host-star contamination in the spectrum of the sub-stellar companion an otherwise challenging task for conventional AO slit spectroscopy in the constrast-limited regime. Our R=2000 Jand H-band spectra of GQ Lup B complement existing K-band spectra and photometry, and improve on the original estimate of its spectral type.

We find that GQ Lup B is somewhat hotter (M6-L0) than reported in the discovery paper by Neuhauser and collaborators (M9-L4), mainly due to the surface-gravity sensitivity of the K-band spectral classification indices used by the discoverers. Using our updated spectroscopic classification of GQ Lup B and a re-evaluation of the age and heliocentric distance of the primary, we perform a comparative analysis of the available sub-stellar evolutionary models to estimate the mass of the companion. We find that the mass of GQ Lup B is 0.010-0.040 solar masses. Hence, it is unlikely to be a wide-orbit counterpart to the known radial-velocity extrasolar planets, whose masses are <=0.015 solar masses. Instead, GQ Lup A/B is a member of a growing family of very low mass ratio widely separated binaries discovered through high-contrast imaging.

196.06

Search for Planetary Transits of the Debris Disk Star AU Mic

Larry D. Petro[1], L. Hebb[2], H. Ford[3], D. Golimowski[3], J. Rogers[3], P. Sackett[4], K. Lewis[4], M. Clampin[5], J. Wisniewski[5], D. Minniti[6], I. Toledo[6], P. Espinoza[6], D. Ardila[7]
[1]STScI, [2]University of St. Andrews, United Kingdom, [3]Johns Hopkins University, [4]Australian National University, Australia, [5]NASA's Goddard Space Flight Center, [6]Pontificia Universidad Catolica de Chile, Chile, [7]CalTech/Spitzer Science Center.

TUESDAY

We have carried out rapid cadence photometric monitoring of AU Mic during the summers of 2005 and 2006 in order to search for possible planetary transits. AU Mic is a young (12 Myr) M1Ve BY Dra star that presents a nearly edge on debris disk. The favorable aspect of the system enables searching for exo planets via the photometric signature of a transit. We obtained photometry with the CTIO/SMARTS 1-m telescope + OSU Y4KCam in 2005 and 2006, and with the ANU MSSSO 40-inch telescope in 2006. Four photometric bands between 4500 and 6600 Angstrom were used on these telescopes to obtain photometric measurements with a cadence of approximately 2 minutes. We have achieved 0.003 mag r.m.s. differential photometry, which is sufficient to detect transits of Neptune radius planets. The two season data set allows to detect approximately 90% of planetary orbits with orbital periods less than 20 d. We present the results of our two season search for planetary transits. This research has been supported in part by NASA grant NAG5-7697.

196.07D

Forming Earth-like Planets With Migrating Giants: Modeling and Observations

Avi Mandell[1], S. Sigurdsson[2], S. Raymond[3], M. Mumma[4], G. Blake[5]
[1]Penn State University / NASA GSFC, [2]Penn State University, [3]Univ. of Colorado / VPL, [4]NASA GSFC, [5]Cal Tech.

Close-in giant planets make up 40% of known extrasolar planets. These 'hot Jupiters' are thought to have formed in the cold outer regions of planetary systems and migrated inward via interactions with gaseous protoplanetary disks. During their migration, they pass through the orbital region where terrestrial planets in our own Solar System. I will present results of dynamical simulations of young planetary systems undergoing migration of a Jovian-type planet through the terrestrial region. We find that a significant fraction of the initial planetary embryos remain after giant planet migration, and subsequent evolution of the system results in the formation of terrestrial planets in various configurations, often including a water-rich planet in the Habitable Zone and/or a 'hot Earth' within the orbit of the 'hot Jupiter'. Additionally, I will highlight an on-going observational program to characterize the chemical environment in young circumstellar disks in order to pin down the initial conditions in which nascent systems begin forming.

196.08

Correlations Between Stellar Metallicity and the Frequency of Planetary and Stellar Companions

Charles Lineweaver[1], D. Grether[2]
[1]Australian National University, Australia, [2]University of New South Wales, Australia.

We analyze the relationship between the frequency of close companions (stellar and planetary companions with orbital periods < 5 years) and the metallicity of their Sun-like (~ FGK) hosts. We confirm and quantify a positive correlation between host metallicity and the presence of an exoplanetary companion. We find little or no host-mass-dependence or distance-dependence in this correlation. In contrast to the metallicity dependence of planetary companions, stellar companions tend to be more abundant around low metallicity hosts. We find an anti-correlation between host metallicity and the presence of a stellar companion. We investigate possible selection effects that could explain the preferential detection of stellar binarity in low metallicity hosts, including spectral type, distance and kinematic selection. Upon dividing our sample into FG and K sub-samples, we find a strong anti-correlation in the K sub-sample and a negligible correlation in the FG sub-sample. We were unable to identify any strong selection effects that could explain this anti-correlation.

197: Galaxy Clusters IV
AAS Oral, Tuesday, 2:00-3:30pm, 608-10

197.01D

Radio and X-ray Properties of Cavities in the Hot Atmospheres of Ellipticals, Groups, and Clusters

Laura Birzan[1], B. R. McNamara[2], C. L. Carilli[3], P. E. Nulsen[4], M. Wise[5]
[1]Ohio University, [2]University of Waterloo, Canada, [3]NRAO, [4]CfA, [5]University of Amsterdam, The Netherlands.

Motivated by the impact that active galactic nuclei (AGN) can have on large scale structure formation and on the intracluster environment, we investigate the properties of the AGN at the cluster core. We present new, high resolution radio images of sources associated with cD galaxies and X-ray cavities located in cluster cores. The cavity properties derived from archival Chandra observations give reliable estimates of the total jet power and age independently of the radio synchrotron flux. We combine the X-ray data and VLA radio images at multiple frequencies to investigate several fundamental properties of cluster radio sources, including their radiative (mechanical) efficiencies, magnetic field contents, and particle contents, and we evaluate the assumption of equipartition in these systems. We show that high radio frequencies probe the current AGN output, while frequencies at or below 327 MHz trace the history of AGN activity in the cores of clusters over the past several hundred million years.

197.02D

The X-Ray Luminosity-Mass Relation for Local Clusters of Galaxies

Rebecca Stanek[1], A. Evrard[1], H. Boehringer[2], P. Schuecker[2], B. Nord[1]
[1]Univ. of Michigan, [2]Max-Planck-Institut fur extraterrestrische Physik, Germany.

My thesis is centered on investigating scaling relations of galaxy clusters. Focusing on the relationship between soft X-ray luminosity and mass (L-M) for low-redshift clusters of galaxies, I have determined the mean parameters to ~5%, and calculated a formal measure of the scatter in the L-M relation. I model the L-M relation with a conditional probability function including a mean power-law scaling relation, $L{\sim}M^p\rho^s_c(z)$, and log-normal scatter in mass at fixed luminosity, $\sigma_{\ln M}$. Convolving with the halo mass function, I compute expected counts in redshift and flux that, after appropriate survey effects are included, are compared to REFLEX survey data. Combining the likelihood analysis with the measured variance in L-T relation from HIFLUGCS, I obtain fit parameters p=1.59+/-0.05, $\ln L_{15,0}$=1.34+/-0.09, and $\sigma_{\ln M}$=0.37+/-0.05 for self-similar redshift evolution (s = 7/6) in a concordance (Ω_m=0.3, Ω_Λ=0.7, σ_8=0.9) universe. I find a substantially (factor 2) dimmer intercept and slightly steeper slope than the values published using hydrostatic mass estimates of the HIFLUGCS sample and show that a Malmquist bias of the X-ray flux-limited sample accounts for this effect. I accommodate the new WMAP constraints with a compromise model with Ω_m=0.24, σ_8=0.85, and somewhat lower scatter $\sigma_{\ln M}$=0.25.

I will also present work in progress from galaxy cluster population statistics in the Millennium Simulation with Gas (MSG), specifically focusing on the scatter and covariance between cluster properties at a fixed epoch.

197.03D

Cosmological Constraints from the maxBCG Cluster Sample

Eduardo Rozo[1]
[1]Ohio State Univeristy.

The SDSS maxBCG cluster catalog is a highly pure and complete cluster sample for which dynamical, lensing, and X-ray properties of the clusters have been studied. In this talk, we will present the current cosmological constraints derived from the SDSS maxBCG sample. We emphasize the considerable care that has gone into calibrating and properly marginalizing over systematic uncertainties in the cluster selection function, and discuss prospects for improvement in the near future.

197.04

The Age Dependence of Galaxy Clustering

Darren S. Reed[1], F. Governato[2], T. Quinn[2], J. Stadel[3], G. Lake[3]
[1]Los Alamos National Laboratory, Theoretical Astrophysics (T-6), [2]Univ. of Washington, [3]Univ. of Zurich, Switzerland.

We construct mock galaxy catalogues to analyse clustering properties of a Lambda cold dark matter (LCDM) universe within a cosmological dark matter simulation of sufficient resolution to resolve structure down to the scale of dwarfs. We show that the age-clustering correlation, recently found among discrete virialized haloes by Gao et al., is strong for objects likely to host luminous galaxies, which includes the satellite halo (subhalo) population.

Older mock galaxies are significantly more clustered in our catalog, which consists of satellite haloes as well as the central peaks of discrete haloes, selected solely by peak circular velocity. This suggests that the clustering age dependence is manifested in real galaxies. At small scales (less than ~5 Mpc/h), the very simple assumption that galaxy colour depends solely on halo age is inconsistent with the strength of the observed clustering colour trends, where red galaxies become increasingly more clustered than blue galaxies toward smaller scales, suggesting that luminosity weighted galaxy ages do not closely trace the assembly epoch of their dark matter hosts. The age dependence is present but is weaker for satellite haloes lying within groups and clusters than for the global population.

197.05

Tracing Galaxy Evolution in Clusters and Groups at z>1

Simona Mei[1], A. Stanford[2], J. Blakeslee[3], R. Demarco[4], P. Eisenhardt[5], H. Ford[4], B. Holden[6], N. Homeier[4], M. J. Jee[4], T. Kodama[7], F. Nakata[8], M. Postman[9], P. Rosati[10], R. White[9]
[1]Johns Hopkins Univ., UC Berkeley, Obervatoire de Paris, [2]IGPP/LLNL, [3]Washington State University, [4]Johns Hopkins Univ., [5]JPL, [6]University of California Santa Cruz, [7]National Astronomical Observatory of Japan (NAOJ), Japan, [8]University of Tokyo, Institute of Astronomy, Japan, [9]Space Telescope Science Institute, [10]European Southern Observatory, Germany.

Observing galaxies in groups and filaments before they enter the environs of massive clusters provides important clues to the processes driving galaxy evolution. We present new results from recent ACS/HST observations in five galaxy groups around the central two clusters in the Lynx Supercluster region at z=1.3. We discuss the environmental differences in morphology, colors and distribution of the group galaxy population as compared to that of the two central clusters.

197.06

Evidence of Hierarchical Galaxy Formation from Strong MgII Absorbers

Andrew Mshar[1], J. C. Charlton[1], C. W. Churchill[2], T. Kim[3]
[1]Penn State, [2]New Mexico State University, [3]Institute of Astronomy, United Kingdom.

We consider the evoluton of strong MgII absorbers, most of which are closely related to luminous galaxies. Using high resolution quasar spectra from the VLT/UVES public archive, we examine these absorbers in the redshift range $0.3 < z < 2.5$. The most significant evolution is in the number of separate subsystems in an MgII &#955 2796 profile, which increases with decreasing redshift. We find that neither equivalent width nor kinematic spread (the optical depth weighted second moment of velocity) of MgII &#955 2796 evolve. However, the kinematic spread is sensitive to the highest velocity component, and therefore not as sensitive to additional weak components at intermediate velocities relative to the profile center. The fraction of absorbing pixels within the full velocity range of the system does show a trend of decreasing with decreasing redshift. Most high redshift systems exhibit absorption over the entire system velocity range. This a result of low redshift MgII profiles tending to represent well formed galaxies, many of which have kinematics of a disk/halo structure. Many high redshift MgII profiles show evidence of protogalactic structures with multiple accretion events. Although these results are derived from measurements of gas kinematics, they are consistent with hierarchical galaxy formation evidenced by deep galaxy surveys.

198: ISM/Star Formation
AAS Oral, Tuesday, 2:00-3:30pm, 611-12

198.01

Using Cloudshine to Constrain Turbulent Star Formation

Jonathan B. Foster[1], A. A. Goodman[1], J. Pineda[1], P. Caselli[2]
[1]Harvard Univ., [2]Osservatorio Astrofisico di Arcetri, Italy.

The COMPLETE (COordinated Molecular Probe Line Extinction and Thermal Emission) Survey of Star Forming Regions provides a wealth of public data for multi-wavelength analysis of several nearby molecular cloud complexes. Cloudshine, which is the diffuse interstellar radiation field reflecting off dust within dark clouds, provides a unique way to examine the density structure of molecular cores (both protostellar and starless) on arcsecond scales without the complications of chemistry present in molecular line observations. We discuss the comparison of cloudshine observations in Perseus and Ophiuchus to models of turbulence in molecular clouds, and describe how these observations may be used with other COMPLETE data to probe the dust to gas ratio and optical properties of dust on small spatial scales.

198.02

The Scale of Turbulence in Molecular Clouds

Naomi A. Ridge[1], A. A. Goodman[1], N. Whitehorn[1]
[1]Harvard-Smithsonian, CfA.

A long standing problem in astronomy is that molecular cloud (MC) lifetimes are much longer than their free-fall time, and hence MCs must be supported against gravitational collapse. This support is thought to be due to turbulent pressure. Molecular line emission shows line-widths ~10 times the thermal line width, supporting this hypothesis. However, numerical simulations have shown that such turbulence should decay quickly, and hence must be constantly driven. The source of this turbulence is still a topic of much debate, with possible mechanisms ranging from Galactic rotation and cloud collisions which would drive the turbulence on large scales (tens of parsecs) down to jets and outflows from individual protostars driving turbulence on <1pc scales.

As part of the COMPLETE Survey we have obtained large-scale maps of the molecular-line emission in three nearby star-forming regions, Perseus, Ophiuchus and Serpens (Ridge et al. 2006). These maps cover a few tens of parsecs each, and with an angular resolution equivalent to ~0.2pc provide an excellent laboratory for investigating turbulence on a range of scales. Using the Spectral Correlation Function, I have been investigating whether there is a characteristic scale of turbulence in the three molecular clouds. Work by Padoan, Goodman and collaborators (2001, 2003) has shown that the slope of the SCF is a power-law for observational data over several orders of magnitude. My working hypothesis is that a characteristic length scale in the turbulence would show up as a break in this power law. As a first step I have tested this hypothesis by applying the SCF method to simulated data in which the driving scale of the input turbulence is known. I have then applied the SCF to the 13CO data of the three molecular clouds, and searched for a characteristic length scale of the turbulence in these regions.

198.03

What is the True Core Mass Function?

Di Li[1], X. Guan[2], Y. Dai[2]
[1]Jet Propulsion Laboratory / Caltech, [2]Peking University, China.

TUESDAY

The cause of the stellar initial mass function (IMF) has been a difficult subject in the field of star formation. Given the variation in conditions of star forming regions, the universality of IMF is surprising. In the recent decade, one line of investigation has focused on the mass function of dense molecular cores (CMF), which are precursors of new stars. The majority of these studies claim to find a CMF similar to IMF, which has a slope similar to that of the Salpeter IMF and flatterns toward lower mass end. These results suggest a uniform star formation efficiencies in cores within a large range of mass.

We have reanalyzed the observed CMFs from literature with emphasis on the statistical significance of the model fits. We conclude that the previous, essentially, two power law fit of the CMF is not convincing. Many existing data can be modeled by a single power law of a slope flatter than that of the Salpeter IMF. Given the vast variation in conditions and masses of cores included in this study, our result suggests that the initial mass function is shaped later in the process of star formation than the core accretion phase.

We also caution against any direct power law fit to a cumulative mass function. More sophisticated procedures, one of which we will introduce, would be necessary to derive a meaningful slope for the CMF.

198.04D

Updated Interstellar Abundance Studies with FUSE and STIS

Adam G. Jensen[1]
[1]*Univ. Of Colorado.*

The introduction of UV instruments with higher resolution and/or throughput, namely FUSE and STIS, has allowed for a new generation of elemental abundance studies in the interstellar medium over the past several years. In my thesis I have undertaken studies of interstellar nitrogen, oxygen, magnesium, silicon, and iron. The results of these and other studies have confirmed that the line of sight parameter with the most significant correlation to the depletion of most elements is the average hydrogen volume density. However, my work has shown that correlations with other line of sight parameters do exist, in particular between depletions and extinction (both total visual extinction and selective extinction, particularly when either is scaled by the pathlength of the line of sight), the ratio of total visual extinction to selective extinction (a measure of average grain size), and the molecular fraction of hydrogen. While these trends hold in lines of sight with up to a few magnitudes of visual extinction and densities over 10 cm^{-3}, we have yet to see the more extreme depletions expected to be associated with translucent clouds. In my talk, I will summarize the results of my studies and other similar studies, as well as the current state of ″cosmic″ abundance standards. I will also discuss the implications of these results for the physical conditions of interstellar clouds and dust composition. Finally, I will discuss the implications of these results and other results--such as the detection of very weak lines in my work--for future work with the next important UV instrument, the Cosmic Origins Spectrograph, which is expected to be installed on HST in late 2007 or early 2008.

198.05

Study of Diffuse Interstellar Bands in 7 Intermediate Redshift Galaxies

Brandon L. Lawton[1], C. W. Churchill[1], B. A. York[2], S. L. Ellison[2], T. P. Snow[3], R. A. Johnson[4], S. G. Ryan[5]
[1]*New Mexico State Univ.,* [2]*University of Victoria, Canada,* [3]*University of Colorado,* [4]*Oxford University, United Kingdom,* [5]*University of Hertfordshire, United Kingdom.*

Diffuse Interstellar Bands (DIBs) are hundreds of absorption features, typically associated with organic molecules, observed throughout the optical spectrum. There are only a handful of galaxies outside of the Milky Way with known DIB absorption. Understanding the source of the DIBs and the environments that are conducive for their appearance has implications in understanding galactic ISM. There are also possible implications in the likelihood of organic life arising in galaxies with an abundance of the DIB producing organic molecules as is theorized for our own Solar System.

We present our study of 7 damped Lyman-alpha (DLA) galaxies located from z~0.1 to z~0.5 as observed via background QSOs. Of the seven there are 6 non-detections with 3-sigma limits. There are multiple reasons why the DIBs could be unobservable in other galaxies when they are so readily seen in multiple sight-lines within the Milky Way. We discuss environmental factors that can inhibit or enhance DIB strengths assuming they are caused by organic molecules. These factors include metallicity, ionizing radiation, and dust content, as well as observer bias such as galaxy orientation. In the one detection of the 5780 Angstrom DIB along the QSO sight-line Q0235+164 the 4428 Angstrom DIB is previously known; furthermore, there is evidence that Q0235+164 has a significantly higher metallicity than the typical one-tenth solar common among DLAs at these redshifts.

198.06

The Discovery of Extragalactic Magnetic Fields in OH Megamasers

Timothy Robishaw[1]
[1]*UC Berkeley.*

We shall present the discovery of the first extragalactic Zeeman-splitting detections seen in emission from OH megamasers. We conducted a survey of OH megamaser emission from 6 ULIRGs (including the archetypal ULIRG Arp 220) using the Arecibo 300-m telescope and measured the Zeeman effect in 16 masing regions in 4 of the 6 galaxies. These measurements suggest a typical field of about 3 mG in ULIRGs. Field reversals were seen in 3 of the galaxies and an amazing 7 Zeeman-splitting detections were found in Arp 220 alone. Our largest detected field, with a line-of-sight magnitude of 18 mG, was seen in one of only three known OH gigamasers, at a z of 0.217. Prior to these observations, Zeeman splitting had only been seen in one extragalactic source and, at that, in absorption of HI against a background source. Our results demonstrate that OH megamasers are a sensitive extragalactic magnetometer and a promising new tool for probing the astrophysics of distant galaxies. Support for this work was provided in part by the NSF through award GSSP06-0003 from the NRAO and NSF grant AST-0406987.

198.07

The Effect of Star Formation Activity on the Far-Infrared--Radio Correlation within Spiral Galaxies

Eric J. Murphy[1], G. Helou[2], R. Braun[3], J. D. Kenney[1], L. Armus[2], the SINGS team
[1]*Yale Univ.,* [2]*Caltech,* [3]*ASTRON, The Netherlands.*

Using Spitzer far-infrared (FIR) and Westerbork Synthesis Radio Telescope (WSRT) imaging as part of the Spitzer Infrared Nearby Galaxies Survey, we study how the FIR-radio correlation behaves within a sample of spirals. Specifically, we test a phenomenological model which describes the FIR-correlation as the result of massive star formation; massive stars both dust and end their lives as supernovae whose remnants accelerate cosmic-ray (CR) electrons responsible for the observed synchrotron emission within star-forming galaxies. Since the mean-free-path of dust-heating photons is significantly shorter than the diffusion length of CR-electrons, the radio image of a galaxy should appear as a smoother version of its infrared image. We find that this description works well as smoothing the infrared maps improves the spatial correlation between the FIR and radio maps by a factor of ~3. We also find that the size of the scale-length which yields the best correlation between the FIR and radio spatial distributions is related to the amount of ongoing star formation activity. We demonstrate that this trend is not the result of increased Inverse Compton losses nor a decrease in the mean-free-path traveled by CR-electrons due to varying ISM parameters, but rather due to the predominant youth of the CR-electron population within galaxies having high star-formation activity. We conclude that these galaxies have likely undergone a recent episode of enhanced star formation.

198.08

Disentangling Density and Heating Effects in the Infrared Emission of SINGS Galaxies

Caroline Bot[1], SINGS team

[1]Caltech.

The infrared surface brightness of a galaxy or of a region within a galaxy depends mainly on the heating intensity and on the interstellar density of the region observed. This project studies how these two contributions are related in SINGS galaxies and how to disentangle them using mid-IR diagnostics.

Helou & Wang used the FIR surface brightness of galaxies in the IRAS Bright Galaxy Sample in conjunction with the infrared to blue ratios and observed a correlation between the interstellar column density and the radiation density. This density-intensity diagram shows that star formation scales with the density of the ISM.

Spitzer offers a great improvement over IRAS in the variety, resolution and sensitivity of the data available, and the SINGS sample and data offer a unique opportunity to revisit the question and constrain the physical parameters of the ISM in these galaxies.

199: Kinematics of Galaxies Internal and External AAS Oral, Tuesday, 2:00-3:30pm, 204

199.01

The Kinematics of the Disk-Halo Interaction in Spiral Galaxies

George H. Heald[1], R. J. Rand[2], R. A. Benjamin[3]
[1]ASTRON, The Netherlands, [2]U. New Mexico, [3]U. Wisconsin.

Moderateto high-velocity resolution optical spectroscopic observations of the gaseous halos of three galaxies (NGC 5775, NGC 891, and NGC 4302) have shown that they do not rotate cylindrically; rather, the rotation speed is observed to fall off roughly linearly with increasing height above the midplane. The measurements of these velocity gradients, which have magnitudes of approximately 8, 15, and 30 km/s/kpc, respectively, are briefly summarized. Correlations with other observables are presented. Signs point to the kinematics of gaseous halos being related to the star formation activity in the underlying disk, as well as to the distribution and morphology of the halo gas. Of particular interest is the apparent connection between the magnitude of the velocity gradient and the vertical scale height of the gas distribution: suggesting that the decrease in rotation speed per unit scale height may be a constant parameter of gaseous halos. Such a constant parameter may help constrain theoretical models of the disk-halo interaction in spiral galaxies. The implications of this possibility on the idea that gaseous halos are supported by disk star formation are briefly discussed.

199.02D

Thick Disks in External Galaxies: Structure, Kinematics, and Abundances

Peter Yoachim[1]
[1]Univ. of Washington.

We have collected photometric and spectroscopic observations of thick disks in a large sample of edge-on disk galaxies. We find that thick disks are more prominent in lower mass galaxies, to the point of dominating the total stellar mass. Kinematically, most thick disks (8 of 9) are analogous to the Milky Way thick disk showing a moderate rotational lag and are consistent with being a kinematically hot stellar population in equilibrium with the overall galaxy potential. However, we find one example of a thick disk which is counter-rotating when compared to the thin disk. We have derived ages and metallicities using the Lick spectral indices and confirm that thick disks are older and metal poor when compared to the thin disks. Our observations support thick disk formation models where the thick disk is formed from the direct accretion of stars from infalling satellite galaxies. The presence of a counter-rotating thick disk rules out models where the thick disk is the kinematically heated remnant of a previously thin disk.

199.03

Dwarf Satellites of Distant Galaxies

Michael R. Blanton[1]
[1]New York Univ..

Most theories of galaxy formation incorporate elements like supernova feedback, ram pressure stripping, and other poorly understood physical effects. Dwarf galaxies, with their shallow potential wells, are the galaxies most sensitive to these processes. Thus, the study of dwarf galaxies may lead to a better understanding of these effects. Using the Sloan Digital Sky Survey, I examine the properties of dwarf satellites of luminous galaxies. By deprojecting the distribution, I determine the three-dimensional radial distribution of satellites around host galaxies. Treating blue (dIrr) and red (dE or dSph) satellites separately, I demonstrate that the trend seen in the Milky Way, that nearby dwarfs are much redder, also holds for other systems. Our results suggest that interaction with a large host is the only process which can end star-formation in dwarfs. I compare these results to theoretical predictions based on semianalytic models.

199.04D

The Motions of the Magellanic Clouds About the Milky Way

Nitya Kallivayalil[1], R. van der Marel[2], C. Alcock[1]
[1]Harvard-Smithsonian Center for Astrophysics, [2]Space Telescope Science Institute.

It is expected from current models of hierarchical structure formation that the interaction between the Large and Small Magellanic Clouds (LMC & SMC) and the Milky Way (MW) will have played an important role in the dynamical evolution of the MW's outer parts. A major uncertainty in decoding this evolution is the space velocity of the Clouds and thus their orbital motion. While the radial velocities of the Clouds have been measured to high precision, the velocity transverse to the line of sight (the proper motion) has been harder to constrain. I will present a project that has allowed us to determine the systemic proper motions of the Clouds to better than 5% accuracy for the LMC, and 15% for the SMC, using two epochs of HST/ACS (Advanced Camera for Surveys) data and just a 2 year baseline. The result for the LMC is the most accurate proper motion measurement for any MW satellite thus far. I will also discuss the conclusions we can draw about the Clouds' orbits around the MW. When combined with HI data from the Magellanic Stream our measurements should provide new constraints on both the mass distribution of the Galactic halo and models of the Stream.

Support for this work was provided by NASA through grant numbers associated with projects GO-09462 and GO-10130 from the Space Telescope Science Institute (STScI), which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS5-26555.

199.05

Spectral Indices of Early Type Galaxies in Rich Clusters of Galaxies

Robert C. Berrington[1], M. Pierce[1], A. Monson[1]
[1]Univ. of Wyoming.

We present several velocity dispersions and Lick line index measurements for a large sample of early type galaxies within several nearby Abell clusters. The data is a result of the Wyoming Fundamental Plane survey (WyFPS) which contains ~1,500 galaxies within 32 Abell clusters for an average of ~45 galaxies per cluster are included in the WyFPS. The WyFPS includes all Abell clusters that satisfy the following selection criteria: richness class R $\geq$ 1, and redshift $z < 0.05$. All spectra were acquired by the multi-fiber spectrograph (Hydra) on the WIYN 3.5m telescope, and were obtained at a dispersion of 0.48 Å/pixel with typical signal-to-noise ratios ranging from ~ 100/pixel for the brighter galaxies to ~ 30/pixel for the fainter galaxies. We report the Hβ, Mg$_2$, Fe5270, and Fe5335 Lick indices for each of the galaxies in the survey, and use these measurements to investigate possible cluster-to-cluster variations and trends with galaxy velocity dispersion.

199.06

Gas Dynamics and Star Formation in the Barred Galaxy NGC 4303

Jin Koda[1]
[1]Caltech.

Despite numerous observational and theoretical studies, the nature of interstellar medium (ISM) gas dynamics remains uncertain. The dynamical response of the gas depends significantly on whether the ISM is a continuous hydrodynamic fluid or a set of discrete molecular clouds. The hydrodynamic fluid produces shocks along spiral arms or bars in galaxies, while the molecular clouds could ballistically pass the spiral/bar structures without encountering a shock. Such differences must change not only the dynamical response of the gas (e.g. shock, dissipation), but also the evolution timescale (e.g. gas inflow) and star formation. Continuous hydrodynamic models are often discussed to reproduce the narrow gas/dust lanes observed in barred galaxies; however, we demonstrate that an alternative scenario, cloud-based gas dynamics, also reproduces the narrow gas distribution and associated gas kinematics in bars. We compare the cloud-based gas dynamics model with CO observations of the barred galaxy NGC 4303 (M61). The cloud-based model better explains the distribution of young stellar clusters revealed in HST images as well as the observed velocity structure.

200: Supernovae Ia, Ib, Ic & II
AAS Oral, Tuesday, 2:00-3:30pm, 613-14

200.01

Type Ia Supernova Spectral Line Ratios as Luminosity Indicators: ″From Phenomenology to Radiative Transfer and Back Again″

Sebastien Bongard[1], E. Baron[2], G. Smadja[3], D. Branch[2], P. Hauschildt[4]
[1]Lawrence Berkeley Lab., [2]University of Oklahoma City, [3]Institut de Physique Nucleaire de Lyon, France, [4]Hamburger Sternwarte, Germany.

Type Ia supernovae have played a crucial role in the discovery of the dark energy, via the measurement of their light curves and the determination of the peak brightness via fitting templates to the observed lightcurve shape. Two spectroscopic indicators (RSi and RCa) are also known to be well correlated with peak luminosity. Since the spectroscopic luminosity indicators are obtained directly from observed spectra, they may emphasize different aspects on the intrinsic scatter and will have different systematic errors than do measurements using photometry. We present new variants of such spectroscopic indicators which are easy to automate and which minimize the effects of noise. Using the radiative transfer code PHOENIX, we isolate the main spectral contributions to the RSi wavelength region and propose an explanation for the counterintuitive correlation of this spectral indicator with luminosity. Based on these results we introduce RSiS, a new spectral indicator which correlation with luminosity is twice as good as RSi. Finally, we quantify the accuracy of the measure of SNeIa peak brightness with these indicators in the context of SNAP/JDEM.

200.02

Type Ia Supernova Model Light Curves And The Width-Luminosity Relation

Daniel Kasen[1]
[1]Johns Hopkins Univ..

Several large observational campaigns are now underway to collect light curves and spectra for a large sample of Type~Ia supernovae (SNe~Ia). The ultimate goal is to monitor and limit any intrinsic variations in SNe~Ia which could potentially bias our measurements of cosmological distances. Here I discuss a parallel theoretical effort to explore the diversity of SN~Ia explosions using numerical simulations. We have constructed a grid of ~130 parameterized models which span essentially the entire range of conceivable explosions a Chandrasekhar mass white dwarf. For each model we calculate the broadband light curves and full spectral time series. Within the resulting templates are models that provide good photometric and spectroscopic matches to essentially the entire range of observed SNe~Ia. However, in contrast to the observations, the models span a wide range in B-band peak luminosity and decline rates and do not obey a tight width-luminosity relation. The potential diversity of SNe~Ia light curves is therefore large. Apparently only a small subset of the theoretically conceivable explosions is realized in nature, placing tight constraints on the underlying explosion paradigm. Analysis of the model grid provides important insights into the physical origin of the SN~Ia width-luminosity relationship and the secondary parameters that lead to dispersion from it.

200.03

Numerical Simulations of Carbon Ignition in Type Ia Supernovae

Haitao Ma[1], S. Woosley[1], M. Kuhlen[2], M. Evonuk[1], G. Glatzmaier[1]
[1]UC, Santa Cruz, [2]Institute for Advanced Study.

When and how the type Ia supernovae ignite is a crucial parameter for the study of the following burning process, subsonic deflagration and maybe a later transition to supersonic detonation. Using 2D grid-based anelastic codes, we investigated numerically the convective flow property in the convective core of a Chandrasekhar mass white dwarf just one minute before it explodes to determine the location of ignition sparks and their distributions. We found the convective flow shows a clearly dipole feature, and the dipole axis flips around. First sparks take place around 100 km away from center. This work has been supported by the NSF (AST 02-06111), NASA (NAG5-12036), and the DOE Program for Scientific Discovery through Advanced Computing (SciDAC) under grant DEFC02-01ER41176.

200.04D

Varied Deaths of Massive Stars: Optical and NIR Properties of Type Ib/c Supernovae

Maryam Modjaz[1]
[1]Harvard Univ..

Supernovae of Type Ib/c are core-collapse supernovae whose massive progenitors have been stripped of their hydrogen and helium envelopes. While the Type Ic Supernovae (SN Ic) associated with long Gamma Ray Bursts (GRBs) have been studied, we do not know the full range of properties of normal or broad-lined SN Ic with which they should be compared. Nor do we fully understand the conditions that lead to each kind of explosion in a star with extensive mass loss. I will present a densely covered and homogeneous sample of optical and NIR data of SN Ib/c that doubles the world supply of well-observed events. The data begin as early as two weeks before maximum light and go to late times, when the supernovae enter the nebular phase. I discuss general properties of this population of stripped-envelope core-collapse supernovae, including their luminosity distribution, and photometric and spectroscopic relationships. Specifically, I will present data of SN 2005bf, a unique Type Ib SN, and of SN 2006aj, the most recent spectroscopically-confirmed SN associated with GRB060218. I will emphasize signs of asphericity seen even in normal SN Ib/c, their NIR properties and their host galaxy characteristics. In conjunction with the most recent literature, I will discuss their implications for the SN-GRB connection.

The CfA Supernova program is supported in part by the National Science Foundation through grant AST-0606772 to Harvard University.

200.05

VLT-FORS1 Spectropolarimetry of Core-Collapse Supernovae

Justyn R. Maund[1], L. Wang[2], F. Patat[3], P. Hoeflich[4], D. Baade[3], C. Wheeler[1]
[1]Univ. of Texas, Austin, [2]Texas A&M, [3]ESO, Germany, [4]Dept. of Physics, Florida State.

The technique of spectropolarimetry can be used to study the geometry of supernova explosions that cannot be spatially resolved. Asymmetries are thought to be inherent to the core-collapse supernova mechanism and, in particular, crucial for the link between supernovae and gamma-ray bursts.

We have employed the ESO VLT FORS1 instrument to obtain high signal-to-noise observations of core-collapse supernovae at different stages in their evolution. Here, we present a montage of multi-epoch spectropolarimetric observations of a sample of 14 core-collapse supernovae with a range of subtypes: Type II, Type IIb, Type Ib, and Type Ic. We emphasize the differences among these supernovae depending on the amount of hydrogen present in their spectra or lack thereof.

200.06

Lost and Found: Another Missed Type IIn SN, CG X-2

Franz E. Bauer[1], S. Smartt[2], W. N. Brandt[3], S. Immler[4]
[1]Columbia Univ., [2]Queen's University Belfast, Ireland, [3]Pennsylvania State University, [4]GSFC.

Circinus Galaxy (CG) X-2 is an ultraluminous X-ray source discovered by Chandra in 1999/2000 which exhibits many traits of a young, rapidly-evolving supernova (SN): >40x increase in X-ray flux between 1997-2000, a kT~10 keV thermal spectrum with emission line components, and spatial coincidence with a strong, variable Halphaand radio-emitting point source. We have recently confirmed it as late-time type IIn SN with the VLT. Only a few dozen young SNe have been been studied at X-ray wavelengths at all, and only a two of these are brighter at X-ray wavelengths than CG~X-2. We will present a best guess timeline for CG X-2 and outline what the wealth of optical/X-ray/radio archival observations can tell us about this rather enigmatic source.

201: Effective Mentoring of Women and Minority Students in Physics and Astronomy AAPT Invited, Tuesday, 2:00-3:30pm, 615

Chair

Timothy F. Slater[1]
[1]Univ. of Arizona.

201.01

Building Bridges to Diversity in Graduate Physics & Astronomy: The Fisk-Vanderbilt Masters-to-PhD Bridge Program

Keivan G. Stassun[1]
[1]Vanderbilt University and Fisk University.

We describe the Fisk-Vanderbilt Masters-to-PhD Bridge program as a successful model for effective partnerships with minority-serving institutions toward significantly broadening the participation of underrepresented groups in the physical sciences. The program couples targeted recruitment with active retention strategies, and is built upon a clearly defined structure that is flexible enough to address individual student needs while maintaining clearly communicated baseline standards for student performance. A key precept of the program's philosophy is to eliminate passivity in student mentoring; students are deliberately groomed to successfully transition into the PhD program through active involvement in research experiences with future PhD advisers, coursework that demonstrates competency in core PhD subject areas, and frequent interactions with joint mentoring committees. This approach allows student progress and performance to be monitored and evaluated in a more holistic manner than usually afforded by limited metrics such as standardized tests. Since its inception in 2004, the program has attracted a total of 18 underrepresented students, with a retention rate of 90%. Recent research indicates that minority students are nearly twice as likely as non-minority students to seek a Masters degree en route to the PhD. In essence, the Bridge program described here builds upon this increasingly important pathway, with a dedicated mentoring process designed to ensure that the Masters-to-PhD transition is a successful one.

201.02

A Novel Approach to Improving Diversity in Science: A Post-Baccalurate Research Year

Kartik Sheth[1]
[1]Caltech / Spitzer Science Center / IPAC.

After several decades of effort, the fraction of students from traditionally under-represented groups in science remains low. How can we change this? We describe a novel idea to target students who have completed baccalaurate degrees in mathematics and science from liberal arts, HBCs, and HLCs for a research year at a science center (e.g., Spitzer Science Center, GSFC) or University. We argue that these students represent a rich and untapped pool of talented scientists who, for a variety of reasons do not choose a career in science. The aim of this program is to mentor students through a one-year research project in which they will work on cutting-edge research, enhancing their curriculum vita and building their research network. The mentors too benefit in a variety of ways (e.g., multiplexing their research efforts). We describe pilot efforts at implementing such a program and the lessons learned so far.

201.03

Increasing Underrepresented Student Participation in Science Majors: The Pre-Major in Astronomy Program

Daryl Haggard[1]
[1]University of Washington.

The University of Washington's Pre-Major in Astronomy Program (Pre-MAP) is designed to increase the number of highly qualified students graduating with science, technology, engineering, and mathematics (STEM) degrees. Pre-MAP recruits underrepresented first-year students into a special seminar where the students learn research techniques and apply them to research projects conducted in small groups. Pre-MAP students also receive one-on-one mentoring from Pre-MAP graduate students, post-doctoral fellows, and faculty. The Pre-MAP seminar gives students skills that make them more attractive to U.W. faculty as research assistants, and also strengthens their candidacies as they apply for outside research programs (such as REUs) and later to graduate programs or for STEM jobs. Pre-MAP also provides an invaluable training experience for the graduate teaching assistant who leads the research seminar. This graduate student develops curricula, presents difficult concepts in the classroom, and trains students to conduct research, and thus will leave the U.W. with exceptional teaching skills and experience working with underrepresented students. By introducing undergraduate students to scientific research at the beginning of their college careers, and by providing them with academic advising and mentorship, Pre-MAP gives underrepresented students the tools and confidence they need to make the transition between entering college and declaring a STEM major.

Pre-MAP is made possible in part by a two-year grant from the University of Washington's Diversity Appraisal Implementation Fund.

202: Visualizing and Simulating the Cosmos with Computers AAPT Invited, Tuesday, 2:00-3:30pm, 616

Chair

Wolfgang Christian[1]
[1]Davidson College.

202.01

Discovering the Complexity of Supernovae through Three-Dimensional Simulations

John M. Blondin[1]
[1]North Carolina State University.

Computational physics has played a key role in our understanding of core-collapse supernovae, beginning with the seminal work of Colgate and White in 1966. There is a growing body of evidence that these supernova explosions are inherently asymmetric, and today's computing platforms provide sufficient power to begin to study the origin of this asymmetry using multidimensional simulations. We will show how the jump to full three-dimensional simulations has revealed new insights to this age-old problem of how a massive star explodes, as well as providing more realistic models of the expanding relic blastwave. Unexpected results from these multidimensional simulations include the spinning up of pulsars via shocked accretion flow and the formation of 'jets' in otherwise spherical explosions.

202.02

Scientific Computation and Astrophysical Gas Dynamics

James M. Stone[1]
[1]*Princeton University.*

The ever increasing performance of computer hardware and improvements to the accuracy of numerical algorithms are revolutionizing scientific research in many disciplines, but perhaps none more so than astrophysics. I will begin by describing why computation is crucial for the solution of a variety of problems at the forefront of research in astronomy and astrophysics, with particular emphasis on understanding accretion flows onto black holes. I will outline the challenge of developing, testing, and implementing numerical algorithms for the investigation of these problems. Finally, I will describe efforts to introduce scientific computation into the graduate and undergradaute curriculum in astrophysics in order to better prepare students with the tools they will need for scientific research in the future.

202.03

Computational Astrophysics reaches its Third Age: From Star Formation to the Death of the Sun.

Adam Frank[1]
[1]*University of Rochester.*

The use of simulations in astrophysics has progressed to the point where computational datasets can be as rich as those obtained from observations. In this sense the field has reached maturity or its "third age". In this talk I will review progress in the use of simulations as a tool for astronomical research. The talk will include the basic elements of numerical simulations as well as advances in algorithms which have led to recent dramatic progress.

The scientific focus will be hydrodynamic and magneto-hydrodynamic simulations of star formation and the death of solar-type stars. We will explore the most recent models of collimated outflows (jets) from young stars and their interaction with natal environments. The source of these outflows are magnetized disks surrounding the stars. Models of this process have also reached new levels of realism. At the other end of a star's lifetime we also find outflows to be ubiquitous phenomena. Here magnetic fields are again a principle actor creating collimated jets though in this case binary companions may be critical. In all cases the physics involved is too non-linear to investigate solely with analytic methods. Direct simulation must be used to fill out the story. Finally we introduce the field of High Energy Density Laboratory Astrophysics where fusion devices are used to create astrophysically relevant laboratory experiments. Simulations play a key role in the design and analysis of these studies as well.

203: Panel on Choosing a Keypad System
AAPT Panel, Tuesday, 2:00-3:30pm, 303

Chair

Ray Burnstein[1]
[1]*Illinois Institute of Technology.*

Chair

Leon M. Lederman[1]
[1]*Illinois Institute of Technology.*

204: University Supervisors and Cooperating Teachers: Their Critical Roles for Student Teaching
AAPT Special, Tuesday, 2:00-3:40pm, 310

Chair

Stamatis Vokos[1]
[1]*Seattle Pacific University.*

204.01

Field Experiences for Prospective Physics Teachers*

Ingrid Novodvorsky[1]
[1]*University of Arizona.*

In the College of Science Teacher Preparation Program at the University of Arizona, physics teachers in our community play a key role in the preparation of their successors. We have recruited exemplary physics teachers to serve as mentor teachers for field experiences, and our University Supervisors are all secondary teachers with significant classroom experience. In addition, all of the evaluation materials used for field experiences are aligned with our program philosophy, which emphasizes teaching for understanding. In this talk, I will describe how we have involved physics teachers in all aspects of the program, share some of our evaluation documents, and provide suggestions on how other institutions can provide a more cohesive approach to physics teacher preparation.

*Work partially supported by NSF Grant PHY-0108787.

204.02

Essential Support Systems for Emerging Physics Teachers

Sally Luttrell-Montes[1]
[1]*University of Washington.*

The University of Washington is one of eleven sites across the country participating in a Carnegie-funded project called *Teachers for a New Era,* which has a focus on renewing teacher preparation--from the undergraduate phase through the first five years of a teacher's career. What happens at the preservice phase, especially during student teaching, is critical in laying the foundation for successful classroom teaching during the early career years. For the emerging physics teacher, having a cooperating teacher and university supervisor who have deep content/pedagogical knowledge within the discipline is ideal but providing specific supports and appropriate feedback are also necessary. During this talk, we will explore the value of a teacher continuum for emerging physics teachers and the kinds of experiences, structures, and feedback mechanisms the UW Teacher Education Program provides through the cooperating teachers and university supervisors to encourage alignment to reformed physics curriculum--using face-to-face interactions, dilemma-based protocols, documentation, and new possibilities for online support systems.

204.03

Teachers in Residence: University Supervisors, Cooperating Teachers, and In-Service Mentors

Michael D. Wolter, Mr.[1]
[1]*Muncie Central HS.*

The Physics Teacher Education Coalition (PHYSTEC) has provided Teachers in Residence (TIR) an opportunity to interact with pre-service and in-service teachers in roles ranging from University Supervisors, to Cooperating Teachers, and even to state certified mentors for in-service teachers.

At Ball State University a structured ″decision point″ process has been implemented to track pre-service teacher preparation from freshman orientation through graduation.

This presentation will describe how the Teacher in Residence experience has impacted the supervisory and supporting roles in pre-service teacher preparation. In addition, recommendations will be highlighted describing the need for ″university″ support and mentoring to continue beyond pre-service teacher preparation and graduation to roles not traditionally covered by professional development workshops, university courses, or physics department open houses.

204.04

A Student Teacher Effectiveness Review System

Carl J. Wenning[1]
[1]Illinois State University.

Student learning is one measure of the efficacy of a student teacher. The current NCATE/NSTA accreditation process for teacher education programs calls for student teachers to demonstrate efficacy in different areas of instruction. In response to this call for performance-based assessments, the secondary science teaching sequences at Illinois State University have developed a Student Teacher Effectiveness Review System. The system consists of seven lesson types with corresponding assignments that cumulatively validate the impact on science learning during the student teaching practicum. Both university supervisors and cooperating teachers in inextricably involved in the success of these lessons and their associated assessments.

205: Implementing Reform Instruction
AAPT Oral, Tuesday, 2:00-3:30pm, 307-08

Chair

Ann Brandon[1]
[1]Joliet West HS.

205.01

Promoting Instructional Change: Beyond an Emphasis Curriculum

Charles Henderson[1], M. H. Dancy[2], A. Beach[1]
[1]Western Michigan University, [2]University of North Carolina at Charlotte.

For the last few decades science education researchers have focused on developing curricular materials and strategies for use at the college level. This strong emphasis on curriculum appears to be based on the implicit assumption that once these materials and strategies become available they will be put into widespread use. We argue that curriculum is only one aspect of educational change. In this talk we describe three aspects of educational change curriculum, teachers, and structures and argue that all three are necessary in order for widespread and lasting change to occur. Examples from our research will be used to illustrate the necessity of expanding the emphasis beyond curriculum. We will also discuss recent efforts by others to move in this direction.

205.02

Replicating Reforms in a Large-scale Lecture Environment

Noah Finkelstein[1], S. Pollock[1]
[1]University of Colorado at Boulder.

We present a longitudinal study of the implementation of a series of reforms in the large-scale, calculus based introductory physics sequence at University of Colorado. As part of the Colorado Physics Teacher Education Coalition and an NSF CCLI grant, we have implemented Tutorials in Introductory Physics, Peer Instruction, personalized computerized homework sets, and in-class personal response systems[1]. While we have demonstrated that these combined efforts result in significant improvement in student learning gains [1], we turn our attention to what it means to hand off these course transformation to faculty who have historically focussed on more traditional methods (e.g. those who are not members of AAPT). We present empirical data on the success and fidelity of implementation of the reforms, and identify two key factors in the overall program success: 1) Colorado's Learning Assistant program [2] which enables these course transformation, while simultaneously increasing the pool of talented physics teachers and explicitly valuing teaching and education within physics, and 2) explicit efforts to support faculty change as they adopt new educational tools and practices.

