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MOORHEAD

Python across the curriculum

From glowscript to Jupyter and beyond

AAPT Summer 2017 Meeting

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Thank you!

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Outline

- Short history of
  - vpython @MSUM
  - computational physics @MSUM
- What is a Jupyter notebook?
- Examples of Jupyter notebooks
- Notebook widgets
  - simple
  - more complicated
- Deploying Jupyter notebooks in the cloud
- Use conda environments!

History: Computational Phys (CP)

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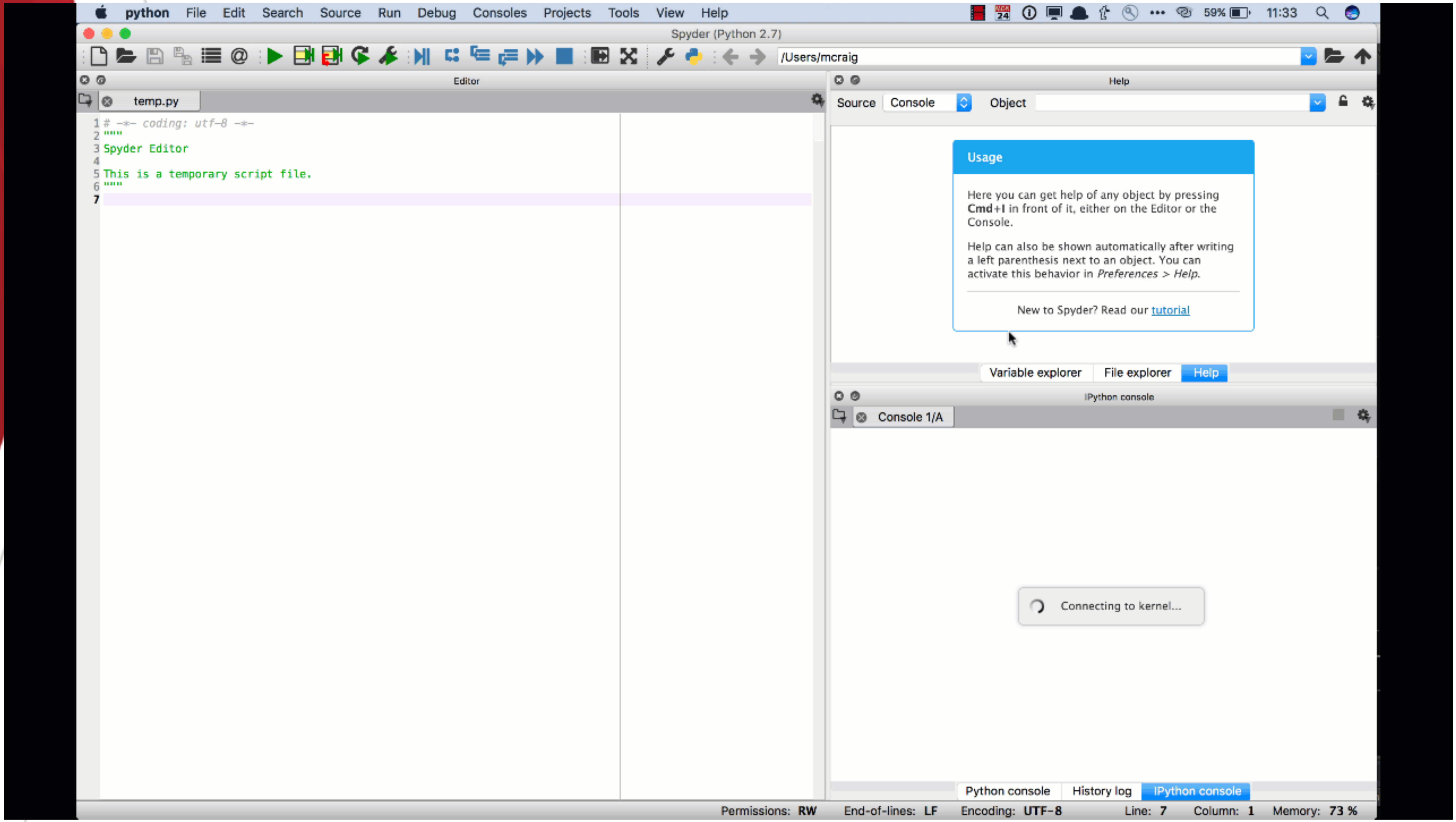
- late 1990s-early 2000s
  - Mathcad, 1-credit, all physical sciences
- mid-2000s-2010: 3 credits, Maple and IDL
  - Math also adopted Maple for computer calculus
  - IDL because one faculty used it for research
- 2012: Maple and Python
- 2014 & 2015: Pure Python, mostly VIDLE
- 2016: Python/Atom/terminal
- 2017: Python/Spyder

