A Solar Spectroscope Exhibit at Utah Valley University
Objective:

Bright, 2-meter-long display of the Sun’s visible spectrum

- made with “live” sunlight
- projected onto a screen
- showing many absorption lines
Large public university
(almost 40k students)

Dual mission:
university + community college

Master’s, bachelor’s, associate degrees, certificates

Established 1941 as Central Utah Vocational School
Pope Science Building

Chemistry
Earth Science
Physics
Spectroscope

Objective

Slit

Collimator

Imaging lens

Grating
Eight Feet of Solar Spectrum
Grace Flandrau Planetarium, University of Arizona
Collimator and Imaging lens
Slit width

Trade-off between bright spectrum and good spectral resolution
Rough calculations!

\[ B = \frac{\text{Average irradiance of spectrum on screen}}{\text{Irradiance of direct sunlight}} \]

\[ B \approx (0.0035 \text{ m}) \frac{D^2 G^2 \Delta \lambda}{L^2} \]

\( D = "\text{diameter}" \text{ of grating} \)
\( G = \text{grating constant (lines per unit width)} \)
\( \Delta \lambda = \text{spectral resolution} \)
\( L = \text{length of spectrum} \)
Experiments in Pope Science suggest that we need $B > 0.007$ to obtain a “bright” spectrum.

With

\[
D = 170 \text{ mm}
\]

\[
G = 1200 \text{ lines per mm}
\]

\[
\Delta \lambda = 0.25 \text{ nm}
\]

\[
L = 2000 \text{ mm}
\]

we get

\[
B = 0.009
\]
Étendue

- Étendue = “geometrical extent”
- Also known as $A\Omega$ product
- Related to Lagrange invariant

(area of image of slit on screen) $\times$
(solid angle of imaging lens viewed from screen) $\approx$
(area of objective lens/mirror) $\times$
(accepted solid angle on sky)
ASTM reference spectra
sea level irradiance:
air mass 1.5
(solar zenith angle 48.19°)
ASTM G173-03 Reference Spectra Derived from SMARTS v. 2.9.2

Direct+circumsolar irradiance \([W \text{ m}^{-2} \text{ nm}^{-1}]\) vs wavelength [nm]
Multiplied by photopic response function of human eye…
Test setup

300 mm concave mirror

140 mm collimator/imaging lens

206mm x 154 mm grating (plastic cover on!)

(thin clouds)

spectrum 1.1 m long
Plans

- Design of optical system using WinLens3D and homemade ray tracing program
- Reduce curvature of image
- Prepare proposal to UVU College of Science and UVU Facilities
- Phase Two: spectrometer (view spectrum through eyepiece) with 0.01 nm resolution; user can scan spectrum
Students

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Bibliography


CIE color matching functions at http://cvrl.ucl.ac.uk/cmfs.htm

Please send me your ideas and suggestions!

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Thank you!
Étendue

\[ d(\text{etendue}) = n^2 \ dS \ \cos \theta \ d\Omega \]