[1] N.D. Finkelstein and S.J. Pollock, (2005). Replicating and Understanding Successful Innovations: Implementing Tutorials in Introductory Physics. Physical Review, Special Topics: Physics Education Research.1,1, 010101.

[2] V. Otero, N.D. Finkelstein, S.J. Pollock and R. McCray, (2006). Who is Responsible for Preparing Science Teachers, Science, 313, 445.

205.03

Implementation and Results of a Learning Assistant Program

Thomas B. Bogue[1], L. Seeley[1], S. Vokos[1]
[1]Seattle Pacific University.

The Physics Department at Seattle Pacific University has recently completed a three-year CCLI grant to integrate Tutorials in Introductory Physics , Activity Based Physics , and Real Time Physics into our one-year introductory curriculum. One of the difficulties encountered in doing this at a small undergraduate university was the need for additional instructors. This need is met through the use of undergraduate learning assistants. The development of recruitment and implementation methods will be discussed, along with the advantages to physics education, and the challenges encountered. We will also discuss several strategies we have identified as critical to a successful learning assistant program.

205.04

Understanding Graduate Teaching Assistants as Tutorial Instructors

Rachel E. Scherr[1], A. Elby[1]
[1]University of Maryland.

Physics graduate teaching assistants are essential to the implementation of many collaborative active-learning environments, including tutorials. However, many TAs have trouble teaching effectively in these formats. Anecdotal evidence suggests that the problems may include inappropriate models of physics students, unproductive theories of learning, lack of experience with modern pedagogical methods, and weaknesses in understanding basic physics topics. A new research project at the University of Maryland is investigating the specific nature of TAs' experience with reform instruction using in-depth studies of TAs in course preparation sessions, in the tutorial classroom, in a weekly teaching seminar, and in reflective interviews. We find that all TAs studied recognize the insufficiency of traditional instruction to at least some extent, citing as evidence their own learning experiences, prior teaching experiences, and exposure to FCI-type data. We also observe great variability in views of the nature of physics knowledge and learning (both professed and enacted). These results are informing the development of the professional development program for physics teaching assistants at the University of Maryland.

205.05

Graduate TAs as Tutorial Instructors: A Case Study

Renee Michelle Goertzen[1], R. E. Scherr[1], A. Elby[1]
[1]University of Maryland.

A new research project at the University of Maryland is investigating the specific nature of TAs' experience with reform instruction. The study combines data from many sources to create detailed case studies of individual TAs as they develop into experienced tutorial instructors. For example, we may observe an individual TA as he works through a specific tutorial in preparation for his teaching that week; serves as a tutorial instructor, perhaps multiple times in the course of one week; reflects on his teaching experience in a weekly teaching seminar; gives feedback to the course professor in the following week's course preparation session; and responds to a course evaluator who inquires about his impressions of the course's success and his own plans for future teaching. We will outline one such case study, illustrating some issues that individual TAs face in tutorial teaching and the processes by which their beliefs and practices are changed or reinforced.

205.06

Teaching AP Physics with the Activity Based Physics CD

Maxine C. Willis[1]
[1]Dickinson College.

The **Activity Based Physics High School CD** distributed by Pasco scientific and Vernier Software contains selections from **Interactive Lecture Demonstrations, RealTime Physics, Workshop Physics** and additional materials created by the *Activity Based Physics Group*. The AP Physics College Board committee chose **Workshop Physics** as an exemplary college physics course to use as a model for a high school AP Physics Course. I will describe an AP Physics course that combines materials from Workshop Physics and other activity-based curricula included with HS CD. In addition several video analysis and computer centered data acquisition activities will be described.

205.07

Adventures in Studio Physics

Sarah D. Johnson[1], N. Alberding[1]
[1]Simon Fraser University, Canada.

In the Fall of 2005 we began offering a calculus-based first-year, two-course introductory physics sequence using the studio format, based on Workshop Physics[1] by P. Laws *etal*. We will recount our experiences in introducing a workshop-based physics course at a large Canadian university from the initial push to the final implementation. In particular, we will discuss the details of our curriculum and what modifications were made to align our Studio Physics I&II courses with the currently existing lecture courses. This involved, among other things, adapting some of our first-year physics laboratory experiments in optics and electricity and magnetism to the workshop format. We will also discuss the myriad of obstacles that were encountered along the way. The results of before-and-after FCI testing for the first two offerings of Studio Physics I will also be presented along with student feedback from course evaluations. And finally, we will elaborate on our plans for the future.

[1] Priscilla Laws, ″Workshop Physics: Reflections on Six Years of Laboratory Based Introductory Physics Teachings,″ Proceedings of the American Association of Physics Teachers Conference: Lab Focus '93, August 1993

205.08

Tracking and Analyzing Student Writing in Physics by Inquiry

Dedra Demaree[1], G. Aubrecht[2], L. Bao[2], W. Zhao[2]
[1]College of the Holy Cross, [2]The Ohio State University.

The Ohio State University Physics Education Research Group (OSU PERG) developed a novel word tracking program for analyzing student writing. In an ongoing study of writing to learn, this tracking program was used during Spring Quarter 2006 to characterize patterns in student writing and to look for correlations between student writing behaviors and course grades in Physics by Inquiry at OSU. In addition, we look to see if writing behavior changes with practice. The overall aim is to see if we can quantify student writing behaviors, determine if the practice of writing in physics classes impacts student writing, and if any writing behaviors are correlated with content understanding. Although we find interesting patterns in student behaviors and some suggestive results, overall there are few consistent behaviors or correlations in the data. In addition there is no indication that practice in writing impacted student behaviors.

205.09

Student Evaluation Differences between Diffrent Physics by Inquiry Courses

Gordon J. Aubrecht, II[1]
[1]Ohio State University at Marion.

The setting of Physics by Inquiry (PbI) classes is the laboratory. Students do experiments as suggested by the text as well as doing their own experiments to test predictions they have made about nature's behavior. This is guided inquiry, and students assessments of PbI classes reflect important aspects of inquiry, while not supporting others. We report here on results from different versions of Physics by Inquiry courses (properties of matter, electric circuits, and astronomy by sight and optics) using the Laboratory Program Variables Inventory (LPVI), a Q-sort instrument.

206: Stardust Mission
Plenary, Tuesday, 3:40-4:30pm, Ballroom 6

206.01

The Return of Stardust

Andrew J. Westphal[1]
[1]UC, Berkeley.

In January 2006, the Stardust capsule landed in the Dugway Proving Grounds in Utah carrying, in aerogel tiles and in aluminum foils, the first bona fide samples from the Kuiper Belt, and the first samples of dust from the local Interstellar Medium. This is the first solid sample return mission since the 1970's, and the first ever from beyond the Moon. Here I summarize the results of the Preliminary Examination of the cometary sample -a massive effort involving more than 200 scientists from around the world. In many ways, the Stardust extraterrestrial samples are the most technically challenging that we have ever faced. I will describe some techniques that have been developed for preparing these challenging samples for analysis. I will also give an update on the search for contemporary interstellar dust in the interstellar dust collector, using $>$15,000 highly sophisticated image processors -human eyes and brains.

207: Richtmyer Memorial Lecture
Plenary, Tuesday, 4:40-5:30pm, Ballroom 6

Chair

Richard Peterson[1]
[1]Bethel Univ..

207.01

Evidence from Type Ia Supernovae for an Accelerating Universe and Dark Energy

Alexei V. Filippenko[1]
[1]University of California, Berkeley.

The measured luminosity distances of hydrogen-deficient Type Ia (white-dwarf) supernovae as a function of redshift (z) have shown that the expansion of the Universe is currently accelerating, probably due to the presence of "dark energy" (X) having a negative pressure, such as Einstein's infamous cosmological constant (Λ). Combining all of the data with existing results from large-scale structure surveys, we find a best fit for Ω_{M} and Ω_{X} of 0.28 and 0.72 (respectively), in excellent agreement with the values derived independently from WMAP measurements of the characteristic angular scale of fluctuations in the cosmic microwave background radiation. A number of possible systematic effects (e.g., dust, supernova evolution) thus far do not seem to eliminate the need for $\Omega_X > 0$. Recently, analyses of supernovae at $z = 1.0$-1.7 reveal an early epoch of deceleration ending at $z \approx 0.5$, followed by acceleration as dark energy began to dominate over dark matter. Several research groups are now in the process of measuring hundreds of Type Ia supernovae in the range $z = 0.2$-0.8 to determine the equation-of-state parameter of the dark energy, $w_X = P/(\rho c^2)$, where P is the pressure and ρ is the energy density. Thus far, the best-fit value is $w_X = -1$, and dw/dz is consistent with 0, suggesting that the dark energy may indeed be the cosmological constant Λ or something quite similar. The true nature of the dark energy is one of the major unsolved problems in fundamental physics, with far-reaching implications beyond the standard model.

208: Rossi Prize Lecture
Plenary, Wednesday, 8:30-9:20am, Ballroom 6

208.01

Spin and Magnetic Evolution of Millisecond Pulsars in X-Ray Binaries

Deepto Chakrabarty[1]
[1]*MIT.*

Accretion-powered and nuclear-powered millisecond pulsars are old neutron stars which have been spun up to rapid rotation by magnetic accretion torque. They are among the most rapidly rotating stars known, with surface velocities of order 0.1c. However, the spin frequency distribution of these systems, as observed by the Rossi X-Ray Timing Explorer (RXTE), cuts off sharply above 700 Hz, well below the presumed centrifugal break-up limit. The radio millisecond pulsar population appears to exhibit a similar cutoff. A variety of braking mechanisms might contribute to this cutoff, including magnetic accretion torques, magnetic dipole radiation, and gravitational radiation from the rapidly rotating neutron star. I will briefly describe the ongoing effort to understand the millisecond pulsar spin distribution.

208.02

Burst Oscillations: A New Spin on Neutron Stars

Tod E. Strohmayer[1]
[1]*NASA's GSFC.*

Observations with NASA's Rossi X-ray Timing Explorer (RXTE) have shown that the X-ray flux during thermonuclear X-ray bursts from accreting neutron stars is often strongly pulsed at frequencies as high as 620 Hz. We now know that these oscillations are produced by spin modulation of the thermonuclear flux from the neutron star surface. In addition to revealing the spin frequency, they provide new ways to probe the properties and physics of accreting neutron stars. I will briefly review our current observational and theoretical understanding of these oscillations and discuss what they are telling us about neutron stars.

208.03

Accreting Millisecond Pulsars An Overview of Recent Developments

Rudy Wijnands[1]
[1]*University of Amsterdam, The Netherlands.*

It has been nearly nine years since the first accreting millisecond pulsar was discovered. Since then six additional systems have been found. I will present a brief historical overview about the discovery and properties of these seven systems. In addition, I will discuss the most important recent developments in our understanding of these systems and their relationship with the non-pulsating accreting neutron stars. The accreting millisecond pulsars have played a crucial role in increasing our understanding of the kilohertz quasi-periodic oscillations and burst oscillations seen in the X-ray flux in the non-pulsating systems.

209: Poster Session IV
AAPT Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

209.01

Reasoning Ability and Epistemological Attitudes as Predictors of Success

Elizabeth B. Etters[1], O. Tfeily[1], M. Dancy[1]
[1]*UNC-Charlotte.*

We report on a two part study designed to understand why some students struggle in the introductory course. We first collected numerical data on students' reasoning skills (Lawson Test), math skills, attitudes (CLASS Test), and various other personal attributes such as time spent studying or hours working on a job. Math skill, reasoning skill and some attitude measures were correlated with course performance. The following semester we identified and interviewed students on the extremes of these significant measures in order to better understand how and why the significant factors relate to course performance.

209.02

Optical Limiting in Solid-Core Holey Fibers

Stacey R. Sueoka, Ms.[1], J. Butler[1], S. Montgomery[2], J. Shirk[3], S. Flom[3], R. Pong[3], B. Wright[3], T. Tauney[3], A. Rosenberg[3], C. Menyuk[4], J. Hu[4]
[1]*Pacific University,* [2]*United States Naval Academy,* [3]*Naval Research Lab,* [4]*University of Maryland.*

High intensity lasers play a major role in our current technical society. Military and telecommunication systems are prone to critical damage from powerful lasers, therefore it is imperative to find ways to provide protection from these lasers. Optical limiters are devices that reduce transmission of high intensity light and can be used to protect these systems. Our goal is to develop optical limiters that are compatible with current fiber optic devices.

This work focused on the optical properties of solid-core holey fibers where the fiber holes were filled with a solution that exhibited a strong nonlinear absorption. We observed optical limiting at visible wavelengths due to the interaction of the nonlinear absorber with the evanescent tails of the propagating mode. Experimental results were compared to theoretical calculations of the modal profiles of the holey fiber. Dr. Stephen Hall is the AAPT sponsor for this presentation.

209.03

Is Fresnel Diffraction a Unified Diffraction Model ?

Mark P. Neyer[1], H. Schmitzer[1]
[1]*Xavier University.*

Physicists use three different models to predict the diffraction pattern resulting when an aperture is placed between a light and a screen: Geometrical Optics when the distance between the screen and the aperture is small, Fraunhofer Diffraction when the distance is large, and Fresnel Diffraction in between these two regimes. We construct computer simulations of aperture experiments to see if the Fresnel Diffraction model can be used to accurately describe the diffraction pattern in all three cases.

Sponsored by Heidrun Schmitzer.

209.04

Repeatability and Precision of Laser Diffraction Measurements of Small Objects

Scott C. Dudley[1], R. Mudry[1]
[1]*USAF Academy.*

In this poster we'll present results of using diffraction measurements to infer the size of small objects such as the diameter of a human hair. We'll compare the diffraction results with visual measurements through a microscope, and we'll discuss repeatability of the diffraction measurements across semesters, which can enable the use of hair samples as an unknown in a diffraction laboratory. Finally, we'll show that there are large variations in the diameter of human hair even from a single spot of an individual's head.

209.05

Applying Archimedes' Law to Ice Melting in Sea Water

Peter D. Noerdlinger[1], K. R. Brower[2]
[1]St Mary's University, Halifax, NS Canada, [2]New Mexico Institute of Technology.

Archimedes stated that a floating body displaces its own *weight* of liquid, but his law has been widely misapplied to ice floating in the oceans by scientists who assumed that equal *weights* correspond to equal liquid *volumes*. It is often said that when floating ice melts, the sea level does not rise ″because of Archimedes' law.″ True when ice floats in fresh water, but a myth for ice in oceans! Most ice floating in the oceans is nearly pure water. When it melts, the pure water produced has about 2.6% more volume than the salt water that was displaced, and the ocean slightly rises. It is often suggested that students demonstrate the ″fact″ of no rise in the sea surface by melting ice cubes floating in a glass of water; such a demonstration even appears in the movie ″An Inconvenient Truth.″ Let's teach students to spot such errors.

We highlight a couple more ″surprise issues.″ First, the density of the floating ice, if it is free of salt and dirt, is irrelevant, so long as it floats. Next, when ″grounded″ ice (resting on land), enters the sea, it initially displaces less water than its melted form will eventually add to the sea. Thus, an event of that kind, such as formation of an iceberg, produces a rise of the sea level in two stages.

We conclude with a series of thought-experiments that could help teachers and students discern the correct result, and a photo of a demonstration.

209.06

Spherical Rare Earth Magnets And The Dipole-Dipole Interaction

Al J. Adams[1]
[1]University Arkansas Little Rock.

Spherical rare earth magnets (SREMs) are useful for teaching fundamental concepts in introductory physics. These applications include kinematics, force and motion, energy, momentum, and their conservation, as well as the traditional areas of basic magnetism, the magnetic field of the earth, and magnetic interactions. One application for upper level undergraduate physics majors is the dipole-dipole interaction. Previous studies have confirmed the validity of the dipole approximation for SREMs. Their spherical shape allows them to combine in ways that readily demonstrate local minima in the potential energy interaction function for multiple dipoles. The potential energy function for the dipole-dipole interaction will be given and will be shown to predict several of the basic stable configurations for 2 and 3 SREM spheres. The relative stability of several of these local potential energy minima will be discussed and the results of tests for their reliability in predicting preferred configurations presented. The use of commercial mathematical analysis software for modeling the dipole-dipole interaction will also be demonstrated.

209.07

The Effects of Magnetic Fields on Cooling Fans

Raphael G. Cherney[1]
[1]Brownell-Talbot School.

It was observed that power supplies failed during large physics experiments around magnetic fields. These failures may be due, in part, to the effects of magnetic fields on the cooling fans. A solenoid was built to replicate the environment. Multiple cooling fans were tested, and measurements were taken on the size of the current drawn by the fan and the speed of the rotation of the motors. The study found two problems: induced currents and the Hall Effect. The largest factor was observed to be the orientation of the fan with respect to the magnetic field.

209.08

Using SAT scores to identify students at risk in introductory physics

Vincent P. Coletta[1], J. Phillips[1]
[1]Loyola Marymount University.

Our previous research has shown a strong correlation between individual students' pre-instruction scores on Lawson's Test of Reasoning Ability and their normalized gains on the FCI. These results have been replicated by researchers at Edward Little High School in Maine, at the University of Colorado, and at the University of Central Florida. We now find that SAT scores also provide a strong correlation with FCI gains. The advantage of using SAT scores is that one does not have to administer another test; these scores are usually readily available through the registrar's office.

209.09

A Methodology for Developing Diagnostic Concept Inventories

Rebecca Lindell[1]
[1]Southern Illinois University Edwardsville.

Since the development of the Force Concept Inventory, there as been a heightened interest in developing other concept inventories that not only assess if students understand a phenomena, but also diagnose specific alternative understandings. Unfortunately, there is no clear-cut methodology on how to construct such inventories. One of the difficulties is that only some parts of test development theory are appropriate for such concept inventories. This is due to the concept inventories being distracter driven, where test-takers do not randomly choose an incorrect answer. In this poster, I will present a methodology for developing diagnostic concept inventories, which combines traditional psychometric theory with modern theories of concentration and model analysis. An example of how this methodology was utilized to develop the successful Lunar Phases Concept Inventory (LPCI) will also be given.

209.10

A Classification Scheme for Categorizing Different Concept Inventories

Rebecca Lindell[1], T. Foster[1]
[1]Southern Illinois University Edwardsville.

Since the development of the Force Concept Inventory (FCI), there as been a heightened interest in developing using concept inventories to assess students understanding of a phenomena. As more and more of these instruments are created, it must be made self-evident to test users that not all tests are created equal. We claim that there are four non-overlapping types of concept inventories and that the Science education research communities have an obligation, through peer review, to label any concept inventory as one of these four types of tests: (1) Local Tests, (2) Concept Surveys (3) Efficacy Concept Inventories, and (3) Diagnostic Concept Instruments. We propose these distinctions based on differences in their development methodology. In this poster, we will present evidence for this new classification scheme, as well as provide an analysis of three common tests from Physics Education Research: FCI, FMCE and CSEM.

209.11

Student Perceptions of Science Ability, Experiences, Expectations, and Career Choices

Michael Cherney[1], I. Cherney[1]
[1]Creighton University.

The decision to study physics or astronomy is affected by many factors, including preferences, motivations, and expectations for success. Differing cognitive profiles contribute to the learning of science through a complex process in which intrinsic capacities are tuned both by everyday experience and by instruction. In an attempt to identify the developmental pathways and intrinsic factors that most strongly influence the choice to study science, we administered an extensive survey to a sample of 400 students. The survey questions were based on Eccles et al.'s model of achievement-related choices and findings showing that previous play experiences, spatial experiences, task beliefs, as well as perceived mathematics ability, motivational and personality characteristics affect mathematics achievement and science career choices. The perceptions of students planning a science career are compared with those planning a career in other areas. Gender differences are also discussed.

209.12

"Is Entropy conserved?" Student Understanding of Entropy in Introductory Physics

Warren M. Christensen[1], D. E. Meltzer[2]
[1]Iowa State University, [2]University of Washington.

As part of our continuing investigation into student learning of thermal physics in an introductory calculus-based course, we are probing student ideas regarding entropy and the second law of thermodynamics. We will present free-response and multiple-choice data collected both preand post-instruction from the previous five semesters. These data suggest that many key concepts are challenging for students. For example, as many as 75% of students, both before and after instruction, incorrectly claim that the total entropy of a system plus its surroundings must stay the same during a spontaneous process. Many of these students base their claim by asserting some sort of conservation principle for entropy. Early indications are that use of modified instruction with research-based materials may have yielded significant learning gains with some of these concepts. However, many student ideas remain resistant to change despite the modified instruction.

*Supported in part by NSF DUE-9981140, PHY-0406724, and PHY-0604703

209.13

Sensemaking: Conceptualizing and Coding for "Good" Student Reasoning

Andrew Elby[1], R. Scherr[1], T. Bing[1]
[1]University of Maryland.

Physics instructors' goals often go beyond improving students' conceptual understanding and problem solving. Instructors also want students to engage in inquiry, become scientific/critical thinkers, understand the scientific process, and so on. We see two problems with these "non-content" goals. First, notions such as inquiry and scientific thinking are often defined vaguely or inconsistently across the literature. Second, even when like-minded instructors share a vision of what we'd love to see our students do, descriptions of that vision are often too squishy to communicate, debate, or assess: "We know it when we see it!" In this talk and poster, we address these problems by introducing *sensemaking* vs. *answermaking*, two mindsets with which students can approach physics. Our definitions of those notions benefit from a theoretical base, and our coding scheme for sensemaking vs. answermaking displays high interrater reliability and rests upon a list of specific indicators.

209.14

Modeling Student Thinking about Motion in Tutorial

Brian W. Frank[1], R. E. Scherr[1]
[1]University of Maryland.

In an ongoing study, we are analyzing students' conceptual resources for understanding motion. Previous work used results of surveys, written questions, and interviews to infer the nature of students' ideas. Video of students working together in tutorial groups now allows us to access the details of their reasoning as they express themselves to their peers. We present examples of students in the algebra-based introductory physics course at the University of Maryland analyzing segments of ticker tape to develop an understanding of constant, instantaneous, and average speeds. The most commonly observed resources involve direct and indirect relationships among speed, distance, and time. Various constructions of ideas built from these resources led to both correct and incorrect accounts of the physical phenomena. We characterize the nature of these various constructions based on a model of student thinking as arising from the activation of conceptual resources, analyze shifts in student reasoning, and discuss the strengths and weaknesses of the resources model in accounting for student performance.

209.15

Keeping a Good Things Going: What does sustaining reforms in physics mean?

Noah D. Finkelstein[1], S. Pollock[1]
[1]University of Colorado at Boulder.

As a result of decades of work in the physics education research (PER), the physics community has successfully demonstrated programs that significantly improve student understanding. At the same time there is less of an understanding of what it means to replicate and sustain these reforms. This poster examines what it means to replicate proven reforms and to develop models for sustainable implementation of educational reforms in physics. As part of the Colorado Physics Teacher Education Coalition and an NSF CCLI grant, we have implemented a number of PER-based reforms in our introductory sequence [1]. We introduce some of these programs, present empirical data on the success and fidelity of implementation of the reforms, and develop theoretical frames for analyzing these data. Two key factors in the program success are: 1) Colorado's Learning Assistant program [2] which enables these course transformation, while simultaneously increasing the pool of talented physics teachers and explicitly valuing teaching and education within physics, and 2) supporting faculty change to adopt and support these new educational tools and practices.

[1] N.D. Finkelstein and S.J. Pollock, (2005). Replicating and Understanding Successful Innovations: Implementing Tutorials in Introductory Physics. Physical Review, Special Topics: Physics Education Research.1,1, 010101.

[2] V. Otero, N.D. Finkelstein, S.J. Pollock and R. McCray, (2006). Who is Responsible for Preparing Science Teachers, Science, 313, 445.

209.16

Graduate TAs as Tutorial Instructors: A Case Study

Renee Michelle Goertzen[1], R. E. Scherr[1], A. Elby[1]
[1]University of Maryland.

A new research project at the University of Maryland is investigating the specific nature of TAs' experience with reform instruction. The study combines data from many sources to create detailed case studies of individual TAs as they develop into experienced tutorial instructors. For example, we may observe an individual TA as he works through a specific tutorial in preparation for his teaching that week; serves as a tutorial instructor, perhaps multiple times in the course of one week; reflects on his teaching experience in a weekly teaching seminar; gives feedback to the course professor in the following week's course preparation session; and responds to a course evaluator who inquires about his impressions of the course's success and his own plans for future teaching. We will outline one such case study, illustrating some issues that individual TAs face in tutorial teaching and the processes by which their beliefs and practices are changed or reinforced.

209.17

The Epistemological Development of Physics Majors

Elizabeth Gire[1], E. Price[2], B. Jones[1]
[1]University of California, San Diego, [2]California State University, San Marcos.

Epistemological beliefs influence how students study physics and how they solve physics problems. In this study, we use the Colorado Learning Attitudes about Science Survey to probe students' beliefs at different stages of an undergraduate physics degree program. We examine the extent to which epistemological beliefs differ at these stages and identify factors that may influence epistemological stance. Differences in specific beliefs, as well as overall sophistication, are reported. We also comment on trends seen in the reported strengths of beliefs. The survey data are supported by interviews with individual students. We find that beginning physics majors are significantly more sophisticated than non-majors in introductory physics courses and that this high level of sophistication is consistent for most of undergraduate study. We conclude that the expert-like views assessed by CLASS are, to a significant extent, an inherent, preexisting characteristic of students who choose to be physics majors, rather than a characteristic that is learned or acquired during the degree program.

209.18

Concepts Retention and Its Dependence on the Type of Instruction

Hugo Alarcon[1], J. J. Velarde-Magana[2], G. Zavala[1]
[1]TecnolÃ³gico de Monterrey, Mexico, [2]Tecnologico de Monterrey, Mexico.

PER community uses to apply validated tests before and after instruction in order to assess learning of some physics concepts. The Hake's gain coefficient obtained from these tests and the concentration factor of incorrect models form a useful couple of methods that permit to assess the instruction (1). These methods should be also useful in the study of retention of concepts. In our institution, studied concepts are evaluated at least twice a semester: after instruction by giving a middle term test, and at the end of the course with an integral examination. In this work we applied these methods to assess an introductory module of a remedial course designed for engineering students in order to evaluate the retention of concepts of the course. We verified that there are some concepts and skills which are strengthened since an important gain coefficient was obtained, while others are forgotten or unlearned. We also investigated the way that this variation depends on the type of instruction.

(1) H. Alarcón and G. Zavala, Announcer **35**, 65-66 (2006).

209.19

Group Problem Solving as a Zone of Proximal Development activity

Eric Brewe[1]
[1]Hawaii Pacific University.

Vygotsky described learning as a process, intertwined with development, which is strongly influenced by social interactions with others that are at differing developmental stages.[i] These interactions create a *Zone of Proximal Development* for each member of the interaction. Vygotsky's notion of social constructivism is not only a theory of learning, but also of development. While teaching introductory physics in an interactive format, I have found manifestations of Vygotsky's theory in my classroom. The source of evidence is a paired problem solution. A standard mechanics problem was solved by students in two classes as a homework assignment. Students handed in the homework and then solved the same problem in small groups. The solutions to both the group and individual problem were assessed by multiple reviewers. In many cases the group score was the same as the highest individual score in the group, but in some cases, the group score was higher than any individual score. For this poster, I will analyze the individual and group scores and focus on three groups solutions and video that provide evidence of learning through membership in a Zone of Proximal Development.

Endnotes

[i] L. Vygotsky -*Mind and society: The development of higher mental processes*. Cambridge, MA: Harvard University Press. (1978).

209.20

Student Estimates of Probability and Uncertainty in Statistical Physics

Donald B. Mountcastle[1], B. R. Bucy[1], J. R. Thompson[1]
[1]University of Maine.

Equilibrium properties of macroscopic (large N) systems are highly predictable as N approaches and exceeds Avogadro's number. Theories of statistical physics depend on these results. Typical pedagogical devices used in statistical physics textbooks to introduce entropy (S) and multiplicity [$S = k \ln(w)$, where w is the system multiplicity] include flipping coins and/or other equivalent binary events, repeated n times. Prior to instruction, our students usually give reasonable answers about the probabilities, *but not the uncertainties* of the predicted outcomes of such events. However, they reliably predict that the uncertainty in a measured quantity (e.g., the *amount* of rainfall) decreases as the number of measurements increases. Typical textbook presentations presume that students will either have or develop the insight that the relative uncertainty of binary outcomes will similarly decrease as the number of events increases. That is at odds with our findings among students in two successive statistical mechanics classes. Many of our students had previously completed mathematics courses in statistics, as well as a physics laboratory course that included analysis of statistical properties of distributions of dart scores as the number (n) of throws (one-dimensional target) increased. There was a wide divergence of predictions about how the standard deviation of the distribution of dart scores should change, or not, as n increases. We find that student predictions about statistics of coin flips, dart scores, and rainfall amounts as functions of n are inconsistent at best.

Supported in part by NSF Grant #PHY-0406764.

209.21

Swoosing: Why and When does it Occur in a Physics Class?

Valerie K. Otero[1], S. Jalovec[1], I. Her Many Horses[1], D. Harlow[1]
[1]University of Colorado, Boulder.

Our research shows that students in physics courses often string together scientific terms in ways that make little sense to the expert. An example of this is, "It's an energy-force. Motion, was there motion in the (magnetized) nail? Force. There was a force to the energy in the nail." We have identified several cases in which the intensive use of scientific terms appears to be a form of sense-making where students are attempting to express their ideas through familiar scientific terms that they do not fully understand. We refer to this process as swoosing* (rhymes with choosing). In such cases, the scientific term serves as a place-holder for an idea that remains vague in the students' minds. As such, it serves to facilitate discourse that may or may not be productive. In this presentation, we will describe some of the basic productive and non-productive features of swoosing in the context of a highly interactive Physics for Elementary Teachers course, and discuss how swoosing differs from other forms of sense-making. We will discuss what elements of the learning environment seem to promote or discourage swoosing and how swoosing can be a form of language appropriation. Data will be presented to support our claims.

*The term originated in early investigations where the intensive use of scientific terms was seen by the researchers as the process of trying out terms to See Which Ones Stick (SWOS). Later investigations have led to refinement of this definition, but we continue to use the term.

209.22

Proportional Reasoning: A Valid Instrument to Survey Understanding

Cheryl P. Schaefer[1]
[1]Missouri State University.

Proportional reasoning is the ability to use rates, ratios, fractions, and proportions. Students need the ability to reason proportionally in order to do well in high school and college physics courses. Since beginning research in this topic in 2000, conducting interviews, writing two-tiered tests, and many discussions on this topic, an instrument has been developed that offers a valid survey of student understanding. This allows the instructor to easily identify students in need of extra help and explanation. The final form is multiple-choice and uses detractors based on actual student responses and covers multiple ways of understanding and misunderstanding proportions. The basic questions are based on problems published in this research area.

209.23

Stabilization: A Descriptive Framework for Problem Solving

Sherry L. Savrda[1]
[1]Seminole Community College.

An alternative description of problem solving was tested against the think-aloud protocols of twelve introductory calculus-based physics students. Think-aloud protocols are transcripts of problem-solving sessions during which participants are asked to verbalize their thoughts as they attempt to solve a problem. The stabilization model tested considers perceptions of problem difficulty to be related to four primary factors: categorization, goal interpretation, resource relevance, and complexity. A fifth superordinate factor, stabilization, considers the shifting relationships between the four primary factors over the problem-solving process. Problem solving is then described in terms of a search for a stable relationship among the four primary factors. Results from the study to be presented suggest that with further refinement, the stabilization model could be an effective alternative model of problem solving. Results related to the observed problem-solving processes undertaken by the participants will also be presented.

209.24

The Background of PER People: A Survey

Laura McCullough[1]
[1]University of Wisconsin-Stout.

Data from a survey given to about 50 PER community members were analyzed to determine the backgrounds of the members. The type of college attended, the type of graduate school, when they chose physics, when they chose PER, and other interesting background information will be presented. Also presented will be gender analyses of background differences. Remarkably little difference in background was found between men and women in the sample.

209.25

What Gets Swept Under the Rug in Teaching Quantum Tunneling

S. B. McKagan[1], K. K. Perkins[1], C. E. Wieman[1]
[1]University of Colorado.

Tunneling is one of the most surprising and interesting consequences of quantum mechanics. Typical instruction on tunneling centers on what can be calculated analytically, namely the transmission coefficient for a plane wave tunneling through a square barrier. To remove the limitation of calculation, and to allow students to explore tunneling of plane waves and wave packets, we have created an interactive computer simulation[1] as part of the Physics Education Technology Project (PhET)[2]. Like all PhET simulations, the Quantum Tunneling simulation is highly interactive, allowing students to manipulate the energy by dragging lines directly on the graph, and to change many other aspects of the physical system and representation. This simulation is based on research, designed to address common student difficulties and misconceptions[3], and allows students to freely explore a great variety of physical situations that would be extremely difficult to calculate by hand. Using this simulation in class has led to an unexpected consequence: because it provides such an accurate and detailed visual representation, many issues which are swept under the rug in standard instruction are suddenly brought to the surface and must be addressed. For example, for plane waves, the wave speed is not equal to the particle speed and the transmitted wave can have higher amplitude than the incident wave. This poster will discuss how to use this simulation to teach tunneling, as well as how to address the many subtle points that it brings to the surface.

1.http://phet.colorado.edu/simulations/quantum-tunneling/quantum-tunneling.jnlp

2.http://phet.colorado.edu

3.S.B. McKagan and C.E. Wieman, PERC Proceedings 2005.

210: Space-Based Instrumentation II
AAS Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

210.01

Status of the James Webb Space Telescope (JWST)

Mark Clampin[1], C. Bowers[1], L. Feinberg[1], JWST Project
[1]NASA's GSFC.

The James Webb Space Telescope (JWST) is a large aperture, space telescope designed for near and mid-IR imaging and spectroscopy. JWST is designed to be launched in 2013, to an orbit at L2 aboard an Ariane 5 launcher. The Goddard Space Flight Center (GSFC) is the lead center for the JWST program and manages the project for NASA. The prime contractor for JWST is Northrop Grumman Space Technology (NGST). JWST is a cooperative project with the European Space Agency (ESA) and the Canadian Space Agency (CSA). In this poster we will review the current status of the JWST architecture and highlight recent progress in design of the telescope's primary mirror backplane structure, wavefront sensing and control and the deployable sunshield. JWST's primary mirrors are well into production since they are on the Project's critical path. We will review the status of the flight mirror production and discuss plans for optical verification of the telescope. Finally, current performance predictions for JWST will be reviewed in the context of its science requirements.

210.02

JWST Mirror Building Paradigms at Tinsley, Part 3

Anthony B. Hull[1], J. Kincade[1], G. Cole[1], R. Garfield[1], R. Bernier[1], C. Kiikka[1], J. Daniel[1], R. Brown[2], B. Gallagher[2], D. Chaney[2], A. McKay[3], D. Neal[4], L. Cohen[5]
[1]L-3 Communications, Tinsley, [2]BATC, [3]NGST, [4]WFSI, [5]SAO.

Tinsley, under subcontract to Ball Aerospace, is optically finishing 18 precise lightweight beryllium mirror segments that constitute the surface of the 6.5m primary mirror for JWST. In a new facility established in Richmond, CA, Tinsley Computer Controlled Optical Surfacing (CCOS) technology is scaled to the size and special requirements of JWST. A complementary suite of mechanical and optical metrology is established. We will illustrate Tinsley's JWST implementation to handle, fabricate and measure these mirrors. The first-of-kind infrared Scanning Shack Hartmann System (SSHS) is described, and progress on the Engineering Development Unit (EDU), three Pathfinder Units, and remaining Flight Units is summarized. The facility and capibilities will provide the community with enhanced capacity for future large optics.

210.03

Status of Wavefront Sensing and Control of the James Webb Space Telescope

Charles W. Bowers[1], S. Acton[2], A. Contos[2], B. Dean[1], L. Feinberg[1], B. Hayden[1], D. Shields[2]
[1]NASA's GSFC, [2]BATC.

The telescope of the James Webb Space Telescope (JWST) is an f/20, three mirror anastigmat design. It consists of a nominal 6.6 meter primary mirror composed of 18 individual, 1.3 meter hexagonal, Beryllium segments, a deployable, secondary mirror and support structure, and a tertiary mirror. During observatory commissioning, the telescope components must be deployed, aligned and co-phased to meet the basic requirement of 0.8 Strehl at 2 microns. To accomplish this, each primary mirror segment is mounted on an actuated hexapod structure providing six degrees of freedom for positioning and an additional radius-of-curvature control, and the secondary is also mounted on a six degree-of-freedom hexapod. A process of wavefront sensing and control (WFS&C) has been designed to progressively adjust the telescope components through a series of steps including segment identification, secondary alignment, coarse phasing and finally, fine phasing. We review the WFS&C process and present the results of some recent laboratory tests using high fidelity simulators to confirm and refine this process.

210.04

Progress on NIRCam, the Near-Infrared Camera for JWST

Marcia J. Rieke[1], S. Horner[2], D. Kelly[1], J. Stansberry[1], E. Young[1], D. Eisenstein[1], D. McCarthy[1], M. Meyer[1], G. Rieke[1], S. Baum[3], C. Beichman[4], R. Doyon[5], A. Dressler[6], L. Ferrarese[7], T. Greene[8], D. Hall[9], K. Hodapp[9], D. Johnstone[7], S. Lilly[10], P. Martin[11], T. Roellig[8], J. Stauffer[12], J. Trauger[4]
[1]Univ. of Arizona, [2]Lockheed Martin Advanced Technology Center, [3]Rochester Institute of Techonolgy, [4]JPL, [5]Universite de Montreal, Canada, [6]Carnegie Observatories, [7]HIA/DAO, Canada, [8]NASA/ARC, [9]Univ. of Hawaii, [10]ETH, Switzerland, [11]Univ. of Toronto, Canada, [12]Spitzer Science Center.

NIRCam will be both a science instrument and the wavefront sensor (WFS) for JWST. The instrument design is now complete, and the engineering test unit (ETU) is being built. The ETU will play a key role in testing JWST's primary mirror, the WFS and control hardware, and the mirror alignment algorithms. Many hardware elements of the ETU are starting testing and characterization including detector arrays.

210.05

Detectors for the James Webb Space Telescope Near Infrared Spectrograph: Test Performance and Calibration Studies

Bernard J. Rauscher[1]
[1]NASA Goddard Space Flight Center.

The James Webb Space Telescope (JWST) was conceived as the scientific successor to the Hubble Space Telescope. Of all JWST near-IR instruments, the Near Infrared Spectrograph (NIRSpec) has the most challenging detector requirements. In this presentation, we summarize progress on the NIRSpec detector subsystem, including recent performance test results for the 5 micron cutoff mercury-cadmium-telluride Teledyne HAWAII-2RG detectors.

210.06

Building the Mid-Infrared Instrument for JWST

George Rieke[1], G. S. Wright[2], MIRI Science Team
[1]Univ. of Arizona, [2]Royal Observatory, United Kingdom.

The Mid-Infrared Instrument (MIRI) for JWST provides imaging, spectroscopy (R ~ 100 and R ~ 2000), and coronagraphy from 5 through 28 microns. Because the instrument operates on a cold telescope in space, its sensitivity for all of these functions is at least three orders of magnitude greater than can be obtained from the ground and nearly two orders of magnitude better than provided by the Spitzer Telescope. Operation above the atmosphere also allows unobstructed access to the full spectral range, important to probe the nature of extrasolar giant planets, to study star formation in cold cloud cores (where there are interstellar windows well aligned with the terrestrial absorptions), and to study molecules that are precursors for life. An important recent upgrade in MIRI is the adoption of a mechanical cooler, so the instrument can function for the entire operating life of JWST. With the exception of the cooler, the instrument subsystems have successfully passed critical design reviews, and an overall CDR is now in progress. This poster will show some of the progress on the instrument hardware and update assessments of the performance it will provide. The instrument components as manufactured are generally in agreement with expectations, providing confidence that MIRI will perform as expected on orbit.

210.07

How can the James Webb Space Telescope measure First Light, Reionization, and Galaxy Assembly?

Rogier A. Windhorst[1], R. A. Jansen[1], S. H. Cohen[1], M. Mechtley[1], H. Yan[2], C. Conselice[3]
[1]Arizona State Univ., [2]Carnegie Observatories, [3]University of Nottingham, United Kingdom.

In this poster, we briefly review the capabilities of the 6.5 meter James Webb Space Telescope (JWST) --slated for launch to a halo L2 orbit in 2013 --including the considerations to make this an optimized infrared telescope that can deploy automatically in space.

The main science themes of JWST are to measure First Light, Reionization, Galaxy Assembly, as well as the process of Star-formation and the origin of Planetary Systems. In this poster, we will summarize how the JWST will go about measuring First Light, Reionization, and Galaxy Assembly, building on lessons learned from the Hubble Space Telescope and the Hubble UltraDeep Field (HUDF) in particular.

We will show what more nearby galaxies observed in their restframe UV--optical light will likely look like to JWST at very high redshifts, and discuss quantitative methods to determine the structural parameters of faint galaxies in deep JWST images as a function of cosmic epoch. We will also discuss to what extent JWST's short wavelength performance --which needed to be relaxed in the 2005 definition of the telescope --may affect JWST's ability to accurately determine faint galaxy parameters.

Space permitting, we will also discuss if ultradeep JWST images will run into the natural confusion limit, and what new generations of algorithms may be needed to automatically detect objects in very crowded, ultradeep JWST fields.

We will show an interactive web-tool (see poster by L. Will, M. Mechtley et al.) that lets the user pan and zoom through the HUDF data-base from redshifts z=0 to z=6, and visualize what JWST will add from AB=29.5-32.0 mag and between redshifts z=7-20.

This work was funded by JWST Interdisciplinary Scientist grant NAG5-12460 from NASA HQ.

210.08

Optimization of the Kepler Field of View

Natalie M. Batalha[1], W. Borucki[2], D. A. Caldwell[3], H. Chandrasekaran[3], T. N. Gautier[4], J. Jenkins[3], D. G. Koch[2]
[1]San Jose State University, [2]NASA Ames Research Center, [3]SETI Institute, [4]Jet Propulsion Laboratory.

The Kepler field was chosen by maximizing the numbers of stars, satisfying constraints on the ecliptic latitude, and ensuring sufficient ground-based resources for follow-up. The question is revisited in an effort to optimize the probability of detecting Earth-size planets in the habitable zone of late-type stars. The number density of stars as a function of galactic coordinates, apparent magnitude, spectral type, and luminosity class is simulated using the Besancon galactic model. Models generate synthetic star samples for specific coordinates and photometer constraints. From synthetic fields, we cull out the primary targets: stars bright and/or small enough to allow for detection of a 1 $R_{\oplus}$ planet within the habitable zone. We look to maximize the number of primary targets in the field. Using the number density of fainter background stars, we quantify the expected number of false-positives due to background eclipsing binaries. For each target, background stars are placed randomly in the photometric aperture. Half are selected as binaries using orbital period and eccentricity distributions as per Duquennoy and Mayor (1991). False positives are identified when a background binary injects a detectable photometric signal for which none of the following are observed: unequal secondary/primary eclipse depths, durations or epoch timings, or photocenter motion. Star counts (l=70) peak near b=+3 degrees and drop by 80% at b=+13. The number of primary targets, however, drops by only 10% in the same interval. The number of expected false positives drops dramatically with increasing galactic latitude. At b=+13, we expect no false positives mimicking habitable, Earth-size planets. A shift of 5-10 degrees in galactic latitude eliminates a significant source of false positives while preserving 90-95% of the primary targets. The Kepler field has, con-

sequently, been moved to a higher galactic latitude centered at l=76.53, b=+13.29.

Support for this work came from NASA's Discovery Program.

210.09

Photometric Analysis for the Kepler Mission: Optimal Aperture Photometry and Difference Image Analysis

Jon M. Jenkins[1], R. L. Gilliland[2], H. Chandrasekaran[1], S. T. Bryson[3], D. A. Caldwell[1], W. J. Borucki[3]
[1]SETI Institute, [2]Space Telescope Science Institute, [3]NASA Ames Research Center.

The science processing pipeline for the Kepler Science Operations Center will use two different approaches for developing stellar flux time series from the pixels downlinked from the spacecraft: Difference Image Analysis (DIA) Photometry and Optimal Aperture Photometry (OAP). We have prototyped both approaches and applied them to artificial data sets containing a wealth of realistic astrophysical phenomena including transiting planets, stellar variability, background eclipsing binaries and differential velocity aberration (DVA). These data sets were furnished using the Kepler End to End Model (see Bryson et al., this session). The primary purpose of the study was to investigate the effect of DVA on the ability of the Kepler processing pipeline to: 1) obtain high precision, high fidelity stellar flux time series, 2) to detect signatures of transiting planets in the data set, and 3) to reject false positives represented by background eclipsing binary systems.

OAP photometry is an extension of the optimal pixel weighting photometry introduced by Jenkins et al. 2000 (ProcSPIE 4013) and is motivated by the slow drift of the stars on the CCDs by up to 0.6 pixels over three months compared to the tight pointing requirements for the attitude control system (0.01 = 1 σ at 15 minutes). The photometry from OAP consists of taking a weighted sum of the pixels in each target's aperture, where the weights are functions of the change in position of the target and hence, can mitigate the large apparent changes in stellar flux for simple aperture photometry. The results of the study indicate that DIA and OAP produce comparable photometric time series, and furthermore, that DVA does not interfere with the ability of Kepler to detect such planets or to reject false positives from background eclipsing binaries.

The Kepler Mission is funded by NASA's Discovery Program.

210.10

Simulating Kepler Data: the End-To-End Model of the Kepler Photometer

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[1]NASA Ames Research Center, [2]SETI Institute, [3]Ball Aerospace.

The Kepler Mission is designed to characterize the frequency of Earth-size planets in the habitable zone of solar-like stars in the solar galactic neighborhood by observing 100,000 main-sequence stars in a 100 square degree field of view (FOV) and seeking evidence of transiting planets. To support engineering design and development of data analysis algorithms, we have developed the End-ToEnd Model (ETEM) of the Kepler photometer that produces simulations of data expected to arrive at the Kepler Science Operations Center. For a specified set of design and operating parameters, ETEM generates pixel time series for all pixels of interest for a single CCD channel of the photometer. The ETEM model incorporates engineering information such as the point-spread function, time histories of pointing offsets, operating temperature and the effects of shutterless readout. The model includes shot, read, quantization, and pointing-jitter-induced noise. Astrophysical parameters, such as a realistic distribution of stars vs. magnitude for the chosen FOV, zodiacal light, stellar variability, stellar background and cosmic ray events are included. To support the development of algorithms for the detection of transiting planets, planetary transit signals and false-positive signals such as background binary eclipses are modeled and injected into the ETEM output. We describe an extremely efficient computational approach to the problem of modeling on the order of a million stars over several thousand frames in a reasonably small time. The simulated data output by ETEM allows us to test our transit detection algorithms as well as study the impact of various engineering parameters and noise sources.

Funding for this mission is provided by NASA's Discovery Program Office.