Spyder



python File Edit Search Source Run Debug Consoles Projects Tools View Help
59%
11:33
Spyder (Python 2.7)
/Users/mcraig
Editor
temp.py
Help
Source Console Object
Variable explorer File explorer Help
IPython console
Console 1/A
Python console History log IPython console

```
# -*- coding: utf-8 -*-
"""
Spyder Editor

This is a temporary script file.
"""

```

Usage

Here you can get help of any object by pressing **Cmd+I** in front of it, either on the Editor or the Console.

Help can also be shown automatically after writing a left parenthesis next to an object. You can activate this behavior in *Preferences > Help*.

New to Spyder? Read our tutorial

Connecting to kernel...

Permissions: RW End-of-lines: LF Encoding: UTF-8 Line: 7 Column: 1 Memory: 73 %

Problems (2011-12)

- Steep learning curve in CP
- Student (non)use of computation in other courses
  - "Good" day: students can graph function
  - "Bad" day: they skip the computer problem because of effort required.
- Rudimentary use of computing in senior projects

Solution: more computation

- Department adopted Matter and Interactions AY2012-13
  - More modern approach to physics
  - Uses computation
  - Python also being adopted for research use

VPython @ MSUM

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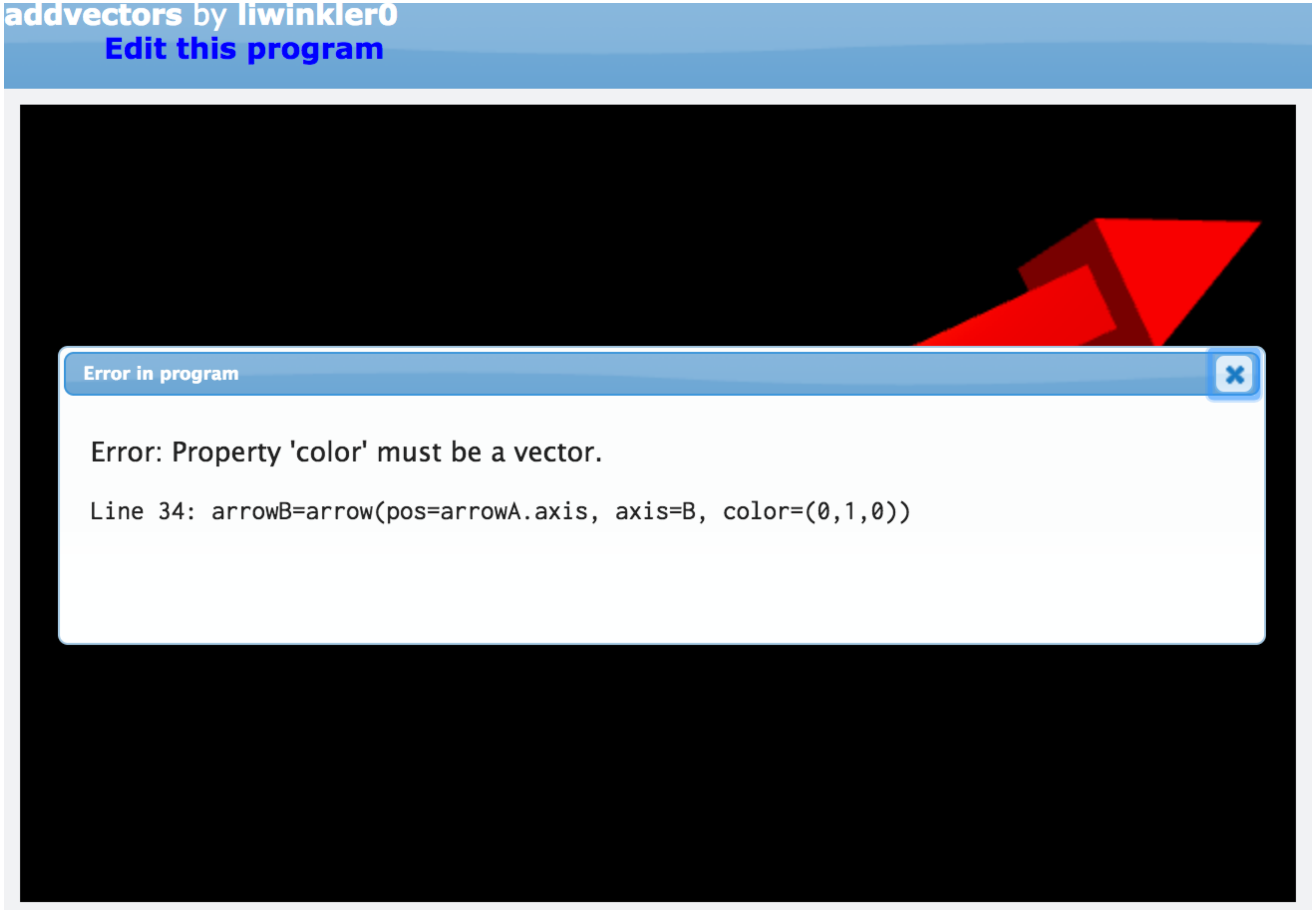
- Fall 2012: “classic” vpython
- Fall 2013: conda-built vpython; also use anaconda for computational physics
- Fall 2014 & 2015: same
- Frequent issues:
    - Installation on lab computers
    - Confusion between IDLE and VIDLE
    - Printing
    - Submission of code
    - Students *rarely* installed it
- Fall 2016: glowscript.org