210.11

First Photometric Performance Results of the Kepler Single String Focal Plane

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The Kepler Mission is designed to detect Earth-size and smaller exoplanets using space based transit photometry. An engineering model (EM) consisting of two flight-like CCDs and the associated control and data acquisition boards representing a portion of the flight focal plane has been built to qualify the flight design. In addition to all of the flight environmental qualification tests, this single-string EM has been photometrically tested using the Kepler Technology Demonstration facility (Koch et al, SPIE, 4013, 508-519, 2000), which includes a star field simulator and the ability to generate Earth-size transit signals in various stars. We present a description of the test methodology, the photometric performance test results and a comparison to the mission design requirements.

210.12

Quick Look Software for the Kepler Photometer

Kenneth Topka[1], J. Jenkins[1], D. Caldwell[1], W. J. Borucki[2]
[1]SETI Institute, [2]NASA Ames Research Center.

Kepler is NASA's first mission capable of finding extra-solar terrestrial planets that are Earth-size and smaller. The instrument includes a high gain antenna that is bolted in a fixed position on the satellite. Thus, the satellite will be rotated in order to point the antenna at Earth for transmission, an operation that will occur approximately once a month. In between Earth pointing communication with Kepler is also possible using a low gain antenna via X-band, normally used for up-link of commands and down-link of engineering data. Some of this band pass is reserved for pixel data as well, making limited amount of science data available for quick look analysis about twice a week.

Quick look software analyzes instrument health and performance as soon as possible after the data are obtained using the pixel data from X-band. The performance assessments are based on examination of time series data generated by the software, and include stellar brightness, centroid locations, plate scale, encircled energy, background flux values, CCD black, smear, and dark current levels, CCD dynamic range, and attitude solution. A more detailed analysis will be performed after the monthly down-link of all science data. New time series analyzed then include cosmic ray hit rate, CCD hot pixel formation rate, and combined differential photometric precision. All the metrics calculated for quick look will be reanalyzed at higher precision and higher time resolution.

The Kepler mission is funded by NASA's Discovery Program

WEDNESDAY

210.13

Validation of Kepler Planet Candidates

Douglas A. Caldwell[1], N. M. Batalha[2], W. J. Borucki[3], D. G. Koch[3], H. Chandrasekaran[1], J. M. Jenkins[1], K. P. Topka[1], T. N. Gautier[4], R. L. Gilliland[5]
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The *Kepler Mission* will be able to detect transiting Earth-size planets in the habitable zone of 30,000 stars and 1.4 Earth radius planets around 100,000 stars. Such sensitivity will allow *Kepler* to detect hundreds of terrestrial planets if they are common, or place significant upper limits on their numbers if they are rare. In addition, *Kepler* will detect many astrophysical

false-positives that mimic transit signals. Most will be background eclipsing binaries as much as nine magnitudes fainter than the target star. We expect 1000 background binaries with periods less than 3 days and 275 with longer periods. We have developed a series of automated tests on each detection, the results of which are used to decide whether planet candidates will be passed on for follow-up imaging and spectroscopic observations.

The validation process begins with model planet and eclipsing binary signal fits to the candidate detections. After subtracting the best-fit planet model, we search the residual flux time series for additional transiting planets around the star. This process is repeated until there are no new candidate detections. The candidate's centroid time series is then tested against the model planet signal(s) in order to eliminate background eclipsing binaries through the change in photocenter position during the eclipse. For a 12^{th} magnitude G2 star we can discriminate a binary mimicking an Earth transit if it is separated from the target star by a quarter of a pixel or more. Tests are also performed to see if the candidate signal is detected anomalously in only a single pixel of the aperture (e.g., a variable bad pixel), or if the signal is seen in the background estimate, or in any of the engineering data (e.g., focal plane temperatures,).

Funding for *Kepler* is provided by NASA's Discovery Program.

210.15

Carbon Star Science with SIM

Guy Worthey[1]
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Carbon stars, intermediate-mass asymptotic giant branch stars that have experienced deep dredge-up, represent a unique window on the Galactic history between 0.5 and 2 Gyr ago. Space Interferometry Mission will be used to find parallax distances to Galactic carbon stars. This will enable the isolation of carbon star streams analogous to moving groups and the subsequent identification of the main sequence turnoff stars that were congenital with the carbon stars. With the ages and initial abundances known, Galactic carbon stars will become useful tools for constraining stellar evolution like the Magellanic Cloud carbon stars are today. However, Galactic carbon stars have a higher initial metallicity and a better spread in age, making them even more useful, especially for application to extragalactic carbon star studies and integrated-light applications.

211: Studying Galaxy Evolution with Nearby Galaxies AAS Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

211.01

Numerical Simulations of Major Barred Galaxies

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Galaxies with major bars such as NGC1300 and NGC1097, are characterized by straight dust lanes, central starburst ring and outer spirals. Recent IR observations also show there are star formation patches and spur-like substructures. Through numerical simulations, we can reproduce the dust lanes, the central starburst ring, and the outer spirals by imposing a single strong bar potential on a self-gravitating gas disk. The strong bar potential also causes the disk to develop shear instability and Toomre's instability in the case of self-gravitating disks, which lead to creation of the star formation patches and chaotic spur-like sub-structures. In our numerical simulations, we use the Antares code we develop, which adopts Cartesian coordinates and uses the high-order Godunov scheme with unsplit flux calculated from the exact Riemann solver. The self-gravitating forces are computed from the discreatization of Green's kernel into the convolution formula and the fast Fourier transforms. This approach is different to the Fourier basis methods and our approach is the second order accuracy. The work is in parts supported by National Science Council, Taiwan, NSC95-2752-M-001-009-PAE.

211.02

The Carnegie-Irvine Nearby Galaxies Survey (CINGS): Surface Brightness Profiles, Color Profiles and 1-D Decompositions

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[1]UC, Irvine, [2]OCIW, [3]STScI.

The Carnegie-Irvine Nearby Galaxy Survey (CINGS) is a project designed to study the detailed structural properties, mass profiles, star formation histories, and AGN content of nearby galaxies across the entire Hubble Sequence. The sample includes the 603 brightest southern hemisphere galaxies with $B_T < 12.9$ mag. The survey consists of imaging in the BVRIK_s wavebands, obtained at the du Pont 2.5-meter Telescope at Las Campanas Observatory. Median seeing is 0.6 arcsec and the images reach depths of 29, 28.5, 28, 27, and 23 magnitudes per square arcsecond (3-sigma). In the future, we will also obtain multi-slit spectroscopy to study kinematics, stellar populations, chemical abundances, and active nuclei. Currently, all optical images have been obtained and reduced, and data collection in the K_s band is well underway. Our imaging analysis will consist of both 1-D radial profile measurements and detailed 2-D model fitting of galaxy subcomponents, including non-axisymmetric features such as bars and spiral arms. On completion of the survey, the images and data products will be available as a public archive. Here, we present initial results from the imaging survey, including surface brightness profiles in the BVRIK_s bands, 1-D bulge-disk decompositions, and color profiles.

211.03

The Angular Momentum of Disk Galaxies: A Multi-Wavelength Study Using the Virtual Observatory

Luca Cortese[1], B. Catinella[2], C. M. Springob[3]
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The determination of the angular momentum distribution of disk galaxies and its dependence on other galaxy properties and environment is essential in order to develop an accurate picture of galaxy formation and evolution. N-body simulations and semi-analytic models of galaxy formation within the standard cosmological framework identify the spin parameter of the dark matter halos as one of the main drivers of galaxy evolution and yield insights into its properties and distribution in present-day galaxies. Various relations have been proposed to link the halo spin parameter to observational data. In this work, we exploit such relations to obtain observational constraints for theoretical models of galaxy formation. To this extent, we used the Virtual Observatory to create a multi-wavelength database for the study of the properties of the angular momentum distribution of disk galaxies. Our sample builds upon the SFI++ database, which includes the largest collection of long-slit optical galaxy rotation curves currently available. Preliminary results of our analysis will be presented.

This work is partially funded by PPARC under grant PPA/G/O/2002/00497. The Arecibo Observatory is part of the National Astronomy and Ionosphere Center, which is operated by Cornell University under a cooperative agreement with the National Science Foundation.

211.04

Tests of the Modified Tremaine-Weinberg Method

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The recent modification to the model-independent Tremaine-Weinberg (TW) method of pattern speed estimation (Merrifield, Rand & Meidt 2006) in which Ωp is allowed radial variation promises to be an invaluable resource for tests of theories of long-lived density waves and for understanding the connection, if any, between bar and spiral pattern speeds. Whereas the standard TW calculation poses a challenge for extracting multiple distinct or radially varying pattern speeds in that it associates information from a range of radii with a single, constant pattern speed, the modified calculation, discretized for numerical solution, provides radially binned estimates for Ωp (also from measurements of observables). The nature of the discretized calculation, however, presents numerical solutions that are highly susceptible to fluctuations as a result of compounded noise in the data. Here, we introduce regularization as a means of smoothing intrinsically noisy solutions, as well as in order to test model solutions of different radial dependence. We perform tests of the Modified Tremaine-Weinberg Method (TWR) with regularization on three simulated galaxy data sets (a spiral, a barred spiral and a double-barred spiral) and find that the TWR method is able to distinguish between constant, linear, and quadratically varying pattern speeds, and in all cases, can be used to extract solutions good to within 20% of the pattern speeds known to exist therein.

211.05

A New Method for Detecting Stellar Streams in the Halos of Galaxies

Jonathan Sick[1], R. S. de Jong[2]
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Observations of stellar streams from accreting dwarf galaxies provide tantalizing insight into the processes of galaxy formation. While such stellar streams are difficult to detect due to their extremely low surface brightnesses, the new GHOSTS survey is resolving stellar populations in the halos of nearby galaxies to an unprecedented depth. The challenge then rests in developing a means to effectively search through resolved stellar halo populations to detect stellar streams. We propose that producing halo surface brightness maps using an adaptive spatial binning scheme can allow structures in the stellar populations to be identified. In particular, the Centroidal Voronoi Tessellation binning algorithm allows bins to be sized and placed in a manner that is responsive to the underlying signal to noise ratio characteristics of the photometry. Thus far in testing, the technique has been able to recover the existence of the low surface brightness dwarf galaxy above the plane of NGC 4631 as an unusually bright region in the computed surface brightness map. Additionally, we shall discuss the methods for removing biases due to background galaxies, and the use of colour magnitude diagram region selections for contrast enhancement in the surface brightness maps. This work was done as part of the Space Telescope Science Institute Summer Student Program.

211.06

Characterizing Disk Truncations with N-Body Simulations

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Disks of spiral galaxies often exhibit a two-slope exponential profile with a sharp 'break' between the inner and outer profile. In most cases, the outer profile is steeper (truncated), but in some the opposite is also observed (anti-truncated), while still others do not reveal a break at all. Several theories attempting to explain the phenomenon of disk breaks have been proposed, ranging from star formation thresholds to bar-driven secular evolution, but most can only account for one piece of observational evidence while neglecting others. We investigate this problem via high resolution N-body simulations. First, we seek to understand the parameter space of collisionless isolated systems dependance of truncations on resonant interactions between bar, disk, and halo, variations in Toomre-Q parameter, and perturbations by massive satellites are considered. In addition to collisionless models, we construct SPH models to investigate the importance of threshold gas surface densities for disk truncation. Ultimately, we will use the results from these isolated models to understand the evolution of galaxies spawned from cosmologically-motivated initial conditions. Preliminary results provide evidence for the previously-established notion that angular momentum transport leads to the formation of disk breaks. Our collisionless models also reveal a clear kinematic signature of the break, while the SPH models do not such kinematic signatures could therefore provide an observable diagnostic for distinguishing between different break-forming mechanisms.

211.07

A Detailed Look at 13 of the Nearest E+A Galaxies

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[1]Gemini Observatory, Chile, [2]Swinburne University of Technology, Australia, [3]University of Texas at Austin, [4]University of New South Wales, Australia.

We present spatially resolved GMOS spectroscopy for 13 of the closest E+A galaxies yet studied, at $0.005 < z < 0.04$, representing a variety of morphological types. Caught in the brief E+A transition, these galaxies are evolving quickly from actively star-forming to passive early-type states, yet still allow us to separate the kinematics and distributions of their young and old stellar populations. In addition to global long-slit spectra for all the targets, we show ~0.5 arcsecond resolution integral-field spectroscopy of the central kinematics and stellar populations of 5 objects. For the closest 3 targets, we present high-resolution optical/NIR imaging of the galaxies and their globular cluster systems. The proximity of our sample allows detailed comparison with numerical modelling of evolutionary processes. Together, these observations represent the most detailed study undertaken to date of a sample of E+A galaxies.

Supported by the Gemini Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., on behalf of the international Gemini partnership of Argentina, Australia, Brazil, Canada, Chile, the United Kingdom and the United States of America.

211.08

Modes of Star Formation in an Early Universe Laboratory: HST/ACS Imaging of Hickson Compact Group 31

Joshua Tobolewski[1], S. C. Gallagher[2], R. Chandar[3], C. Gronwall[1], J. English[4], K. E. Johnson[5], P. R. Durrell[6], J. E. Hibbard[7], C. Mendes de Oliveira[8], B. C. Whitmore[9], J. C. Charlton[1]
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We present a BVI HST/ACS image of Hickson Compact Group 31, and an analysis of its star formation history based on point-source and extended source photometry. We also incorporate information from our 3.6-24 micron Spitzer imaging. We examine the old star cluster populations in the galaxies, as well as new clusters that have recently formed in the tidal debris of the interacting group. Several tidal dwarf galaxies have formed in this group, amidst the multiple gravitational encounters within an HI envelope. Star formation has occurred over a large range of times in multiple locations in the group, and is still occurring at present. One of the tidal dwarf galaxies (HCG 31F) showed no evidence for stars older than several million years in HST/WFPC2 images, but in our deeper ACS images we see an older population. This tidal dwarf is likely to survive the present major encounter in the group though its ultimate fate depends on whether an additional giant galaxy will ultimately merge with the group.

211.09

Analysis of Star Formation in Closely Interacting Galaxy Pairs

Jacob Arnold[1], E. J. Barton[1]
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We analyze the effects of galaxy interactions on star formation for close galaxy pairs derived from the Two Degree Field Galaxy Redshift Survey (2dFGRS). A volume-limited sample containing galaxies with $M_{bJ} \leq -19$ provides a uniform data set consisting of 41,239 galaxies. Using a line-of-sight velocity difference (ΔV) of 1000 km/s and a projected separation (D_p) of 50 kpc/h, we obtain a sample of 1,344 galaxies in close pairs. Analysis of this sample reproduces previously shown linear correlations between EW(Ha) and ΔV and EW(Ha) and D_p for galaxy pairs. Using the number of companions within 1 Mpc/h on the sky and 1000 km/s in redshift as an environment statistic, we explore the dependence of star formation on both the pair orbit parameters and the local environment. Results indicate that it is primarily the pairs in extremely low-density environments that have statistically elevated amounts of star formation when compared to other galaxies within the same environment.

211.10

Modes of Star Formation in an Early Universe Laboratory: HST/ACS Imaging of Hickson Compact Group 7

Patrick Durrell[1], S. C. Gallagher[2], C. Gronwall[3], J. English[4], R. Chandar[5], K. E. Johnson[6], J. E. Hibbard[7], A. L. Heiderman[8], B. C. Whitmore[9], J. C. Charlton[3]
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We report on our analysis of our BVI ACS images of Hickson Compact Group (HCG) 7, one of twelve that we will obtain as part of a Cycle 15 HST program. HCG 7 is at an early stage of compact group evolution, as evidenced by HI gas that is confined to the individual galaxies in the group. Nonetheless, it has evidence of considerable amounts of star formation in three of the four giant galaxies, one of which is significantly disturbed. This star formation is evident from our 3.6-24 micron Spitzer images of the group. We will present the point source and extended source photometry based on the ACS images, and will use these results to consider the early evolutionary history of this group.

211.11

Where in the Virgo Cluster are Galaxies Stripped?

Hugh H. Crowl[1], J. D. Kenney[1], J. H. vanGorkom[2], A. Chung[3], J. A. Rose[4]
[1]Yale University, [2]Columbia University, [3]University of Massachusetts, [4]University of North Carolina.

The nearby Virgo Cluster provides an ideal laboratory to study galaxy-galaxy and galaxy-cluster interactions at a level of detail impossible at higher redshift. In Virgo, there exists a large population of spiral galaxies with mostly undisturbed stellar disks, but truncated gas disks. We present results of an observational study of several of these galaxies, utilizing optical and UV imaging, HI observations and optical spectroscopy. By combining optical spectroscopy and UV imaging, we are able to constrain the time since star formation ended in the outer disk and, therefore, constrain the time since the galaxies were stripped. Our results show that there is a correlation between the time since the end of star formation and the morphologies of the neutral hydrogen gas, in the sense that the outer disks of galaxies with asymmetric HI distributions have only recently stopped forming stars. In the case of the stripped spiral NGC 4522, we find evidence that a modest starburst occurred at the time of stripping, suggesting that stripping events can briefly increase the star formation rate. Finally, while most of the galaxies in our sample are consistent with being stripped near the cluster center, several show evidence for being stripped well outside the core, suggesting that the ″reach″ of the intracluster medium is greater than is suggested by simple ICM models.

211.12

Deep X-ray (and Multiwavelength) Survey of the Coma Cluster of Galaxies

Ann E. Hornschemeier[1], B. Mobasher[2], L. P. Jenkins[1], N. A. Miller[3], C. A. Kilbourne[1], M. W. Bautz[4], D. M. Hammer[3]
[1]NASA GSFC, [2]STScI, [3]Johns Hopkins University, [4]MIT.

We present some preliminary results on a 220 ks XMM-Newton survey of an off-center region in the Coma cluster. These observations are sensitive to $L_X \sim 10^{39}$ erg/s, allowing us to probe the X-ray emission from normal galaxies to ~0.1 L* and to construct an X-ray luminosity function. This represents a major step forward in characterizing the high energy emission of lower-luminosity galaxies in cluster/group environments. We also report on a major multiwavelength campaign to study the Coma cluster which includes Spitzer, GALEX, and HST data. The Spitzer data in particular, have uncovered a large population of dwarf galaxies. The steep faint end of the infrared luminosity function indicates a larger population of dwarf galaxies than previously identified in optical surveys.

211.13

Grism Selected Emission Line Galaxies in the Field Of Abell 1689

Gerhardt R. Meurer[1], N. Benítez[2], D. Coe[1], J. M. Vilchez[2], B. L. Frye[3], H. C. Ford[1], G. D. Illingworth[4], C. Gronwall[5], ACS ScienceTeam
[1]Johns Hopkins Univ., [2]Instituto de Astrofísica de Andalucía, Spain, [3]Dublin City University, Ireland, [4]University of California Santa Cruz, [5]Pennsylvania State University.

Massive clusters of galaxies are the earliest cosmic structures to form. Deep images show a strong overdensity of galaxies in the cluster as well as gravitationally lensed background field sources. We have observed Abell 1689, one of the most massive clusters in the nearby universe, using the Wide Field Camera and G800L grism of the Advanced Camera for Surveys onboard the Hubble Space Telescope. Here we present a catalog of Emission Line Galaxies (ELGs) identified in this field. This field is about 70% richer in ELGs compared to a ″blank″ field observed to a comparable depth. About half of the over density in ELGs results from H-alpha emitters at or near the cluster redshift. Background galaxies are also detected including a spectacular example of a strongly magnified galaxy displaying line emission over much of its distorted face. The ELGs are predominantly blue, although we do find some cases of line emitters on the Red Cluster Sequence. ACS was developed under NASA contract NAS5-32865, and this research was supported by NASA grant NAG5-7697.

211.14

A UV-NIR Photometric Comparison of Simulated and Observed Cluster Galaxies

Cameron B. Hummels[1], D. Schiminovich[1], G. Bryan[1], GALEX Science Team
[1]Columbia Univ.

We have developed a method for producing projected photometric images for the outputs of the hydrodynamics code Enzo. Population synthesis models are applied to the Enzo stellar particles to produce synthetic spectra and broadband fluxes for each star particle. Projecting these star particles' positions and applying a dust attenuation prescription we produce realistic two-dimensional images in different filter bands. We apply this method to the outputs of a cosmological cluster simulation at z~0 and extract photometric information pertaining to individual galaxies present in the cluster. We compare the resulting data set with the photometric properties of a subsample of cluster galaxies that have been observed with GALEX, SDSS and 2MASS. In particular, we use our knowledge of the formation history of each simulated galaxy to relate the observed properties of galaxies to the physical processes driving their evolution in dense cluster environments.

212: Gamma-Ray Bursts
AAS Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

212.01

Multi-wavelength Study of Prompt Optical Counterparts of Swift GRBs Detected by ROTSE-III

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Gamma-ray bursts (GRBs) are some of the most energetic explosions in the universe, releasing over 10^51 ergs in gamma-rays in tens of seconds. GRBs have broadband prompt emission and early afterglows that are visible in optical light, X-Rays, and gamma-rays. Observations of the prompt and early multi-wavelength emission from GRBs are essential to constrain models of GRB emission and late-time energy injection. The narrow-field instruments on the Swift satellite are able to respond to GRBs in under 90s, but this cannot probe the earliest phase of the

explosion. The Robotic Optical Transient Search Experiment (ROTSE-III) is a global array of 0.45m telescopes designed for rapid 5-10s responses to GRB triggers from the Swift satellite. We have obtained over 12 multi-wavelength lightcurves covering the gamma-rays (BAT), X-rays (XRT), and optical (ROTSE-III), with the first optical observations less than 20 s after the start of the burst in many cases. We find a heterogeneous set of prompt emission and early afterglow behavior, often with different wavebands quite dissimilar. Although many of the early X-ray lightcurves are less steep than predicted in the standard fireball model of GRBs, the multiwavelength lightcurves are not consistent with simple energy injection models. We also discuss the possible implications for GRB emission.

212.02

The Diverse eV Emission from Gamma-ray Bursts

Sarah Yost[1], F. Aharonian[2], C. Akerlof[1], M. Ashley[3], S. Barthelmy[4], N. Gehrels[4], E. Gogus[5], T. Guver[6], D. Horns[2], U. Kiziloglu[7], H. Krimm[4], T. McKay[1], M. Ozel[8], A. Phillips[3], R. Quimby[9], G. Rowell[2], W. Rujopakarn[1], E. Rykoff[1], B. Schaefer[10], D. Smith[11], H. Swan[1], W. Vestrand[12], C. Wheeler[9], J. Wren[12], F. Yuan[1]
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We discuss the variety of broadband optical to gamma-ray properties during gamma-ray burst (GRB) events. With rapidly-disseminated positions and automated telescope responses, there is a growing sample of prompt optical detections and limits contemporaneous with the gamma-ray emission. The ROTSE project has yielded over a half-dozen prompt detections, and approximately 10 prompt limits. Along with cases from the literature, we discuss the diverse prompt broadband spectral shapes and connections between the temporal properties at high and low energies. Cases with prompt optical limits are not demonstrably darker than prompt detections, relative to the gamma-ray emission. There is great variety in the optical rise times relative to the GRB onset, as well as relations between temporal properties at high and low energies. With no single pattern for low-energy emission behavior, GRB models must be able to account for diverse outcomes.

212.03

Temporal and Angular Properties of GRB Jets Emerging from Massive Stars

Brian J. Morsony[1], D. Lazzati[1], M. C. Begelman[1]
[1]University of Colorado, Boulder.

We study the long-term evolution of relativistic jets in collapsars and examine the effects of viewing angle on the subsequent gamma ray bursts. We present a series of high-resolution simulations of a jet propagating through a stellar envelope in 2D cylindrical coordinates using the FLASH adaptive mesh relativistic hydrodynamics module. Our simulations allow us to single out three phases in the jet evolution. First, there is a precursor phase in which relativistic material turbulently shed from the head of the jet first emerges from the star over a wide opening angle. Second, in the shocked jet phase fully shocked jet material is emerging with a narrow, constant opening angle. And finally, there is an unshocked jet phase during which the jet consists of a free-streaming, unshocked core surrounded by a thin boundary layer of shocked jet material. The opening angle increases logarithmically with time during the unshocked jet phase. As a consequence, some observers see prolonged dead times of emission between the precursor and unshocked phases, even for constant properties of the jet injected in the stellar core. We discuss the observational implications of our results, emphasizing the possible ways to test progenitor models through the effects of jet propagation in the star.

212.04

An Estimation Of The Gamma-Ray Burst Afterglow Apparent Optical Luminosity Distribution Function

Carl W. Akerlof[1], H. F. Swan[1]
[1]Univ. of Michigan.

By using recent publicly available observational data obtained in conjunction with the NASA *Swift* gamma-ray burst mission and a novel data analysis technique, we have been able to make some rough estimates of the GRB afterglow apparent optical luminosity distribution function. The results suggest that 80% of all bursts have optical magnitudes with $m_R < 20.5$ at 1000 seconds after the burst onset. If the estimated integral distribution function is extrapolated crudely to saturation at unit probability, the darkest burst would correspond to $m_R \sim 22$ at $t = 1000$ s. Only GRBs dimmer than this should be truly labeled as “dark”. These results have implications for future plans for multiwavelength GRB studies. The employed numerical techniques might find application in a variety of other data analysis problems. This research was supported by NSF/AFOSR grant AST-0335588, NASA grant APRA03-0000-0063 and NSF grant AST-0407061.

212.05

A Search for Short Timescale Structure in GRB041223

Stephanie L. Fiorenza[1], E. E. Fenimore[2], M. Galassi[2], B. Norman[2]
[1]Pennsylvania State University, [2]Los Alamos National Lab.

Gamma ray bursts can be used to discover the history of the universe back to the very first objects created after the Big Bang. The more we understand about the mechanism behind gamma ray bursts, the more we can exploit them to increase the precision of our knowledge of the universe’s history. This poster presents an analysis of the lightcurve of GRB041223, as observed by the Burst Alert Telescope (BAT) on the Swift satellite. We performed a Fourier transform and a wavelet transform and verified that there is not short timescale (millisecond) structure in the burst. This result is consistent with current models for the geometry of the energy shells emitted from a gamma-ray burst.

212.06

Probing the Early Universe with GRBs

Adria C. Updike[1], D. H. Hartmann[1], J. R. King[1], S. D. Brittain[1]
[1]Clemson University.

The redshift distribution of gamma-ray bursts as established by the SWIFT satellite demonstrates that GRBs can be used as cosmological probes well into, and perhaps beyond, the reionization epoch at z~5-10. To utilize this unique probe, it is important to follow up with photometry and spectroscopy from the ground and possibly also from space. We carry out a Monte Carlo simulation of the cosmic GRB activity and the world-wide response of optical facilities. The goal of this study is to determine the limitations of the current global GRB response capabilities which may have to be overcome in order to fully benefit from opportunities provided by new GRB missions, such as EXIST.

212.07

GRB Photometric Redshifts and Spectral Slopes From the Swift UVOT

Daniel Vanden Berk[1], Swift UVOT Team
[1]Pennsylvania State Univ..

We show how data from the Swift UVOT can be used to provide early estimates of photometric redshifts and spectral slopes of GRB afterglows. The UVOT has detected 80% of the Swift afterglows with secure redshifts, including GRB060522 at z=5.11. The correlation between photometric and spectroscopic redshifts is very strong, but is best beyond z=1.3, where Lyman absorption becomes significant in the UVOT bands. Spectral slopes are best constrained at low redshifts, where photometric detections span a wide wavelength range. We discuss the prospects for quickly flagging very high-redshift (z>5) GRB candidates.

212.08

New Catalog of Astrometry Corrected Swift XRT GRB X-ray Afterglow Positions

Judith L. Racusin[1], D. N. Burrows[1], Swift XRT team
[1]Penn State University.

We present a new catalog of astrometry corrected positions for Swift XRT detected GRB X-ray afterglows. These new positions have substantially smaller error radii than previous measurements for fields with long exposure times (>50 ks) and many (>10) serendipitous X-ray sources. We match these sources to ground based optical catalogs in a statistical manner that does not require specific assumptions about the morphology or SEDs of the objects being matched. We have tested and are able to quantify the accuracy of our methods using a subset of the GRBs with optical/UV/IR/radio afterglow counterparts. Improvements in XRT positions are a valuable asset in GRB host galaxy determination when an optical/UV/IR/radio afterglow is not detected.

212.09

Using Interplanetary Network Data to Search for Hypernova/GRB Coincidences

Kevin C. Hurley[1], E. Pian[2]
[1]UC, Berkeley, [2]INAF, Italy.

The Interplanetary Network of GRB detectors has been detecting about 200 bursts/year since 1991. It has roughly isotropic response and close to 100% duty cycle for the more intense events. The IPN is therefore an ideal complement to missions and experiments such as BATSE, HETE, BeppoSAX, INTEGRAL, and Swift, which have restricted sky coverage. It can therefore be used to search efficiently for GRBs that are coincident in time and space with supernovae which are thought to be hypernovae. For several years, we have been performing this search, and have now looked at several dozen supernovae. I will discuss the results to date.

213: How To ... Resources for Scientist Educators
AAS Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

213.02

SABER: The Searchable Annotated Bibliography of Education Research in Astronomy

David H. Bruning[1], J. M. Bailey[2], G. Brissenden[3]
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Starting a new research project in astronomy education is hard because the literature is scattered throughout many journals. Relevant astronomy education research may be in psychology journals, science education journals, physics education journals, or even in science journals themselves. Tracking the vast realm of literature is difficult, especially since libraries do not carry many of these journals and related abstracting services.

SABER is an online resource (http://astronomy.uwp.edu/saber/) that was started in 2001 specifically to reduce this "scatter" by compiling into one place an annotated bibliography of relevant education research articles. The database now includes more than 150 articles specifically addressing astronomy education research. Visit SABER and see what it can do for you.

213.03

Edplum: A Wikipedia-Style Resource for Educators

David M. Rothstein[1]
[1]Cornell Univ..

Where do teachers find interesting and engaging material for their classrooms? Right now, there are a host of great lesson plans and other materials available on the Internet and elsewhere (much of it written by astronomy outreach professionals), but these materials are scattered and not always organized in a way that is easy for busy teachers to find and use. Also, much of this material is distributed in a ″top-down″ fashion, and it can be difficult for teachers to customize it for their own particular teaching style. Edplum is a website under development that will help solve these problems by allowing teachers and other educators to share small nuggets of material with each other and build up lesson plans, units and even entire curricula in a collaborative fashion. It will borrow principles from Wikipedia (the enormously successful online encyclopedia that anyone can edit) and other websites to create an online community in which teachers can share material with each other, see what material other teachers are using, and overall improve the quality of instruction in classrooms around the world in a ″teacher-centric″ way.

The Edplum project is supported by an NSF Astronomy and Astrophysics Postdoctoral Fellowship under award AST-0602259.

213.04

Best Practices for Modifying Astronomy Curriculum for Special Needs Students

Julia K. Olsen[1], T. F. Slater[1]
[1]University of Arizona.

Current instructional issues necessitate educators start with curriculum and determine how educational technology can assist students in achieving positive learning goals, functionally supplementing the classroom instruction. Technology projects incorporating principles of situated learning have been shown to provide an effective framework for learning, and computer technology has been shown to facilitate learning among special needs students. Students with learning disabilities may benefit from assistive technology, but these resources are not always utilized during classroom instruction: technology is only effective if teachers view it as an integral part of the learning process. In early 2006, the Lawrence Hall of Science conducted a national field -test of a new GEMS space science curriculum package for middle school students which they had developed. LHS collected preand post-test data for each unit based on student work samples. During this field-testing, we modified a subset of the curriculum materials so that they could be delivered via computer mediated instruction for the students in a subset of the field-test classrooms in order to determine if the students in the classrooms using the curriculum modified for computer mediated instruction scored differently on the assessments than students in the larger assessment database. Results suggest that many students, not just those with special needs, demonstrate greater achievement gains using materials modified using the principles of best practice for special needs students. This poster illustrates curriculum materials before and after modification based on best practice.

213.05

Resources and Issues to Consider for Astronomers Who Wish to Work with Out-of-School Time Organizations and Programs

Julie H. Lutz[1], D. Powell[2], J. Frieling[3]
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Out-of-school time (OST) programs provide rich opportunities to inspire and engage young people in astronomy and other sciences. OST programs include non-profit and commercial programs that provide before and/or after school care, youth organizations such as Boys and Girls Clubs, 4-H and Scouts, summer camps and other summer programs, library programs and a wealth of other settings that are less restricted (particularly in today's climate of high-stakes testing in public education) than K-12 classrooms. OST programs are of course very different (workforce, modes of youth participation, funding sources, sustainability of partnerships, etc.) than formal education so astronomers and science educators need to know and honor the differences when forming partnerships and/or developing or adapting materials. This poster will provide information on the following four topics:

1. Why astronomers should consider working with OST programs and organizations.

2. How to determine which OST programs and organizations would be good partners for particular astronomy education and public outreach programs.

3. Advice from OST leaders and from astronomers who have partnered with OST programs and organizations.

4. Resources for astronomers who want to start working with OST programs and organizations.

The presenters are members of the NASA Science Mission Directorate Out-of-School Time Working Group (OSTWG) which has been gathering information on OST programs and organizations for four years. In particular, OSTWG has been examining the issues that are driving the rapidly-evolving landscape of OST (e.g., more attention to science standards and connections to school programs) and the research on OST program outcomes. The OSTWG Web site is at http://www.s2n2.org/ostwg. The presenters would like to thank the NASA Science Mission Directorate for supporting the activities of OSTWG.

213.06

Adapting Formal Education Materials for Out-of-School Settings

Denise A. Smith[1], H. Gibbons[2]
[1]STScI, [2]Pacific Science Center.

Out-of-school programs present significant opportunities to reinforce and extend classroom learning. How can we work effectively with these programs to engage youth in science and technology? What types of materials can be easily integrated into out-of-school learning experiences? How can existing formal education materials be adapted for use in out-of-school settings? To address these questions, the Space Telescope Science Institute and the Pacific Science Center have engaged in a project that builds on a network of informal science education centers and community-based organizations developed for a national outreach program associated with the NOVA/PBS Origins series. As part of this effort, the Pacific Science Center has held a focus group with local community-based organizations serving underserved and underrepresented youth, and engaged 20 sites in Washington, California, and Tennessee in testing formal education materials adapted for use in out-of-school settings. We report preliminary focus group and field-test results, including emerging best practices for adapting formal education materials for use in out-of-time settings. Results from this project will enable a variety of education and public outreach programs to extend the reach of their materials to new audiences in a way that bridges the formal and informal science education realms.

214: It's All About Clear Skies
AAS Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

214.01

Controlling Light Pollution in Chile A Status Report.

Malcolm G. Smith[1], P. Sanhueza[2], H. E. Schwarz[1], A. R. Walker[1]
[1]Cerro Tololo Inter-Amer. Obs., Chile, [2]OPCC, Chile.

In 1999, after 6 years of intense work wirh Chilean authoritie Eduardo Frei Ruiz-Tagle, the then President of Chile signed into law Supreme Decree 686, the environmentally-linked ″Norma Luminica″. This, in effect, required that lighting in the three astronomically-sensitive Regions of Northern Chile (II Paranal,Armazones III Las Campanas IV La Silla, Tololo, Pachon) be directed downwards instead of into the sky. Various grace periods up to a maximum of five years were specified for different types of lighting. Street lighting was due to be fully compliant by 1st October, 2005. 70% of the street lighting in these 3 Regions now meets specifications and work continues towards full compliance.

More sophisticated draft legislation is under consideration with several Chilean national authorities. This may include international lighting norms, energy-saving caps and measures to address energy-saving, environmental and human-health issues.

With vigilance, these measures are likely to extend the useful life of all existing and major planned observatories in Chile by several decades.

214.02

Willingness to Pay for a Clear Night Sky: Use of the Contingent Valuation Method

Stephanie Simpson[1], J. Winebrake[1], J. Noel-Storr[1]
[1]Rochester Inst. of Technology.

A clear night sky is a public good, and as a public good government intervention to regulate it is feasible and necessary. Light pollution decreases the ability to view the unobstructed night sky, and can have biological, human health, energy related, and scientific consequences. In order for governments to intervene more effectively with light pollution controls (costs), the benefits of light pollution reduction also need to be determined. This project uses the contingent valuation method to place an economic value on one of the benefits of light pollution reduction aesthetics. Using a willingness to pay approach, this study monetizes the value of a clear night sky for students at RIT. Images representing various levels of light pollution were presented to this population as part of a survey. The results of this study may aid local, state, and federal policy makers in making informed decisions regarding light pollution.

215: Optical Cluster Finding
AAS Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

215.01

Scatter in the Richness-Velocity Dispersion Relation for SDSS Galaxy Clusters

Matthew R. Becker[1]
[1]University of Michigan.

While weak gravitational lensing can measure the average mass of a group of optically selected galaxy clusters, it cannot yet determine the scatter in mass of that group. We present new measurements of the scatter in the velocity dispersion vs. optical richness relation made using spectroscopic observations of galaxy clusters from the Sloan Digital Sky Survey. We characterize this scatter as lognormal with parameters that vary as a function of optical richness. The scatter is at most 8% in the logarithm of the velocity dispersion and decreases with increasing optical richness. Although velocity dispersion does not map directly to mass, we show that this work is a first step in estimating the total scatter in the mass vs. optical richness relation.

215.02

Optical Galaxy Cluster Detection in SDSS DR5

Wayne Barkhouse[1], T. Hacker[2], J. Song[1], J. J. Mohr[1]
[1]Univ. of Illinois, [2]USAF Academy.

We report here on the detection of ~150,000 galaxy cluster/group candidates based on g', r', and i' imaging (|b| > 30 deg) of the Sloan Digital Sky Survey DR5. Galaxy clusters are detected as overdensities based on the presence of the early-type cluster galaxy red sequence using the Voronoi Tessellation and Percolation technique (VTP). Redshift estimates are derived from the position of the cluster red sequence in the color-magnitude plane. Optical richness measurements, based on the cluster center-galaxy correlation amplitude (Bgc), have been derived. Cluster finding mass-dependent selection functions have been measured based on extensive simulations. Our catalog offers the community a rich resource from which galaxy clusters and groups can be studied.

215.03

Improving Galaxy Cluster Photometric Redshifts

Huan Lin[1], M. Lima[2], H. Oyaizu[2], C. Cunha[2], J. Frieman[3], J. Annis[1], B. Koester[4], J. Hao[4], T. McKay[4], E. Sheldon[5]
[1]Fermilab, [2]University of Chicago, [3]Fermilab/U. Chicago, [4]University of Michigan, [5]NYU.

The measurement of accurate photometric redshifts (photo-z's) is an important ingredient in enabling optimal scientific analysis of the photometric galaxy cluster samples found in large optical imaging surveys like the Sloan Digital Sky Survey (SDSS) and the proposed Dark Energy Survey (DES). Here we use real SDSS cluster catalogs (taken from both SDSS single-pass and coadded imaging data) and simulated DES cluster samples to examine the accuracy of different photometric redshift estimators. In particular, we show how we can significantly improve upon the original photo-z estimates provided by the maxBCG cluster finding algorithm, by the use of empirical photo-z techniques such as neural network and ″nearest-neighbor polynomial″, which have been trained on cluster galaxies with spectroscopic redshifts. In addition, we examine the further improvements made possible by stacking the individual photo-z estimates of all the member galaxies of each cluster, and we measure the scaling of the resulting photo-z error with cluster richness, as well as explore the limitations in this method due to systematic errors. Finally, we present estimates of the uncertainties in cluster photometric redshifts for the proposed DES, a 5000 sq. deg. survey which will use a large sample of galaxy clusters out to redshifts z > 1 to help constrain dark energy and cosmological parameters.

215.04

Selection Effects in Galaxy Cluster Surveys: What Do We Learn from Observed Scaling Relations?

Brian D. Nord[1], A. E. Evrard[1]
[1]University of Michigan.

The plethora of observable quantities across multiple wave bands contains redundant information about the masses of galaxy clusters. Proper calibration across the descriptor set are crucial steps to correctly map the cosmic mass distribution, thereby constraining dark sector cosmology. Survey flux thresholds mask the X-Ray sky, and establish a selection effect that is highly dependent on the intrinsic scatter in the mass at fixed luminosity. A precise model for the L-M relation has emerged from constraints from the REFLEX catalog. We extend this model to include temperature variations, modeled via a log-normal covariance. We show how redshift characteristics of cluster surveys contain a strong degeneracy between intrinsic scatter and true scaling. Knowledge of the covariance behavior is therefore important in recovering true physical evolution of the cluster population. We apply a similar technique to the X-ray properties of optically selected clusters. Intercomparison of cluster properties among samples selected on different, or multiple, observables will potentially break model degeneracies, providing clues to how properties, like X-ray luminosity, optical richness, velocity dispersion, are linked.

Many thanks to the Michigan Space Grant Consortium for their encouragement.

215.05

Luminosity and Color Distributions of Galaxies in Clusters and Groups in the SDSS

Sarah M. Hansen[1], E. S. Sheldon[2], R. H. Wechsler[3], M. Masjedi[2]
[1]Univ. of Chicago, [2]New York University, [3]Stanford.

We present the luminosity and color distributions of galaxies in clusters and groups in the Sloan Digial Sky Survey, examined as a function of several cluster properties. The sample, identified with the maxBCG red-sequence method, covers 7398 square degrees of data between redshifts 0.05 and 0.3 and contains clusters and groups spanning a wide range of optical richness. We determine the density distribution of galaxies in clusters by statistically correcting the projected galaxy-cluster cross-correlation function for the effect of non-cluster interlopers. We then examine the distribution of K-corrected magnitudes and colors of the galaxies associated with clusters. We present the luminosity function and color distribution of cluster galaxies as a function of cluster radius (r/r_200), richness, redshift, and luminosity, and as a function of brightest cluster galaxy luminosity and color. These data may be used to constrain models of cluster formation and galaxy evolution within clusters, and provide a reference point to which high-z cluster samples may be compared.

215.06

Galaxy Cluster Correlation Function in the Dark Energy Survey

Juan Estrada[1], A. Plazas[2], Fermilab Galaxy Cluster Group
[1]Fermilab, [2]Universidad de Los Andes, Colombia.

The potential for doing cosmology using the correlation function of optically selected galaxy clusters is investigated for the future Dark Energy Survey. This survey will map 5000 square degrees of the southern sky to z~1.

215.07

A Systematic Search for High Surface Brightness Giant Arcs in a Sloan Digital Sky Survey Cluster Sample

Victor Scarpine[1], S. Allam[1], J. Annis[1], T. Diehl[1], J. Estrada[1], P. Hall[2], T. Las[1], H. Lin[1], M. Makler[3], W. Merritt[1], D. Tucker[1], D. McGinnis[1], J. Kubo[1], D. Kubik[4]
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We present the results of a search for gravitationally-lensed giant arcs conducted on a sample of 825 SDSS galaxy clusters. Both a visual inspection of the images and an automated search were performed and no arcs were found. This result is used to set an upper limit on the arc probability per cluster. We present selection functions for our survey, in the form of arc detection efficiency curves plotted as functions of arc parameters, both for the visual inspection and the automated search. The selection function is such that we are sensitive only to long, high surface brightness arcs with g-band surface brightness < 24.8 and length-to-width ratio > 10. Our upper limits on the arc probability are compatible with previous arc searches. Lastly, we report on a serendipitous discovery of a giant arc in the SDSS data, known inside the SDSS Collaboration as Hall's arc.

215.08

Red Sequence Cluster Finding in the Millennium Simulation

August E. Evrard[1], D. Croton[2], M. White[2], J. Cohn[2], E. Ellingson[3]
[1]Univ. of Michigan, [2]Univ. of California, Berkeley, [3]Univ. of Colorado.

We use galaxy populations derived from the Millennium Simulation to investigate the nature of high redshift clusters identified by red sequence-based, optical techniques. We build localized sky survey catalogs using projected locations and adjusted r-z colors of galaxies at fixed-time epochs z=0.4, 0.7 and 1. The catalogs are z-band magnitude limited near L_*, and generate samples of one million galaxies in (500 Mpc/h)^2 projected regions at each redshift. The simulated galaxies in massive, dark matter halos tend to lie on a well-defined red sequence (RS), and we use the knowledge of the RS location at each redshift to inform a simple circular overdensity (CO) algorithm. Using galaxy membership as a way to match clusters with halos, we examine the fidelity of this algorithm. Due to projection, essentially all identified clusters contain galaxies from multiple halos, but we categorize them into two simple classes depending on whether ('clean' clusters) or not ('blended' clusters) a single halo contributes a majority of cluster member galaxies. The CO algorithm, with appropriately tuned overdensity, is extremely efficient at z=0.4; fewer than 10 percent of clusters with 20 or more members are blends, and the relation betweeen observed optical richness and best-matched halo mass is a nearly unbiased version of the true underlying RS halo occupation distribution. At z=1, the performance deteriorates, with the fraction of blended systems increasing to ~30 percent. We show that this degradation is driven by weaker evolution in r-z color at high redshift, which effectively increases the projected lengthscale over which galaxies remain within the RS color cut. We discuss implications for existing and upcoming cluster surveys using multi-band optical imaging. In particular, we expect that a significant fraction (~30%) of high redshift RCS clusters will be underluminous in their X-ray luminosity.

215.09

The SDSS Southern Survey Coadd Data

James T. Annis[1], H. Lin[1], G. Miknaitis[1], R. Lupton[2], M. Strauss[2], J. Gunn[2], L. Jiang[3], X. Fan[3], A. Becker[4]
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We present details of the construction and characterization of the SDSS Southern Survey. This survey consists of 300 sq-degrees of repeated scanning by the SDSS camera over -60 < RA < 60 on the equator. Each piece of sky has ~20-30 images contributing and we will reach 2 magnitudes fainter than the SDSS single pass data. By using the repeated standard SDSS calibration, the apache wheel based ubercalibration, and the repeat scans themselves we obtain 1% photometry. We discuss the image coaddition techniques, the PSF construction, and the object measurement using frames of the SDSS PHOTO pipeline. Of interest is the fact that production occurred on the Open Science Grid using hundreds of compute nodes on >10 Terabytes of data. We present star counts, galaxy counts, the galaxy two-pt correlation function, and a photo-z distribution as the base characterization of the data set and we discuss the opportunities for using the dataset to extend the SDSS optical cluster catalog work out to redshifts of z > 0.5.

216: Modelling Variable and Binary Stars
AAS Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

216.01

Light Curves and Spot Modelling for V471 Tauri

Valmin J. Miranda[1], T. Vaccaro[1]
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Reduced photoelectric photometry on V471 Tau was recovered from the 1976-1979 observing seasons. The data were used to create light curves of the eclipsing red dwarf + white dwarf binary. A binary star program was used to model dark spots and calculate times of minima via differential corrections of parameters. Dark spots on the active red dwarf were required for all light curves modeled while subsequent data in the same observing season hint at spot evolution. The O-C values from times of minima follow the trend expected due to the light-travel time of a third body. The errors in the timings may be due to the paucity of data during eclipses and ellipsoidal and spot distortions of the red dwarf outside eclipses.

216.02

Polaris' Pulsational Mass

Siobahn Morgan[1]
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The well known classical Cepheid, Polaris, has recently become the center of attention. Even though it is a very low amplitude overtone mode pulsator, its proximity makes it one of the best observed Cepheids in the sky. A recent study by Evans et al. (2006) provides a new estimate for its mass based upon its membership in a multiple star system. Several recent interferometric studies have provided refined values for its radii and distance, and spectroscopic studies give specific atmosphere details such as composition and surface gravity. All of this recent scrutiny allows us to use Polaris as a test of stellar pulsation and evolution models. Polaris' pulsation models are calculated using a linear non-adiabatic static atmosphere code, that will be compared to the physical characteristics obtained from various authors' stellar evolution models. While there is some general agreement between Polaris' characteristics found in the pulsation and evolution models there still remains a number of unresolved issues.

216.03

Modeling the Stellar Evolution of V725 Sgr

Holly M. Kagy[1], S. M. Morgan[1]
[1]University of Northern Iowa.

The unusual variable V725 Sgr has changed its period several times in the past century, most dramatically between 1926 and 1935. In this study, linear non-adiabatic static atmosphere models are adjusted to fit data for the variable between 1926, when the period was 12 days, to that of 1935, when it had increased to 21 days. The estimated value for the effective temperature is initially set at 5000 K and masses between 3 and 11 solar masses are investigated in the models in order to reproduce the behavior of V725 Sgr during this time. Models of various metallicities are used with values of Z=0.0002 0.0006. A range of likely models will be presented that follow the evolution of the star between 1926 and 1935 and these will be compared to evolutionary models with similar characteristics.

216.04

Angular Momentum Transport in Double White Dwarf Binaries

Patrick M. Motl[1], J. E. Tohline[1], J. Frank[1]
[1]Louisiana State University.

We present numerical simulations of dynamically unstable mass transfer in a double white dwarf binary with initial mass ratio, q = 0.4. The binary components are approximated as polytropes of index n = 3/2 and the synchronously rotating, semi-detached equilibrium binary is evolved hydrodynamically with the gravitational potential being computed through the solution of Poisson's equation. Upon initiating deep contact, the mass transfer rate grows by more than an order of magnitude over approximately ten orbits, as would be expected for dynamically unstable mass transfer. However, the mass transfer rate then reaches a peak value, the binary expands and the mass transfer event subsides. The binary must therefore have crossed the critical mass ratio for stability against dynamical mass transfer. Despite the initial loss of orbital angular momentum into the spin of the accreting star, we find that the accretor's spin saturates and angular momentum is returned to the orbit more efficiently than has been previously suspected for binaries in the direct impact accretion mode. To explore this surprising result, we directly measure the critical mass ratio for stability by imposing artificial angular momentum loss at various rates to drive the binary to an equilibrium mass transfer rate. For one of these driven evolutions, we attain equilibrium mass transfer and deduce that the mass ratio for stability is approximately 2/3. This is consistent with the result for mass transferring binaries that effectively return angular momentum to the orbit through an accretion disk. This work has been supported in part by NSF grants AST 04-07070 and PHY 03-26311 and in part through NASA's ATP program grant NAG5-13430. The computations were performed primarily at NCSA through grant MCA98N043 and at LSU's Center for Computation & Technology.

WEDNESDAY

216.05

A Pulsational Study of V823 Cas

Jennifer N. Wahl[1], S. M. Morgan[1]
[1]*University of Northern Iowa.*

V823 Cas is a triple mode pulsating variable, thought to be pulsating in the fundamental, first and second overtone modes. It is one of only a handful of such stars known to exist in our galaxy, along with AC And, and V829 Aql. The period ratios for V823 Cas, P1/P0 and P2/P1, can be used to derive a range of metallicity, mass, luminosity and temperature values appropriate for the star. We used linear non-adiabatic static pulsation models to determine the parameter space that this star appears to be in, and we will compare these values to the known physical characteristics of the star and stellar evolution models.

216.06

How Do Starspots Affect Light Curves of Contact Binary Stars?

Robert L. Hill[1]
[1]*Ball State University.*

Starspots are not well understood for contact binary star systems. The following properties of spots were systematically investigated: temperature, radius, colatitude, and longitude. The light curve phases of primary minimum and primary maximum were affected in a systematic manner, as well as the secondary minimum and maximum. It will be shown that it is possible to use the shift in these phases to study starspots over time. This information can also be used to identify the presence of spots in binary star systems.

216.07

Extending the Model of KH 15D

Devin W. Silvia[1], E. Agol[1]
[1]*University of Washington.*

The periodic eclipsing properties of the pre-main-sequence binary, KH 15D, are currently predicted to be the result of a circumbinary ring that is inclined to the orbital plane, which causes the system to be occulted. Using a collection of data that includes radial velocity measurements, a decade worth of detailed photometry, and a scattered assortment of archival photometry dating back to the 1950s, we attempt to confirm this theoretical model and further explain the detailed properties of KH 15D's light curve. Particularly, we seek to explain the gradual slope directly preceding total eclipse as well as the slight rise in flux at mid-eclipse. Our chosen explanation is that these features are caused by an intrinsic property of the dust that results in the forward scattering of the light from the binary.

217: Starbursts & Interacting Galaxies
AAS Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

217.01

The Extended Environments of ULIRGS and LIRGS: Clusters in Formation

Edward A. Laag[1]
[1]*UC, Riverside.*

The environments surrounding Ultra-Luminous Infrared Galaxies (ULIRGS; Lir > 10^12 Lsun) and LIRGs (LIRGS; Lir > 10^11 Lsun) are potential laboratories for studying the formation of galaxy clusters. These proto-clusters likely contain large amounts of mass in the form of dark matter (DM) haloes and are actively accreting galaxies, inducing star formation and AGN activity. In addition, possible companions are frequently seen in the vicinity of ULIRGs. We present preliminary results of a project to study clustering properties of ULIRGs in the FIRST sample. We have obtained wide field of view (FOV) (75''x 65'') ESI R-band sub-arcsecond seeing images with limiting magniudes of ~R=25 of the fields surrounding 32 (z < 0.35) ULIRGs and LIRGs. To confirm group membership we have obtained spectra using the Shane 3m telescope at Lick Observatory, for many of the galaxies in these fields. In addition, we discuss a new adaptive optics (AO) technique on the horizon for Keck Observatory that would be helpful for this research. A project to obtain redshifts and wide FOV imaging of a larger sample of ULIRGs is ongoing.

217.02

The Nature of the Densest Gas in Nearby Starbursts

David S. Meier[1], J. L. Turner[2]
[1]*Jansky Fellow; National Radio Astronomy Observatory,* [2]*Dept. of Physics & Astronomy, UCLA.*

Very little is known about giant molecular cloud scale variations in the physical conditions of the *dense* gas component in external galaxies. To understand the physical conditions of the dense component of the ISM in star forming galaxies, we have observed the J = 5 4 transition of HC_3N at 2" resolution in the nearby starburst spiral, IC 342, and the dwarf, strong starburst, M 82, with the Very Large Array. These are the first detections of this transition in an external galaxy. The lower energy state of this transition makes it optimal for mapping the relatively quiescent, dense gas. The dataset is used to locate the sites of densest gas, and determine the fraction of the GMCs that have densities $>10^5$ cm^{-3}. The HC_3N(5-4) emission traces the dense cores seen in HCN, but is much weaker towards the starburst cores. The HC_3N(5-4) intensities are compared with existing high resolution, Owen Valley Millimeter Interferometer observations of HC_3N(10-9) and an LVG model to determine gas excitation. Densities of the cores are found to be $n_{H2} \sim 10^{4.5}$ cm^{-3}. The excitation temperatures derived from HC_3N match well those from ^{13}CO and $C^{18}O$, indicating that the dense cores associated with the starburst do not have significantly different temperatures than the ambient material they are embedded in. Implications for the efficiency of star formation will be discussed.

Support for this research is provided by NRAO, which is operated by Associated Universities Inc., under cooperative agreement with the National Science Foundation, and by NSF Grants AST-0506669 and AST-0506469.

217.03

The Radio Continuum, Far-infrared Emission, and Dense Molecular Gas in Star-forming Galaxies

Fan Liu[1], Y. Gao[1]
[1]*Purple Mountain Observatory, China.*

A tight linear correlation is here established between the HCN line luminosity (from Gao \& Solomon's HCN survey) and the radio continuum (RC) luminosity (at 1.4 GHz from the NRAO VLA Sky Survey) for a sample of 65 galaxies, including normal spiral galaxies and luminous and ultraluminous infrared galaxies (LIGs/ULIGs). After analyzing the various correlations among the global infrared (IR), RC, CO and HCN luminosities and their various ratios, we conclude that only the IR-RC and IR-HCN correlations appear to have truly physically direct relations and the combination of these two tightest correlations could result in the tight RC-HCN correlation we observed. The apparently strong RC-CO correlation is de facto the worst among all correlations we show here and there is no any correlation between ratios of RC/HCN and CO/HCN or RC/IR and CO/IR. In comparison, the RC-HCN correlation stands out significantly better and a meaningful correlation is still observed between ratios of RC/CO and HCN/CO. Based on these results and analysis, we claim that it is practical to use RC luminosity instead of IR luminosity, at least globally, as an indicator of star formation rate in star-forming galaxies. Case study with the Cartwheel galaxy for local correlation between IR (Spitzer) and RC is also conducted in comparison.

217.04

IRS Spectroscopy of Collisional Ring Galaxies

Philip N. Appleton[1], P. Beirao[2], L. Armus[3], B. Brandl[2], V. Charmandaris[4], T. Jarrett[3], S. Lord[1], B. Madore[5], J. Mazzarella[6], W. T. Reach[6], M. Seibert[5], B. J. Smith[7], C. Struck[8]
[1]NHSC-Caltech, [2]Leiden University, Netherlands Antilles, [3]SSC-Caltech, [4]Crete University, Greece, [5]OCIW, [6]IPAC-Caltech, [7]ETSU, [8]ISU.

We present Spitzer IRS Mid-IR spectroscopy of a sub-set of collisional ring galaxies from a larger sample being observed with the imaging cameras on Spitzer, and in the UV with Galex. The paper will concentrate on three systems that have been studied in detail: Arp 143, LT 41 and NGC 985. In Arp 143 and LT 41 we investigate the variations in PAH strength with underlying UV/opt/IR continuum, and discuss the discovery of powerful molecular hydrogen emission from the nucleus and inter-ring region in Arp 143. In the X-ray luminous Seyfert I ring galaxy NGC 985, we present evidence for anomalously strong emission from the 16-20 micron PAH ″plateau″ as compared with the PAH feature at 11.2 microns. We suggest that the large ratio of this emission (L(16-20)/L(11.2)= 5.5), the largest yet seen in any galaxy nucleus, is the result of shocks, perhaps relating to a circumnuclear wind colliding with infalling molecular material--as suggested by previous BIMA, ISO, UV absorption line and XMM observations. Strong molecular hydrogen emission is also seen which may also have an origin in shocks.

217.05

A Radio Spectral Line Study of the 2-Jy IRAS-NVSS Sample

Maria Ximena Fernandez[1], E. Momjian[2], T. Ghosh[2], C. J. Salter[2]
[1]Vassar College, [2]NAIC.

We present HI 21-cm and OH 18-cm spectral line analysis of eighty-five luminous infrared galaxies from the 2 Jy IRAS-NVSS sample observed with the 305 m Arecibo Radio Telescope. We detected HI in 82 galaxies (16 new detections), and OH in 8 galaxies (4 new detections). In some cases, the HI spectra show the classic single-peak or double horn profile, while the majority exhibit distorted features indicating that the galaxies are in interacting/merging systems. The ULIRG IRAS 23327+2913 is discussed in greater detail since both HI emission and OH megamasing activity are new detections.

This ULIRG consists of two galaxies separated by 0.2 arcsec and it is thought to be an early-stage merger.

M.X.F. is grateful for NAIC/Arecibo Observatory’s summer research support. The Arecibo Observatory is part of the National Astronomy and Ionosphere Center, which is operated by Cornell University under a cooperative agreement with the National Science Foundation.

217.06

An Optical Datacube of Seyfert/Starburst Composite Galaxy NGC1365

Katie M. Chynoweth[1], R. A. Knop, Jr.[1], R. A. Gibbons[1]
[1]Vanderbilt Univ..

As part of a larger survey of nearby infrared luminous galaxies ($L_{IR} > 10^{11}, L_{\odot}$), we have obtained an R=2000 spectroscopic datacube of infrared-luminous starburst/Seyfert composite galaxy NGC~1365, using the SMARTS 1.5m telescope at CTIO. The spectra have 2.6’’ spatial resolution, and emission lines are mapped out to 24’’ away from the nucleus, using the SMARTS 1.5m telescope at CTIO. We present maps of line fluxes, line ratios, and velocities of the ionized gas as measured from the emission lines. These measurements allow us to determine the spatial extent of the starburst in the galaxy, and to measure kinematic signatures both of the AGN activity in the nucleus and any outflows or winds associated with the starburst.

218: The 3Ts: Telescopes, Technologies and Techniques for Astronomy Education
AAS Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

218.01

A Labview-controlled Small Radio Telescope

Robert L. Mutel[1], T. Jaeger[1], V. Poole[2]
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We have converted a Haystack-design small radio telescope (SRT) using a Labview virtual instrument control and user interface. In addition, we replaced the original Haystack digital receiver with a conventional superheterodyne receiver and 1024 channel autocorrelator. The advantages of this system over the original Haystack design are (1) a more modular, user-configurable interface, (2) a receiver system similar to traditional radio astronomical receivers with many test points accessible to students, and (3) better system sensitivity, since the entire 21 cm HI velocity range (2 MHz) is sampled simultaneously. We use this system to teach students the fundamentals of radio telescope and autocorrelation receiver instrumentation, as well as galactic rotation using the 21cm HI line. The Labview VI code will be available by Janu-ary 2007 at http://astro.physics.uiowa.edu/srt

218.02

GNAT Educational Opportunities

Roger B. Culver[1], E. R. Craine[2]
[1]Colorado State Univ./GNAT, [2]Western Research Company/GNAT.

The GNAT MG1 Catalogue of Variable Stars contains some 26,000 new variable star entries, many of which are short period variable stars with periods of one day or less. This reservoir of GNAT data provides virtually limitless opportunities for a variety of publishable follow-up observational projects for student involvement at every educational level from middle school through upper division undergraduate college, In addition, analyses of the source images can be employed in a variety of student projects addressing issues such as photometric properties of the night sky and monitoring of sky brightness. To this end, we have developed protocols and software tools to help non-science majors to understand how science is done, and to assist science majors in gaining experience and publications that will help secure their professional futures. We have been fortunate to work with a number of students, representing several colleges and universities, who have helped establish and test pilot programs for these student projects. We describe a number of sample projects as well as several preliminary pilot projects which are currently in progress. Procedures for working with GNAT on these and other projects are also discussed.

218.03

Las Cumbres Observatory Global Telescope Network: Keeping Education in the Dark

Rachel J. Ross[1], W. Geibink[1], W. E. Rosing[1], T. M. Brown[1]
[1]Las Cumbres Observatory.

The Las Cumbres Observatory Global Telescope Network is a privately funded, non-profit organization that is constructing two overlapping networks of robotic telescopes for scientific and educational uses. The educational network will consist of at least thirty 0.4 1.0 meter telescopes that will be longitudinally spaced around the world so that there will always be at least one (more likely several) in the dark at any given time. All will be equipped with high quality CCD imagers, with the 1.0 meters having spectrographs and possible infrared capabilities. All networked telescopes will have identical, completely online interfaces that allow you to control the telescope and use different imaging instruments in either real-time or queued modes. Any registered school or group will have the capability to remotely observe using a telescope that is currently in the dark from the comfort of their classroom or science center, half a world away. Accompanying the robotic observations will be a library of resources and activities that will be usable in the formal classroom setting, informal groups and clubs, and for public outreach in the community for all age-groups and levels of science. Using the LCOGT network as a tool to enjoy real astronomical research will not only create a new awareness for science and technology, but also create connections between science and humanities. We aim to always keep astronomy education in the dark.

218.04

The Little Thompson Observatory Receives the Retired Mt. Wilson 24-inch Telescope

Andrea E. Schweitzer[1]
[1]Little Thompson Obs..

The Little Thompson Observatory is a community-built E/PO observatory and is a member of the Telescopes in Education (TIE) project. The observatory is located on the grounds of Berthoud High School in northern Colorado. Annually we have approximately 5,000 visitors, which is roughly equal to the population of the small town of Berthoud.

During 2006 the LTO received the recently-retired 24-inch telescope from Mount Wilson. To provide a new home for this historic telescope, we are building a second dome and doubling the size of our observatory (all with volunteer labor), as well as refurbishing the telescope.

This past year we held a Colorado Project ASTRO-GEO workshop, and used the funding from our NASA ROSS E/PO grant for additional teacher workshops -making use of the baseball-sized meteorite that landed in Berthoud in 2004. The observatory also supported magnet high-school astronomy courses available to students from the surrounding school districts.

We thank the NASA ROSS E/PO program for providing funding.

218.05

NIRo Telescope: Research and Education

Adam W. Rengstorf[1], S. Slavin[1]
[1]Purdue University Calumet.

The Northwest Indiana Robotic (NIRo) Telescope is a 20-inch telescope and wide-field CCD imager to be used for remote, unattended observing. To be located in southern Lake County, IN, the NIRo Telescope will enjoy darker skies than those around the Purdue University Calumet (PUC) campus. While this project will enable high-quality research for the astronomy faculty and undergraduate students at PUC, its uniqueness lies in the planned education and outreach components. Using synoptic data from the telescope, we will, in conjunction with faculty from the PUC School of Education, develop curricula and assessment tools in line with Indiana earth and space science standards for grades 6 8. While small, robotic telescopes have been successfully used to implement similar programs for undergraduate and secondary education, this is, to the best of our knowledge, the first project to specifically target primary school education. This program will affect a wide range in ethnic and socioeconomic communities immediately surrounding the PUC campus in northwest Indiana. Data from the telescope will be reduced by PUC faculty and undergraduate researchers and disseminated to the participating schools for analysis and discovery and also archived for future use via a dedicated website. The website and its contents will then be accessible to the broader community, allowing schools outside the immediate region to view data and results and potentially participate in the educational component of our proposal.

218.06

Improved Undergraduate Astronomy Laboratories with A Modern Telescope Control System

Anthony J. Milano[1], D. Broder[2], R. Finn[2], H. Newberg[1], A. Weatherwax[2], D. Whittet[1]
[1]Rensselaer Polytechnic Institute, [2]Siena College.

We are in the middle of a cooperative astronomy education project to improve undergraduate laboratories at RPI (a PhD granting institution) and Siena College (a nearby liberal arts college). We have completed an overhaul of a 40-year-old, 16″ B&C telescope on the RPI campus, and have made it available for hundreds of students at both schools, and once per week to the public. We have written an assessment test which was distributed to the students at the beginning and end of the Fall 2006 semester, which will be used as a baseline to determine whether the laboratory activities, which are currently under development, improve student learning in the Fall 2007 semester next year. The studio-style, hands-on, inquiry-based laboratories will be designed to challenge student misconceptions. In order to handle a large number of students using the main telescope and a limited number of smaller telescopes, we will cycle students through concurrent activities. This is enabled by the rapid acquisition and imaging of targets made possible by the upgrade to the control system of our 16″ telescope. We demonstrate the productivity of our newly refurbished telescope, show the baseline results of our assessment, and present samples of activities under development. This project is funded by an NSF CCLI grant, 05-11340.

218.07

The MTSU Uranidrome: A Naked-Eye Observatory for Teaching Astronomy and Geometry

Eric W. Klumpe[1]
[1]Middle Tennessee State University.

Prior to the invention of the telescope astronomy was done with the naked eye. The astronomical models that ancient astronomers were able to construct based upon their naked-eye observations are impressive. Following those examples, Middle Tennessee State University has built a 30-meter diameter, naked-eye, observatory to serve as a hands-on teaching tool for astronomy and geometry. The primary goal is for astronomy students to use their own measurements to develop accurate models of how our solar system works and to better appreciate the creativity of ancient astronomers. Typical Uranidrome activities include measuring the axial tilt of the Earth, the latitude and longitude of MTSU, the spin rate and orbital rate of the Earth, the circumference of the Earth, true-north relative to magnetic-north, short-term predictions of eclipses, and using the Sun to determine the date and time.

The Uranidrome was funded by grants from NASA and Middle Tennessee State University.

218.08

New Searching Capability and OpenURL Linking in the ADS

Guenther Eichhorn[1], A. Accomazzi[1], C. S. Grant[1], E. Henneken[1], M. J. Kurtz[1], D. M. Thompson[1], S. S. Murray[1]
[1]SAO.

The ADS is the search system of choice for the astronomical community. It also covers a large part of the physics and physics/astronomy education literature. In order to make access to this system as easy as possible, we developed a Google-like interface version of our search form. This one-field search parses the user input and automatically detects author names and year ranges. Firefox users can set up their browser to have this search field installed in the top right corner search field to have even easier access to the ADS search capability. The basic search is available from the ADS Homepage at:

http://adsabs.harvard.edu

To aid with access to subscription journals the ADS now supports OpenURL linking. If your library supports an OpenURL server, you can specify this server in the ADS preference settings. All links to journal articles will then automatically be directed to the OpenURL with the appropriate link information. We provide a selection of known OpenURL servers to choose from. If your server is not in this list, please send the necessary information to ads@cfa.harvard.edu and we will include it in our list.

The ADS is funded by NASA grant NNG06GG68G.

218.09

The New Physics and Astronomy Education Portal of the Smithsonian/NASA Astrophysics Data System

Michael J. Kurtz[1], G. Eichhorn[1], A. Accomazzi[1], C. Grant[1], E. Henneken[1],

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The ADS announces the beta release of a new portal into the technical literature for physics and astronomy education. This project is being done in collaboration with ComPADRE.

Currently the collection contains about 30,000 articles covering the Science Education literature; key journals in the collection include Research in Science Education, Physical Review Special Topics Physics Education Research, The Physics Teacher, The American Journal of Physics, Physics Education, Journal of Research in Science Teaching, The International Journal of Science Education. Several other journals are also included, including some from nearby fields, such as computer science and chemistry education.

The system easily has the ability to include any individual article from the research literature of physics and astronomy (such as from the Physical Review or the Astrophysical Journal) either from current or historical research. We encourage educators to suggest such articles to us.

This is the beta release of a new system; we encourage comments, critisms and suggestions.

218.10

Sharing Images Intelligently: The Astronomical Visualization Metadata Standard

Robert L. Hurt[1], L. Christensen[2], A. Gauthier[3]
[1]*Spitzer Science Center/Caltech,* [2]*ESA/Hubble, Germany,* [3]*University of Arizona.*

The astronomical education and public outreach (EPO) community plays a key role in conveying the results of scientific research to the general public. A key product of EPO development is a variety of non-scientific public image resources, both derived from scientific observations and created as artistic visualizations of scientific results. This refers to general image formats such as JPEG, TIFF, PNG, GIF, not scientific FITS datasets. Such resources are currently scattered across the internet in a variety of galleries and archives, but are not searchable in any coherent or unified way.

Just as Virtual Observatory standards open up all data archives to a common query engine, the EPO community will benefit greatly from a similar mechanism for image search and retrieval.

A new standard has been developed for astronomical imagery defining a common set of content fields suited for the needs of astronomical visualizations. This encompasses images derived from data, artist's conceptions, simulations, photography, and can be ultimately extensible to video products.

The first generation of tools are now available to tag images with this metadata, which can be embedded with the image file using an XML-based format that functions similarly to a FITS header. As image collections are processed to include astronomy visualization metadata tags, extensive information providing educational context, credits, data sources, and even coordinate information will be readily accessible for uses spanning casual browsing, publication, and interactive media systems.

218.11

Ensuring Quality of Digital Library Learning Objects for Computational Physics and Astronomy Education

David A. Joiner[1]
[1]*Kean Univ..*

The Computational Science Education Reference Desk, a Pathway project of the National Science Digital Library, is establishing quality control processes to ensure quality of learning objects in its catalog. Objects in the catalog typically involve simulations, and we apply standard verification and validation processes for the simulation and modeling community to each object. Additionally, we use an accreditation process to ensure the appropriateness of materials for their intended audience. The process has been piloted initially with computational biology, chemistry, and mathematics materials in the CSERD catalog, and we are currently seeking reviewers to assist in the evaluation of objects in the fields of physics and astronomy. The initial testing of our review process has shown that a significant portion of the work in reviewing learning objects can be performed by appropriately selected undergraduates, and the results of using undergraduates in science-content degrees for validation testing as well as students in education degrees for accreditation testing will be discussed, along with ideas for using verification, validation, and accreditation of digital learning objects as a classroom activity. These questions of "Is the model well crafted, is the science right, and is the tool useful?" are fundamentally driven by the process of scientific inquiry and can be used to help students better understand the scientific method. This work supported by the National Science Foundation's NSDL program, DUE-0435187.

218.12

Appreciating Hubble at Hyper-speed: A Web-tool for Students and Teachers

Lisa M. Will[1], M. Mechtley[2], S. Cohen[2], R. A. Windhorst[2], S. Malhotra[2], J. Rhoads[2], N. Pirzkal[3], F. Summers[3]
[1]*Mesa Community College,* [2]*Arizona State University,* [3]*Space Telecope Science Institute.*

Even post-instruction, many high school students and non-science college majors lack a firm understanding of the basic concepts of physics and astronomy necessary to appreciate our expanding universe. To mitigate this trend, we are developing a state-of-the-art Web-tool called ″Appreciating Hubble at Hyper-speed″ (AHaH) that uses the HST Cycle 14 Treasury Project ″PEARS″ (Probing Evolution And Reionization through Spectra) data. AHaH will span the fully 3-dimensional PEARS database of the GOODS/HUDF galaxy distribution from redshifts $z = 0.05$ to $z = 6.5$, spanning nearly 90% of the history of the Universe. The web-tool AHaH will allow students to interactively zoom in/out of this PEARS data base, rotate, and accelerate/decelerate towards a specified target, and travel forward or backwards in time. Hence, students can make a complete interactive journey in look-back time. AHaH will help students learn and visually understand basic concepts of physics and astronomy, and at the same time allow them to explore how galaxies change when traveling back in time, how their light is redshifted, and how they are formed and clustered in the expanding Universe. This poster will describe the features of the web-tool and the services that will be offered to help teachers implement this tool in their classrooms.

218.13

Use Authentic Digital Sky Data to Investigate Earth's Motions

Rick Kang[1]
[1]*Friends of Pine Mountain Obs..*

Students being introduced to astronomy typically have a tough time grasping how the sky appears to change hourly/nightly and an even tougher time to relate these changes to Earth's motions. As good as recent sky simulators are, there are the issues of credibility and access. Exacerbating the problem is lack of time and opportunities for students to observe the real sky. During August, 2006, a group of 9th and 10th grade students attending an astronomy camp at University of Oregon's Pine Mountain Observatory, were directed to take wide field digital data to illustrate these sky motions. The data has been assembled into an online lesson plan at a link from http://pmo-sun.uoregon.edu/~pmo/.

Regardless of time of day, weather, or after school time constraints, students can now examine the real sky and synthesize a literal picture of the motions over short and long time intervals. Students can then derive the concepts of rotation and orbit of Earth.

218.14

Hera: Using NASA Astronomy Data in the Classroom

James C. Lochner[1], S. Mitchell[2], W. D. Pence[3]
[1]*USRA & NASA/GSFC,* [2]*SP Systems & NASA/GSFC,* [3]*NASA/GSFC.*

Hera is a free internet-based tool that provides students access to both analysis software and data for studying astronomical objects such as black holes, binary star systems, supernovae, and galaxies. Students use a subset of the same software, and experience the same analysis process, that an astronomer follows in analyzing data obtained from an orbiting satellite observatory. Hera is accompanied by a web-based tutorial which steps students through the science background, procedures for accessing the data, and using the Hera software. The web pages include a lesson plan in which students explore data from a binary star system containing a normal star and a black hole. The objective of the lesson is for students to use plotting, estimation, and statistical techniques to determine the orbital period. Students may then apply these techniques to a number of data sets and draw conclusions on the natures of the systems (for example, students discover that one system is an eclipsing binary). The web page tutorial is self-guided and contains a number of exercises; students can work independently or in groups. Hera has been use with high school students and in introductory astronomy classes in community colleges.

This poster describes Hera and its web-based tutorial. We outline the underlying software architecture, the development process, and its testing and classroom applications. We also describe the benefits to students in developing skills which extend basic science and math concepts into real applications.

218.15

Spitzer Space Telescope Research Program for Teachers and Students: Using Spitzer data in *your* classroom with (relatively) simple software

Theresa E. Roelofsen Moody[1], J. J. Feldmeier[2], V. Gorjian[3], B. Sepulveda[4], E. Sharma[4], T. Spuck[5], C. Weehler[6]
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The Spitzer Space Telescope Teacher Program is a collaboration between the Spitzer Science Center and the National Optical Astronomy Observatory. Through the program, twelve teachers were selected to submit observing proposals for time on the Spitzer Space Telescope. The *Intergalactic Star Formation in Tidal Dwarf Galaxies of M81* Project was one of those selected and awarded director's discretionary observing time to study a small region of an M81 tidal tail. This region had previously been observed at optical wavelengths and contained a candidate tidal dwarf galaxy. The four teachers involved in this project met at the Spitzer Science Center in August 2006 to analyze the data, using both IDL software and MaximDL software. The former software is generally too difficult for students to learn and is not easily accessible to most students and teachers. The latter is software that is readily available in public schools (at a cost <$500) and offers a graphical interface that can be easily manipulated by high school students. Using MSExcel, we were able to generate a simple conversion table to convert Maxim DL photometry values into flux and magnitudes. We compared the values obtained by MaximDL to values obtained by IDL astronomical software and found the results comparable. We feel that MaximDL, in combination with simple conversion spreadsheets, can be used to measure flux values with results comparable to those obtained through IDL. Thus, Spitzer data can now be analyzed and used in classrooms with access to both Maxim and Excel, without the need for IDL. In addition, Maxim can be used to produce three-color images. The team is being mentored by Dr. Varoujan Gorjian from the Spitzer Science Center and John Feldmeier from YSU. Please see our companion poster, Hedden et al. for our science results using these data.

218.16

MPS Internships in Public Science Education: Sensing the Radio Sky

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The intent of the "Sensing the Radio Sky" program is to teach high school students the concepts and relevance of radio astronomy through presentations in STARLAB portable planetariums. The two year program began in the summer of 2004 and was completed in December 2006. The program involved a team of 12 undergraduate physics and multimedia majors and four faculty mentors from Furman University, University of North Carolina-Asheville and Pisgah Astronomical Research Institute (PARI). One component of the program is the development and production of a projection cylinder for the portable STARLAB planetariums. The cylinder gives a thorough view of the Milky Way and of several other celestial sources in radio wavelengths, yet these images are difficult to perceive without prior knowledge of radio astronomy. Consequently, the Radio Sky team created a multimedia presentation to accompany the cylinder. This multimedia component contains six informative lessons on radio astronomy assembled by the physics interns and numerous illustrations and animations created by the multimedia interns. The cylinder and multimedia components complement each other and provide a unique, thorough, and highly intelligible perspective on radio astronomy. The final draft is complete and will be sent to Learning Technologies, Inc., for marketing to owners of STARLAB planetariums throughout the world. We acknowledge support from the NSF Internship in Public Science Education Program grant number 0324729.

219: YSO / Star Formation III
AAS Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

219.01

Young Spectroscopic Binary M Stars in Ophiuchus

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Because the size of the habitable zone around a low-mass star corresponds approximately to the separation of typical spectroscopic binaries in nearby star forming regions, the frequency and properties of these close binary systems have important consequences for potential terrestrial planet formation. Observations of spectroscopic binaries also provide mass ratios independent of many of the assumptions needed to convert visual binary magnitude differences into mass ratios. I present the results of a Keck II NIRSPEC survey of a uniform sample of several dozen T Tauri M stars in the Ophiuchus molecular cloud. The frequency of the young, low-mass, spectroscopic binaries discovered in this study is 12%, +/-3%, comparable to the field star spectroscopic binary frequency as well as the frequency for higher mass young stars in a sample culled from several star forming regions. There is therefore no dearth of these binaries at lower masses, however, it will be revealing to compare these results with similar studies in other star forming regions. This research was supported by NSF grant AST 04-44017 and awards from the NASA Keck PI Data Analysis Fund.

219.02

Keck HiRES Spectroscopy of Candidate Post T Tauri Stars

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We use high-signal-to-noise (between ~ 200-500), high resolution (R~45,000) KECK HIRES spectroscopy of 13 candidate post T Tauri stars in the field to derive basic physical parameters, lithium abundances and radial velocities. We utilize qualitative age information determined from Li abundances, chromospheric emission and kinematic UV plane positions to distinguish pre and post main sequence objects. Based on these criteria and H-R diagram position, we identify 5 probable post T Tauri stars. We also examine irregular variability using the HIPPARCOS photometry annex, and search for the presence of infrared excesses. We thank the South Carolina Space Grant Consortium for providing support for E.J.B. through the Graduate Student Research Fellowship and acknowledge support for this work by NSF grant AST 02-39518.

219.03

Spitzer IR Sudy of Sar Formation in an Embedded Young Cluster NGC2316

William Langer[1], T. Velusamy[1], T. Thompson[1]
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Observations of embedded young star clusters, still contained within their parent molecular clouds provide unique data of stars of similar age to study star formation issues, such as, (i) the IMF, (ii) the frequency and lifetimes of protoplanetary disks, (iii) the history of star formation in the cluster, (iv) the evolution of the cloud and its eventual dispersal, and (v) the subsequent termination or triggering of star formation. To analyze some of these issues we obtained Spitzer IRAC observations at 3.6, 4.5, 5.8, and 8μm and MIPS observations at 24μm of NGC 2316, a young (2-3 Myr) embedded star cluster containing a central HII region powered by a B3 star. In the infrared, we detect more than 200 objects in this cluster. We used Hires deconvolution to enable the detection of point sources more efficiently in the 5.8 and 8μm images (here point source detection is severely limited by the confusion from the bright HII region and the extended dust emission within the cluster). We present results on a statistically significant sample of young stars in this cluster and discuss some of the issues on star formation in the cluster environment, listed above.

This work was performed by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

219.04

SiO Masers in the Orion BN-KL Outflow

Christopher Beaumont[1], S. S. Doeleman[2]
[1]Calvin College, [2]MIT Haystack Observatory.

We present new maps of the v=1,2 J=1->0 transitions of silicon monoxide masers in the Orion KL nebula with data obtained using an array combining the VLA and the VLBA PieTown antenna. These masers are centered on Source I a continuum source thought to mark the position of a massive young star and provide a probe of the stellar environment on scales of tens of AU. The images in both maser transitions achieve angular resolutions of 50 milliarcsec, sufficient to search for the location of emission that has been resolved in previous Very Long Baseline Interferometry observations. Both vibrational maser transitions were registered by using a reference quasar observed for calibration purposes, and spatial offsets between the lines indicate gradients in physical conditions on AU scales. We review implications of these results on current models of the circumstellar environment of this massive Young Stellar Object.

219.05

Infrared and Optical Spectroscopy of Protostars in the Elephant Trunk Nebula

Dohy Faied[1], W. T. Reach[1], A. Tappe[1], J. Rho[1]
[1]Caltech.

We present Spitzer Space Telescope observations of the optically dark globule IC1396A. We have identified red objects located within the molecular globule to be Class I protostars, and objects scattered near the globule are found to be Class II T-Tauri stars surrounded by warm, luminous disks. We obtained simultaneous optical and infrared spectra (5.5 40 microns) with the Palomar Hale 200 inch telescope. The Class I sources were observed to have extremely red continua, rising at 24 microns, with deep silicate absorption at 9-11 microns, and weaker silicate absorption at around 12 microns. Some of these sources also display weak ice features such as CO2 and H2O. In contrast, the Class II sources have strong H-alpha emission and silicate emission features at 9-11 microns, indicative of circumstellar disks. These results all suggest that star formation within this globule is occurring at two different stages the first stage, leading to the Class II sources located in the center of the globule, and a second, very recent one (less than 100,000 yr ago) that is occurring within the globule. This second phase was likely triggered by the wind and radiation of the central O-type star of the IC 1396 H II region.

219.06

Statistical Analysis of the Relationship Between Rotation, Disks, and X-rays Among Low-Mass Pre-Main-Sequence Stars

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Two fundamental outstanding questions in the study of young, low-mass stars are (1) the evolution of angular momentum, and (2) the origin of X-ray emission. Indeed, low-mass stars are observed to decrease their angular momentum content by nearly an order of magnitude during the first ~100 Myr. These stars are also observed to produce X-rays at levels up to 3-4 orders of magnitude higher than the present-day Sun. However, the physical processes governing angular momentum loss and X-ray production during the pre-main-sequence (PMS) phase remain poorly understood. Circumstellar disks are thought to regulate stellar rotation via magnetic star-disk interaction. Stellar magnetic fields, possibly driven by rotation, may also be implicated in the production of X-rays, which may in turn affect disk ionization and thus the efficiency of star-disk coupling. Finally, all of these stellar properties − rotation, disks, X-rays − are dependent in varying degrees on stellar mass. Using a sample of 400 PMS stars with known rotation periods, disk tracers from *Spitzer*, and X-ray luminosities from *Chandra*, we perform a multivariate statistical analysis on the relationships among these manifold mutually correlated variables. Our aim is to discern the fundamental relationship between disks and stellar rotation, and between rotation and X-ray emission. Here we report preliminary results.

219.07

Pure Rotational H2 Emission from GSS 30 IRS 1

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We present spectra of the Class I embedded source GSS 30 IRS 1 covering four pure rotational H2 transitions: J=3-1 (17.0 um), J=4-2 (12.3 um), J=6-4 (8.0 um), and J=11-9 (4.7 um). The observations at 8 um and longer were taken with TEXES, a high resolution, mid-IR spectrograph, during its July Science Verification run at Gemini North. The 4.7 um observations come from NIRSPEC on Keck II. Fitting to the observations, we are able to investigate the temperature and mass of warm, emitting gas. We will discuss our results in the context of CO emission from the same object presented in Pontoppidan et al (2002).

This work was supported by the NSF and NASA.

219.08

Young Vega and Altair Analogs: Rotationally-Enhanced Activity in HD 169142 and HD 135344

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Interferometric studies of bright stars have demonstrated that some of the best studied A stars are rapid rotators which have 2000K latitudinal gradients in T_eff. This large temperature gradient has two important consequences: at A5 or later, such stars can support convection and may have enhanced activity and having depressed UV and FUV fluxes compared to slowly rotating stars. Both of these phenomena have implications for the evolution of protoplanetary disks and the habitability of young planets in such systems. Combining inclinations and v sin i data permits us to identify the rapid rotators among systems which are still accreting and with central disk clearing. For two near-ZAMS Herbig Ae/Fe stars, HD 169142 and HD 135344 with v>235 km/s we find both enhanced x-ray activity and emission in chromospheric and transition region species compared to more typically rotating mid-A and F members of the Beta Pictoris Moving Group (BPMG). Both stars have IR SEDs suggesting that the outer disks are relatively flat. To avoid shadowing of the outer disk under these circumstances, the inner disks are either geometrically thin or are partially devoid of material. The FUV data for HD 135344 are consistent with stellar activity without accretion, while HD 169142 has an X-ray pulse-height spectrum similar to non-accreting early F members of the BPMG. The inner disks in both systems are too large to have been produced by photo-evaporation alone, suggesting the presence of second bodies in the inner disk. For HD 169142, the X-ray spectrum is very soft, unlike young, low-mass stars, and suggesting in tandem with the brown dwarf desert within 100 AU of the star these systems may harbor gas-giant planets.

219.09

The Spin of Accreting Stars and Accretion-Powered Stellar Winds

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Young, accreting, pre-main-sequence stars are often observed to spin much more slowly than expected. This poster presents a scenario in which a powerful stellar wind removes enough angular momentum to explain the observed spin rates. We argue that the energy required to drive the stellar wind ultimately derives from accretion power, and we quantify the necessary conditions in the stellar wind.

This research was supported by the University of Virginia through a Levinson/VITA Fellowship.

219.10

The Gould's Belt Spitzer Legacy Project

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The Gould's Belt Spitzer Legacy Survey will complete the census of star formation in molecular clouds within 500 pc of the sun. Imaging observations with IRAC and MIPS will provide the crucial data shortward of 200 microns to match the data from large projects planned with SCUBA-2 on the JCMT (450 and 850 microns) and SPIRE (200 to 500 microns) on Herschel. Together with the clouds surveyed by the Cores to Disks (c2d) Spitzer Legacy program and clouds studied by GTO/GO programs, these observations will complete the census of star formation regions within 500 pc. Relevant Spitzer data on Gould's Belt clouds, including previous GTO/GO data, will be processed through the c2d pipeline to produce a uniform, complete, and unbiased database for studies of local star formation. Scientific goals include the following: determine which of the many dense cores detected by SCUBA-2 have embedded stars and which are starless; compile the statistics of objects in different evolutionary stages to obtain timescales for these stages, a fundamental check on theory; use the large sample to control for effects of enviroment on star formation; assess the fraction of star formation in distributed and clustered modes, including the number in groups of various sizes; combine the MIPS data with the submillimeter data to study the physical conditions in extended structures with a goal of understanding the formation of dense cores. In this poster we discuss some of these goals in more detail, and present some preliminary results based on data acquired thus far. This project is supported by NASA-JPL under Research Support Agreement no. 1288820.

219.11

The Cores to Disks (c2d) Spitzer Legacy Program: Summary of Resultson Evolution in Five Large Clouds

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We will summarize the primary results of the c2d project, with a focus on evolution from cores to disks in the five large clouds surveyed. Based on nearly 1000 YSOs that we have identified in these clouds,we assess the relative fraction in the different traditional classes and estimate the mean timescales for each class. Using measures of cloud mass from our extinction maps and determinations of dense core mass from millimeter continuum maps, we estimate star formation rates per unit mass of cloud material and per unit mass of dense gas. We also reexamine the traditional classification system, based on SED shape in the near-infrared to mid-infrared,and we suggest some alternative classifications that capture the different possible pathways from Class II to Class III.

219.12

Near-Infrared Spectroscopy of Young Binaries

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We present near-infrared spectra (R~2000) obtained with the SpeX instrument on the IRTF for 11 binary systems embedded in the nearby ρ Ophiuchi and Serpens dark Clouds. We find that: 6/11 young binary systems have both components exhibiting absorption lines, with 3/6 showing strong absorptions; 8/11 systems have at least one component exhibiting Brγ emission, indicative of active accretion; 8/11 systems have at least one component exhibiting significant continuum veiling, indicative of the presence of hot dust associated with the innermost regions of a disk. We also find 50% ''mixed'' systems, with one component exhibiting veiling (and therefore an associated disk), whereas the other does not, in spite of the fact that these systems are coeval. This result further supports the recent finding of a higher proportion of ''mixed'' systems among the Class I/Flat Spectrum objects than amongst the T-Tauri stars (Haisch, Barsony, Greene, & Ressler 2006, AJ, 132, in press). Finally, there is a trend for the most heavily veiled objects to also have Brackettγ emission, indicating the intimate association of gas accretion with the presence of circumstellar material in the innermost disk regions (as also found by Natta, Testi, & Randich 2006, A&A, 452, 245).

This work was supported by the NASA Faculty Fellows Program awarded to M.B. at NASA's Ames Research Center and by NSF AST-0206146 to M.B.

219.13

A Non-Magnetocentrifugal Jet Model for Young Stellar Objects

Peter T. Williams[1]
[1]M.O.I.O..

Many detailed observations of jet launching in young stellar objects (YSOs) appear consistent with magnetocentrifugal models of acceleration. This has been interpreted as support for these models. There are other possibilities, however.

In previous work, I described how turbulence driven by the magnetorotational instability (MRI) may help launch jets. As conceived and formulated, this jet launching mechanism is not magnetocentrifugal. The MRI-driven magnetohydrodynamic (MHD) turbulence creates hoop-stresses both on and above the midplane, and I suggested that these confine and collimate the outflow. This is fundamentally different from far-downstream hoop-stress collimation of jets beyond the Alfvén surface such as occurs in traditional magnetocentrifugal jet mechanisms. Indeed, in standard MHD wind theory, the hoop-stress must vanish on the midplane.

There now exist substantial observational constraints on several quantities fundamental to jet launching in YSOs, including the ratio of jet mass flux to accretion mass flux, the jet thrust, and the jet angular momentum flux. Here I show that this consistency is not as robust a test of magnetocentrifugal acceleration as might be hoped.

In particular, I construct a non-magnetocentrifugal jet model based on MRI-driven turbulent jet confinement and collimation. I show how this model may explain jets in YSOs consistently with the observational constraints, especially in high accretion-rate systems. Finally, I discuss potential observational discriminants between this preliminary model and the magnetocentrifugal class of models.

219.14

An Archive of Chandra Observations of Regions of Star Formation (ANCHORS)

Bradley D. Spitzbart[1], S. J. Wolk[1]
[1]Smithsonian Astrophysical Obs..

We announce the first wide public release of ANCHORS, an archive of Chandra observations of regions of star formation. It is designed to aid both the X-ray astronomer with a desire to compare X-ray datasets and the star formation astronomer wishing to compare stars across the spectrum. We are completing a Phase 2 reprocessing of all datasets (80+ observations, 50+ distinct fields) to provide improved analysis and greater uniformity. The data consist of X-ray source properties including position, net count rates, flux, hardness ratios, lightcurve statistics and plots. Spectra are fit using several models, with final parameters and plots recorded in the archive. Multiwavelength images and data are cross-linked to other resources such as 2MASS and SIMBAD. Results are easily accessible, searchable, and downloadable online. A Virtual Observatory SkyNode is in place for advanced searches and cross-matching. We will demonstrate the system, examine scientific pilot studies using the archive, and solicit users' feedback. This project is supported by Chandra archival grant AR5-6002A and NASA contract NAS8-39073.

219.15

Star Formation in the Gum Nebula: Cometary Globules CG4/6/SA101

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As a part of our on-going program to study star formation under various environments, we present preliminary results from our multi-wavelength study of a bright-rimmed cometary globule complex, CG4/6/SA101 in the Gum Nebula. These cometary clouds are photo-evaporating due to UV radiation from neighboring O stars ($10 < d < 100$ pc) in the Vela OB2 association. The intermediate and low-mass stars in these cometary clouds form in an environment that differs from both the quiet isolation of young stars in T-associations such as Taurus and the violently energetic environment like that of the Orion Nebula cluster (ONC). The moderate separation between the cometary clouds and the O stars creates a radiation environment that has an intensity intermediate between the Taurus and Orion star forming regions. Circumstellar material and accretion disks may last longer than those in ONC, yet may not survive as long as they would in an isolated region such as Taurus or TW Hya. We compare our results with other star forming regions under different environments.

219.16

Clustering around Herbig Ae/Be Stars

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One of the most interesting constraints on star formation models comes from the study of multiplicity of young stars as a function of mass. While multiplicity studies of low-mass T Tauri stars have been quite exhaustive, an unbiased and systematic investigation of multiplicity among intermediate-mass Herbig Ae/Be (HAEBE) stars is still lacking. HAEBE stars have masses in between the T Tauris and the elusive high mass young stars, for which the star formation process is still not well understood. We are therefore conducting a photometric and spectroscopic survey of HAEBE stars, to detect companions, establish their physical association with the primary and investigate their properties. The frequency and degree of multiplicity of HAEBE systems will provide new constraints on their formation mechanism. Here we present preliminary results of the BVRIJHK imaging survey (2.5x2.5 arcmin^2) to study clustering around HAEBE stars.

219.17

MOMIE: MIKE Observations of Mid-Infrared Excesses

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We have identified 36 B8--K main-sequence stars that exhibit a midbut not a near infrared excess from the Spitzer Space Telescope's Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE; Benjamin et al. 2003) and Mid-Course Space Experiment (MSX; Egan 2003) (Uzpen et al. 2006). We have obtained MIKE echelle observations of 15 of these objects. These sources have disk components ranging in temperature from 190-800 K and fractional infrared luminosity from 5.2x10^-4 1.3x10^-2. We also obtained observations of 5 of the 6 sources that exhibited a near-IR and mid-IR excess. These sources range in disk temperature 400-580 K and fractional infrared luminosity from 5.8x10^-2 2.0x10^-1. We highlight what the high resolution spectra for these sources reveals in terms of rotational velocities, gas accretion signatures, and stellar ages of mid-IR excess stars with putative circumstellar disks.

219.18

Visible Spectra of the Central Stars of Proplyds in Orion

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The Orion proplyds are of astrophysical interest because they offer a unique opportunity to study important aspects of protostellar and protoplanetary evolution. Proplyds offer the only opportunity known in which to study the effects of external ionization on this phase of young stellar object disk evolution in an external environment like that of the early Solar System.

Most proplyds have central stars or starlike objects visible in HST WFPC V continuum or narrow-band filters. The physical properties of the central stars are of interest in fully understanding these systems. Some of the observable IR SED of the disk comes from reprocessed emission from the central star and thus depends on central star properties. Also, accretion rates and disk lifetimes are affected by the mass of the central star.

We obtained one spectrum each of three central stars (218-354, 164-510, and 171-340) using the HST STIS instrument. With a spatial resolution of 0.05 arcsecond per pixel STIS easily resolved the central star in all three objects. The spatial resolution of STIS also permits a much more accurate subtraction of the bright nebular background than is possible with ground-based observations. Nebular contamination can be a significant source of error in performing spectral classification. We have completed our analysis and will report on the spectral types, masses, and luminosities for the three central stars.

219.19

An X-ray Survey of FU Orionis Stars andUnusual X-ray Emission from Embedded YoungStars in NGC 2071

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We present new results from the first X-ray survey of accreting FU Orionis stars (FUors) and a pointed X-ray observation of the infrared cluster near the reflection nebula NGC 2071 in the Orion B cloud. Both observations reveal unusual X-ray spectra that challenge interpretive models. FUors are low-mass pre-main sequence (PMS) stars that have undergone optical eruptions attributed to a large increase in the disk accretion rate. The prototype FU Ori and V1735 Cyg were both detected and show high temperature plasma typical of magnetic (e.g. coronal) emission. FU Ori also reveals a cooler component at kT = 0.7 keV viewed through lower absorption that could be shock-related, but a magnetic origin seems more likely (Skinner et al. 2006, ApJ, 643, 995). The IR cluster in NGC 2071 is one of the closest star-forming regions known to contain young high-mass stars. We have detected an unusual X-ray source within 1 arcsec of IRS-1, which is thought to be an embedded high-mass star. It drives a powerful outflow and is surrounded by a dense molecular disk or ring. The X-ray spectrum shows a hard continuum extending up to at least 8 keV and a broad fluorescent Fe line at 6.43 keV. The fluorescent line likely originates in cold nearby material (possibly the surrounding disk) illuminated by the heavily-absorbed X-ray source. This work is supported by NASA grants NNG05GJ15G, NNG05GK52G, and NNX06AE93G.

219.20

The Eagle Nebula: Pillars of Creation, EGGs, and PMS Stars in NGC 6611

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We report on our 78 ks Chandra ACIS-I observation of the Eagle Nebula (M16) and the young cluster NGC 6611. We detected a total of 1101 X-ray sources, most of which are PMS stars in the cluster. Near the tip of the one of the Pillars of Creation, we detect a luminous X-ray source M16ES-1 which we believe is a high mass embedded protostar perhaps heated by magnetically channeled wind shocks. We detected no X-rays from the EGGs, the evaporating gaseous globules first observed in a WFPC2 image by Hester et al. (1996) near the edges of the Pillars. The EGGs could contain condensations that are very early stages of low mass star formation. The nondetection of EGGs with embedded infrared sources at X-ray luminosities well below the low-mass PMS stars in Orion indicates either that the EGGs do not contain protostars or that at the very early stage of evolution low-mass protostars have not yet become X-ray active. We also report on the X-ray properties of the YSOs in NGC 6611 and compare their properties to the YSOs in the Orion Nebula Cluster and other young clusters.

This work is supported by NASA through grant H-04630D to the University of Colorado.

219.21

Outflows in the Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE)

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We have found over 200 objects in the GLIMPSE survey that appear to be outflows. These objects show excess emission in the [4.5] micron band compared to the other IRAC bands ([3.6], [5.8], and [8.0]). They are extended typically on scales of 10 arcseconds. We obtained molecular hydrogen (2.122 micron) images with the WIYN Observatory on three of the sources. The excess molecular hydrogen in each of the objects provides further evidence that these are shocked outflows from young stellar objects. We measured the [24] micron flux for each source available from the MIPSGAL Survey. The [8.0]-[24] colors are generally greater than 5, indicating that these are very young sources. In this poster we show sample images of selected outflow regions from GLIMPSE, MIPSGAL and WIYN, and discuss the energetics of the three sources with the ancillary WIYN data.

220: Fortune and Fame: Fellowships, Textbooks, Cartoons
AAS Poster, Wednesday, 9:20am-4:00pm, Exhibit Hall 4

220.01

The Lowell Observatory Predoctoral Program

Lisa A. Prato[1], W. M. Grundy[1]
[1]Lowell Observatory.

Lowell Observatory is pleased to announce the continuation of our Predoctoral Fellowship Program. This program is designed to provide unique research opportunities to graduate students in good standing currently enrolled at Ph.D. granting institutions. Several projects are available now in collaboration with Lowell staff astronomers; we anticipate the availability of an increasing variety of projects over the next years as construction of our new 4.2 meter Discovery Channel Telescope and corresponding instrumentation progresses. Student research is expected to lead to the completion of a thesis dissertation appropriate for graduation at the doctoral level at the student's home institution.

220.02

The Textbook of the Future: What Will It Look Like?

Harry L. Shipman[1], N. Finkelstein[2], D. McCray[3], M. Mac Low[4], D. Zollman[5]
[1]Univ. of Delaware, [2]University of Colorado, [3]Univ. of Colorado, [4]American Museum of Natural History, [5]Kansas State University.

In May 2006, a group of scientists, publishers, technology gurus, National Science Foundation officers, and other interested parties met for a few days to think collectively about the future of the textbook. We met because:

-The Web and search engines like Google change the relationship between students and information. If the textbook no longer needs to be encyclopedic, then what is its role?

--Knowing information is not enough. Our students, whether they follow academic or other careers, will need to know how to get information, evaluate it, and use it to solve real world problems. How can a textbook help students in these environments?

--The static, comprehensive narrative of a textbook does not always lend itself well to inquiry learning, which is strongly encouraged by science education research and by national science k-12 education standards.

How can textbooks support active, student-centered learning and support new faculty as they adopt it?

The workshop generated partial and uncertain answers to these questions, providing some ideas for the future, though not a complete roadmap. A metaphor that generated considerable support among the group was the idea of a textbook as a compact travel guide, like the Lonely Planet guides. It should be adaptable, and thus web-based, but it might still exist in paper form.

The participants discussed barriers on the path ahead. How will peer review, which many workshop participants value, be incorporated? What incentives could motivate textbook authors and publishers to produce truly innovative products? How will new technologies such as computer simulations & animations, electronic readers, and widely accessible databases reshape the role of the textbook in education?

Many workshop participants including this paper's authors acknowledge support from the NSF Distinguished Teaching Scholars Program and the NSF CAREER awards program.

220.03

Eustace Tilley Views our Profession: The Astronomer as Portrayed in the Cartoons of *The New Yorker* Magazine

Kenneth S. Rumstay[1]
[1]Valdosta State Univ..

Astronomy has always enjoyed broad public appeal, as evidenced by the extensive media attention given to the recent “demotion” of Pluto by the IAU. While public planetaria and college courses provide limited outreach, most members of the public have little formal exposure to astronomy as a scientific discipline. Consequently, public opinion as to what astronomers do is largely shaped by the news media and by popular culture.

One icon of “elite” popular culture is *The New Yorker* magazine. Founded by Harold Ross and his wife Jane Grant, *The New Yorker* was intended to be a sophisticated cosmopolitan humor magazine. The first issue appeared on newsstands on February 17, 1925. While humor was always an important aspect of the magazine, *The New Yorker* quickly established itself as a forum for serious journalism and fiction. It currently boasts a worldwide circulation of well over one million readers.

For many readers the cartoons are the highlight of each issue of *The New Yorker*, and since its first issue more than 70,000 have appeared in print. These have been analyzed to see how professional astronomers are typically portrayed. Not surprisingly, the average reader would conclude that observational astronomy is done almost exclusively at visible wavelengths with ground-based telescopes, usually large-aperture refractors which protrude through the slit of a traditional hemispherical dome. In a few cases the artist has been inspired by a real (and readily recognizable) telescope. Radio and space-based telescopes are rarely cartoon subjects. The professional astronomer is typically portrayed as a middle-aged male, unfortunate when one considers the large representation of women in our field. Amateur astronomy appears with surprising frequency, but rarely as a serious pursuit. Finally, astronomical objects (Pluto, Halley’s comet, etc.) frequently appear as cartoon subjects when they have been in the news, but rarely otherwise.

221: Biology of Astrobiology I Extremes of Earth Life AAS Special, Wednesday, 10:00-11:30am, 611-12

Chair

Sanjoy Som[1]
[1]University of Washington.

Chair

Woodruff T. Sullivan[1]
[1]Univ. of Washington.

221.01

The Dark, Hot Biosphere on Earth and Elsewhere

John Baross[1]
[1]UW School of Oceanography.

The subseafloor is one of the modeled settings for the earliest microbial ecosystem. The subseafloor is a site of ubiquitous and active geophysical processes, such as hydrothermal activity. There are two types of hydrothermal processes that drive warmto hightemperature fluid flow in the subseafloor. These include magma hosted and ultramafic-rock (rocks with high iron and magnesium content such as olivine) hosted systems. Both can result in hot fluids that can be acid or alkaline and both can generate carbon and chemical energy sources, along with other elements required for life. The implication is that submarine hydrothermal systems can both generate and support life without the need for oxidants produced by photosynthesis. Moreover, there is evidence that microorganisms that thrive in the hot subseafloor are the most ancient of extant life. These hyperthermopilic microorganisms (capable of growth >80°C) are capable of exploiting the chemical energy sources at vents including hydrogen and sulfur and use carbon dioxide or abiotically produced organic compounds as carbon sources. In the absence of a light-driven ecosystem, other planets and moons would have to have a source of chemical energy and other inorganic nutrients to maintain an active microbial ecosystem. The presence of hydrothermal systems would provide these nutrients. Clearly, any evidence for hydrothermal activity on Mars or Europa would greatly increase the chance for the existence of microbial life that would use predictable carbon and energy sources. Moreover, if hydrothermal systems exist on Europa and other icy moons, or in the deep subsurface of Mars, than the resultant carbon and energy source could reach into the cold ocean of Europa or into the Martian regolith. By this rationale, Enceladus, which shows evidence for hydrothermal activity, should be a focus for future life-detection missions.

221.02

Of Ice and Microbes

Jody Deming[1]
[1]School of Oceanography.

Inuit hunters of the North have long recognized ice as the natural state of water from which life flows on Earth. Although unaware of the microscopic world, they chart changes in properties of ice and water that derive from a succession of microbial inhabitants. Scientific hunters of the West have largely overlooked all but the warmest of ices as dynamic scenes of microbial life, considering the frozen realm to archive life forms instead. Deeply frozen glacial ice on Earth does appear to preserve microbes effectively, but isn’t the ocean beneath the geologically dynamic ice of Europa believed too salty? Aren’t the subsurface ices of Mars expected to be rich in all manner of mineralogical impurities? Wherever salt and other mineral impurities are sufficiently abundant in Earth ice, the ice contains interior liquid water that can range from nano-layer films on grain surfaces (glacial ice) to a porous network of brine (Arctic winter sea ice down to 20°C). Other recent studies of saline ices have indicated a world of interacting life forms, with viruses infecting bacteria in brines at -12°C (the lowest temperature tested), the domains of Bacteria and Archaea undergoing succession in winter ices (down to -28°C), and evidence that cellular maintenance may go forward incrementally even below the eutectic of seawater (-55°C). Microbes are also known to alter the physical properties of their icy homes by producing exopolymers that further depress the freezing point, either directly or by entraining more salt into the ice. Even the most inhospitable of ices to human hunters may contain interior oases for microbes, in control to some degree of their own space. In considering the habitability of icy worlds beyond Earth, we’d do well to learn more about the evolutionary prowess of microbes in adapting to conditions beyond our warm-blooded imaginations.

222: Optical Cluster Finding: SDSS, RCS, DEEP AAS Special, Wednesday, 10:00-11:30am, 613-14

Chair

Timothy A. McKay[1]
[1]University of Michigan.

222.01

Photometrically Identified Clusters from the RCS

Michael Gladders[1], RCS Collaboration
[1]University of Chicago.

The Red-Sequence Cluster Surveys (RCS-1, now complete, and RCS-2, ongoing) are a pair of large optical surveys comprising about 1100 square degrees of imaging, designed to find clusters to redshifts beyond one. In addition to a description of the surveys and the expected sensitivities, I will present a number of recent results, including the cosmological analysis of RCS-1, and many new strong lenses found in RCS-2.

222.02

Optical Clusters from SDSS Imaging: The MaxBCG Cluster Catalog

Ben Koester[1]
[1]University of Michigan.

Several wide-angle CCD-imaging surveys on the horizon propose large galaxy cluster searches as a means for extracting cosmological information. The recently completed Sloan Digital Sky Survey (SDSS) serves as a testing ground for such programs, which demand immense cluster catalogs covering a range of masses, with accurate photometric redshifts and mass proxies, and with well-understood selection functions made possible by realistic mock galaxy catalogs.

In this talk, we present one of the first such samples: the publicly-available MaxBCG optical cluster catalog. 13,823 galaxy clusters and large groups with 10 or more bright red galaxies are detected in nearly 8000 square degrees of 5-band SDSS imaging using the maxBCG method, which detects clusters by exploiting 1) their observed color and spatial clustering and 2) the presence of a bright cluster galaxy (BCG). The catalog is approximately volume-limited and covers redshifts $0.1 < z < 0.3$, and masses $> 1 \times 10^{14}$ solar masses, making it the largest cluster sample constructed to date. Using high-fidelity mock galaxy catalogs, we show the sample to be $>90\%$ complete for masses $> 2 \times 10^{14}$ and $>90\%$ pure for systems with $>$ 10 bright red galaxies. The photometric redshifts are measured with $\sigma_z <$ 0.015, and the richnesses are shown to scale well with dynamical mass.

This catalog forms the foundation for a range of ongoing low-redshift studies which aim to calibrate the observable-mass relation, cross-correlate optical observables with those at radio and X--ray wavelengths, and develop methods for quantifying the cluster selection function in imaging-based cluster samples in an effort to constrain cosmological parameters.

222.03

Groups and Clusters in DEEP2: The Evolution of Massive Halos and their Contents over 10 Gyr

Brian Gerke[1]
[1]UC-Berkeley.

The DEEP2 Galaxy Redshift Survey has produced the largest sample of optically selected galaxy groups and clusters currently available at z~1. By comparing the DEEP2 sample to local surveys, it will be possible to learn a great deal about large-scale structure formation and galaxy evolution. In this talk, I will discuss the identification of groups and clusters in DEEP2 and describe an ongoing project to compare DEEP2 groups to the low-redshift 2PIGG group sample from the 2dFGRS. By measuring the mass-to-light ratios of dark matter halos at different redshifts, this work will provide an important means to refine theories of galaxy formation. In addition, by measuring the mass function of groups and clusters, and its evolution from z~1 to the present day, this work will place important new constraints on cosmological parameters, including the equation of state of the dark energy.

222.04

Cluster Mass Profiles and Mass-to-light Ratios from Weak Lensing in the SDSS

Erin Sheldon[1]
[1]New York University.

The Maxbcg catalog of galaxy clusters, created from 7500 square degrees of Sloan Digital Sky Survey (SDSS) imaging data, is the largest yet assembled. These objects, ranging from small groups to massive clusters, provide an excellent laboratory to study the formation of structures in our universe. I will present measurements of the mean radial mass profile measured from weak gravitational lensing as a function of cluster richness and luminosity. The wide area of the SDSS allows measurements ranging from the inner halo (25 kpc) well into the surrounding large scale structure (30 Mpc). As predicted by the cold dark matter model, these mass profiles have a distinctive non-power law shape. They are well described by a universal NFW profile in the inner halo and linear correlations on large scales. The virial mass scales strongly with cluster richness. We also measure the total light of the galaxies in and around the clusters. The light is distributed in the cluster differently than the mass, with the light being more centrally concentrated. We find that the mass to light ratio is scale dependent and asymptotically approaches the same global value on large scales, independent of cluster mass.

222.05

Simulating Galaxy Populations in Clusters

Risa H. Wechsler[1]
[1]Stanford University.

The recent generation of large surveys (e.g., SDSS, 2dF, RCS, and DEEP) has ushered in a new era of optical cluster finding, which is likely to continue well into the future with photometric surveys like the DES and LSST. These large optical cluster studies hold promise both for powerful cosmological constraints and for constraining the connection between galaxies and dark matter halos. However, fulfilling either of these goals requires a detailed understanding of the selection effects of the relevant cluster finder and a robust and well-understood way to calibrate the mass scale, which can be challenging for photometrically-selected catalogs. The best way to do this is with simulations that have galaxy populations with photometric and clustering properties that are as realistic as possible. I will describe one method for doing so, which allows the creation of large mock galaxy catalogs with properties (number density, luminosity function, color distribution and evolution, and luminosity and color dependent clustering) that are in excellent agreement with those of bright galaxies in the Sloan Digital Sky Survey. These catalogs associate galaxies with dark matter in large volume simulations using only the smoothed density field, and allow us to detail the accuracy with which we can recover the relation between observed cluster properties and dark halo masses for a given cluster finding method. I will describe their application to deriving cosmological constrains from the maxBCG cluster catalog. I will then discuss complementary techniques and the improvements that will be necessary to take optical cluster cosmology to the next level.

223: AGN General Properties and Relativistic Jet Acceleration.
AAS Oral, Wednesday, 10:00-11:30am, 6A

223.01

Probing the Black Hole-Galaxy Connection with AGN Host Galaxy Morphologies

Brooke Simmons[1], C. M. Urry[1], COSMOS Team
[1]Yale Univ..

There is increasing evidence that galaxies and supermassive black holes form and evolve together, exerting mutual feedback that governs the galaxy dynamics and the black hole mass. During their growth phase, supermassive black holes are readily visible as Active Galactic Nuclei (AGN). The morphologies of AGN host galaxies offer a powerful, direct probe of the AGN-galaxy connection. We are carrying out morphological analysis of large AGN samples from deep multi-wavelength surveys, comparing the results to well-selected samples of inactive galaxies. To interpret the results properly requires understanding the observational bias introduced by the central point source, which can hide compact features and thus influence the extracted AGN host morphological parameters. Therefore, we performed extensive simulations, involving a variety of galaxy types over a range of redshifts. Here we present results of these simulations and describe preliminary work on deep HST ACS images from the COSMOS field.

We gratefully acknowledge support from HST grants AR-10689.01-A and GO-09822.09-A, and Yale University.

223.02D

Refining the Radius-Luminosity Relationship for AGNs

Misty C. Bentz[1], B. M. Peterson[1], R. W. Pogge[1]
[1]Ohio State Univ..

We more accurately quantify the relationship between the size of the broad-line region (BLR) and the luminosity in active galactic nuclei. The radius-luminosity (R-L) relationship is the fundamental basis for estimating the masses of AGNs, such as distant quasars, where direct mass measurements cannot be performed. As such, it is crucial that our calibration of the R-L relationship be as accurate as possible to mitigate the effects of systematic errors in mass estimates. We account for host-galaxy contamination in luminosity measurements of reverberation-mapped AGN using images from the Hubble Space Telescope's Advanced Camera for Surveys High Resolution Channel. The images were fit with 2-dimensional models of a disk, bulge, and central point spread function (PSF). A PSF-subtracted image was then created, from which we calculated the host galaxy starlight contribution at 5100 Å through the ground-based monitoring aperture geometry. The host-galaxy starlight contribution was then subtracted from the spectroscopic luminosity noted for each object during its ground-based monitoring campaign. Additionally, we have carried out a new reverberation-mapping campaign at MDM Observatory to replace earlier inadequate BLR radius measurements for NGC 4151, and NGC 4593, two objects that were initially studied in the early days of monitoring campaigns where the timescales and data requirements were not yet fully understood. We have recalibrated the radius-luminosity relationship by including host-galaxy starlight corrections to the spectroscopic luminosity and new measurements for the radius of the BLR in these two objects. We find a power law slope of ~0.5, a much shallower slope than has previously been found, and consistent with naïve expectations from simple photoionization arguments. This recalibration has an especially large effect on mass estimates at the low mass end.

223.03D

Models of the Molecular Interstellar Medium in Starbursts and AGN from z=0-6

Desika T. Narayanan[1], T. Cox[2], S. Chakrabarti[2], R. Dave[1], T. Di Matteo[3], B. Kelly[1], L. Hernquist[2], P. Hopkins[2], C. Kulesa[1], Y. Li[2], B. Robertson[4], C. Walker[1]
[1]Univ. of Arizona, [2]CfA, [3]CMU, [4]KICP, University of Chicago.

Recent pioneering CO observations of infrared luminous galaxies and AGN at high-z allow us to study coevolution of black hole growth and star formation in galaxies during the heydey of massive galaxy formation. However, little is known concerning the physical nature of these crucial galaxies, and the relationship between the central AGN, ISM, and host galaxy properties to the observed CO emission. In order to provide a framework for an interpretation of these observations, I investigate the nature of the CO emission in starburst galaxies and quasars by combining a 3D non-LTE radiative transfer code with cosmological and galaxy merger hydrodynamic simulations. Here, I highlight recent results from these simulations. Specifically, I will discuss the following: 1. The effect of black hole growth and starbursts on CO emission patterns; 2. The role of galactic winds on CO emission morphologies and line profiles; 3. The nature of CO emission in z~6 Quasars, and how we might use this to constrain models of primordial galaxy formation.

223.04

The Black Hole Mass and Eddington Ratio Distributions of the 2QZ

Christopher A. Onken[1], J. A. Kollmeier[2]
[1]Herzberg Inst. of Astrophys., Canada, [2]OCIW & Princeton.

From the 25000+ AGNs in the 2dF QSO Redshift Survey (2QZ), we select the ~5000 AGNs for which the 2QZ spectra provide reliable estimates of the black hole (BH) mass. We measure BH masses with the virial relations and compute the Eddington ratio for each object. We compare the distributions of BH mass and Eddington ratio to those of AGN surveys with complementary coverage in redshift and luminosity. Measurement of these distributions over a range of z and L provides a key observational benchmark for models of AGN evolution and galaxy-BH co-evolution.

223.05

Radiation from Relativistic Poynting Jets and Collisionless Shocks

Edison P. Liang[1], K. Noguchi[1], S. Sugiyama[2]
[1]Rice Univ., [2]Osaka University, Japan.

We present PIC simulation results of radiation from particles accelerated by Poynting jets (electromagnetic-dominated directed outflows) and relativistic collisionless shocks, both popular paradigms for gamma-ray burst (GRB) prompt emissions. We show how the radiation power output, polarization, and spectra depend on the ejecta Lorentz factor, magnetic field, ion loading and density contrast between ejecta and upstream matter. We find that in all cases the intrinsic radiation output of the highest energy particles is many orders of magnitude below that of classical synchrotron radiation because these particles are accelerated to first order by forces parallel, not perpendicular, to their momentum. We also show results for inverse Comptonization of blackbody soft photons, and discuss their implications for interpreting GRB light curves and spectra.

223.06

Local Electron Acceleration in GRB Shocks

Mikhail Medvedev[1]
[1]Univ. of Kansas.

The shock model of gamma-ray bursts (GRBs) has two free parameters: ε_B *and* ε_e *-the magnetic energy density and the kinetic energy density of the electrons relative to the total energy density of the shock, respectively. The Weibel shock theory confirmed by numerical simulations gives us physical insight into microphysics of the GRB shocks. It has been shown that* ε_B *should range between few x* 10^{-3} *and few x* 10^{-4}*. However, how to calculate the value of* ε_e *has been an outstanding theoretical problem for over a decade. Here we demonstrate that the Weibel theory inevitably predicts that* $\varepsilon_B \sim \sqrt{\varepsilon_e}$*. The GRB afterglow data fully agree with this theoretical prediction. Our result explains why the electrons are close to equipartition in GRBs. This* ε_B*--*ε_e *relation can potentially be used to reduce the number of free parameters in afterglow*

models.

224: CMB Theory and 21 cm Cosmology
AAS Oral, Wednesday, 10:00-11:30am, 6B

224.01D

Probing the First Sources with the Redshifted 21 cm Line

Jonathan R. Pritchard[1], S. R. Furlanetto[2], M. Kamionkowski[1]
[1]Caltech, [2]Yale.

Observations of the redshifted 21 cm line offer a promising probe of early radiation backgrounds. Anisotropies in the 21 cm signal arise from fluctuations in the IGM temperature, density, and neutral fraction and through the Lyman alpha flux. These fluctuations contain a wealth of information on the background radiation field at UV and X-ray frequencies. Before reionization, spatial variation in the Lyman alpha flux from the first sources imprints information about the source distribution on the 21 cm signal. Later, as the IGM is heated by X-rays, inhomogeneous heating leads to gas temperature fluctuations whose detection could constrain the luminosity and spectrum of the first X-ray sources. In this talk, I will discuss theoretical models for both of these mechanisms and outline the possiblities for detection with future experiments. I will also comment on the effect of these sources on galaxy formation. This work was supported at Caltech in part by DoE DE-FG0392-ER40701.

224.02D

Revealing the Epoch of Reionization with Redshifted 21 cm Measurements

Judd D. Bowman[1]
[1]*MIT.*

Within the next two years, the Mileura Widefield Array_Low Frequency Demonstrator (MWA-LFD) will begin observations leading toward the detection of redshifted 21 cm emission from neutral hydrogen gas in the high-redshift (z>6) intergalactic medium (IGM). We present the first realistic simulations to characterize the ability of the upcoming measurements to isolate foreground contaminants and constrain the reionization signal.

The redshifted 21 cm hyperfine line of neutral hydrogen gas in the high-redshift IGM is an extraordinary resource for studying some of the most pressing topics in contemporary astrophysics, including the nature of the first luminous objects and the processes responsible for reionization, structure formation, and inflationary cosmology. The extent to which this resource can be exploited, however, depends on the success of a new class of low-frequency radio arrays, including the MWA-LFD, that are pioneering new approaches to radio astronomy. The MWA-LFD is currently under development in Western Australia and is designed specifically to detect the power spectrum of fluctuations in the 21 cm emission between redshifts 6 and 12. When completed, the array will consist of 500 phased-array antenna tiles that are sensitive to wavelengths between 1 and 3 meters (300 to 100 MHz) and scattered over a 1.5 km diameter region.

The separation of Galactic and extragalactic foreground contaminants from the desired signal will be a significant challenge. As with the cosmic microwave background, the astrophysical foregrounds in redshifted 21 cm measurements are approximately five orders of magnitude brighter than the (~10 mK) signal and can only be isolated due to their spectral properties. We describe the foreground sources and the unique properties of the MWA-LFD; and discuss the derived foreground contamination and the implications for the interpretation with the upcoming measurements of the underlying processes responsible for reionization.

224.03

Integrated Sachs-Wolfe Effect Tomography

Shirley Ho[1], C. Hirata[2], N. Padmanabhan[3], U. Seljak[4]
[1]*Princeton Univ.,* [2]*Institute of Advanced Studies,* [3]*Lawrence Berkeley Lab/ UC Berkeley,* [4]*International Center for Theoretical Physics, Italy.*

We use the Integrated Sachs-Wolfe (ISW) effect to probe the evolution of the gravitational potential from redshift 0.1-2. We cross-correlate the temperature fluctuations in the CMB measured by the WMAP satellite with three low redshift tracers of the matter distribution : the 2MASS galaxy sample (z=0.0-0.3), the SDSS Luminous Red Galaxies (z=0.2-0.6), and SDSS quasars (z=0.7-2.5). We present results from a combined analysis of these data, including constraints on cosmological parameters.

224.04

Measurement of Gigaparsec-Scale Perturbation Modes with Remote Quadrupole Observations

Emory F. Bunn[1]
[1]*Univ. of Richmond.*

Observations of cosmic microwave background (CMB) anisotropy suggest the possibility that the Universe is not statistically isotropic --that is, that it has a preferred direction. Because of the well-known problem of intepretation of a posteriori statistics, the statistical significance of these claims is controversial. To settle the question we need an independent data set probing the same physical scales. Scattering of CMB radiation in galaxy clusters may provide the information we need. Such scattering produces a polarization signal proportional to the CMB quadrupole anisotropy at the cluster's location and lookback time, thus probing ultra-large-scale perturbations. I will present calculations of the number of independent modes that can be obtained from such a ″remote quadrupole'' survey, along with the length scales probed by these modes. These modes can be chosen to be statistically uncorrelated with local CMB anisotropy and polarization measurements, thus providing the needed independent probe of the gigaparsec-scale Universe. In a sparse survey of a large area of sky, the largest-scale modes probe length scales comparable to the large-angle CMB anisotropy but with much narrower Fourier-space window functions. Instruments such as the South Pole Telescope will have the sensitivity to detect remote quadrupole signals, although confusion may prove to be an obstacle. In addition to large-scale modes, the formalism presented here is also useful for analyzing smaller-scale surveys to probe the late integrated Sachs-Wolfe effect and hence the properties of dark energy.

224.05

Sunyaev-Zeldovich effect from Active Galactic Nuclei

Suchetana Chatterjee[1], A. Kosowsky[1]
[1]*Univ. Of Pittsburgh.*

The observed x-ray luminosity Temperature relationship of the diffused intercluster medium clearly shows the effect of non-thermal heating on formation of galaxy clusters. Quasar feedback into the inter galactic medium can be potentially an important source, in producing the level of preheating required and can have great impact on structure formation. Using an one-dimensional Sedov-Taylor solution for modelling the outflow scales, we have studied the effect of this feedback process in the thermal Sunyaev-Zeldovich distortions of the cosmic microwave background. We have calculated the angular power spectrum of the temperature distortion, which appears to have a maximum amplitude of the order of a μK . We have also discussed the implications of this signal in the context of the upcoming Millimeter wave observations.

This research was funded by the National Science Foudation through grant AST-0408698

224.06

Improving the Cosmological Recombination Calculation

Wan Yan Wong[1], D. Scott[1]
[1]*Univ. Of British Columbia, Canada.*

In this era of high precision cosmology, the theoretical calculation of anisotropies C_l in the cosmic microwave background (CMB) should be well below the 1% level in order to avoid biasing the estimates of cosmological parameters. The dominant uncertainty in computing the anisotropies is the precise recombination calculation, which determines the profile of the last scattering surface. We revisit the multi-level atom calculation of recombination (without any thermal equilibrium assumptions for the excited states) and investigate the relevant forbidden transitions for hydrogen and helium, for example, the two-photon transitions and the semi-forbidden transitions for HeI. We find that the most significant change in ionization fraction x_e comes from the intercombination, spin-forbidden transition (triplet 2P state to singlet 1S ground state) for HeI, which produces a more than 1% change in both x_e and C_l (in the range of l from 2 to 2500) compared with the results from the current version of RECFAST. We also discuss some other effects proposed previously in the literature and show that several such corrections have been over-estimated. Improved calculation of atomic transition rates, as well as increasingly complex multi-level atom computations, are required to achieve sub-precision accuracy on C_ls. In other words: in order to probe 10^15 GeV physics we need to know eV physics extraordinarily well.

225: COSMOS and Other Surveys
AAS Oral, Wednesday, 10:00-11:30am, 605-07

225.01

First Results from S-COSMOS: the Spitzer Legacy Survey of the HST-ACS 2sq.deg. Field

David B. Sanders[1], M. Salvato[2], O. Ilbert[1], H. Aussel[3], J. Kartaltepe[1], J. Surace[4], D. Frayer[4], K. Sheth[4], N. Scoville[2], B. Bhattacharya[4], T. Brooke[2], G. Helou[2], L. Yan[4]
[1]Univ. of Hawaii, [2]Caltech, [3]CEA/Saclay, France, [4]SSC/Caltech.

The Spitzer-COSMOS survey (S-COSMOS) is a Legacy program (Cycles 2+3) designed to carry out a uniform deep survey of the full 2-deg^2 COSMOS field in all seven Spitzer (IRAC + MIPS) bands (3.6, 4.5, 5.6, 8.0, 24, 70, 160μm). Our Cycle 2 observations show that the observed infrared backgrounds in the S-COSMOS field are smooth and within 10% of the predicted background levels, and appear to be devoid of any significant cirrus contamination. Our first analysis results confirm that S-COSMOS will have sufficient sensitivity with IRAC to detect L^* disks and spheroids out to $z >$ 3, and with MIPS-24 to detect ultra-luminous starbursts and AGN out to $z \sim$ 3. We also discuss the IRAC and MIPS colors of galaxies detected in the MIPS-deep "Test area" observed in Cycle 2, and relate the optical properties of these nearand mid-infrared selected objects to the "red sequence" and "blue cloud" colors used to characterize the galaxy population in deep optical surveys.

225.02

Large Structures and Galaxy Evolution in the COSMOS Survey

Nicholas Scoville[1]
[1]Caltech.

We have indentified Large Scale Structures in the COSMOS Survey field at z < 1.1 from photometric redshifts. Forty LSS are found with stellar masses

up to 2x10^13 solar masses. We investigate the evolution of key galactic properties -mass, luminosity, SED and star formation rate (SFR) -with redshift and environmental density.

225.03

The Evolution of Bulges in COSMOS Spirals

Kartik Sheth[1], L. Spalsbury[1], N. Scoville[1], COSMOS Collaboration
[1]Caltech.

We present results from an analysis of the B/D ratio in over 4000 L* spiral galaxies at z<0.8 from the Cosmic Evolution Survey (COSMOS). Preliminary analysis shows a monotonic increase by a factor of 2--3 in the median B/D ratio. But the change is predominantly seen in bluer (late Hubble type) galaxies. The decreasing star formation rate in disks may explain this trend. However, in galaxies between T-type 2 and 3, the B/D ratio does not evolve, suggesting that bulges in these spirals were already present by z~0.8.

225.04

Morphology of z~0.7 Star-forming Galaxies from Deep GALEX Imaging of the COSMOS Field

Michel A. Zamojski[1], D. Schiminovich[1], M. Rich[2], B. Mobasher[3], A. M. Koekemoer[3], P. Capak[4], GALEX Team, COSMOS Team
[1]Columbia Univ., [2]UCLA, [3]Space Telescope Science Institute, [4]Caltech.

We selected a sample of 8,146 galaxies with brightness *F814W*(HST) < 23 mag (AB) and photometric redshifts in the range 0.55 < z < 0.8 from the COSMOS field, 5,777 of which are detected in the GALEX near-ultraviolet band (2310Å) down to a limiting magnitude of 25.5 (AB), to study the relation between star formation and galaxy morphology at a redshift of z ~ 0.7. For all galaxies in our sample, we computed, from the ACS F814W images, their concentration (C), asymmetry (A) and clumpiness (S) as well as their Gini coefficient (G) and the second moment of their light distribution (M20). We observe a bimodality in the galaxy population in asymmetry and in clumpiness, with the separation being most evident when either of those parameters is combined with a concentration-like parameter (C, G or M20). We see a strong correspondence between this morphological bimodality and the red and blue sequence color bimodality, suggesting that color and morphological evolution occur concurrently and on similar time scales. We further observe many of the most star-forming galaxies to have compact dusty disks with important bulges and morphologies approaching that of early-type galaxies, which we interpret as evidence that strong starburst events can bring galaxies from the blue sequence onto the red sequence while simultaneously modifying their morphology accordingly.

225.05D

The X-ray Evolution of Early-Type Galaxies in the Extended Chandra Deep Field-South

Bret Lehmer[1]
[1]Pennsylvania State University.

We investigate the evolution over the last 6.3 Gyr of cosmic time (i.e., since z = 0.7) of the average X-ray properties of early-type galaxies within the Extended Chandra Deep Field-South (E-CDF-S). We utilize the deep Chandra observations over the E-CDF-S and X-ray stacking analyses to constrain primarily the average X-ray emission from normal early-type galaxies (i.e., those that are not dominated by luminous active galactic nuclei [AGNs]). We study separately optically luminous (L_B = 10^10-10^11 L_B,sol) and faint (L_B = 10^9.3-10^10 L_B,sol) samples of early-type galaxies, which are expected to have 0.5-2.0 keV emission dominated by hot interstellar gas and low mass X-ray binaries (LMXBs), respectively. For our optically luminous early-type galaxies, we find that the average X-ray power output has not evolved significantly since z = 0.7, indicating there must be a general balance between the heating and cooling of the hot interstellar gas over this redshift range. If such a balance is maintained as a result of AGN feedback, then on average 1-5% of the bolometric AGN output would go into heating the hot gas. For our optically faint early-type galaxies, we find suggestive evidence for a rise in average X-ray power with redshift, possibly due to global changes in LMXB populations with redshift; however, due to relatively low numbers of sources, we consider this result to be marginal at present.

225.06

Revealing the Star-formation History of the Universe up to z=2.5 from Deep Radio Surveys

Nick Seymour[1], I. McHardy[2], M. Page[3], D. Moss[2], T. Dwelly[2]
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The true nature of the faint radio population remains elusive despite the many observations of the ''sub-mJy'' bump over the last two decades. This lack of information is largely due to the faint magnitudes of the optical counterparts to the radio sources. There are strong theoretical reasons (and a few observational ones) to believe that this rise in the counts is due to the emergence of a rapidly evolving star-forming population. Now, for the first time, we are able to separate the AGN and star-forming populations below 1mJy using a combination of multi-wavelength data from Spitzer, GMRT, CFHT, Chandra and XMM-Newton. The many discriminators include MIR colours, MIR/radio flux ratios, X-ray luminosities/spectra, optical spectra, radio morphologies and radio spectra. We can now derive the source counts seperately for AGN and star-forming galaxies confirming that the latter population dominate at faint flux densities. We also derive the star-formation rate density from radio sources across 0<z<2.5 which is found to be similar to previous results at other wavelengths. We also find strong evidence for ''downsizing'', where most of the star-formation is in massive galaxies at high redshift whereas less massive galaxies dominate the local star-formation rate. Furthermore we discuss the effects of the presence of both obscured and un-obscured AGN in star-burst galaxies.

225.07

The Nature of Lyman Alpha Emitters at z=3.1 in the MUSYC Survey

Eric J. Gawiser[1], C. Gronwall[2], R. Ciardullo[2], H. Francke[3], P. G. van Dokkum[1], J. Feldmeier[4], C. M. Urry[1], MUSYC Collaboration
[1]Yale Univ., [2]Penn State, [3]U. de Chile, Chile, [4]Youngstown St..

The Multiwavelength Survey by Yale-Chile (MUSYC) consists of deep UBVRIzJHK+NB5000 coverage of 1.2 square degrees comprised of four fields. Satellite coverage includes Spitzer-IRAC+MIPS, HST-ACS, GALEX, XMM and Chandra. Multi-object spectroscopy has been obtained with Magellan+IMACS, VLT+VIMOS, and Gemini+GNIRS. MUSYC has used these data to investigate Lyman Alpha Emitters, Lyman break galaxies, Distant red galaxies, Damped Lyman alpha absorption systems, and AGN in the same volume of the universe in order to separate physical properties from selection effects. We have shown that Lyman Alpha Emitters at z=3.1 are predominantly dimmer than the R<25.5 Lyman break galaxies but have similar blue continuua, little dust, average star formation rates of 6 M_sun/yr and an average stellar mass of 5x10^8 M_sun (Gawiser et al. 2006, ApJ 642, L13). Only 2% of these objects show evidence for AGN via X-ray emission or high-ionization emission lines. We will also present other properties of the Lyman Alpha Emitters, including their space density, luminosity function, cosmic star formation rate density, correlation function and dark matter halo mass. A data release of images and catalogs is available at http://www.astro.yale.edu/MUSYC .

We gratefully acknowledge support from NSF grants 00-71238, 01-37927 and HST AR10324.01A, Yale University, and Fundacion Andes. EG and JF acknowledge the support of NSF Astronomy & Astrophysics Postdoctoral Fellowships.

225.08

Cosmic Shear and its Redshift Evolution from the Deep Lens Survey

Vera E. Margoniner[1], D. M. Wittman[1], D. Rusin[1], T. Tyson[1], I. P. Dell'Antonio[2]
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The Deep Lens Survey (DLS; http://dls.physics.ucdavis.edu/) is a ultra-deep multi-band (BVRz) optical survey of 20 square degrees, which an observation scheme that maximizes lensing measurements, while providing color information. From the best seeing images we derive shape measurements, and from the multi-band observations we estimate photometric redshifts with an uncertainty of ~10% in (1+z) per galaxy. After 5 years (~120 nights) of observations with mosaic CCD imagers at NOAO's Blanco and Mayall 4-meter telescopes, we have very recently completed data acquisition for the survey.

In 2005, we presented the first cosmic shear results from the DLS, based on one or our five 4-square degree fields. Here we present measurement of cosmic shear and its redshift evolution from the entire 20 square degree survey.

226: Extrasolar Planets II
AAS Oral, Wednesday, 10:00-11:30am, 608-10

226.01D

Results From the KELT Transit Survey

Joshua Pepper[1]
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The Kilodegree Extremely Little Telescope (KELT) survey is a wide-field, small aperture transit survey of bright stars. The project objective is to discover transits of bright ($8 < V < 10$) stars suitable for intensive follow-up. The project has completed commissioning campaigns on the Hyades and Praesepe, and is well into a multi-year survey of a large portion of the Northern Hemisphere. I will present the results of our commissioning data, including both newly discovered variable stars and the best transit candidates. I will also present initial results from the main survey.

226.02D

Detection and Exploration of Planets from the Trans-atlantic Exoplanet Survey

Francis T. O'Donovan[1], D. Charbonneau[2], L. Hillenbrand[1]
[1]California Institute of Technology, [2]Harvard-Smithsonian Center for Astrophysics.

The Trans-atlantic Exoplanet Survey (TrES) is a network of three small-aperture telescopes dedicated to searching the skies for new transiting extrasolar gas giants. The TrES team have discovered two of the 14 known transiting exoplanets. We discuss the detection and exploration of these nearby planets and present the latest observations of TrES-2. TrES-2 is the most massive of the nearby transiting planets, and the first transiting planet found within the field of view of the NASA Kepler transit-search mission. TrES was motivated by our incomplete understanding of the structure and composition of highly-insolated gas giants, and is one of several wide-field photometric campaigns to find new transiting planets. Astrophysical false positives, such as grazing eclipsing binaries, are the dominant source of transit-like periodic signals from these campaigns. Hence follow-up observations are required for all planet candidates. In particular, recent experience has highlighted the need for careful analysis to eliminate astronomical systems where light from a faint eclipsing binary is blended with that from a bright star. We present here examples of the procedure followed by the TrES network to identify false positive candidates. This material is based upon work supported by the National Aeronautics and Space Administration under grant NNG05GJ29G, issued through the Origins of Solar Systems Program.

226.03D

An L' and M-band AO Imaging Survey for Extrasolar Giant Planets: Progress and Preliminary Results

Aren Heinze[1], P. Hinz[1], S. Sivanandam[1], M. Meyer[1]
[1]Univ. of Arizona.

Self luminous extrasolar giant planets can in principle be imaged by ground based telescopes equipped with adaptive optics (AO) systems at a variety of infrared wavelengths. The H band (1.6 microns) has been most widely used in surveys for such planets. However, interesting complementary results can be obtained with observations at longer wavelength, in particular the L' band (3.8 microns). We summarize our technique, and describe preliminary results. Our survey is complementary to other work in that we observe nearby, older stars, while H band surveys target younger stars that tend to be more distant. This division of targets comes about because the H band planet/star brightness ratio falls quickly as planets age and cool, while the same ratio in L' remains more favorable for older stars. Because our target sample is comprised of stars closer to the sun, we are sensitive to planets in orbits as close-in as our own Jupiter and Saturn. We have chosen F through early M stars as our survey targets to match (roughly) the samples of radial velocity surveys. This should allow us to constrain the observed distributions of planets as a function of planetary mass and orbital radius and compare with results for closer-in planets from radial velocity surveys. Our sample consists of about 50 stars within 25pc, with ages from 0.1 to about 2 Gyr, chosen so that our predicted sensitivity limit for each target corresponds to less than 10 Jupiter masses. To date, we have completed about half of our survey, and have developed careful strategies to maximize sensitivity and detect and characterize any real sources. We report on these, and on the sensitivity we have obtained.

226.04

Astrometric Discovery of M-Dwarf Planets

Steven H. Pravdo[1], S. B. Shaklan[1], M. J. Ireland[2], P. G. Tuthill[3]
[1]JPL, Caltech, [2]Caltech, [3]U. of Syndney, Australia.

The ultimate goal of the Stellar Planet Survey (STEPS) program is to discover planetary companions to M-dwarfs. A secondary goal is to inventory all other low mass companions and their properties. Thus far these have been other M-dwarfs and at least one brown dwarf (BD), GJ 802B, that is one of the few BD to have a dynamical mass measurement. With increased temporal baseline the data have become more sensitive to extra-solar giant planets (EGPs). In addition collaborative imaging efforts have complemented the astrometric work. One such technique is adaptive optics imaging with a non-redundant mask. This talk describes the program, the collaborative work, and the recent results, including a possible EGP discovery. The research described in this talk was performed in part by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

226.05

A KECK HIRES Doppler Search for Planets Orbiting Metal-Poor Dwarfs. II. On the Frequency of Short-Period Giant Planets in the Low-Metallicity Regime

Alessandro Sozzetti[1], D. W. Latham[1], G. Torres[1], B. W. Carney[2], A. P. Boss[3], J. B. Laird[4], R. P. Stefanik[1]
[1]Harvard-Smithsonian, CfA, [2]University of North Carolina, [3]Carnegie Institution of Washington, [4]Bowling Green State University.

We present an analysis of four years of high-precision Doppler measurements with Keck HIRES, searching for giant planets within 1 AU of a well-defined sample of field metal-poor dwarfs in the solar neighborhood. We report on variability, periodicity, and long-term radial-velocity trends for each star. We place upper limits on the companion mass as a function of orbital period and eccentricity. We examine the implications of our results for the observed orbital elements and mass distributions of extrasolar planets. Finally, we place meaningful constraints on the frequency of close-in giant planets around metal-deficient ([Fe/H] < -0.5) dwarfs, thereby helping to distinguish between proposed scenarios of gas giant planet formation.

226.06

The All Sky Extrasolar Planet Survey Using New Generation Multi-object Keck Exoplanet Tracker Instruments at the SDSS 2.5m telescope

Jian Ge[1], J. C. van Eyken, M[1], S. Mahadevan[1], X. Wan[1], B. Zhao[1], A. Hariharan[1], C. DeWitt[1], P. Guo[1], R. Cohen[1], S. W. Fleming[1], J. Crepp[1], C. Warner[1], S. Kane[1], F. Leger[2], K. Pan[3], S. Snedden[3], S. Shaklan[4], E. Ford[5], D. P. Schneider[6], S. Seager[7], E. Agol[8], H. Ford[9]
[1]Univ. of Florida, [2]Fermilab, [3]Apache Point Observatory, [4]JPL, [5]CFA, Harvard University, [6]Penn State, [7]Carnegie Institution of Washington, [8]Univ. of Washington, [9]John Hopkins University.

All Sky Extrasolar Planet Survey (ASEPS) will use the Sloan 2.5-m wide field telescope and multiple-object high-throughput W.M. Keck Exoplanet Tracker (Keck ET) Doppler instruments to undertake a large-scale visible and near-IR band Doppler survey of relatively bright stars (generally V < 13 for the visible and J < 11 for the near IR) for extrasolar planets. During 2008-2013, ASEPS could search as many as ~250,000 stars to find thousands of planets. An extended survey continuing until ~2020 could survey an additional ~250,000 stars and obtain information on long-period planets from the earlier detected planet sample, possibly detecting many solar analogs. ASEPS aims to increase the number of known extrasolar planets by nearly two orders of magnitude (~10,000 planets in the 12-year survey using all clear nights). This dramatic increase in the number of known planets would allow astronomers to study correlations among the diverse properties of extrasolar planets much more effectively than at present. Additionally, the large number of planet discoveries will enable the detection of rare planets that may have eluded previous planet searches. Early results from the first Keck ET commissioning and also a trial planet survey will be presented.

227: Gamma-Ray Bursts
AAS Oral, Wednesday, 10:00-11:30am, 3B

227.01

GRB 060607A: A Bright Early Optical Afterglow with Minimal Prompt Emission

Stephen Holland[1], Swift Science Team
[1]NASA's GSFC & USRA.

The afterglow of the $z = 3.08$ gamma-ray burst GRB 060607A shows a remarkable, broad, strong peak in the optical reaching maximum brightness at 180 s post-trigger, and not coincident with the strong early-time flares seen in the *X*-ray and gamma-ray energy bands. The optical rise is sharp, with an increase of nearly 3 mag occurring in roughly 100 s. The initial rise is followed by a slow decay for about the next 1000 s. Optical light curves in several bands show weak evidence for variability superposed on an exponential rise and power-law decay. An episode of nearly constant emission starts about 1000 s after the trigger and lasts for several hundred seconds before fading resumes. While previous optical afterglows have been observed with a well-sampled flare during times with simultaneous *X*-ray and gamma ray data, the afterglow of GRB 060607A is unique compared to the others in that it shows no evidence for correlated prompt emission. This allows us to test predictions that assert that early optical flux is a convolution of a prompt component and a related delayed response component, which is dependent on properties of the system.

227.02D

A Multi-wavelength Perspective on the GRB-SN Connection

Alicia M. Soderberg[1]
[1]Caltech.

With the discovery of Type Ic SNe 1998bw and 2006aj in association with nearby GRB 980425 and XRF 060218, respectively, a new class of cosmic explosion has been identified. In comparison with typical GRBs, these events are sub-energtic by a factor of 100 but are up to 10 times more common. Moreover, they are distinguished from ordinary Type Ibc supernovae by the presense of a central engine. These intermediate explosions are identified through radio observations which probe relativistic material. Motivated by SN 1998bw, we began a comprehensive study of local Type Ibc SNe with the Very Large Array in 1999. Since then we have observed ~150 optically-selected local (d < 150 Mpc) SNe Ibc, each within a few weeks of explosion. This six-year effort has resulted in two key advances. The first is a clear distinction between GRBs/XRFs and ordinary SNe Ibc: engine-driven explosions are rare, less than 3% of the local sample, and couple at least 10^{48} erg to mildly-relativistic ejecta. Second, we find a wide dispersion in the radio properties of SNe Ibc, implying significant variations in their ejecta properties, environments and/or progenitor systems. I will discuss the surprising results of our ongoing survey and the complex picture of stellar death that is emerging.

227.03

Pulse-Width Evolution of Late Time X-ray flares in GRBs

Daniel Kocevski[1], N. Butler[1], J. Bloom[1]
[1]UC Berkeley.

We employ a variety of techniques to examine the timing and variability of late time x-ray flares observed in GRBs by the XRT instrument aboard the

Swift spacecraft. These flares are thought to be indicative of late time activity by the central engine that powers the GRB and produced by means similar to those which produce the prompt emission. We use a Bayesian block denoising procedure to study the overall temporal properties of the flares and a Haar wavelet analysis to look for an evolution of the fundamental variability time-scale between the prompt and late time emission. We find evidence for pulse width evolution in the host frame of 17 flares as well as a qualitative trend of decreasing variability as a function of the flare's time of peak flux which we interpret as evidence of an expanding and cooling emitting region.

227.04

X-ray Flares in GRB Afterglows: Spectral and Temporal Characteristics

David Morris[1]
[1]PSU.

The frequent presence of x-ray flares in GRB afterglows is one of the surprising discoveries of the Swift mission. We present time-resolved, spectral and temporal analysis of simultaneous XRT and BAT data for a select sample of bright x-ray flares. Our goal is to investigate the nature of the flare emission mechanism. Spectrally, we examine whether a simple powerlaw spectrum is adequate to describe the flare at all times or whether a higher order model such as an exponentially cutoff powerlaw, Band function or thermal model is required. We also examine spectral evolution within individual bright flares and between multiple flares within a single GRB. Temporally, we examine the power density spectra of the flares for evidence of a characteristic slope as has been reported in studies of GRB prompt emission. We discuss our results in the context of whether a common mechanism, namely activity of the GRB central engine, is responsible for both GRB prompt emission and x-ray flares.

227.05

Observations of Unusual Gamma-ray Burst Afterglows with the Robotic Palomar 60-inch Telescope

Stephen B. Cenko[1]
[1]Caltech.

We present a brief overview of the roboticized Palomar 60-inch telescope, as well as scientific highlights from the first two years of operation. The facility was designed for moderately fast (t ~ 3 minutes) and sustained (R < 23 mag) observations of gamma-ray burst (GRB) afterglows. Early-time, multi-color P60 observations, coupled with complementary high-energy data from Swift, made GRB 050820A one of the select few events with contemporaneous optical, X-ray, and gamma-ray observations. This event was optically bright enough to monitor for over one week with P60; coupled with radio data from the Very Large Array, X-ray data from Swift, and late-time Hubble Space Telescope observations, GRB 050820A is one of the best studied events in the Swift era. We have also obtained a multi-color light curve of XRF 060218 / SN2006aj with P60. Combined with regular spectroscopic monitoring from Palomar, Keck, and Gemini, we present a detailed study of the properties of this unusual transient. Finally, we conclude with a discussion on the future of transient astronomy with P60 and other robotic facilities.

227.06D

Afterglow and Environment of the High-redshift GRB 050904

Lijun Gou[1], D. Fox[1], P. Meszaros[1]
[1]Penn State Univ..

GRB 050904, at redshift z=6.3, is the highest-redshift gamma-ray burst detected to-date. Apart from its extreme redshift, which places it in the first billion years of cosmic history, this event is interesting in two additional respects: First, it exhibited a fast-evolving flare in the X-ray and near-infrared (NIR) bands that peaked approximately 450 seconds after the gamma-ray trigger; and second, its afterglow exhibited a relatively slow decay in the NIR from 0.5 to 1.0 days after the burst, coincident with repeated and energetic flaring activity in the X-ray band. We have made a complete analysis of the available X-ray, NIR, and radio afterglow observations, utilizing afterglow models that incorporate a range of physical effects not previously considered in addressing this or any other GRB afterglow. In particular, using a Markov Chain Monte Carlo method, we investigate the possibility that the early flare is due to synchrotron and inverse Compton emission from the reverse shock regions of the outflow, and we suggest that inverse Compton interactions of X-ray flare photons suppress the NIR flux, accounting for the interval of slow decay in the NIR. We will present and discuss in detail the results of our model fits, which imply that GRB 050904 had substantially greater (beaming-corrected) kinetic energy than typical GRBs at low redshift.

227.07

GRB 060614 Opens a New Window on Short and Long Burst Categorization

Neil Gehrels[1], Swift Team
[1]NASA's GSFC.

We have learned in the Swift era that short and long bursts have very different origin. Short burst are produced by old-population stars, perhaps through binary mergers. Long bursts are produced by young-population stars, most likely as a collapsar. Until last summer, all well-observed long bursts at low redshift (z<0.2) had associated supernova explosions. GRB 060614 is an important exception. It is a long burst with a duration of 100 s that was located in a star-forming galaxy at z=0.125 but had no supernova detected to stringent limits. We show that the spectral lag for this event groups it with short bursts. Implications will be presented.

228: Star Clusters I
AAS Oral, Wednesday, 10:00-11:30am, 204

228.01

The Convergence Age of the Globular Cluster NGC 6397

Harvey B. Richer[1], B. M. Hansen[2], S. Davis[1], J. Anderson[3], G. G. Fahlman[4], J. S. Kalirai[5], I. R. King[6], M. Rich[2], M. M. Shara[7], P. B. Stetson[4]
[1]Univ. of British Columbia, Canada, [2]UCLA, [3]Rice University, [4]Herzberg Institute of Astrophysics, Canada, [5]UCSC, [6]Univ. of Washington, [7]AMNH.

NGC 6397 was imaged with HST/ACS for a total of 126 orbits. The imaging was done in two filters, F606W and F814W. With proper motion cleaning from archival WFPC2 data, we have constructed a color-magnitude diagram for this cluster which reaches to unprecedented depth. In particular, we have detected a truncation in the white dwarf cooling sequence and what appears to be the termination of the hydrogen-burning main sequence. This has allowed us to determine the cluster age by two largely independent techniques, from the main sequence turnoff and from the cooling white dwarfs. We present these ages and compare them with ages of other globular clusters, the age of the Universe, and the white dwarf cooling age of the Galactic thin disk.

228.02

Globular Clusters in a Globular Cluster

Jason S. Kalirai[1], H. Richer[2], J. Anderson[3], J. Strader[1], K. Forde[1]
[1]UC, Santa Cruz, [2]University of British Columbia, Canada, [3]Rice University.

We present one of the deepest optical images ever taken with the Hubble Space Telescope Advanced Camera for Surveys, a 126 orbit integration

of a small field within the nearby Galactic globular cluster NGC 6397. The data set allows us to construct a very clean, deep (V = 30)

color-magnitude diagram from which we study the stellar populations of this cluster (see Richer et al. abstract at this meeting). In analyzing the distribution of objects across the deep image of NGC 6397, we discovered an unexpectedly high concentration of several hundred faint, blue point-like sources in one region of the image. A closer look revealed the presence of a large background elliptical galaxy at the center of this distribution of unresolved sources. These objects are themselves extragalactic star clusters bound to this elliptical galaxy. We measure a redshift for the galaxy using the Gemini/GMOS spectrograph and conclude that this is one of the furthest samples of star clusters ever studied and therefore could potentially hold

important clues for understanding the evolution of globular clusters.

This research was funded by grants from NASA/STScI.

228.03

Are white dwarfs born with a 'KICK'?

Saul Davis[1], H. B. Richer[1], J. Coffey[1], J. Anderson[2], J. Brewer[1], G. G. Fahlman[3], B. M. Hansen[4], J. Hurley[5], J. S. Kalirai[6], I. R. King[7], D. Reitzel[4], R. M. Rich[1], M. R. Rich[4], M. M. Shara[8]
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The unusually large kinetic energies possessed by some pulsars, as inferred from their observed velocities in excess of the escape speed of the Galaxy, imply that the violent explosions in which they are born impart some fraction of their energy into the motion of the pulsar. Does a similar, but less energetic process occur during the birth of a white dwarf? Two major Hubble Space Telescope imaging campaigns of the two nearest globular star clusters, NGC 6397 and Messier 4, yield the radial distribution of both white dwarfs and main-sequences. Because globular clusters are relaxed populations, the velocity dispersion, and hence radial distribution, for stars of a particular mass is directly dependent on that mass. To first approximation, all white dwarf s have a mass of 0.55 M⊙. If white dwarfs are not born with a kick, we expect white dwarf s of an age younger than a relaxation time to have a radial distribution similar to main-sequence stars of 0.8 M⊙ i.e.~the mass of their progenitor. Conversely, if white dwarf s are born with a kick, the radial distribution of white dwarfs younger than the relaxation time should mimic that of main-sequence stars of lesser mass. By comparing the radial distributions of white dwarfs of various ages with those of main-sequence stars of various masses in these two globular clusters, we find that the radial distributions of young white dwarfs are most similar to that of main-sequence stars of 0.2 M⊙, implying a natal kick of $>$1.6 km/s.

228.04

Chemical Composition of Globulars of the Sagittarius System

Marta Mottini[1], G. Wallerstein[1], A. McWilliam[2]
[1]University of Washington, [2]Observatories of the Carnegie Institution of Washington.

We will present results about the abundances of iron, alpha-elements, and the r-process element Eu of six red giant stars belonging to Sagittarius globular clusters Terzan 8 and Arp 2. The Sagittarius dwarf galaxy (Sgr) offers an opportunity to study the chemical evolution of a galaxy very different from the Milky Way. Detailed chemical composition measurements of the Sgr globular clusters (GCs) will permit us to define the differences between this dwarf galaxy and the Milky Way, that would provide a check on current ideas in the chemical evolution, place constraints on the star formation rate and IMF in the Sgr, and set limits on the accretion of objects similar to Sgr in the construction of the Galactic halo. Thus, it is particularly important to have a complete census of the handful of GCs (M54, Terzan 7, Pal 12, Terzan 8, and Arp 2) associated with the Sgr galaxy. Well determined chemical composition for the most metal-poor Sgr GCs would be very useful, as currently there is data only for M54. Photometric estimates suggest that Ter 8 and Arp 2 have metallicities near -1.6 and -2.0 dex respectively. Thus, these two GCs are vital to our knowledge of the metal-poor Sgr GC population and they are also thought to be among the oldest GCs in the Sgr system, so their measured abundances would significantly clarify the age-composition relation of the Sgr dwarf galaxy. With the scenario described above in mind, we have collected high-resolution spectra of six red giant stars to undertake the first detailed chemical abundance analysis of globular clusters Terzan 8 and Arp 2. Spectra with resolving power of 40,000 and spectral range between 3400 and 9400 A were obtained with the echelle spectrograph MIKE mounted on the 6.5m telescope at Las Campanas Observatory.

228.05

NGC 346: Mass Function at Low Metallicity

Elena Sabbi[1], M. Sabbi[2], A. Nota[2], M. Tosi[3], J. Gallagher, III[4], M. Meixner[1], S. Oey[5]
[1]STScI, [2]STScI/ESA, Space Telescope Operation Division, [3]INAF-Osservatorio Astronomico di Bologna, Italy, [4]University of Wisconsin, [5]UNIVERSITY of Michigan.

The Small Magellanic Cloud (SMC) is an ideal "empirical" laboratory to study the impact of low-metallicity (Z=0.004) and low-dust content (30 times lower than our Galaxy) on the star formation process. In addition its close proximity allows us to perform a detailed and accurate census of its stellar content.

In the quest of understanding how star formation occurs and propagates in the SMC, we acquired deep F555W and F814W HST/ACS images of NGC 346, the most massive and active star forming region of this galaxy.

Our observations allowed us to sample the luminosity function of NGC 346 down to a limiting magnitude of m(F555W)=26.5. Our observations reveal that NGC 346 stellar content is concentrated in a number of small compact sub-clusters, which vary in density and morphology.

We present the luminosity function and the present-day mass function of NGC 346 in the 0.8-40 Mo range, with the goal to establish whether differences in the dust-to-gas ratio have an impact on the slope(s) of the stellar mass function.

Variations of the mass function with radial distance from the center of gravity of NGC 346 will indicate whether the stellar association is mass segregated.

We also present the mass distribution of the sub-clusters we identified in the area, and their spatial mass distribution.

We discuss the implication of our results for our understanding of star cluster formation and evolution.

228.06

The B and Be Star Population of NGC 3766

M. V. McSwain[1]
[1]Yale Univ..

I present results from a spectroscopic monitoring program of B and Be stars in the open cluster NGC 3766. From a 4-year time baseline of photometric and spectroscopic data, I have identified 9 Be stars in the cluster that have undergone disk outbursts or whose disks have disappeared. Using Kurucz ATLAS9 model spectra to measure temperatures, gravities, rotational velocities, and abundances among the cluster members, I present preliminary results of the stellar and cluster properties that may affect the long term variability of Be stars. M.V.M. is supported by an NSF Astronomy and Astrophysics Postdoctoral Fellowship under award AST-0401460.

229: The Supernova Legacy Survey and other SN Ia Surveys
AAS Oral, Wednesday, 10:00-11:30am, 3A

229.01

Galaxy Clustering in Environments of Type Ia Supernovae from the CFHT Supernova Legacy Survey (SNLS).

Melissa L. Graham[1], C. J. Pritchet[1], Supernova Legacy Survey
[1]University of Victoria, Canada.

The Canada-France-Hawaii Telescope Supernovae Legacy Survey (CFHT SNLS) has created the largest homogeneous database of intermediate redshift ($0.2 < z < 0.9$) type Ia supernovae (SNe Ia). The SNLS team has shown that correlations exist between SN Ia rates, properties, and host galaxy star formation rate (SFR) (Sullivan et al. 2006). The SNLS SN Ia database has now been combined with photometric redshift catalogs (Ilbert et al.

2006, Gwyn 2006) to investigate the possible influence of galaxy clustering on the SN Ia rate, over and above the expected effect due to the dependence of SFR on clustering through the morphology-density relation. This paper will present the methods used to quantify galaxy clustering, and show that an influence on SN Ia rates and properties from galaxy clustering is improbable. This work has been supported by NSERC and the University of Victoria.

229.02

Dark Energy Constraints from the Supernova Legacy Survey

Mark Sullivan[1], Supernova Legacy Survey
[1]University of Toronto, Canada.

The CFHT Supernova Legacy Survey (SNLS) is a 2003-2008 program which uses high-redshift ($0.1<z<1.0$) Type Ia Supernovae to constrain the average equation-of-state parameter of dark energy, w. We will present an analysis of the cosmological constraints derived from around 250 supernovae segregated according to their host galaxy environment using the first three years of data. The comparison provides a powerful test of systematics, such as dust extinction and evolution, that effects the use of supernovae as precision cosmological probes.

229.03

Analysis Techniques and Systematics in the Supernova Legacy Survey

Alexander J. Conley[1], Supernova Legacy Survey
[1]Univ. of Toronto, Canada.

We discuss the analysis of the first three years of the SNLS data which consists of approximately 250 high-redshift SNe Ia in the range z=0.1-1 with 4 band photometric follow-up. We provide a brief introduction to our light-curve analysis and calibration techniques, and also discuss systematic uncertainties that affect our analysis.

229.04

Predicted Evolution in the Mean Properties of SNe Ia from SNLS Data

Dale A. Howell[1], Supernova Legacy Survey
[1]Univ. of Toronto, Canada.

Recent results indicate that SNe Ia with broader lightcurves have a rate proportional to the star formation rate in their host galaxies. Thus, as star formation increases with redshift, these brighter SNe Ia should start to dominate the total sample. Here we use the two component model of Scannapieco & Bildsten (2006), and data from the Supernova Legacy Survey (SNLS) to make an empirical prediction of the evolution of mean SN Ia properties with redshift. We find that on average supernovae should become intrinsically brighter with increasing redshift. The nuber of exotic supernovae, such as SNLS-03D3bb, thought to be from a super-Chandrasekhar mass progenitor, should also increase. We test these predictions on 3rd year data from the SNLS, and examine possible effects on cosmology.

229.05D

The Texas Supernova Search

Robert Quimby[1]
[1]Univ. of Texas.

Supernovae (SNe) are popular tools to explore the cosmological expansion of the Universe owing to their bright peak magnitudes and reasonably high rates; however, even the relatively homogeneous Type Ia supernovae are not perfect standard candles intrinsically. Their absolute peak brightness must be established by corrections that have been largely empirical. Hundreds of SNe are now found every year, shrinking the statistical errors in the cosmological terms, but most of these distant discoveries do little to further the physical understanding of SNe, which may illuminate unknown systematics.

This talk will describe recent results from the The Texas Supernova Search, a campaign designed to discover not the most SNe nor the most distant SNe, but instead to amass a small collection of well-observed nearby SNe with detailed, multi-epoch spectral observations beginning at the earliest possible phases. For the past two years, we have pointed ROTSE-IIIb's 1.85 x 1.85 degree field of view at nearby galaxy clusters and searched thousands of galaxies, covering hundreds of square degrees on the sky, for supernovae. With ToO time on the neighboring 9.2m Hobby-Eberly Telescope, we have captured SNe spectra at some of the earliest phases ever. I will discuss the implications of these data on the physics of SNe explosions, including the propagation of the burning front and the progenitors of Type Ia supernovae.

229.06D

Spectropolarimetry of Type Ia Supernovae

Ryan Chornock[1]
[1]UC Berkeley.

I will present some recent results using optical spectropolarimetry as a tool to probe the three-dimensional structure of Type Ia supernovae (SNe Ia). Normal SNe Ia typically have small observed continuum polarizations, which are interpreted as being due to electron scattering in supernova atmospheres with global asphericities. Line polarization features seen in several objects reveal compositional inhomogeneities in the ejecta. In particular, some SNe Ia with high-velocity spectral features formed above the photosphere show strong polarization signatures. Even some normal SNe Ia, such as SN 2004S, show rotations in the polarization angle across photospheric line features of species such as Si II and Ca II. The spectropolarimetric features indicate that the line-forming region in this object cannot share the same global axis of symmetry as the continuum. These observations can be used as a test of three-dimensional numerical models of SN Ia explosion mechanisms.

229.07

Nearby Supernova Factory Spectroscopy of the Type Ia Supernova 2006D

Rollin Thomas[1], G. Aldering[1], S. Bailey[1], S. Bongard[1], S. Loken[1], P. Nugent[1], S. Perlmutter[1], R. Scalzo[1], L. Wang[1], B. Weaver[1], P. Antilogus[2], S. Gilles[2], R. Pain[2], R. Pereira[2], C. Buton[3], Y. Copin[3], E. Gangler[3], G. Smadja[3], E. Pecontal[4], G. Rigaudier[4], R. Kessler[5], E. Baron[6], J. Parrent[6], C. Baltay[7], D. Rabinowitz[7]
[1]LBNL, [2]LPNHE, France, [3]IPNL, France, [4]CRAL, France, [5]KICP, [6]University of Oklahoma, [7]Yale University.

We present spectroscopy of the Type Ia supernova (SN) 2006D. The spectra include the strongest signature of unburned material at photospheric velocities observed in a SN Ia to date. The earliest spectrum exhibits C II absorption features below 14,000 km/s, including a distinctive C II 658.0 nm absorption feature. The carbon signatures dissipate as the SN approaches peak brightness. In addition to discussing implications of photospheric-velocity carbon for white dwarf explosion models, we outline some factors that may influence the frequency of its detection before and around peak brightness. Two effects are explored in this regard, including depopulation of the C II optical levels by non-LTE effects, and line-of-sight effects resulting from a clumpy distribution of unburned material with low volume-filling factor.

230: Variable and Binary Stars
AAS Oral, Wednesday, 10:00-11:30am, 201

230.01

Interacting Binaries with Eccentric Orbits

Jeremy F. Sepinsky[1], B. Willems[1], V. Kalogera[1]
[1]*Northwestern Univ..*

The Roche model has served for a long time as a fundamental tool to study the interactions and observational characteristics of the components of gravitational two-body systems. More often than not, applications of this model are built on the assumption that the orbit of the system is circular and that the system components are rotating synchronously with the orbital motion. Under this assumption, the components can be treated as static with respect to the co-rotating frame of reference, and the shapes of their equipotential surfaces are constant in time.

When eccentricity and/or asynchronicity are included in the derivation of the Roche potential, such a frame of reference no longer exists and the equipotential surfaces are no longer constant in time. In this case, the ballisitic trajectories of matter passing through the inner Lagrangian point must take into account the change in the potential due to the motion of the donor. In this presentation, we will discuss the typical orbits that can be obtained by matter passing through the inner Lagrangian point for a variety of initial conditions. In addition, depending on the parameters of the orbit, we find that it is energetically possible for mass being transferred through the inner Lagrangian point to escape from the system. Thus, we also investigate the possibility of non-conservative mass transfer in eccentric binaries.

This work is supported by a NASA Graduate Student Research Fellowship to J.S.

230.02

StarSpotz: A Sensitive Probe of the Differential Rotation Profile of Stars using MOST Photometry

Bryce Croll[1], G. A. Walker[2], R. Kuschnig[2], J. M. Matthews[2], J. F. Rowe[2], A. Walker[3], S. M. Rucinski[1], A. P. Hatzes[4], W. D. Cochran[5], R. M. Robb[6], D. B. Guenther[7], A. F. Moffat[8], D. Sasselov[9], W. W. Weiss[10]
[1]*University of Toronto, Canada,* [2]*University of British Columbia, Canada,* [3]*Sumus Technology Limited, Canada,* [4]*Thuringer Landessternwarte Tautenburg, Germany,* [5]*McDonald Observatory,* [6]*University of Victoria, Canada,* [7]*St. Mary's University, Canada,* [8]*Universite de Montreal, Canada,* [9]*Harvard-Smithsonian Center for Astrophysics,* [10]*Universitat Wien Turkenschanzstrasse, Austria.*

MOST has detected the differential rotation of spots on a number of stars. We have developed the program StarSpotz to define the spots and derive the range in best-fit values of the relevant stellar parameters. Markov Chain Monte Carlo (MCMC) and Parallel Tempering techniques have been applied to eliminate the correlation among parameters and the non-uniqueness issues often associated with photometric spot-modeling. We illustrate the effectiveness of these techniques by applying them to MOST's recent observations of the spotted star epsilon Eridani. When combined with the accurate, near-continuous photometry returned by MOST, these techniques should be able to constrain theories of the exact nature of the differential rotation profiles of stars.

230.03

Mean Pulsation Period of Cool White Dwarf Variables Gauges Stellar Temperature

Anjum S. Mukadam[1], M. H. Montgomery[2], A. Kim[2], D. E. Winget[2], S. O. Kepler[3], J. C. Clemens[4]
[1]*Univ. of Washington,* [2]*Univ. of Texas at Austin,* [3]*Universidade Federal do Rio Grande do Sul, Brazil,* [4]*Univ. of North Carolina.*

The coolest class of pulsating white dwarf stars comprises of hydrogen atmosphere variables called the ZZ Ceti stars. The mean pulsation period of ZZ Ceti stars increases with decreasing effective temperature as we traverse from the hot to the cool edge of the instability strip (see Clemens 1993, Kanaan et al. 2002, Mukadam et al. 2006). This well-established correlation between the mean pulsation period and spectroscopic temperature suggests that the mean period could be utilized as a tool to measure the relative temperature of the star independent of spectroscopy. Measuring the pulsation periods of a ZZ Ceti star is a simple, model-independent, and straight forward process as opposed to a spectroscopic determination of its temperature. Internal uncertainties in determining the spectroscopic temperature of a ZZ Ceti star are at least 200K, 15% of the 1350K width of the instability strip. The uncertainties in determining the mean period arise mostly from amplitude modulation in the pulsation spectrum and are smaller than 100s for 91% of the ZZ Ceti stars, $<$8% of the 1300s width of the instability strip. In principle this implies that for 90% of the ZZ Ceti stars, the average uncertainty in determining the location of the star within the instability strip decreases by a factor of two in utilizing the mean pulsation period as a temperature gauge rather than traditional spectroscopy. Presently we only claim that the relative temperatures of ZZ Ceti stars derived by using the mean pulsation period are certainly as good as and perhaps about 15% better than spectroscopy. Support for this work was provided by NASA through the Hubble Fellowship grant HST-HF-01175.01-A awarded by the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., for NASA, under contract NAS 5-26555.

230.04

Measurement of the Surface Gravity of η Boo

Gerard van Belle[1], D. R. Ciardi[1], A. F. Boden[1]
[1]*Michelson Science Center.*

Direct angular size measurements of the G0IV subgiant η Boo from the Palomar Testbed Interferometer are presented, with limb-darkened angular size of $\theta_{LD}=2.1894^{+0.0055}_{-0.0140}$ mas, which indicate a linear radius of $R=2.672 \pm 0.028\ R_{SUN}$. A bolometric flux estimate of $F_{BOL} = 22.1 \pm 0.28 \times 10^{-7}$ erg cm^{-2} s^{-1} is computed, which indicates an effective temperature of $T_{EFF}=6100 \pm 28$ K and luminosity of $L = 8.89 \pm 0.16\ L_{SUN}$ for this object. Similar data are established for a check star, HD 121860. The η Boo results are compared to, and confirm, similar parameters established by the *MOST* asteroseismology satellite. In conjunction with the mass estimate from the *MOST* investigation, a surface gravity of log g=3.817 $\pm$ 0.016 [cm s^{-2}] is established for η Boo.

230.05

An X-ray View of the Interacting Binary Beta Lyrae with Suzaku

Richard Ignace[1], L. Oskinova[2], W. Waldron[3], J. Hoffman[3], W. Hamann[2]
[1]*East Tennessee State Univ.,* [2]*University of Potsdam, Germany,*
[3]*Eureka Scientific.*

The famous interacting and eclipsing binary beta Lyr shows a variety of interesting dynamic processes, with a circumbinary disk, magnetic fields, jets, and mass transfer, likely between a pair of B stars. The system has been well-studied in most wavebands, except for the X-rays. Beta Lyr was detected by Einstein suggesting a rather hard spectrum. Consequently, we observed this binary in 2006 May with the XIS of Suzaku at three roughly equally spaced phases within its orbit. According to the optical light curve, one exposure was entirely out of eclipse, one was midway in egress of secondary eclipse, and one was midway through ingress of primary eclipse. A preliminatry inspection of the light curve and three spectra indicate little or no change in the X-rays. We offer tentative conclusions about the location of the hot plasma in this system. This research is supported through a NASA grant award, NNX06AI04G.

230.06

Late-Type Near-Contact Binary [HH97] FS Aur-79

Scott J. Austin[1]
[1]Univ. Of Central Arkansas.

We find that the secondary photometric standard star #79 for the FS Aur field (Hendon & Honeycutt 1997) designated as [HH97] FS Aur-79 (GSC 1874 399) is a short period (0.2508 days) eclipsing near-contact binary system with dK7e and dM4e components. The system has a gamma-velocity of about +83 km/sec, with the primary having an orbital velocity around 115 km/sec, and the secondary predicted to have an orbital velocity near 210 km/sec. The primary mass, temperature, and radius are approximately 0.6M M⊙, 4100 K, and 0.67 R ⊙. The secondary mass, temperature, radius are approximately 0.3M ⊙, 3425 K, and 0.48 R ⊙. The unequal eclipse depths indicate a temperature difference between the components (near contact), and unequal quadrature magnitudes indicating the presence of star spots. A U-B excess, and H-Balmer lines in emission are further evidence of chromospheric activity. Modeling indicates the presence of two major spot regions on the primary and one on the secondary. It is likely that this system has evolved from larger separations through angular momentum loss. This system may eventually become an W UMa system with unique late-type components, which is rare.

230.07

A Search for Variable Stars in Selected Fields of the Open Cluster NGC 752

Eugene F. Milone[1], M. D. Williams[1], L. Kim[1], T. Lenhardt[1], S. J. Schiller[1]
[1]University of Calgary, Canada.

NGC 752 is an intermediate age open cluster that has been on the binaries-in-clusters program at the Rothney Astrophysical Observatory (RAO) of the University of Calgary. About 2000 images of the open cluster NGC 752 in UBVI passbands were obtained with a 2048x2048 pixel CCD on the 40-in telescope at the Mount Laguna Observatory (MLO), Nov 5-20 UT, 2004, complementing observations made in the 1990s at the same site, and photoelectric photometry carried out at Table Mountain Observatory and at the the RAO in the 1980s by (SJS). The 14 arc-min. fields were selected near the two known eclipsing variables in the cluster, QX And and DS And, and around the cluster's one known blue-straggler, Heineman 209, once suspected of variability. New light curves and limits to variability will be discussed. The variability search has made use of detection and period-finding algorithms developed by one of us (MDW). It is a pleasure to thank the former and present directors of MLO, Ron Angione, and Paul Etzel, for generous amounts of observing time. This work was supported by grants to EFM from NSERC of Canada.

230.08

Mid-IR Keck Segment-Tilting Observations of the Disk Around Mira B

Michael J. Ireland[1], J. D. Monnier[2], P. G. Tuthill[3], R. Cohen[4]
[1]Caltech, [2]University of Michigan, [3]University of Sydney, Australia, [4]W.M. Keck Observatory.

The Mira AB system is a nearby (~107 pc) example of a wind accreting binary star system. In this class of system, the wind from a mass-losing red giant star is accreted onto a companion, as indicated by emission related to an accretion shock at ultraviolet and X-ray wavelengths. Imaging the companion is difficult because of the small separation (~0.5″) and the large contrast between Mira A (~5000 L_{sun}) and Mira B (< 1 L_{sun}). These difficulties are one reason for the controversial nature of Mira B, which has been labelled both a low-mass main sequence star and a white dwarf by different authors.

We have imaged Mira B at mid-infrared wavelengths by turning the segmented Keck telescope into several non-redundant arrays, by individually re-pointing and co-phasing sets of segments. This technique enables excellent visibility amplitude and closure-phase calibration, which can in turn produce high-contrast images. Using this technique, we report the detection of Mira B at wavelengths of 10.7 and 12.5 microns at a position offset by about 15 AU (0.48″) from the ultraviolet position of Mira B and a contrast ratio of ~50:1.

We interpret the mid-infrared emission as the edge of an optically-thick accretion disk heated by Mira A, and interpret Mira B as a main-sequence star based on accretion luminosity arguments. We argue that this disk should be similar to disks around T Tauri stars, and that in the solar neighbourhood, planets formed in this class of disk should be relatively common compared to those formed alongside young stars.

M.I. is supported by a Michelson Fellowship with funding provided by the Michelson Science Center and the NASA Navigator Program.

231: Physics in Art and Art in Physics AAPT Invited, Wednesday, 10:00-11:30am, 211

Chair

Stanley Micklavzina[1]
[1]University of Oregon.

231.01

Did the great masters ″cheat″ using optics? Image analysis of Renaissance masterpieces sheds light on a bold theory

David Stork[1]
[1]Ricoh Innovations.

In 2001, artist David Hockney and scientist Charles Falco stunned the art world with a controversial theory that, if correct, would profoundly alter our view of the development of image making. They claimed that as early as 1420, Renaissance artists employed optical devices such as concave mirrors to project images onto their canvases, which they then traced or painted over. In this way, the theory attempts to explain the newfound heightened naturalism or ″opticality″ of painters such as Jan van Eyck, Robert Campin, Hans Holbein the Younger, and many others.

This talk will describe the application of rigorous computer image analysis to masterpieces adduced as evidence for this theory. It covers basic geometrical optics of image projection, the analysis of perspective, curved surface reflections, shadows, lighting and color. While there remain some loose ends, such analysis of the paintings, infra-red reflectograms, modern reenactments, internal consistency of the theory, and alternate explanations allows us to judge with high confidence the plausibility of this bold theory. You may never see Renaissance paintings the same way again.

231.02

Science Circus

Rhys D. Thomas[1]
[1]Up For Grabs, Inc..

As a Smithsonian artist in residence Rhys Thomas taught basic Newtonian Physics using circus tricks. As an Oregon Museum of Science and Industry outreach performer he has used his juggling and equilibristic skills to demonstrate gyroscopics, gravity, inertia and other topics in 10 states and three countries. Rhys will share his insights and tips on ″performing″ rather than just ″presenting″ physics. He will perform some demos ala Ed Sullivan. He will also discuss how a basic understanding of physics has influenced his artistic expression in non-educational theatrical performances that earned him an Oregon Arts Fellowship in 2005.

Sponsored by Stanley Micklavzina of the University of Oregon.

232: Demonstrations for Teaching Astronomy AAPT Special, Wednesday, 10:00-11:30am, 617

Chair

Stephen M. Pompea[1]
[1]NOAO.

232.01

Astronomy LITE Demonstrations

Kenneth Brecher[1]
[1]Boston University.

Project LITE (Light Inquiry Through Experiments) is a materials, software, and curriculum development project. It focuses on light, optics, color and visual perception. According to two recent surveys of college astronomy faculty members, these are among the topics most often included in the large introductory astronomy courses. The project has aimed largely at the design and implementation of hands-on experiences for students. However, it has also included the development of lecture demonstrations that employ novel light sources and materials. In this presentation, we will show some of our new lecture demonstrations concerning geometrical and physical optics, fluorescence, phosphorescence and polarization. We have developed over 200 Flash and Java applets that can be used either by teachers in lecture settings or by students at home. They are all posted on the web at http://lite.bu.edu. For either purpose they can be downloaded directly to the user's computer or run off line. In lecture demonstrations, some of these applets can be used to control the light emitted by video projectors to produce physical effects in materials (e.g. fluorescence). Other applets can be used, for example, to demonstrate that the human percept of color does not have a simple relationship with the physical frequency of the stimulating source of light. Project LITE is supported by Grant #DUE-0125992 from the NSF Division of Undergraduate Education.

232.02

A Status Report on the ALIVE Project

James B. Dove[1]
[1]Metropolitan State College of Denver.

This talk will give a status report on the Astronomy Learning in Immersive Virtual Environments (ALIVE) project. The goal of this study is to determine optimal learning modes for several astronomical topics, and to quantify the benefits that immersive virtual environments may have for enabling spatial learning in introductory astronomy courses. Through oral interviews with over 100 astronomy students, we have identified common student misconceptions on basic astronomical topics such as lunar phases, eclipses, seasons, orbital motion, and scales. We have written questions to assess these misconceptions in astronomy courses, and have designed several sessions in Gates Planetarium (which is now a full-dome facility with 11 DLP projectors with interactive, 3D VE software) to help teach these topics.

232.03

Using Planetarium Software as a Virtual Observatory

Richard Ditteon[1]
[1]Rose-Hulman Institute.

One way to get students actively involved in astronomy is to use a planetarium program as a virtual observatory to determine various angles or times. From these "observations" relative distances can be deduced.

For example, parallax can be demonstrated by using a planetarium program to determine the position of the moon at a particular instant in time as observed from different locations on the Earth.

Another example is that the size of Earth's orbit relative to the moon's orbit can be determined by using a planetarium program to measure the angular separation between the moon and the sun when the moon is exactly half illuminated. The distance ratio is simply the cosine of this angle.

In addition, the size of the orbit of Venus relative to the size of Earth's orbit can be determined by finding the angle of greatest elongation of Venus. The distance ratio is the sine of the greatest elongation angle.

Finally, the size of the orbit of Mars relative to the size of Earth's orbit can be determined first finding the synodic period of Mars. The sidereal period of Mars can be determined after the planetarium program is used to determine the sidereal period of the Earth. Next, the time between opposition and quadrature can be determined with the software. From these times, the angular displacement of the superior planet can be found and the relative orbit size is the sine of the angular displacement.

232.04

Affordable Laser Communication in the Classroom

Constance E. Walker[1], R. Sparks[1], S. Pompea[1]
[1]National Optical Astronomy Observatory.

Several companies sell systems that illustrate laser communication such as Arbor Scientific[1]. These systems can be too expensive for classroom use. We will demonstrate a technique to modulate a standard diode laser using a microphone or other sound source that is capable of transmitting voice and music. This affordable system can transmit over 350 feet using simple, inexpensive parts readily available at your local electronics store. We will provide a list of parts necessary for assembly, detailed assembly instructions, as well as some suggested investigations using the laser communication system. This system can be used in the classroom either as a demonstration or hands-on activity to explore the physics and technology involved, citing more sophisticated laser communication systems on board spacecraft such as the Mercury Messenger Mission and the Mars Telecommunications Orbiter.

[1]http://www.arborsci.com

233: Bringing Physics by Inquiry to K-12 Classrooms, Part II AAPT Oral, Wednesday, 10:00-11:30am, 303

Chair

Paula Heron[1]
[1]Univ. of Washington.

233.01

Teaching Physical Science by Inqiry in the K-12 Classroom

Brian E. Meza[1], D. L. Messina[2], L. C. McDermott[2]
[1]Seattle Preparatory School, [2]Univ. of Washington.

The National Science Education Standards emphasize the role of inquiry in the K-12 science classroom and the need for teachers to be prepared to teach using this instructional approach. I participated for several years in the NSF-funded Summer Institute conducted by the Physics Education Group at the University of Washington that provides an opportunity for teachers to deepen their understanding of topics they are expected to teach and to experience a pedagogical approach that facilitates bringing inquiry-based learning to the classroom. Physics by Inquiry, the research-based curriculum developed by the group, guides teachers in developing their understanding while serving as a model for the development of ideas in their own instructional materials.(1) Results of K-12 student learning in my classroom will be presented as well as reflections on the curriculum adaptation and implementation necessary to bring reform teaching to the precollege classroom.

233.02

Effects of a Research-based Curriculum on the Learning of Physics by K-12 Teachers and Students*

Donna L. Messina[1], M. R. Stetzer[1], L. C. McDermott[1]
[1]Univ. of Washington.

The Physics Education Group at the University of Washington conducts courses in physics and physical science for preservice and inservice teachers. Physics by Inquiry, a research-based curriculum, is used to help teachers develop in-depth understanding of topics relevant to the K-12 classroom.(1) The courses also help teachers become familiar with instructional strategies that have proved effective in addressing common conceptual and reasoning difficulties. Results will be presented that demonstrate how on-going collaboration between group members and K-12 teachers contributes to changes in teaching practice and improvement in student learning in precollege classrooms.

234: Introductory Physics Curriculum and Delivery AAPT Oral, Wednesday, 10:00-11:30am, 616

Chair

Charles F. Niederriter[1]
[1]Gustavus Adolphus College.

234.01

A Mechanics Curriculum as a Prelude to Electricity and Magnetism

Poovan Murugesan[1]
[1]San Diego City College.

In the first semester of the calculus-based and algebra-based introductory physics, particle and rigid-body mechanics make an overwhelming presence. So much so that concepts like the field and potential, central to electricity and magnetism that are usually taught in the second semester, are all but ignored. In other words, there is no smooth transition from mechanics to electricity and magnetism. It is possible to include concepts like the field, potential and Gauss' law in mechanics without placing an undue demand on the length or the number of chapters, thus providing a better preparation to face the second semester.

234.02

Scientific Reasoning Outcomes and the General Education Physics Course

Stephen P. Phipps[1], D. B. Morris[1], M. E. Dearborn[1], G. M. Novak[1]
[1]United States Air Force Academy.

In the context of the Air Force Academy's drive to become a more learning-focused institution, we chose as the primary outcome desired for all cadets taking our required two-semester physics sequence (2000 cadets per academic year) the development of scientific reasoning skills . We describe the physics teaching environment at the Academy, the sources of our scientific reasoning outcomes, curriculum changes we have implemented, the response of the physics teaching faculty, and future plans.

234.03

Teaching to Promote Deep Understanding and Instigate Conceptual Change

Esther Zirbel[1]
[1]Tufts University.

This paper focuses on how to promote deep understanding by making the students to question their inherent conceptual knowledge of how the world works, and on how to correct these views should they be different form the scientifically proven views. This paper reviews the conceptual change model and suggests additional steps. First, the student has to consciously notice and understand what the problem is; second, s/he has to assimilate more information and try to fit it into already existing neural networks; third, s/he has to critically think through all the argumentation in his/her own words and reorganize this thoughts s/he has to accommodate the knowledge and evaluate against his or her prior beliefs; forth s/he has to own the concept and has to consider it her/his personal construct; and finally, s/he has to work towards obtaining fluency in the newly acquired and understood concept so that this concept itself has then becomes a mere building block for future, more advanced concepts. The claim is that during the process of conceptual change what happens in the student's mind is a reorganization of his or her thoughts, the creation of new neural networks, and the rewiring of old ones. This process is difficult to provoke and requires the student to work hard. Instructors can challenge the student to undergo the process of conceptual change but cannot do it for the student.

234.04

Implementing Interactive Lecture Experiments in Large Introductory Physics Courses (Part I)

Rachel Moll[1], M. M. Milner-Bolotin[1], K. McPhee[1], S. Zhdanovich[1], A. Kotlicki[1], G. Rieger[1], F. Bates[1]
[1]University of British Columbia, Canada.

This presentation describes a pedagogical approach, Interactive Lecture Experiments (ILE), which builds on Interactive Lecture Demonstrations proposed by Sokoloff and Thornton (2004) and extends it by providing students with the opportunity to analyze experiments demonstrated in the lecture outside of the classroom and report the result of their analysis suing Peer Response System during the following lecture. Real time experimental data is collected, using Logger Pro technology combined with digital video recording. Then the data is uploaded to the Internet and made available to the students for further analysis. Student understanding of the experiment is assessed in the following lecture using clickers and conceptual questions. The goal of this project is to use ILE activities to make large lectures more interactive and to promote student interest in science, critical thinking and data analysis skills.

Sokoloff, D.R. and R.K. Thornton (2004). Interactive Lecture Demonstrations: Active Learning in Introductory Physics, John Wiley and Sons, INC.

Interactive Lecture Experiments at the University of British Columbia: http://www.physics.ubc.ca/~year1lab/p100/LectureLabs/lectureLabs.html

234.05

The Impact of Interactive Lecture Experiments on Student Academic Achievement, Motivation and Attitudes towards Science (Part II)

Marina M. Milner-Bolotin[1], R. Moll[1], A. Kotlicki[1], F. Bates[1], G. Rieger[1], S. Nashon[1]
[1]University of British Columbia, Canada.

Interactive Lecture Experiments (ILE) have been used in the introductory physics course at the University of British Columbia for over two years. During the Fall of 2006 a systematic study was conducted using the Colorado Learning Attitudes about Science Survey (CLASS), Force Concept Inventory (FCI), physics open-ended exam problems and focus group interviews to determine the impact of ILE on student academic achievement, motivation and attitudes towards physics. Three sections of students (750 students) experienced four ILE experiments. FCI and CLASS were administered twice and academic results for students who experienced the ILE for a particular topic were compared to students, from a different section, who did not complete the ILE for that topic. Qualitative data on students' attitudes was also collected using open ended survey questions and interviews. Preliminary results will be presented with conclusions about the impact of using ILE as an effective pedagogy in large introductory physics courses.

234.06

GRIPs (Group Investigation Problems) for Introductory Physics

Thomas A. Moore[1]
[1] *Pomona College.*

GRIPs lie somewhere between homework problems and simple labs: they are open-ended questions that require a mixture of problem-solving skills and hands-on experimentation to solve practical puzzles involving simple physical objects. In this talk, I will describe three GRIPs that I developed for a first-semester introductory calculus-based physics course based on the ″Six Ideas That Shaped Physics″ text. I will discuss the design of the three GRIPs we used this past fall, our experience in working with students on these problems, and students' response as reported on course evaluations.

234.07

New Insights into Student Understanding of Complete Circuits*

MacKenzie R. Stetzer[1], P. van Kampen[2], P. S. Shaffer[1], L. C. McDermott[1]
[1] *Univ. of Washington,* [2] *Dublin City University, Ireland.*

New insights into student understanding of complete circuits continue to emerge from an ongoing investigation conducted by the Physics Education Group at the University of Washington. Recent results suggest that student difficulties associated with the concept of a complete circuit often persist, even after certain types of research-based instruction. Such difficulties may contribute to poor student performance when more advanced contexts (e.g., multiple battery circuits) are encountered. The insights gained from this research have strong implications for instruction and are guiding the development and refinement of instructional materials on electric circuits for several different populations.[1,2]

*This work has been supported in part by the National Science Foundation.

1. Physics by Inquiry, L.C. McDermott and the Physics Education Group at the University of Washington, Wiley (1996).

2. Tutorials in Introductory Physics, L.C. McDermott, P.S. Shaffer and the Physics Education Group at the University of Washington, Prentice Hall (2002).

234.08

Andes: An Intelligent Homework System for Introductory Physics

Brett van de Sande[1], K. VanLehn[1], R. Hausmann[1], D. Treacy[2], R. Shelby[2]
[1] *University of Pittsburgh,* [2] *US Naval Academy.*

We know that students benefit from solving homework problems under the guidance of an expert (human) tutor. The Andes system (http://www.andes.pitt.edu) is designed for students to solve homework problems under the guidance of an expert computer tutor. Andes encourages students to use sound problem solving techniques and provides immediate right/wrong feedback on each step of a solution. On request, Andes also provides hints based on previous student actions. I will discuss how Andes works, from a student's perspective, and summarize research that demonstrates its effectiveness as a pedagogical tool. I will also discuss how Andes can function as a tool for conducting educational research, presenting an investigation of students' hint usage as an example.

234.09

Helping Student Relate Work and Changes in Energy*

Beth A. Lindsey[1], P. R. Heron[1], P. S. Shaffer[1], L. C. McDermott[1]
[1] *Univ. of Washington.*

The first law of thermodynamics states that doing work on an otherwise isolated system will cause its energy to change. Student performance in introductory mechanics on pretest and post-test questions suggests that traditional instruction is insufficient to develop a functional understanding of this principle. At the University of Washington, the Physics Education Group has been developing research-based materials[1] on these topics. We will discuss common student difficulties in applying the relationship between work and energy, and implications these have for instruction on energy conservation.

*This work has been funded in part by the National Science Foundation.

[1] Tutorials in Introductory Physics, L.C. McDermott, P.S. Shaffer and the Physics Education Group at the University of Washington, Prentice Hall (2002).

235: Teacher Learning
AAPT Oral, Wednesday, 10:00-11:30am, 310

Chair

Harold Stokes[1]
[1] *Brigham Young Univ..*

235.01

What Did We Learn from the Teachers' Journals?

Kastro M. Hamed[1]
[1] *University of Texas at El Paso.*

As a cohort of 21 science teachers joined our newly established MAT (Masters in the Art of Teaching) graduate program, I took the opportunity to have them capture and document their experiences in their own words. Every student wrote and submitted a weekly journal. The participants wrote about a variety of topics such as: becoming a student again; the joys and obstacles of being a teacher; what were they learning in the program; how they transferred what they were learning in our program to their own classrooms; the assigned readings; the class projects, among other topics. I read and commented on the journals on weekly basis. Then at the end of the year, and with students' permission, the journals were collected, typed, and analyzed. This talk provides the results of the analysis, and the implications and recommendations for anyone interested in having a similar program.

235.02

Support for New Physics Teachers

Brian W. Adrian[1], D. Zollman[1], S. Stevens[2]
[1] *Kansas State Univ,* [2] *Carnegie Mellon University.*

Teachers of physics can often lack the type of support they desperately need. The Physics Teaching Web Advisory (Pathway) is a dynamic digital library for physics teaching that is designed to offer such support. Carnegie Mellon University's synthetic interview technology provides the foundation for a system that allows physics teachers to ask questions of a virtual mentor and get video responses. A log of the questions asked of our system provides a rich database of information about just what types of support teachers are requesting. This talk will present a summary of the common types of questions teachers ask. Such information is valuable as we design support systems for physics teachers, both new and experienced. In addition, recent progress and developments will be discussed.

Supported by NSF grant numbers DUE-0226157, DUE-0226219, ESI-0455772 & ESI-0455813

WEDNESDAY

235.03

Using Facet Clusters to Map Learner Modes of Reasoning

Stamatis Vokos[1], L. S. DeWater[1], L. Seeley[1], P. Kraus[2]
[1] *Seattle Pacific University,* [2] *Facet Innovations, LLC.*

The Department of Physics and the School of Education at Seattle Pacific University, together with FACET Innovations, LLC, are beginning the second year of a five-year NSF TPC project, *Improving the Effectiveness of Teacher Diagnostic Skills and Tools.* We are working in partnership with school districts in Washington State to use formative assessment as a means to helping teachers and precollege students deepen their understanding of foundational topics in physical science. We utilize a theoretical framework of knowledge-in-pieces to identify and categorize widespread productive and unproductive modes of reasoning in the topical areas of *Properties of Matter, Heat and Temperature,* and *Physical and Chemical Changes.* In this talk, we describe the development and iterative refinement of certain facet clusters of student ideas, as well as the usefulness and limitations of such a mapping scheme.

* Supported in part by NSF grant #ESI-0455796, The Boeing Corporation, and the SPU Science Initiative.

235.04

Using Facet Clusters to Guide Teacher Professional Development

Lane Seeley[1], L. S. DeWater[1], S. Vokos[1], P. Kraus[2]
[1]Seattle Pacific University, [2]Facet Innovations, LLC.

The Department of Physics and the School of Education at Seattle Pacific University, together with FACET Innovations, LLC, are beginning the second year of a five-year NSF TPC project, *Improving the Effectiveness of Teacher Diagnostic Skills and Tools.* We are working in partnership with school districts in Washington State to help teachers make their classrooms into better diagnostic learning environments. In this talk, we describe initial efforts to construct content-rich professional development courses for teachers, which are infused with diagnostic assessment that target the fine structure of student ideas in specific topical areas.

* Supported in part by NSF grant #ESI-0455796, The Boeing Corporation, and the SPU Science Initiative.

235.05

Teaching about 21st Century Energy Sources to Pre-college Students and Teachers

Andrew P. Zwicker[1], J. Morgan[1], C. Ritter[1], J. DeLooper[1], N. Guilbert[2]
[1]Princeton Plasma Physics Laboratory, [2]The Peddie School.

For several years, the Princeton Plasma Physics Laboratory has led a weeklong summer workshop on alternative energy sources for high school students. We have several versions of the workshop, depending upon the students participating. Recently, we offered the workshop to students attending a science magnet school, students from a large, urban school, and “learning different” students. Students perform a variety of “design and build” projects, one for each of the major energy sources. Energy sources typically explored include solar, hydrogen fuel cells, and fusion. Along with the laboratory exercises, students work on virtual experiments, computer simulations and some lecture. This summer, we will begin a four-week professional development program centered on the same topic. Participants will use their work in the laboratory and classroom to develop inquiry-based curricula, aligned with State and National standards that use energy as a theme for exploring various topics in physics and physical science. A description of each workshop will be given along with results from various exit surveys that probe the impact of the workshop on student attitudes towards energy.

235.06

Conceptual Dynamics: Comparing Inquiry and Direct Instructional Designs

Adriana Undreiu[1], B. Adams[1], D. Schuster[1]
[1]Western Michigan University.

We present and compare ‘inquiry’ and ‘direct’ instructional designs for teaching physics topics. A scientific inquiry process approach develops physics concepts and laws as ‘science-in-the-making’, rather than presenting them directly as ‘already-made-science’. The contrasting designs reflect different views of’ ‘what is science’ and ‘what shall we teach’. We also distinguish the guided scientific inquiry approach from ‘discovery learning’ and from some inquiry approaches which ‘elicit conclusions’ upfront. We have produced a set of parallel lesson units, in inquiry and direct modes, for teaching introductory conceptual dynamics. Each mode is reflected in an appropriate learning cycle, including application and assessment. We are using the units in a physics course for prospective teachers, and in a research study comparing the effects of the two approaches, with respect to both content and process. Examples from dynamics will be presented.

235.07

Pre-Service Elementary Teachers’ Ideas about the Nature of Science

Rhett Allain[1]
[1]Southeastern Louisiana University.

To investigate the understanding of the nature of science, pre-service elementary teachers were given the Epistemological Beliefs Assessment for Physical Science (EBAPS)(1). The course uses Physics for Elementary Teachers(2), which is a guided inquiry curriculum. For a comparison, the EPABS was also given to other traditional introductory science classes, most notably a large astronomy lecture course for non-science majors. It was found that the pre-service elementary teachers increased their understanding of the nature of science significantly more than more traditional courses.

(1) http://www2.physics.umd.edu/~elby/EBAPS/home.htm

(2) Goldberg, F., Robinson, S., and Otero, V., Physics for Elementary Teachers, It’s About Time, 2005.

235.08

Integrals for Pre-service Elementary Teachers: Approximating Seasonal Solar Radiation Differences

Paul G. Ashcraft[1]
[1]Penn State Erie, The Behrend College.

Seasonal differences in incoming solar radiation were examined in a preservice elementary teacher’s physical science content course by approximating daily incoming radiation totals. Students used actual data to approximate length of daylight and the angle of elevation of the sun at local noon at their university’s location for the solstices and equinoxes. Using a linear approximation of radiation between sunrise and local noon and again between local noon and sunset, students graphically represented the daily energy/area data for the astronomically significant days. The students were able to visualize the effects the varying length of day and the varying angle of elevation of the sun had on daily solar radiation. The effects that differences in Earth-Sun distances were examined and found to be negligible compared to those caused by the tilt of the Earth.

236: Cannon Award in Astronomy
Plenary, Wednesday, 11:40am-12:30pm, Ballroom 6

236.01

The Star Formation and Metallicity History of Star Forming Galaxies

Lisa J. Kewley[1]
[1]University of Hawaii.

Observing the star formation rate (SFR) and metallicity since the earliest times in the universe is crucial to understanding galaxy formation and evolution. Current cosmic star formation history studies are hindered by significant discrepancies between star formation rate density estimates at different wavelengths: the discrepancy between the H-alpha and IR SFRs results from a lack of correction for stellar absorption and reddening, while the discrepancy between SFR([OII]) and SFR(H-alpha) is due to the effects of reddening and metallicity. I derive a new theoretical SFR([OII]) calibration that successfully removes the SFR discrepancies in both nearby and distant samples. A truly reliable [OII] star formation history requires knowledge of the metallicity history of star forming galaxies. I present the latest results from our new observational investigation into the metallicity history of star-forming galaxies between $0<z<3$. I compare our observed metallicity history with predictions from cosmological hydrodynamic simulations, and discuss future directions for metallicity history research. This analysis provides initial insight into the cosmic evolution of metallicity for star-forming galaxies between $0<z<3$.

237: Biology of Astrobiology II History of Earth's Life AAS Special, Wednesday, 2:00-3:30pm, 611-12

Chair

Mark Claire[1]
[1]Univ. of Washington.

Chair

Woodruff T. Sullivan[1]
[1]Univ. of Washington.

237.01

From the Earliest Evidence of Life to Complex Single-cell Organisms: The First 3 Gyr on Earth

Roger Buick[1]
[1]UW Dept. of Earth & Space Sciences.

Life has probably been present on Earth since the time of the oldest sedimentary rock record ~3.8 Gyr ago, as indicated by graphite with light carbon isotope ratios consistent with derivation from organic matter. But certain evidence for life appears only at 3.52 Gyr, in the form of kerogen (insoluble organic matter) in sedimentary carbonate showing a -25‰ carbon isotope fractionation identical to that imparted by biological carbon fixation. Soon after, at ~3.48 Gyr, the first visible evidence for life appears as stromatolites (sediment mounds constructed by microbes), as well as the first evidence for a specific metabolism (large negative sulfur isotope fractionations indicating microbial sulfate reduction). By ~2.7 Gyr ago, molecular biomarkers (hydrocarbons derived from biomolecules with distinctive carbon skeletons such as steroids) indicate that all 3 Domains of life: bacteria, eukaryotes (organisms with compartmentalized cells like us) and archaea (bacteria-like organisms with different biochemistry, often inhabiting extreme environments); had evolved. The first multicellular eukaryotes appeared by 1.84 Gyr in the form of fossilized filamentous algae, after the atmosphere changed from anoxic to moderately oxygenated at 2.4 Gyr and following a series of extreme "Snowball Earth" glaciations between 2.4-2.2 Gyr. Planktonic algae diversified thereafter and modern algal groups arose ~1.2 Gyr ago, apparently at the end of a prolonged period of ocean anoxia when the deep sea was sulfidic and presumably toxic. Animal evolution was delayed until ~0.65 Gyr ago when biomarkers for sponges first appear in the record, evidently after a further rise in atmospheric oxygen to modern levels but surprisingly pre-dating the last of another series of "Snowball Earth" glaciations. These sponges co-existed with an enigmatic extinct group of large flat marine organisms called "Ediacaran fossils" that may have been ancestral to modern animal groups but might also have been a failed attempt at complex multicellular evolution.

237.02

A New History of Animal Life on Earth

Peter Ward[1]
[1]UW Dept. of Biology.

The history of life since the advent of animals is one of rapid evolution by more complex animals and plants in response to changing environmental conditions. While the overall history of animals and plants from the Cambrian until the present has been well known for decades, it is in the history of the environmental changes that newer progress has been made. Understanding the changes in global temperature, oceanic chemistry, and atmospheric composition require more sophisticated analyses than simply charting the presence of absence of particular organisms as represented by their fossil record. In this talk I will concentrate on new environmental findings concerning the oceans and atmosphere over the last 500 million years that had only newly appreciated and major effects on not only the composition of flora and fauna, but on the very origination and extinction rates of these organisms. The role of oxygen and hydrogen sulfide in evolution and extinction are particularly interesting as lessons learned from their history on Earth have important Astrobiological implications for the frequency of advance life in the Universe.

238: Ground-Based Mid-IR Astronomy in the Spitzer Era AAS Special, Wednesday, 2:00-3:30pm, 613-14

Chair

Jay A. Frogel[1]
[1]AURA, Inc.

238.01

Synergy between Mid-IR Astronomy from 8-meter Class Ground Based Telescopes and Spitzer

Tom Soifer[1]
[1]Caltech.

The Spitzer Space Telescope represents many orders of magnitude gain in sensitivity over prior platforms for observations in the mid-infrared.

While 8-10 m class ground-based telescopes cannot approach the raw sensitivity of Spitzer for mid-infrared observations, they can address problems raised by Spitzer observations with complementary observations that exploit their higher spatial and spectral resolution capabilities.

In this talk I will highlight a few areas where Spitzer and ground-based mid-infrared observations can work in tandem to address important astrophysical problems

238.02

Mid-IR Capabilities of the Gemini Telescopes

Scott Fisher[1]
[1]Gemini Observatory.

The telescopes and instruments of Gemini have been designed from the ground up to deliver excellent performance in the infrared regime. This is particularly true for the mid-IR where the low emissivity of the telescopes boosts the raw sensitivity of the instruments, and the instruments take advantage of this by delivering diffraction-limited images with high strehl the majority of the time. The facility instruments MICHELLE and T-ReCS both provide sub-arcsecond imaging ($<0.4''$ at 10 microns) through a suite of broad and narrowband filters as well as R=100 and 1000 spectroscopy at both 10 and 20 microns. MICHELLE also has a R~20000 echelle spectroscopy mode as well as a unique imaging polarimetry mode. The visiting instrument TEXES extends our spectroscopic capabilities to R~100000. Although mid-IR observing from the ground has always been a daunting task, Gemini has made strides in all fronts to integrate the mid-IR instruments into the overall observing queue. While there are remaining issues to deal with, both Gemini North and South are now routinely delivering high-quality mid-IR data to PI's within the partnership.

238.03

Mid-IR Observations of the Outer Planets

Heidi B. Hammel[1]
[1]Space Science Institute.

Mid-infrared spectroscopy and imaging of planets is used to characterize both chemistry and dynamics in their atmospheres. I will review highlights from current observational programs studying Neptune and Uranus. For example, a recent assessment of ground-based spectroscopic observations of Neptune has revealed ethane and methane variability over decadal time scales, and has also yielded a detection of ethane on Uranus. Spectral observations with the Spitzer Space Telescope show strong indications for the presence of several new hydrocarbons in Uranus' atmosphere in addition to ethane, including diacetylene and methylacetylene, along with suggestive evidence of carbon dioxide and cyanoacetylene. Observers at several ground-based facilities, including Gemini, have produced the first mid-infrared images of the outer planets. The distribution of hydrocarbon emission in these images indicates stratospheric dynamical circulation similar to that seen on Saturn. The Uranus data is of special interest due to the planet's equinox, or ring-plane crossing, in 2007 (the last equinox was 1965; the next will be in 2049). HBH's outer planet work is supported in part by NASA grants NAG5-10451, NAG5-11961, and NNG06GI25G.

238.04

Evaporating Disks, Outflows, and their Embedded Sources in Orion

Nathan Smith[1]
[1]University of California.

I will review several recent results of a large mosaic of the Orion Nebula made with T-ReCS at Gemini South. Spitzer has transformed our ability to study star formation in the Galaxy on a large scale, but in bright nearby regions like Orion, the high spatial resolution achievable only with large ground-based telescopes still plays a dominant role at mid-IR wavelengths. Specifically, in studying diffuse shock structures, disks, and embedded sources, mid-IR images obtained with 8m class telescopes allow us to compare thermal dust emission to high resolution HST images of ionized gas at similar spatial resolution. Ground-based mid-IR imaging at high spatial resolution allows provides unique clues to regions of embedded massive star formation, such as the BN/KL core in Orion.

238.05

Protostars and Disks

Doug Johnstone[1]
[1]NRC Canada:HIA (and UVic), Canada.

Understanding the earliest stages of protostars requires peering through the enshrouding natal envelope of dust and gas and is best accomplished in the mid-IR. In this talk I will discuss how mid-IR observations provide crucial constraints on protostellar and disk evolution. The synergy between space-based missions and ground-based telescopes will be detailed.

238.06

High Resolution Mid-infrared Spectroscopy of Star Formation Regions

John Lacy[1]
[1]University of Texas.

The sensitivity of Spitzer is much better than that of ground-based telescopes in the mid-infrared, but Spitzer is limited in spatial and spectral resolution.

Using TEXES on the NASA IRTF and Gemini North, we have have studied three high-mass star formation regions with 0.5-1.5″ spatial and 3-4 km/s spectral resolution.

In Orion we observed outflow of C2H2 and HCN through holes in the KL cavity walls and resonant scattering of radiation from the hidden luminosity sources by molecules in the surrounding ambient gas.

In W51 IRS 2 we observed a massive jet emerging from a molecular cloud into an HII region, where it is being photoionized by radiation from a young OB star cluster.

In NGC 7538 IRS 1 we observed ionic line emission and molecular line absorption from the surface of an edge-on disk around a massive star.

The combination of high spatial and high spectral resolution provided a more complete picture than had been available of these prototypical high-mass star formation regions.

This work was supported by the National Science Foundation.

238.07

Mid-IR Observations of Herbig Ae and Be Stars

Marshall D. Perrin[1], J. R. Graham[1]
[1]UC Berkeley.

Spitzer has unparalleled sensitivity to infrared excesses around young stars due to circumstellar dust, but can only spatially resolve the closest few systems. Large, ground-based telescopes with their higher angular resolution play a key role in studying the close environments of these stars. I will present mid-infrared imaging that spatially resolves circumstellar dust on subarsecond scales around more than a dozen Herbig Ae/Be stars. These 10-18 um observations were obtained using LWS on Keck I and Michelle on Gemini North. The observed dust geometries variously take the form of circumstellar disks, bipolar envelopes, and extended asymmetric nebulae. Many Herbig Ae/Be stars have very complex circumstellar environments, frequently including deeply embedded companions and/or complicated streamers and arcs of dust, along with circumstellar disks traced by scattered light, thermal emission, and PAHs. Understanding these complex environments will require sophisticated multiwavelength analyses which incorporate mid-infrared imaging along with optical imaging from HST, near-infrared adaptive optics imaging and polarimetry, and millimeter interferometry.

238.08

MIR-Imaging brown dwarfs in binary systems with ESO/VLT and Gemini

Michael Sterzic[1]
[1]ESO/VLT, Chile.

Diffraction-limited mid-infrared imaging is required to resolve individual components in close low-mass binary or multiple systems in order to constrain their atmospheres or circumstellar disks.

Gemini(T-Recs) and VLT(VISIR) demonstrate the power of high-sensitivity, high-spatial resolution ground-based MIR observations of brown dwarfs binaries. I will highlight recent results where differential MIR photometry allows to probe the cool atmospheres of the nearby brown dwarf binary eps Indi B, and the disks around several young, nearby, very-low mass, objects.

238.09

High Spatial Resolution Observations of AGN at Mid-IR Wavelengths

Chris Packham[1], A. Alonso-Herrero[2], L. Colina[2], T. Diaz-Santos[2], J. Radomski[3], R. Mason[4], P. Roche[5], E. Perlman[6], N. Levenson[7], M. Elitzur[7], S. Young[8], C. Telesco[1]
[1]University of Florida, [2]CSIC, Spain, [3]Gemini Observatory, Chile, [4]Gemini Observatory, [5]University of Oxford, United Kingdom, [6]Florida Institute of Technology, [7]University of Kentucky, [8]University of Hertfordshire, United Kingdom.

High spatial resolution, mid-IR observations from the ground offer the chance to observe AGN at unprecedented spatial detail. Recent observations reveal striking changes in AGN spectral features at sub-arcsecond scales. Additional imaging observations place tight constraints on dust associated with the torus and the SED. I show new results obtained from the Gemini 8m telescopes, and discuss impact on models of the central regions of AGN.

239: AGN Jets
AAS Oral, Wednesday, 2:00-3:30pm, 3B

239.01D

New Multiwavelength Variability and Optical Microvariability Investigations of X-ray and Radio Selected Blazars

Margaret A. Osterman[1]
[1]*Georgia State Univ..*

Blazars may be classified as X-ray and radio selected blazars (XBLs and RBLs) based on their spectral properties. The results for four new multiwavelength campaigns are reported; two for XBLs and two for RBLs. Each campaign contains simultaneous observations in the radio, optical, and X-ray regimes. A campaign on a third RBL was completed using near-simultaneous archival radio, optical/IR, and EGRET data. The simultaneous multiwavelength behavior is analyzed by examining the multiwavelength variability and using spectral analysis. Observations of prominent optical microvariability are quantitatively analyzed. Previously published results for other blazars are compared to the new and archival results.

The campaigns on PG 1553+11, CTA 102, and PKS 1622-297 were the first simultaneous multiwavelength campaigns performed for these objects. PG 1553+11, a radio-weak blazar, was found to be an extreme XBL. PKS 2155-304 a freqently studied XBL, appears to exhibit different variability behavior during different epochs. Furthermore, flares in different wavebands appeared to have smaller time lags and similar structure as the flux state increased. For objects in which the results of at least two campaigns were available, including PKS 2155-304, correlations that appear at one epoch may vanish at other times. In all cases, the SSC model serves to represent the observations well. The RBLs all exhibited large amplitude optical microvariability. CTA 102, an RBL, exhibited some of the most extreme optical microvariability ever observed. Surprisingly, the optical spectra of RBLs CTA 102 and PKS 1622-297 were found to become redder when in a brighter flux state. Color studies for the selected BL Lac objects found them to be bluer when brighter, while the selected FSRQs were found to be redder when brighter.

This research was supported in part by the Program for Extragalactic Astronomy's Research Program Enhancement funds from GSU.

239.02

Beaming and the Intrinsic Properties of Extragalactic Radio Jets

Marshall H. Cohen[1]
[1]*CalTech.*

A 15-GHz VLBA survey of 119 compact extragalactic radio jets has yielded accurate values of apparent transverse velocity, β (units of c), and apparent luminosity, L. A plot on the (β, L) plane shows the 119 points closely bounded by an aspect curve, which is the track of (β, L) for a source when the aspect (angle to the LOS) is changed. From the parameters of this envelope the maximum Lorentz factor in the sample is estimated at Γ ~ 32, and the maximum intrinsic luminosity is estimated at ~ 10E26 W/Hz. Probability arguments show that there are too many low-speed (β<3) quasars in the sample, and in some of them the pattern speed must be less than the beam speed. Three of the 10 galaxies in the sample show superluminal motion and have values of Γ up to 6, but the others are only mildly relativistic. They are not off-axis versions of the powerful quasars. Cygnus A may be an exception. It has a weak subluminal jet in spite of its powerful lobes. and we suggest that it has a ″spine-sheath″ structure, with a fast off-axis jet that is deboosted and not seen from our direction. This work shows that the common model for a compact extragalactic jet, that the beam is relativistic and that the fastest moving component has about the same velocity as the beam, is valid for many sources.

239.03

Constraining Electron Spectra in the Hotspots of Cygnus A with Spitzer

D. E. Harris[1], L. Stawarz[2], C. C. Cheung[3], M. Ostrowski[4]
[1]*HEACenter for Astrophysics,* [2]*Kipac, Stanford U.,* [3]*NRAO and Kipac, Stanford U.,* [4]*Astronomical Observatory UJ, Poland.*

Our new Spitzer data at 4.5 and 8 microns for the classical radio galaxy Cygnus A provide detections or upper limits for both the primary and secondary hotspots. Together with photometry from the literature (radio through X-rays), we find strong support for the notion that the western hotspot's infrared flux densities are reasonably consistent with an extrapolation of the radio data, whereas the eastern hotspots display characteristics of a high frequency cutoff of the synchrotron emission. The optical detections reported by Nilsson et al. (1997) for hotspots D and B are found to lie on the extrapolation of the X-ray spectra reported by Wright and Birkinshaw (2004). These high frequency spectral components are normally considered to come from synchrotron self-Compton (SSC) emission. The lower cutoff frequency for the eastern hotspot D (compared to A) is consistent with equipartition and SSC determinations of a stronger magnetic field strength for D. This work was partially supported by Spitzer grant 1279229.

239.04

The Kiloparsec Scale Jet of the Quasar 1317+520

Svetlana G. Jorstad[1], A. P. Marscher[1], J. M. Gelbord[2], H. L. Marshall[2], D. A. Schwartz[3], D. M. Worrall[4], M. Birkinshaw[4], E. S. Perlman[5]
[1]*IAR BU,* [2]*MIT,* [3]*CfA,* [4]*Univ. of Bristol, United Kingdom,* [5]*UMBC.*

We present images of the quasar 1317+520 (z=1.06) obtained with the Infrared Array Camera (IRAC) of the Spitzer Space Telescope at 4.5/8 mum along with X-ray and radio images collected with Chandra and the Very Long Array. The IR emission is detected at a distance of ~10'' from the core and coincides with the brightest X-ray and radio feature in the extended jet. The spectral energy distribution of the feature fits very well with a synchrotron emission model from X-rays to radio wavelengths. This model allows estimation of the jet parameters at a distance of about 200 kpc from the core (deprojected). The polarized intensity image at 5 GHz provides clues concerning how the reacceleration of relativistic electrons might occur.

This research was funded in part by the National Science Foundation through grant AST-0406865 and by Jet Propulsion Laboratory through research support agreement no. 1276241.

239.05

Limit to the Positron Content of the Jet in 3C 120 from INTEGRAL and mm-Wave VLBI Observations

Alan P. Marscher[1], S. G. Jorstad[1], J. L. Gomez[2], I. M. McHardy[3], T. P. Krichbaum[4], I. Agudo[4]
[1]*Boston Univ.,* [2]*IAA, Spain,* [3]*Univ. Southampton, United Kingdom,* [4]*MPIfR, Germany.*

We report an attempt to detect the redshifted 511 keV electron-positron annihilation line from the radio galaxy 3C 120, in which the jet interacts strongly with interstellar clouds. Such interactions should cause most of the jet plasma to mix with the gas in the clouds. This will thermalize the majority of any positrons in the jet, leading to continuous annihilation with ambient electrons. We derive the number density of the combined electron-positron population in the core and compact knots in the jet of 3C 120 using ultra-high resolution observations with the Global mm-VLBI Array at 86 GHz and the Very Long Baseline Array at 43 GHz, along with the millimeter-wave continuum spectrum. If the jet contains a pure pair plasma, the production rate of positrons required to produce this density plus the efficiency of eventual annihilation predict a high luminosity in a narrow emission line at an energy of 495 keV in the observer's frame. Our spectral observations with the SPI instrument on INTEGRAL failed to detect the line. The upper limit constrains the maximum positron-to-proton ratio in the jet of 3C 120.

This research was funded in part by the National Science Foundation through grant AST-0406865 and by NASA through INTEGRAL Guest Investigator Program grant NNG05GN23G.

239.06

Multiple Circular Polarization Outbursts in the QSO 3C 279 at Centimeter Wavelengths

Hugh D. Aller[1], M. F. Aller[1], P. A. Hughes[1]
[1]*Univ. of Michigan.*

Using the University of Michigan 26-meter telescope we have followed the variations of 3C 279 at 4.8, 8.0 and 14.5 GHz in all four Stokes parameters since late 2003. A series of small outbursts in total flux density have been accompanied by significant variations in circular polarization (CP = Stokes V) at all three frequencies: at 8.0 and 14.5 GHz the sign of V has remained positive, but at 4.8 GHz V has exhibited both polarities. During 2006, V at 14.5 GHz exhibited a change of ~0.4% while V at the two lower frequencies exhibited only small or no change: a signature of self-absorption within the radio-emitting region. VLBA measurements made in late 2005 (Homan et al.; this conference) indicate that although this source contains multiple components, the CP originates in the core (partially self-absorbed) region. The observed behavior of V is consistent with the expectations of mode-conversion models incorporating random magnetic fields (Jones & O'Dell ApJ, 214, 522, 1977), but the sign of V has remained suprisingly stable at the higher frequencies. The high levels of both linear and circular polarization in this source place lower limits on the energy of the radiating electrons in the emitting region. This research was supported in part by the NSF (grant AST-0607523).

239.07

Relativistic Ejections Associated with High-energy Outbursts in the M87 Jet

Chi C. Cheung[1], D. E. Harris[2], L. Stawarz[3]
[1]*NRAO & Stanford,* [2]*Harvard-Smithsonian Center for Astrophysics,* [3]*KIPAC/Stanford.*

Our monitoring of the nearby radio galaxy M87 with NASA's Chandra X-ray Observatory isolated short (month) timescale variability in ′HST-1', a region of the jet >60 parsecs from the central supermassive black hole. The variability culminated in a remarkable X-ray outburst peaking in mid-2005. The outburst is >50 over quiescent and was for a few years, the brightest X-ray source in the galaxy. Prompted by this remarkable discovery and the detection of a comparable increase in radio activity, we began to monitor the jet with the NRAO Very Long Baseline Array (VLBA). These high spatial resolution observations resolved dynamic structures in the variable knot HST-1 and clear superluminal motion in multiple features. The HESS collaboration has recently reported a TeV flare broadly mimicking our radio/optical/X-ray lightcurves for HST-1. This multi-frequency variability and accompanying superluminal behavior is reminiscent of blazars in more distant active galaxies except here, the action is clearly displaced from the central supermassive black-hole. This gives us crucial insight into the production region of blazar-like emission.

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239.08

Synthetic Maps of Relativistic Jets The Origin of Bright Features

Carrie Swift[1], P. Hughes[2]
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Using hydrodynamic simulations of the flow of relativistic jets, we generate simulated flux maps of their emissivity. We present a method for determining the combination of physical conditions and angle of view that result in an individual radio feature. By analysis of the physical conditions encountered by a given line of sight through the jet, and the effects of relativistic boosting and time-delay, we can understand what combination of events leads to the formation of bright features. We present flux maps of both axially symmetric and fully three dimensional simulated relativistic jets. We show that both angle of view, which determines boost, and time-delay effects have a major impact on the jet's apparent morphology. We display evolutionary sequences, which show the formation of jet structure over time, and demonstrate that some bright features are long-lived relative to the dynamical time scale of the flow. By examining the histories of sample lines of sight, the contributions of both relativistic effects and flow conditions to the formation of bright features are shown. We find that for mildly relativistic jets the radio core arises from Kelvin-Helmholtz instabilities occurring near the axis of flow, while the extended emission is a manifestation of the bow shock. For three dimensional jets, this method allows for a straight forward analysis of radio features arising from a complex flow.

240: CMB-Experiments
AAS Oral, Wednesday, 2:00-3:30pm, 6A

240.01D

Prospects for the ACBAR Experiment

Christian L. Reichardt[1]
[1]*Caltech.*

The Arcminute Cosmology Bolometer Array Receiver (ACBAR) is a 16-element bolometer array with an angular resolution of 5'. Taking advantage of the excellent observing conditions at the South Pole, ACBAR has produced temperature maps of the cosmic microwave background with unprecedented resolution and sensitivity. I will discuss the prospects for the complete data set which will nearly quadruple ACBAR's integration time and increase ACBAR's sky coverage by a factor of 6.5. We expect the uncertainties on the band-powers to be halved over the fourth and fifth acoustic peaks and the damping tail of the CMB power spectrum. The final data set should also constrain the magnitude and spectrum of the ″excess power″ first reported by CBI.

240.02

Preliminary Results from ARCADE II

Dale J. Fixsen[1], A. Kogut[1], M. Limon[1], E. Wollack[1], P. Mirel[1], J. Singal[2], P. Lubin[2], S. Levin[3], M. Seiffert[3]
[1]*NASA's GSFC,* [2]*UCSB,* [3]*JPL.*

The ARCADE II instrument was designed to compare the cosmic microwave background spectrum to a blackbody spectrum at long (cm) wavelengths where the first stars are predicted to distort the ideal spectrum of the big bang. Reionization generates larger relative distortions at low frequencies. ARCADE II observed at 5 frequencies (3, 8, 10, 30 & 90 GHz). Each radiometer has a corrugated feed horn, a Dicke switch, internal calibrator, and amplifier mounted in an open liquid helium Dewar. The Dewar is 1.5 m in diameter and 1.8 m deep.

The ARCADE II employs a double difference scheme to control systematic errors, similar to the design of the COBE FIRAS instrument. The input to each radiometer is switched at 75 Hz between its internal calibrator and its horn antenna. The horn can observe either the sky or an external calibrator which is temperature controled to match the temperature of the CMB.

Detailed thermal charactorization of the external calibrator is enabled by 35 RuO thermometers embedded in the calibrator. The external calibrator has demonstrated 2.725 K operation even in the residual atmosphere at balloon altitudes.

The ARCADE II was launched on a balloon from Palestine TX on 2006 July 28. Approximately 3 hours of data were obtained, at 115000 feet, that allow calibration of the instrument and precise measurements of the spectrum of the CMB down to 3 GHz. The 12 degree beams of the radiometers were swept across the sky to show the Galaxy as well as the CMB. Pictures taken in flight show that cryogenic surfaces open to the sky can remain relatively frost free for hours with proper helium gas flow.

240.03

The Atacama Cosmology Telescope

Joseph W. Fowler[1], ACT Collaboration
[1]*Princeton University.*

We discuss the Atacama Cosmology Telescope (ACT). The goal of ACT is to map the microwave background temperature anisotropy with arcminute resolution. The six-meter telescope will observe from the Chilean Atacama Desert near the ALMA site. The completed focal plane will hold three arrays of one thousand multiplexed transition-edge sensor (TES) bolometers each, operating at 150, 220, and 280 GHz. Our science goals include measuring the slope of the primordial scalar anisotropy power spectrum, the kinetic SZ effect, and the thermal SZ effect. The ACT observations are being coordinated with optical observations to measure, for example, the redshifts of the galaxy clusters identified with the SZ effect.

240.04

Status of EBEX, a Balloon Borne CMB Polarization Experiment

Johannes Hubmayr[1], EBEX collaboration
[1]*University of Minnesota.*

We discuss the status of EBEX, a NASA funded balloon-borne polarimeter equipped with 1462 bolometric transition edge sensor (TES) detectors and designed to measure the B-mode polarization of the cosmic microwave background radiation. EBEX will scan 350 square degrees of the sky over a 14 day long-duration balloon flight. Given the expected sensitivity we will put a 2σ upper limit of $r \leq 0.03$. The EBEX instrument employs a 1.5 meter Gregorian-type telescope giving 8 arcminute resolution. Three frequency bands at 150, 250 and 420 GHz provide strong leverage against polarized dust foreground. Systematic errors are controlled by modulating the input polarization with a continuously rotating achromatic half wave plate (AHWP). Signal is detected in 1462 independent polarimeters distributed over two focal planes such that both polarization states are detected simultaneously. A superconducting magnetic bearing (SMB) allows smooth rotation of the AHWP with low heat dissipation suitable for a long duration balloon flight. The detectors are read out with a frequency domain multiplexing SQUID system.

240.05

The Millimeter-Wave Bolometric Interferometer

Andrei Korotkov[1], P. A. Ade[2], S. Ali[3], E. Bierman[4], E. F. Bunn[5], C. Calderon[2], A. C. Gault[6], P. O. Hyland[6], B. G. Keating[4], J. Kim[1], S. S. Malu[6], P. D. Mauskopf[2], J. A. Murphy[7], C. O'Sullivan[7], L. Piccirillo[8], P. T. Timbie[6], G. S. Tucker[1], B. D. Wandelt[9]
[1]*Brown University,* [2]*Cardiff University, United Kingdom,* [3]*LLNL,* [4]*University of California San Diego,* [5]*University of Richmond,* [6]*University of Wisconsin Madison,* [7]*National University of Ireland, Ireland,* [8]*University of Manchester, United Kingdom,* [9]*University of Illinois Urbana-Champaign.*

We report on the status of the Millimeter-Wave Bolometric Interferometer (MBI), an instrument designed for polarization measurements of the cosmic microwave background (CMB). MBI combines the differencing capabilities of an interferometer with the high sensitivity of bolometers. The design of the ground-based four-channel version of the instrument with 7-degree-FOV corrugated horns (MBI-4) and first measurements results are discussed. Corrugated horn antennas with low sidelobes and nearly symmetric beam patterns minimize spurious instrumental polarization. The MBI-4 optical band is limited by filters with a central frequency of 90 GHz. The antenna separation is chosen so the instrument is sensitive over the multipole range l=150-270. In MBI-4, the signals from antennas are combined with a quasi-optical Fizeau beam combiner and interference fringes are detected by an array of spider-web bolometers with NTD germanium thermistors. In order to separate the visibility signals from the total power detected by each bolometer, the phase of the signal from each antenna is modulated by a ferrite-based waveguide phase shifter. First observations will be from the Pine Bluff Observatory outside Madison, WI. The project is supported by NASA.

240.06

Point Source Power in 3-year Wilkinson Microwave Anisotropy Probe Data

Kevin M. Huffenberger[1], H. K. Eriksen[2], F. K. Hansen[2]
[1]*Caltech/Jet Propulsion Lab,* [2]*University of Oslo, Norway.*

Using a set of multifrequency cross-spectra computed from the three year WMAP sky maps, we fit for the unresolved point source contribution. For a white noise power spectrum, we find a Q-band amplitude of A = 0.011 ± 0.001 muK^2 sr (antenna temperature), significantly smaller than the value of 0.017 ± 0.002 muK^2 sr used to correct the spectra in the WMAP release. Modifying the point source correction in this way largely resolves the discrepancy Eriksen et al. found between the WMAP Vand W-band power spectra. Correcting the co-added WMAP spectrum for both the low-l power excess due to a sub-optimal likelihood approximation---also reported by Eriksen et al.---and the high-l power deficit due to over-subtracted point sources---presented here---we find that the net effect in terms of cosmological parameters is a ~ 0.7 sigma shift in n_s to larger values: For the combination of WMAP, BOOMERANG and ACBAR data, we find n_s = 0.969 ± 0.016, lowering the significance of n_s not equal to 1 from ~2.7 sigma to ~2.0 sigma. We acknowledge financial support from NASA and from the Research Council of Norway.

241: Extrasolar Planets IV
AAS Oral, Wednesday, 2:00-3:30pm, 605-07

241.01

Detecting Neptune-mass Planets Around 2,000 Nearby Stars with SIM

Nicholas M. Law[1], A. Tanner[2], S. Kulkarni[1], M. Shao[3], C. Gelino[4]
[1]*Caltech,* [2]*JPL/IPAC,* [3]*JPL,* [4]*IPAC.*

We describe the SIM EPIcS Tier-2 survey, a search for Neptune-mass planets around 2,000 nearby stars. The list of targets comprehensively covers a wide range of stellar masses, metallicities, ages, and multiplicity. The survey includes stars which cannot be easily searched with other methods, such as faint (V=19) low-mass targets. Four micro-arcsec astrometry will be acquired per visit on each target with several dozen visits occurring during the SIM mission time. Initial close-companion searches for the 2,000 targets will be performed with high time efficiency using the new Lucky Imaging technique for high-angular-resolution imaging from the ground. The EPIcS Tier-2 survey will provide a detailed view of the nature of the planetary systems around a wide variety of stars. It complements the SIM EPIcS Tier-1 narrow-angle survey, which is sensitive to terrestrial planets in the habitable zones of their parent stars.

WEDNESDAY

241.02

Finding Terrestrial Planets in the HZ of Nearby Stars with SIM PlanetQuest

Angelle M. Tanner[1], J. Catanzarite[2], M. Shao[2], S. Unwin[2]
[1]*JPL/IPAC,* [2]*JPL.*

SIM PlanetQuest will be an essential tool in determining the population and diversity of terrestrial planets in the habitable zone of nearby stars. It is a space-borne Michelson interferometer with a nine meter baseline that will survey ~240 stars within 30 parsecs for terrestrial mass planets. Ultra-precise astrometric observations will reveal the gravitational wobble of the target star (due to a planetary companion) against an inertial frame of reference stars located within a 1.5 degree radius. Here, I report the results of multiple Monte Carlo simulations which predict SIM's ability to detect and determine the orbital parameters and masses of the terrestrial mass planets around a sample of 250 proposed SIM target stars. If each target star has a terrestrial mass planet orbiting in its mid-habitable zone, for sample of the best 240, 120 and 60 targets, SIM will discover 91, 74 and 50 terrestrial planets with mean masses of 6.0, 5.0 and 4.2 Mearth, respectively. Of those

stars detected, 10, 18 and 21 of them will have masses below 3 Mearth. I will discuss the implications of what we will learn from SIM for both planet formation and future missions.

241.03

Spectral Evolution of an Earth-like Planet

Lisa Kaltenegger[1], W. A. Traub[2], K. W. Jucks[1]
[1]Harvard-Smithsonian, CfA, [2]Harvard-Smithsonian CfA & JPL.

We have developed a characterization of the geological evolution of the Earth's atmosphere and surface in order to model the observable spectra of an Earth-like planet through its geological history. These calculations are designed to guide the interpretation of an observed spectrum of such a planet by future instruments that will characterize exoplanets. Our models focus on spectral features that either imply habitability or are required for habitability. These features are generated by H_2O, CO_2, CH_4, O_2, O_3, N_2O, and vegetation-like surface albedos. We chose six geological epochs to characterize. These epochs exhibit a wide range in abundance for these molecules, ranging from a CO_2 rich early atmosphere, to a CO_2/CH_4-rich atmosphere around 2 billion years ago to a present-day atmosphere.

We analyzed the spectra to quantify the strength of each important spectral feature in both the visible and thermal infrared spectral regions, and the resolutions required to unambiguously observe the features for each epoch. We find a wide range of spectral resolutions required for observing the different features. For example, H_2O and O_3 can be observed with relatively low resolution, while O_2 and N_2O require higher resolution. We also find that the inclusion of clouds in our models significantly affects both the strengths and resolutions required to observe all spectral features.

241.04

PHASES: A Search for Planets in Binary Systems

Benjamin Lane[1], M. Muterpspaugh[2], M. Konacki[3], S. Kulkarni[4], M. Shao[5], M. Colavita[5], B. Burke[1]
[1]MIT, [2]Berkeley Space Science Lab, [3]Nicolaus Copernicus Astronomical Center, Poland, [4]Caltech, [5]JPL.

For the past three years we have used the Palomar Testbed Interferometer to undertake an astrometric search for planets in binary stellar systems. By using phase referencing and long-baseline near-IR interferometry we are able to obtain an astrometric precision of approximately 20 microarcseconds between pairs of stars with separations in the range 0.1-1 arcsecond. We have followed 40 systems intensively and to date have over 800 astrometric measurements. We will present results from the first comprehensive analysis of this data set, including strong limits on the occurrence of planets in our target systems. The PHASES program serves as an excellent precursor to the type of program we expect to undertake with the Space Interferometry Mission PlanetQuest.

241.05D

M Dwarf Planetary Systems

Peter Plavchan[1], M. Jura[2], R. Cutri[1], J. D. Kirkpatrick[1], S. C. Gallagher[2], S. J. Lipscy[3]
[1]IPAC/Caltech, [2]UCLA, [3]Ball Aerospace.

We present the results of three projects investigating M dwarfs and their circumstellar environments, with a particular focus on whether M dwarfs harbor planetary systems. For the first project, we present 11.7μm observations of nine late-type dwarfs obtained at the Keck I 10-meter telescope. Our targets were selected for their youth or apparent IRAS 12μm excess. For all nine sources, excess infrared emission indicative of a planet-forming debris disk is not detected. We find that stellar wind drag can dominate the circumstellar grain removal and plausibly explain the dearth of M dwarf systems older than 10 Myr with currently detected infrared excesses. We predict M dwarfs possess fractional infrared excess on the order of $L_{IR}/L_* \sim 10^{-6}$ and this may be detectable with future efforts.

The 2MASS photometric calibration database covers ~4 square degrees on the sky in 35 "calibration fields" sampled in nominal photometric conditions between ~550 and ~3700 times over the four years of the 2MASS mission. For the second project, we compile a catalog of variables in this database that is motivated by a search for M dwarfs transited by extra-solar planets. We present our methods for measuring periodicity and variability. We identify 246 variables, including 23 periodic variables. We have discovered three M dwarf eclipsing systems, including two candidates for transiting extrasolar planets.

For the third project, we constrain the frequency of M dwarfs with hot Jovian companions. We present Monte Carlo simulations to estimate the number of companions we can detect in our sample of M Dwarfs. We present a model for the photometry of eclipsing systems, and apply it to three new M dwarf eclipsing systems to estimate component mass, radii and orbital parameters. We find that M Dwarfs are not likely to have close-in Jovian companions in greater abundance than solar type stars.

241.06

Evidence From Spitzer for a Low-Mass Companion and a Circumbinary Disk Around a Pre-Cataclysmic Variable

Carolyn Brinkworth[1], D. W. Hoard[1], T. R. Marsh[2]
[1]Spitzer Science Center, [2]University of Warwick, United Kingdom.

We present Spitzer Space Telescope data on the non-mass transferring close binary system, NN Ser. Between 2002 and 2004 we measured a change in the orbital period of NN Ser with the ultra-fast, triple-beam CCD camera, ULTRACAM. We found that the rate of period change was consistent with an evolutionary rate of 2 orders of magnitude faster than expected from close binary evolutionary theory. We concluded that either the current theory of close binary evolution is flawed, there is an extra mechanism draining angular momentum from the binary system (probably in the form of a circumbinary disk), or the period change is due to a light-travel time effect caused by an orbiting third body. We therefore obtained Spitzer data in Aug 2006 to search for an infrared excess indicative of either a circumbinary disk or third body, and we have high-resolution HST observations scheduled for January. The Spitzer data show an infrared flux density in excess of that expected from the binary system components, but only at 4.5 and 8.0 microns. The 8.0 micron flux density can be easily modeled with a circumbinary disk, but cannot simultaneously match the 4.5 micron point without exceeding the measured flux density at 5.8 microns. This leads us to believe that there is another system component possibly a low mass companion in orbit around the binary system. If so, this raises the intriguing possibility that we have observed both a disk and a low-mass body in orbit around the same system, leading to the question of whether the disk is coalescing to form new planetary bodies, or whether an old planetary system is being destroyed by the tidal forces of the inner binary.

241.07

New Very Low Mass Binaries in the Taurus Star-Forming Region

Quinn M. Konopacky[1], A. M. Ghez[1], E. L. Rice[1]
[1]UCLA.

We observed thirteen very low mass (VLM; $M <\sim 0.2\ M_\odot$) objects in the Taurus star-forming region using near-infrared diffraction-limited imaging techniques on the W.M. Keck I 10 m telescope. Of these thirteen, five were found to be binary, with separations ranging from 0″.04 to 0″.6 and flux ratios from 1.4 to 3.7. In all cases, the companions are highly likely to be physically associated (probability $>~4$\sigma$). Using the theoretical models of Baraffe et al. (1998), we find that all five new companions, as well as one of the primaries, are likely brown dwarfs. The discovery of these systems therefore increases the total number of known, young VLM binaries by ≈50%. These new systems, along with other young VLM binaries from the literature, have properties that differ significantly from older field VLM binaries in that the young systems have wider separations and lower mass ratios, supporting the idea that VLM binaries undergo significant dynamical evolution ≈5 10 Myr after their formation. The range of separations of these binaries, four of which are over 30 AU, argues against the ejection scenario of brown dwarf formation. While several of the young, VLM binaries discovered in this study have lower binding energies than the previously sug-

gested minimum for VLM binaries, the apparent minimum is still significantly higher than that found among higher mass binaries. We therefore suggest that a possible cause of this discrepancy may be a preference for VLM objects to form in unstable higher order multiple systems. This work is supported by NASA Astrobiology Institute, the NSF Science & Technology Center for AO, managed by UCSC (AST-9876783), and the Packard Foundation. QMK is supported by the NASA Graduate Student Research Program (NNG05-GM05H) through JPL.

242: Milky Way Topics
AAS Oral, Wednesday, 2:00-3:30pm, 3A

242.01D

Probing the Milky Way at Mid-Infrared Wavelengths using GLIMPSE

Emily P. Mercer[1]
[1]*Boston Univ..*

A critical assessment of the mid-infrared as a tool for probing the structure and star-forming nature of the Galaxy is presented. This evaluation has been carried out using Spitzer/IRAC observations obtained as part of the GLIMPSE project. In the GLIMPSE data, star-forming nebulae, star clusters, and large-scale structures in the Milky Way have been identified. Analysis of the GLIMPSE data, along with ancillary datasets, reveals massive YSOs embedded in these recently discovered IR-bright nebulae. A systematic search of the GLIMPSE data has yielded a total of 92 newly detected star cluster candidates found toward the inner Galaxy. Distances to several of these IR sources have been determined from morphological matching with CO survey data and targeted new CO observations. A sample of these sources is highlighted, analysis techniques employed to study the sources are described, and results from these studies are presented. Based on conclusions drawn from these investigations, the utility of the mid-IR for studying Galactic star forming regions and identifying key structures within the Galaxy is assessed. The advantages and disadvantages of using mid-IR light to examine such environments are summarized.

Support for this work was provided by NASA through contract 1225025 to Boston University and by the NSF through grant DGE-0221680.

242.02D

The Frequency of Warm Carbon-Enhanced Metal-Poor Stars in SDSS-I DR-5

Brian E. Marsteller[1], T. C. Beers[1], T. Sivarani[1], S. Rossi[2], J. Knapp[3], B. Plez[4], J. Johnson[5], T. Masseron[5]
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There exists current a debate concerning the frequency of stars with large enhancements of carbon ([C/Fe] $> +1.0$) among very metal-poor ([Fe/H] $<$-2.0) stars in the Galactic halo. Some authors, e.g., Marsteller et al. (2005) and Lucatello et al. (2006), have concluded that a rather high frequency, on the order of 20%-25% exists, while other authors (e.g., Cohen et al. 2005) have claimed lower frequencies. One of the difficulties in making a precise estimate is that many previous samples of stars are dominated by giants, which are subject to alteration of the surface carbon abundance due to evolutionary effects. Fortunately, there is now an attractive alternative. The publicly available stellar database from SDSS-I (DR-5) contains large numbers (more than 24,000) warm (Teff $>=$ 5700 K), very metal-poor stars (many of which were selected as calibration objects during the course of SDSS-I) which are not expected to have evolved to the point where carbon can be diluted on their surfaces. An estimate of the frequency of carbon-enhanced stars from this sample should provide one of the best available estimates of the true value of this quantity. In order to obtain estimates of [Fe/H] and [C/Fe] for this large sample, I have developed an automated spectral synthesis technique, making use of Sneden's MOOG program. With reasonable first estimates of the atmospheric parameters for our sample (obtained by the SDSS/SEGUE spectroscopic pipeline discussed elsewhere in this meeting), this approach quickly converges to the best available combination of [Fe/H] and [C/Fe] required to fit the spectral regions around the CaII K and CH G-bands. I will discuss the resulting frequency of carbon-enhanced metal-poor stars among the very metal-poor stars in this sample.

242.03

A Search for Obscured Dwarf Novae in the Galactic Bulge

Silas Laycock[1], J. E. Grindlay[1], M. van den Berg[1], J. Hong[1], P. Zhao[1]
[1]*Harvard-Smithsonian, CfA.*

In order to test population theories for the X-ray point-source population in the Galactic Bulge, we are conducting a search for candidate dwarf novae and Be stars. Using 3 years of infrared imaging observations with the CTIO 4m and Magellan 6.5m telescopes we have detected several hundred variable stars and transients within about 5 arcmin of SgrA* with image subtraction techniques. Measurement of the dNe rate can potentially test the hypothesis that a large population of CVs lies in the GC. Furthermore association of X-ray emission with IR transients and large amplitude variables provides positive identification for individual systems. This approach goes some way to circumventing the crowding problem.

242.04

Observations of the Unidentified TeV Gamma-ray Source in the Cygnus Region with the Whipple Observatory 10 m Telescope

Alexander Konopelko[1], VERITAS collaboration
[1]*Purdue University.*

We report on observations of the sky region around the unidentified TeV gamma-ray source (TeV J2032+4130) carried out with the Whipple Observatory 10 m imaging atmospheric Cherenkov telescope for a total of 65.5 hrs between 2003 and 2005. The standard analysis developed by the Whipple collaboration for a stand-alone telescope reveals an excess in the field of view at a pre-trials significance level of 6.1 sigma. The estimated integral flux for this gamma-ray source is about 8% of the Crab-Nebula flux. The data are consistent with a point-like source. The results for the TeV J2032+4130 observing campaign will be presented. Discussion of the physical mechanisms that may be responsible for the observed gamma-ray emission, based on the possible associations of the Whipple TeV gamma-ray source with known astrophysical objects, will be also given.

242.05

The Sagittarius Spiral Arm of the Galaxy: Now You See It, Now You Don't

Robert A. Benjamin[1], E. Churchwell[2], M. Haffner[2], GLIMPSE team
[1]*Univ. of Wisconsin,Whitewater,* [2]*Univ. of Wisconsin-Madison.*

We present an analysis of star count data using the GLIMPSE Point Source Catalog of Spitzer/IRAC sources focusing on the directions of the Sagitarrius arm tangency (galactic longitude l=49-53) and the (Scutum)-Crux arm tangency (l=306-309). Nearly all models of Galactic spiral structure place the location of these tangencies at the same distance from the Sun (d~6 kpc). We clearly detect the Crux spiral arm tangency over galactic longitude range l=306-309 as a 10-30% excess in star counts over the magnitude range m=6.5-12.5. We demonstrate that (1) the asymmetric shape of the excess as a function of longitude is consistent with the expectation of a stellar spiral arm seen in tangency, (2) the direction is consistent with the claims of a spiral arm tangency seen in gas tracers, and (3) the physical width of the Crux arm (w=300+/40 pc) is consistent with other spiral galaxies. We use data from WHAM (Wisconsin H-alpha Mapper) to demonstrate that the Sagittarius arm tangency at l=50 is clearly seen in H-alpha emission, but find no evidence of an excess in infrared star counts. This confirms the analysis of COBE K-band light by Drimmel (2000) and Drimmel & Spergel (2001), and provides further evidence that the mass of the Galaxy (traced by infrared light) is organized in a two-armed, not four-armed, spiral structure. We also discuss the relationship of the Scutum-Crux and Perseus arms to the stellar bar of the Galaxy.

243: SNR, Cosmic Rays and Neutron Stars
AAS Oral, Wednesday, 2:00-3:30pm, 201

243.01

A Plausible X-ray Counterpart of the Unidentified TeV Gamma-ray Source HESS J1804-216

Wei Cui[1], A. Konopelko[1]
[1]*Purdue Univ..*

We present high-resolution X-ray images taken with the Chandra X-ray Observatory of the field that contains the unidentified TeV gamma-ray source HESS J1804-216. Among the sources detected, only one is significantly extended. The source is about 40″ away from the radio pulsar PSR J1803-2137. The X-ray spectrum of the new source can be fitted well with a power law, although the model is not well constrained due to large statistical uncertainties. The spectrum seems to be very hard, with the best-fit photon index about 1.2. We argue that the source is likely the X-ray counterpart of HESS J1804-216, based on the fact that the Galactic TeV gamma-ray sources are predominantly shell-type supernova remnants or pulsar wind nebulae.

243.02

Thermal and Non-thermal Emission from Cosmic Ray Modified Shocks

Daniel Patnaude[1], D. Ellison[2], P. Slane[1]
[1]*Harvard-Smithsonian, CfA,* [2]*North Carolina State Univ..*

Efficient cosmic ray acceleration in supernova remnants results in both higher shock compression and lower post shock temperatures compared to cases where cosmic ray production is ignored. These changes in the properties of the shocked plasma will translate into changes in the thermal X-ray emission in the interaction region between the forward and reverse shocks. Furthermore, the relativistic cosmic ray electrons produced in the diffusive shock acceleration process generate nonthermal X-ray synchrotron emission which is self-consistently determined with the thermal emission through the nonlinear shock acceleration mechanism. We present results from simulations where the remnant hydrodynamics are coupled to efficient cosmic ray acceleration and to a nonequilibrium ionization calculation of thermal X-ray emission. By varying the particle injection efficiency, ambient density, and the electron heating mechanism, we produce a grid of models which show variations in the resultant X-ray spectra where the thermal and nonthermal contributions are determined self-consistently.

243.03

SUBARU HDS Observation of Balmer-Dominated Shock in Tycho

Jae-Joon Lee[1], B. Koo[1], J. Raymond[2], P. Ghavamian[3], T. Pyo[4], A. Tajitsu[4], M. Hayashi[4]
[1]*Seoul National Univ., Republic of Korea,* [2]*Harvard-Smithsonian Center for Astrophysics,* [3]*Johns Hopkins University,* [4]*Subaru Telescope, NAOJ.*

We present Hα spectral observations of a Balmer-dominated shock on the eastern side of Tycho's supernova remnant using SUBARU Telescope. Utilizing the High Dispersion Spectrograph (HDS), we measure the spatial variation of the line profile between preshock and postshock gas. Our observation clearly shows a broadening and centroid shift of the narrow-component Hα line relative to the Hα emission from the preshock gas. The observation supports the existence of a thin precursor where gas is heated and accelerated ahead of the shock. Furthermore, the spatial profile of the emission ahead of the Balmer filament shows a gradual incline in the Hα intensity and line width ahead of the shock. We propose that this region (~ 10^16 cm) is likely to be the precursor resolved. The line width increases from ~ 30 km/s up to ~ 45 km/ s and its central velocity shows a redshift of ~ 5 km/s across the shock front. The characteristics of the precursor are consistent with a cosmic ray precursor, although a possibility of a fast neutral precursor is not ruled out.

243.05

Suzaku Observations of Supernova Remnant G93.3+6.9 (DA 530)

Michael Stage[1], D. Q. Wang[1]
[1]*Univ. of Massachusetts.*

Supernova remnants, and the chemical enrichment and energy they transport, are a key component in the development of galaxies. Necessarily, most studies focus on bright, easily observed remnants--a biased sample generally found in dense environments. In fact, most supernova likely occur in low density environments. Since they are consequently harder to observe these remnants represent a largely unseen but very important piece of the supernova puzzle, both in terms of understanding enrichment and also for collecting data to model the explosions in low density environments. The Crab pulsar is presumed to have originated from such a supernova, and would probably be unknown to us if not for the pulsar wind nebula. G93.3+6.9 is a shell-type supernova remnant, located in a low density region at high Galactic latitude, about 420 pc above the Galactic plane. It emits radio synchrotron emission at the blast wave edge but only weak, interior, extended thermal X-ray emission. We present images and spectral analysis of the X-ray emission observed with the XIS instrument on Suzaku in June 2006, from a series of 5 pointings totaling 70 ksecs.

243.06

Probing Ejecta Properties in Supernova and GRB Remnants: The example of W49B

Laura A. Lopez[1], E. Ramirez-Ruiz[1], D. Pooley[2], S. K. Patel[3], D. Chelouche[4]
[1]*UC, Santa Cruz,* [2]*UC, Berkeley,* [3]*NASA Marshall Space Flight Center,* [4]*Institute for Advanced Study.*

A new mathematical approach is introduced in order to quantify ejecta properties in supernova remnants. As an example of these techniques, we present the archival Chandra ACIS observation of W49B, a barrel-shaped galactic SNR with infrared and X-ray morphology suggestive of a bipolar explosion. We apply wavelet transform analysis and two-point correlation methods to measure the relative distributions and clump sizes of individual ions, including silicon and iron. In combination with the spatially-resolved spectral information from Chandra, our results set tight constraints on the ion abundances, and consequently, the masses of the individual ejecta. These methods offer an exciting tool for probing the explosion histories and evolutions of supernova and GRB remnants.

243.07

Initial Results From CHAZSS: the Chandra HETGS Atoll/Z Spectroscopic Survey

Edward Cackett[1], J. Miller[1], CHAZSS team
[1]*Univ. Of Michigan.*

CHAZSS is a survey using high-resolution Chandra spectroscopic observations of 6 Z and atoll neutron star binaries, with simultaneous X-ray timing, radio and optical observations. Here we present an initial analysis of the high-resolution X-ray spectra, with specific attention to absorption lines that may be due to disk winds or may arise in the ISM. In at least one of the sources there is evidence for broadened emission lines.

243.08

X-ray Binaries in Nearby Galaxies: Identifying Black Hole and Neutron Star Candidates

Sergey P. Trudolyubov[1], W. C. Priedhorsky[2], F. A. Cordova[3]
[1]*IGPP/UCR,* [2]*LANL,* [3]*UCR.*

Using the data of XMM-Newton and Chandra observations, we explore the possibility of identification of bright neutron star and black hole binary systems in nearby galaxies, based on the comparisons of their spectral properties and variability with that of the canonical Galactic neutron star and black hole X-ray binary systems. We show that X-ray spectral hardness-luminosity diagrams (or spectral photon index vs. luminosity diagrams) can be very effective tool for distinguishing between luminous (>3e37 ergs/s) neutron star systems and stellar-mass black hole candidates in the intermediate/high/very-high state. Using the central region of M31 as a case study, we identify 8 and 29 out of total 87 sources with luminosities above 5e36 ergs/s as probable black hole and neutron star candidates, combining X-ray spectral and variability information. Finally, we extend our study to several nearby galaxies of different morphological type.

Support for this work was provided through NASA Grant NAG5-12390.

243.09

Evidence that (some) Ultra High Energy Cosmic Rays Come From a Bursting Source

Glennys R. Farrar[1]
[1]New York Univ..

A cluster of 5 Ultrahigh Energy Cosmic Rays (UHECRs) in the combined published AGASA-HiRes data has a probability of about 2 10^{-3} of occurring by chance. The observed energies of the events in this cluster favor a bursting rather than continuously emitting source, with a relative likelihood of about 500. Assuming the UHECRs experience many incoherent small magnetic deflections enroute from source to Earth, the arrival direction distribution allows estimation that $< B^2$ lambda$>$ D ~ 8 nG^2 Mpc^2, where lambda is the coherence length of the magnetic field and D is the distance of the source. If the spectrum at the source ~ E^{-2} and the events are emitted on a time scale short compared with 350 D_Mpc years, the total energy emitted in CRs above 10^{19} eV is 2×10^{43} D_Mpc ^{3} ergs. Implications for global models of UHECR production are discussed

244: Star Clusters II
AAS Oral, Wednesday, 2:00-3:30pm, 204

244.01D

High Resolution Analysis of Globular Clusters in M87

Christopher Z. Waters[1]
[1]Michigan State Univ..

Recent space based observations have allowed globular clusters to be studied in other galaxies with high precision. I present preliminary results from a study of the globular cluster system of M87, based on data from a 50 orbit HST/ACS program. This very deep data allows for the detection of faint clusters far beyond the turnover of the globular cluster luminosity function. These faint clusters provide constraints on dynamical models of globular cluster destruction, and also test recent predictions for the changes in the color distribution of dissipating clusters. The high signal to noise this data allows the structure of the clusters to be fit using PSF-convolved King model templates. By modeling the clusters in this way, I can determine estimates for the cluster concentration and tidal radius, which constrains the M87 mass profile and the cluster orbits.

244.02

Probing the M87 Globular Cluster System with Deep NICMOS Imaging

Arunav Kundu[1], S. E. Zepf[1], M. Hempel[2]
[1]Michigan State Univ., [2]Univ. of Florida.

The rich globular cluster (GC) system of M87 has long been a cornerstone of cluster research. We have analyzed deep HST-NICMOS H-band images of the cluster system of M87. While the optical color distribution of the M87 GCs has long been known to be bimodal the addition of mass sensitive near-infrared observations helps lift the age-metallicity degeneracy, and hence constrain the age, metallicity, and mass of individual clusters. We investigate the distributions of ages, metallicities, and masses in the globular cluster system of M87, the possible correlations between these properties, and the implications on models of globular cluster system formation and evolution. We show that the bimodality in the M87 GC system reflects the underlying metallicity distribution of old cluster populations and is unlikely to be due to differences in the horizontal branch structures, as has recently been suggested.

This research was supported by NASA LTSA grant NAG5-12975.

244.03

Extragalactic Star Clusters: the Resolved Star Approach

Anne Pellerin[1], M. J. Meyer[1], H. Jason[2], D. Calzetti[1]
[1]STScI, [2]Steward Observatory.

The physical processes leading to the dissolution of star clusters is a topic barely studied and still not understood. We started a pilot project to develop a new approach to directly detect and study the properties of stellar clusters while they are being destroyed. Our technique currently under development makes use of the exceptional spatial resolution and sensitivity of the ACS camera onboard HST to resolve individual stars in nearby galaxies. PSF stellar photometry and color-magnitude diagrams allows us to separate the most massive stars (more likely to be in clusters) from the star field background. While applying the method to the normal spiral galaxy NGC1313, we found that the method of studying star clusters through resolved stars in nearby galaxies is even more powerful than we first expected. The stellar maps obtained for NGC1313 show that a large fraction of early B-type stars contained in the galaxy are already part of the star field background rather that being in star clusters. Such stars live for 5 to 25 Myr. Since most stars form in clusters, the presence of such massive stars in the field means that they must have left their birthplace very rapidly. It also means that the processes involved in the dissolution of the clusters are extremely efficient. The only plausible explanation for so many young stars to be in the field background is the infant mortality of star clusters. We will present the latest results on the two galaxies NGC 1313 and IC 2475 and discuss the potential of the new approach for studying extragalactic stellar clusters.

244.04D

Tidal Tales of Minor Mergers II: Star Formation in the Tidal Debris of Minor Mergers

Karen A. Knierman[1], P. Knezek[2], E. Wehner[3]
[1]Univ. of Arizona, [2]WIYN, [3]McMaster University, Canada.

How does the tidal debris of minor galaxy mergers contribute to structures in spiral galaxies or in the intergalactic medium? While major mergers are known to create structures such as tidal dwarf galaxies and star clusters within their tidal debris, little is known about minor mergers (mass ratios between a dwarf galaxy and disk galaxy of less than one-third) and their tidal debris. This work surveys 15 minor mergers using optical and infrared imaging to characterize star formation in their tidal debris. For example, NGC 2782, a minor merger having a mass ratio of 0.25 that occurred ~200 Myr ago, has a population of young star clusters which formed along both tidal tails. In particular, the presence of young clusters in the Western tail is unexpected due to the lack of molecular gas observed in previous studies. Also, the star cluster populations of each tidal tail have very different masses ($<\Delta$ M$>$ ~ 10) with the Western tail having smaller mass clusters. This result has implications for the wider field of star formation, suggesting that star cluster formation is a common outcome of minor mergers regardless of gas content in the tidal debris. However, the properties of the star clusters formed may be dependent on local properties such as metallicity, gas pressure density, gas content, etc. Even if minor mergers contribute less tidal debris per interaction than major mergers, they are more common and possibly contribute structure to all types of galaxies and to the intergalactic medium throughout the history of the universe.

244.05

Restarting Galaxy Formation in Arp 82: An UV, Optical and Mid-IR Study of Star Formation in NGC 2535/6

Mark Hancock[1], B. J. Smith[1], C. Struck[2], M. L. Giroux[1], P. N. Appleton[3], V. Charmandaris[4], W. T. Reach[3]
[1]East Tennessee State University, [2]Iowa State University, [3]Spitzer Science Center, [4]University of Crete, Greece.

As part of our Spitzer Spirals, Bridges, and Tails project to help understand the effects of galaxy interactions on star formation, we analyze GALEX ultraviolet, SARA optical, and Spitzer infrared images of the interacting galaxy pair Arp 82 (NGC 2535/6) and compare to a numerical simulation of the interaction. We investigate the multiwavelength properties of several individual star forming complexes (clumps). Using optical and UV colors, EW(Halpha), and population synthesis models we constrain the ages of the clumps and find that the median clump age is about 12 Myr. The clumps have masses ranging from a few times 10^6 to 10^9 solar masses. In general, the clumps in the tidal features have similar ages to those in the spiral region, but are less massive. The 8 micron and 24 micron luminosities are used to estimate the far-infrared luminosities and the star formation rates of the clumps. The total clump star formation rate is 2.0+/-0.8 solar masses per year, while the entire Arp 82 system is forming stars at a rate of 4.9+/-2.0 solar masses per year. We find, for the first time, stars in the HI arc to the southeast of the NGC 2535 disk. Population synthesis models indicate that all of the observed populations have young to intermediate ages. We conclude that although the gas disks and some old stars may have formed early-on, the progenitors may have been late-type or low surface brightness and the evolution of these galaxies seems to have halted until the recent encounter.

245: Instructional Technology in Physics and Astronomy Courses
AAPT Oral, Wednesday, 2:00-3:30pm, 303

Chair

Jeffrey Williams[1]
[1]Bridgewater State College.

245.02

Web-based Classroom Interaction System and Impact on Student Learning

Joseph Beuckman[1], N. Rebello[2]
[1]Southern Illinois University-Edwardsville, [2]Kansas State University.

We have developed and deployed a Web-based wireless classroom interaction system in a large-enrollment introductory physics lecture class that uses HP handheld computers (PDAs) to facilitate real-time two-way student interaction with the instructor. Our system is ahead of other “clicker” based systems that are primarily limited to multiple-choice responses. Our system allows for a variety of questions including short answer questions. It also allows for adaptive questioning and two-way communication that provides real-time feedback to the instructor. We will share results from student feedback as well as the impact of this technology on student learning. Comparisons to the more commonly used multiple-choice response systems will be discussed.

Supported in part by HP Technology for Teaching Grant 2004.

245.03

Grid-based e-Labs for Pre-College Research in Physics and Astronomy

Thomas J. Loughran[1]
[1]University of Notre Dame Department of Physics/Fermi National Accelerator Lab.

e-Labs are Grid-enabled collaborative research environments which make data and analysis tools from large scientific collaborations available for pre-college science research. Guided-inquiry pedagogy underlies a workflow consisting of a series of performance milestones and associated resources, providing assistance for students in climbing the learning curve so as to query data, publish studies and interact with readers in the e-Lab. Teacher pages are available to help them use e-Labs in their classrooms. Currently three e-Labs--using data from the QuarkNet/WALTA Cosmic Ray collaboration, the CMS test beam, and the environmental sensing monitors from LIGO-Hanford--are currently deployed in production or testing runs. Students at Saint Joseph’s High School in South Bend, IN are extending the e-Lab pedagogy to astronomy using data from the National Optical Astronomy Observatory’s TLRBSE research projects, as well as data from the Spitzer Space Telescope under the NOAO/NASA Spitzer Research Teacher program. The prospects of developing and employing e-Labs to facilitate high school student research using data from virtual observatories will be discussed. e-Labs are being developed under the NSF-supported Interactions in Understanding the Universe (I2U2) program. (This presentation is sponsored by AAPT member Beth Marchant.)

245.04

Preparation Strategies for Video-based Introductory Physics

David M. DeMuth, Jr.[1], M. Schwalm[2]
[1]Un. of Minnesota, Crookston, [2]Un. of North Dakota.

A video capture and Macromedia Flash-based video analysis system is used in an implementation of the problem solving and collaborative methodologies (UMinn, Heller/Heller) at the University of Minnesota, Crookston, where an open source polling system has been developed to verify preparation. Its features include a platform independent web interface, assignable and automatic polling intervals, and graphical reporting. Question types: Multiple Choice (optionally randomly presented), random variable, ranking, and survey. An HTML editor with image/video/file uploading allows for high quality presentation of questions. An optional collaborative feature forces agreement among students in small groups. An overview of the system and its impact on preparation will be presented. http://ray.crk.umn.edu/aapt/ Funded by NSF-CCLI 102280781

245.05

PowerPoint Nuggets for Pre-lab Content Review

Michael R. Meyer[1]
[1]Michigan Tech University.

At Michigan Tech, students often take physics lab the semester BEFORE they take the associated course. I’ve built a collection of short (8-10 slide) PowerPoint presentations which serve as a media-rich content introduction to each of my introductory university physics labs. These presentations are viewed independently by lab groups at their own pace. Students can come back to them throughout the lab (or during the next labs) for reference. The availability of simple animation makes this a more attractive medium than text for certain topics. The method is relatively inexpensive (the viewer is free, editing can be done quickly, and development costs are low). This technique, including the ability to link from one “nugget” to another, could be applied in many on-line and other classroom settings and/or using many other types of software.

245.06

Optical Analogies for Teaching Physics of X-rays and CAT Scans*

Spartak Kalita[1], D. A. Zollman[1]
[1]Kansas State University.

Our Modern Miracle Medical Machines project is devoted to improving motivation and performance of pre-med students in their undergraduate Physics classes. Under its framework we designed some non-traditional hands-on lab activities involving optical analogies to teach the application of contemporary physics to medical imaging. On the basis of our previous research (primarily clinical interviews with the target student population) we

created activities using semi-transparent Lego blocks as analogs for understanding the image reconstruction process in computerized axial tomography (CAT or CT). Teaching interviews have been conducted with pre-med and other health-related majors using these materials. Students had to determine the shape of an object constructed of Lego blocks and hidden within a closed box. This arrangement imitated an unknown entity within a part of the human body. Using LEDs (light-emitting diodes) and a photo detector the students attempted to learn the contents of the box. They also had access to another similar Lego arrangement which they were free to open. Interviewees successfully transferred knowledge from their science and math classes (as well as from other sources) while completing activities and expressed great interest in this endeavor. Improvements to the activities have been based on the students' feedback.

*Supported by the National Science Foundation under grant 04-2675

245.07

How Converging Lens Simulation Designs Affect Understanding of Image Formation

Joel A. Bryan[1]
[1]*Texas A&M University.*

Although computer technology has greatly enhanced the teaching and learning of all science disciplines, computer simulations, in particular, have become exceptionally beneficial to physics education. As with any innovation, computer simulations should be most effective when used as part of guided inquiry or other research-supported instructional methodologies. In addition to the manners in which physics instructors integrate computer simulations into their instructional practices, computer simulations' designs must also be considered when evaluating their impact on students' conceptual development and understandings. This presentation describes the effects of the number of rays depicted and their origination points in three converging lens simulations on students' predictions of the images observed on a screen when portions of the lens or object are covered. A comparison of student predictions under differing levels of instructor guidance is also presented.

246: Physics and Society Education
AAPT Oral, Wednesday, 2:00-3:30pm, 617

Chair

Gordon McIntosh[1]
[1]*University of Minnesota, Morris.*

246.01

The Fusion Energy Problem Has Been Solved

John W. White[1]
[1]*LLNL & Modesto J C.*

Inertially confined fusion has already been proven for large scale explosives in the US Plowshare program. There are MANY potential applications.

246.02

Energy Storage Systems as a Compliment to Wind Power

Jared D. Sieling[1], C. F. Niederriter[1], D. A. Berg[1]
[1]*Gustavus Adolphus College.*

As Gustavus Adolphus College prepares to install two wind turbines on campus, we are faced with the question of what to do with the excess electricity that is generated. Since the College pays a substantial demand charge, it would seem fiscally responsible to store the energy and use it for peak shaving, instead of selling it to the power company at their avoided cost. We analyzed six currently available systems: hydrogen energy storage, flywheels, pumped hydroelectric storage, battery storage, compressed air storage, and superconducting magnetic energy storage, for energy and financial suitability. Potential wind turbine production is compared to consumption to determine the energy deficit or excess, which is fed into a model for each of the storage systems. We will discuss the advantages and disadvantages of each of the storage systems and their suitability for energy storage and peak shaving in this situation.

246.03

Quantoons: Physics, Art, and Literature

Larry D. Kirkpatrick[1], A. Eisenkraft[2]
[1]*Montana State University,* [2]*University of Massachusetts Boston.*

Quantoons, a new NSTA publication, is a compilation of intricate, engaging, and sophisticated cartoons by noted MAD magazine and Garbage Pail Kid artist Tomas Bunk. These quantoons are accompanied by a literary quote as well as a description of a physics principle and a challenging physics problem and solution. People can appreciate physics through the cartoon, literary, or problem window. The cartoons and quotes provide a way to assess student learning or prior knowledge as presented in the classroom. The problems provide enhanced articulation of the physics principles. Many of these problem have been used in the International Physics Olympiad and will certainly be suitable for undergraduate and graduate students. All illustrations are accompanied by a description of the artist's conceptions and thoughts. A look into science through the creative mind of a non-science person helps us to see how our students can appreciate our science lessons in a novel way.

246.05

Michael Faraday vs. the Spiritualists

Alan Hirshfeld[1]
[1]*UMass Dartmouth.*

In the 1850s, renowned physicist Michael Faraday launched a public campaign against pseudoscience and spiritualism, which were rampant in England at the time. Faraday objected especially to claims that electrical or magnetic forces were responsible for paranormal phenomena, such as table-spinning and communication with the dead. Using scientific methods, Faraday unmasked the deceptions of spiritualists, clairvoyants and mediums and also laid bare the credulity of a public ill-educated in science. Despite his efforts, Victorian society's fascination with the paranormal swelled. Faraday's debacle anticipates current controversies about public science education and the interface between science and religion. This episode is one of many described in the new biography, The Electric Life of Michael Faraday (Walker & Co.), which chronicles Faraday's discoveries and his unlikely rise from poverty to the pinnacle of the English science establishment.

246.06

Maupertuis, Leibniz, Least Action and Design

James K. Simmons[1]
[1]*Waynesburg College.*

In current controversies regarding Intelligent Design (ID), critics of ID often claim that naturalisitc science (i.e., science that attempts to explain natural phenomena in terms of strictly non-supernatural processes) has such a good track record that there is no need to introduce supernatural design hypotheses into our thinking. Since ID is not a new idea, we can search through the history of science and look also at ID's track record. In this talk, we focus on the ID thinking of Maupertuis and Leibniz when the former developed the Principle of Least Action and when both of them applied the principle to Snell's law of refraction. In this case, we find that ID did no harm and made no lasting contribution.

246.07

Spotting Junk Science A Classroom Exercise

Brian Houser[1]
[1]*Eastern Washington University.*

This presentation is on an exercise in teaching non-science students to spot junk science and to be better consumers of scientific information. It is based upon critical analysis of the website advocating the theory of the solid surface of the sun. I will present examples of student work and solicit comments on how to improve the exercise.

246.08

Service Learning in Physics Courses in the United States

Lynn Aldrich[1]
[1]*College Misericordia.*

Learn how colleges and universities are implementing service learning in physics courses. Results will be presented from a survey of physics departments at colleges and universities in the United States as to how service learning is incorporated in physics courses at each institution. Although few colleges and universities in the US have physics courses in which service learning is a requirement, the ways in which service learning activities have been incorporated into physics courses will be presented.

246.09

Never Before Seen Mnemonic Technique

Shannon Schunicht[1]
[1]*Texas A&M University.*

While in the Army, Mr. Schunicht was involved in a mid-air collision rendering himself unconscious for three weeks. Everything had to be relearned, as nursing actions were reported as having been displayed upon awakening from the extended unconsciousness (19 days). Studies in recovery brought about some pragmatic discoveries to compensate for the residual memmory deficits. The most valuable discovery was having each vowel represent a mathematical sign, i.e. ″a″ multiplication implying ″@″, ″o″ for division implying ″over″, ″i″ for subtraction implying ″minus″, ″u″ for addition implying ″plus″, and ″e″ implying ″equals″. Most constants and variables are consonants, e.g. ″c″ = ″speed of light″, and ″R″ = ″Rate/time variable″

247: Teacher Professional Development Programs and Assesments
AAPT Oral, Wednesday, 2:00-3:30pm, 310

Chair

Todd Leif[1]
[1]*Cloud County Comm. College.*

247.02

Expanding Science Teacher Preparation: the Role of External Funding

John M. Lindberg[1], S. Vokos[1], L. Seeley[1], E. Close[1]
[1]*Seattle Pacific University.*

The Department of Physics and the School of Education at Seattle Pacific University are in the early stages of expanding the scope and reach of our science teacher preparation. We will describe how we are putting the puzzle together and our results to date.

* Supported in part by NSF grant #ESI-0455796, NSF grant # DUE-0630460, NSF grant DUE-0310583, The Boeing Corporation, PhysTec and the SPU Science Initiative.

247.03

Courses and Programs to Motivate and Train Future Science Teachers

Suzanne Amador Kane[1], A. Lesnick[2], J. Cantley[3]
[1]*Haverford College,* [2]*Haverford College & Bryn Mawr College,* [3]*Ohio State University.*

At Bryn Mawr and Haverford Colleges, we have developed an array of responses to the need to both train and recruit students from the natural sciences in K-12 education. Special courses have been developed in many of our natural science departments as well as in our education program to provide hands-on training and mentoring for students interested in teaching. These include courses where students shadow introductory physics and mathematics instructors, working with them to learn instructional skills in both the lecture and laboratory setting. In other contexts, students can study recent developments in science pedgagoy research. In response to student demand, we also have developed a formal program to train undergraduate teaching assistants and tutors in our natural science courses. This program also serves as bridge between our formal science education program and science majors not ordinarily participating in teacher training. We describe the format of our training program and share materials developed specifically for this purpose.

247.04

Instruments for Assessment of Instructional Practices in Standards-Based Teaching

Camille L. Wainwright[1]
[1]*Pacific University.*

This paper describes the development of two forms of an instrument used as a classroom observation protocol, designed to document the impact of reform-based professional development with undergraduate mathematics and science faculty and its impact on the resultant preparation of teachers (PreK 12). A rationale for the development and utilization of this instrument (known as the OTOP, or the Oregon Teacher Observation Protocol) is provided. Constructed upon review of the research on teaching and standards documents in mathematics and science, the protocol formed the basis for data collection in a three-year longitudinal study of teaching practice among early career teachers as well as undergraduate college faculty. In addition, this paper suggests further applications of the observation protocol beyond the original research study purpose. One prominent use for the protocol is in supervisor observations of mathematics and science student teachers.

247.05

Future Elementary Teachers' Epistemological Beliefs and Views of Science

N. Sanjay Rebello[1]
[1]*Kansas State University.*

We administered two popular survey instruments (EBAPS and VNOS) at the beginning and end of a physics course for elementary physics teachers. The course was taught in a learning cycle format and involved hands-on activities and active learning in the classroom. We report on the impact the course had on students' epistemological beliefs and views about the nature of science as measured by these two instruments.

247.06

Exploring Relationships: Teacher Characteristics and Student Learning in Physical Science

Eleanor Close[1], S. Vokos[1], L. Seeley[1]
[1]*Seattle Pacific University.*

The Department of Physics and the School of Education at Seattle Pacific University, together with FACET Innovations, LLC, are beginning the second year of a five-year NSF TPC grant, *Improving the Effectiveness of Teacher Diagnostic Skills and Tools.* We are working in partnership with school districts in Washington State to identify and characterize widespread productive and unproductive modes of reasoning employed by both pre-college students and teachers on foundational topics in physical science. In the first year of the grant, base-line preand post-test data were collected from a large number (N ~ 2300) of middle and high school students. We will discuss relationships between preand post-test results, student learning gains, and student and teacher characteristics.

* Supported in part by NSF grant #ESI-0455796, The Boeing Corporation, and the SPU Science Initiative.

248: Theoretical and Diagnostic Issues
AAPT Oral, Wednesday, 2:00-3:30pm, 307-08

Chair

Mary Mogge[1]
[1]California State Polytechnic Univ..

248.01

Diagnostic Tests for Entering and Departing Undergraduate Students

Chris Waltham[1], A. Kotlicki[1]
[1]Department of Physics & Astronomy, University of BC, Canada.

A diagnostic test administered at the start of a class should test basic concepts which are recognized as course prerequisites. The questions should not be over-packaged: e.g. students should be required to create models, rather than this being done for them each time. Students should be allowed great latitude in their answers, so we can discover what they are thinking. When administered at the end of a class the goals should be similar: testing concepts taught in the class itself and the retention of necessary concepts from previous classes. Great care has to be taken to avoid teaching to the test. In assessing an entire program, for example an undergraduate majors degree in physics, then one looks for very general skills and knowledge not specific to any one course. The purpose of an undergraduate degree in physics (or indeed any science) is to equip the students with a set of problem-solving skills and basic knowledge which can be applied in a large variety of workplace settings and to allow that student to contribute to civic society as a science-literate person. The creator of any diagnostic test should always have these big goals in mind.

We have developed a set of questions which we think fulfill these criteria, yet are not specific to any particular level of science education. They have been administered to students in secondary schools across Canada, incoming first-year science students and final-year physics students at the University of British Columbia. The results will be presented.

248.02

Student Preparation, Aptitude, and Performance in a First-Semester Algebra-Based Physics Course

Robert L. Hill[1], D. Grosnick[1], D. Ober[1]
[1]Ball State University.

For several years measures of student performance have been investigated in the first semester of the two-semester algebra-based physics course. Pre- and post-tests using the Force Concept Inventory (FCI) and course grades were used as measures of student performance and preparation. In addition, information on high school preparation in physics and mathematics, student demographics (college major, classification, SAT math scores, etc.), and grades earned were collected. Results will be presented that indicate high school physics preparation, college major, and SAT math scores strongly correlate with grade earned, FCI pre-instruction scores, and FCI normalized gains. Using the current investigation and institutional data from the work of Coletta and Phillips[1], it will be shown that a strong correlation exists between FCI pre-instruction scores and normalized gain.

1. V.P. Coletta and J.A. Phillips, Am. J. Phys 73, 1172 (2005).

*Work sponsored by PhysTEC and supported by grants from the National Science Foundation and FIPSE.

248.03

Comparing Item Responses on the FMCE and FCI

Karen Cummings[1], J. Marx[2], R. Thornton[3], D. Kuhl[4]
[1]Southern Connecticut State Univ, [2]McDaniel College, [3]Tufts Univ, [4]Marietta College.

In this talk we compare and contrast student's responses and scores on the Halloun-Hestenes Force Concept Inventory (FCI) to the Thornton-Sokoloff Force and Motion Conceptual Evaluation (FMCE). Both tests are multiple-choice assessment instruments whose results are used to characterize how well a first-term, introductory physics course promotes conceptual understanding. However, the two exams have slightly different content domains, as well as different representational formats. Hence, one exam or the other might better fit the interests of a given instructor/researcher. To begin the comparison, we outline how to determine a single-number score for the FMCE. We then compare scores on the FCI and the FMCE for more than one thousand students in the Studio Physics course at Rensselaer Polytechnic Institute. We found that the mean score on the FCI is significantly higher than the mean score on the FMCE, however there is a very strong relationship between scores on the two exams. The slope of a best fit line drawn through FCI versus FMCE data is approximately 0.65, and the correlation coefficient is approximately $r = 0.8$, for both pre-instructional and post-instructional testing. In spite of this strong relationship, the assessments measure different normalized gains under identical circumstances. Additionally, students who scored well on one exam did not necessarily score well on the other. We use this discrepancy to uncover some subtle, but important, differences between the exams. We also present ranges of normalized gains for the FMCE in a variety of instructional settings.

248.04

Exploration of Epistemological Beliefs in a Summer Science Program for High Achieving Students(1)

Sebastien Cormier[1], F. Raia[1], R. Steinberg[1]
[1]City College New York.

We will describe changes in epistemology of students in a comprehensive summer science program for high achieving students at City College New York. The program focuses on having students participate in the process of scientific discovery using inquiry based activities such as the astronomy units from Physics by Inquiry(2). Multiple tools were used throughout the program to study student epistemological beliefs about science. We administered a Likert scale survey about how science is done as well as multiple content questions from which student beliefs were inferred. Instructor perspectives on student epistemologies are used in conjunction with these tools to study improvements and correlations between the different measures.

(1) Supported in part by the National Science Foundation

(2) Physics by Inquiry, L.C. McDermott, John Wiley & Sons, Inc., New York, 1996

248.05

Rate of Learning Models, Mental Models, and Item Response Theory

David E. Pritchard[1], Y. Lee[1], L. Bao[2]
[1]Massachusetts Institute of Technology, [2]Ohio State University.

We present three learning models that make different assumptions about how the rate of a student's learning depends on the amount that they know already. These are motivated by the mental models of Tabula Rasa, Constructivist, and Tutoring theories. These models predict the postscore for a given prescore after a given period of instruction. Constructivist models show a close connection with Item Response Theory. Comparison with data from both Hake and MIT shows that the Tabula Rasa models not only fit incomparably better, but fit the MIT data within error across a wide range of pretest scores. We discuss the implications of this finding.

248.06

Transfer of Learning: From Physical Models to Understanding Complex Phenomena*

Bijaya Aryal[1], D. A. Zollman[1]
[1]*Kansas State University.*

This study describes the student associations made in order to understand the application of physics to a medical imaging technology positron emission tomography. We define this association as the transfer of learning. The physical models, which have a functional resemblance to portions of the positron emission tomography (PET) process, were introduced to the students without any mention of PET during a teaching session. After a hiatus of a few days they attended another session where PET was briefly mentioned to them. Immediately after that they were asked questions that involved the application of physics ideas underlying the model to describe the PET process. Results of this study indicate that physical models are useful in this transfer of learning. We also observed facilitation in transferring ideas from the models to the problem through peer interaction.

*Supported by the National Science Foundation under grant *04-2675*.

248.07

A Transformed Introductory Mechanics Lab Focused on Developing Reasoning

Vincent P. Coletta[1], J. Evans[1], J. Phillips[1]
[1]*Loyola Marymount University.*

We will describe a pilot program designed to improve the reasoning ability of students who we have identified as being at risk in introductory physics on the basis of Lawson test scores, SAT scores, and other measures. These students were placed in a special section of our regular two hour per week lab, with activities specifically focused on developing reasoning, rather than just learning physics.

248.08

Content-Independent Problem Categorization to Cultivate Real Problem Solving Skills

Kathleen A. Harper[1], R. J. Freuler[1], J. T. Demel[1]
[1]*The Ohio State University.*

A commonality throughout the STEM disciplines is the need for effective problem solving skills. However, studies indicate that the bulk of students who graduate from problem-solving intensive programs display little increase in their problem solving abilities.[1] Also, there is little evidence for transfer of general skills from one subject area to another.[2] Furthermore, the types of problems typically encountered in introductory STEM courses do not often cultivate the skills students will need when solving "real-world" problems. A content-independent problem categorization matrix has been developed as a starting point in addressing these instructional deficiencies. The matrix has led to useful problem-solving discussion among faculty and the design of new introductory physics problems.

1 Woods, "PS Corner," J. Coll Sci Teach 23, 157-158 (1994) & 12, 446-448 (1983).

2 Bransford, Brown, & Cocking, ed, How People Learn (National Academy of Science, 1999).

248.09

Discussion of the *Correlation Coefficient and R^2-Value Survey*

Jeffrey Marx[1]
[1]*McDaniel College.*

When formally reporting summative statistics, it is crucially important that both the reader and the reporter agree on what such statistics represent about the larger data set that they are meant to characterize. At the summer meeting of the AAPT, I circulated a short survey about correlation coefficients and R^2-values. The survey had three types of items: multiple-choice items based on graphs of data sets, three-point Likert-scale items asking responders to comment on the confidence of their answers, and open-end questions. Twenty people anonymously completed and returned the surveys. Not one survey was answered entirely correctly and many were almost entirely incorrect. (Despite the fact that most responders were at least "Confident" if not "Very confident" with their answers.) After a short presentation of my results, I plan to open the floor for questions, comments, and discussion about my results and survey, as well as what these results might imply about an important component of the dialogue in our community.

249: Oersted Medal Lecture
Plenary, Wednesday, 3:40-4:30pm, Ballroom 6

Chair

Richard Peterson[1]
[1]*Bethel Univ..*

249.01

Interactive Simulations for Teaching Physics; What Works, What Doesn't, and Why

Carl E. Wieman[1]
[1]*Univ. of British Columbia and Univ. of Colorado, Canada.*

The interactive online simulation is a new technology for teaching physics. The physics education technology project (phet.colorado.edu) has developed about 50 sophisticated simulations that are run through a regular browser and are available for free. These cover topics ranging in complexity from addition of vectors to challenging ideas in quantum mechanics. We use professional software engineers in the creation of the simulations and physics education researchers in an extensive study of student use and learning from these simulations. Here I will present a number of our simulations and discuss what our research has shown about simulations and their use. We find they can be uniquely powerful learning tools, but only if they adhere to certain guiding principles.[1] Our study of student learning from simulations has provided something of a microcosm of the general field of research on student motivation and learning, in that we have seen many elements for effective learning emerging from our research that match closely with what has been seen in other very different contexts. I will show many of our simulations and discuss what and how students learn from them, and what our research has shown is important for creating effective simulations. In the process, I will discuss some lessons this work offers for physics education more generally.

This work has been carried out by the entire PHET team and has been supported by the NSF, the Hewlett Foundation, and the Kavli Operating Institute.

1. Adams, W. K., Reid, S., LeMaster, R., McKagan, S., Perkins, K. and Wieman, C. E., A Study of Interface Design for Engagement and Learning with Educational Simulations. http://phet.colorado.edu/web-pages/research.html

250: New Planets
Plenary, Wednesday, 4:40-5:30pm, Ballroom 6

250.01

The Dwarf Planets of the Outer Solar System

Michael E. Brown[1]
[1]*Caltech.*

The past few years have seen an explosion in the discoveries of Plutoand near Pluto-sized bodies in the outer solar system, giving rise to a new classification of ″dwarf planets.″ Like Pluto, each of these largest dwarf planets has a unique story to tell about the history and evolution of the solar system. I'll discuss the discoveries of these objects and the new views of giant collisions, stellar encounters, and planetary rearrangement that we are gaining from their study.

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