VPython: student reaction

- Fall 2012: Reactions not printable
- Fall 2013 & 2014: Students more receptive, instructors more experienced
- Fall 2015: some resistance, little enthusiasm
- Fall 2016: switch to glowscript.org
  - "Can't we do another glowscript lab this week?"
  - "I love glowscript, it saved me several times"

Teach them errors

- Week 1 sample program does this

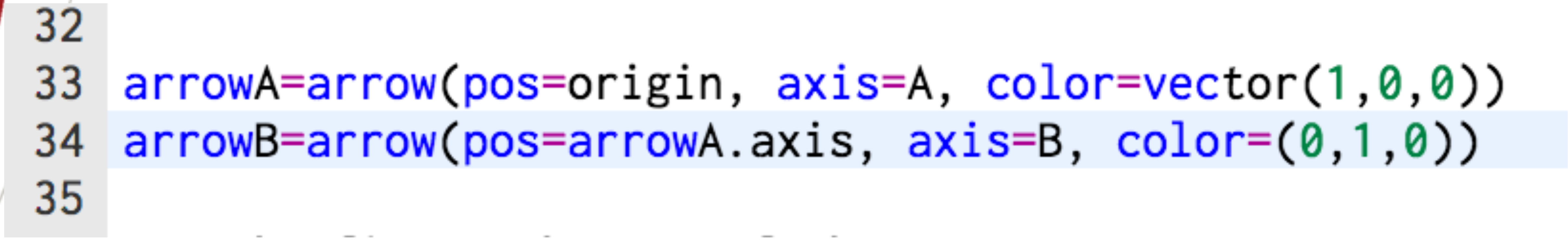


Error: Property 'color' must be a vector.

```
Line 34: arrowB=arrow(pos=arrowA.axis, axis=B, color=(0,1,0))
```

Teach them errors

- Week 1 sample program does this

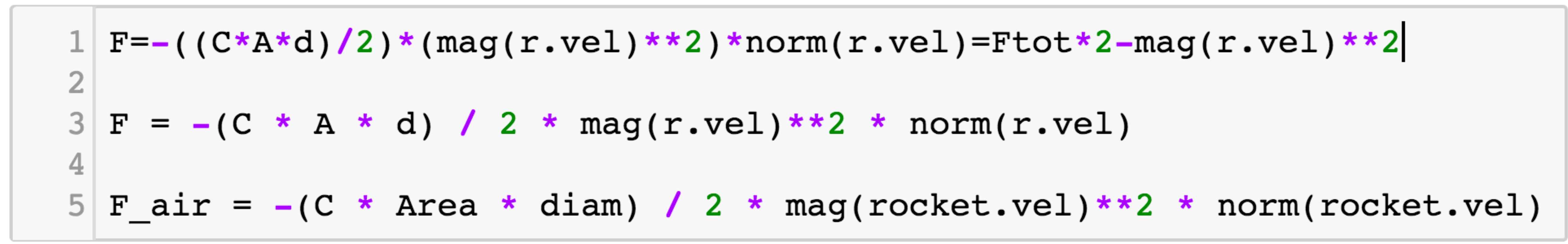


```

arrowA=arrow(pos=origin, axis=A, color=vector(1,0,0))
arrowB=arrow(pos=arrowA.axis, axis=B, color=(0,1,0))

```

Please have students

- Write easier-to-read (“well punctuated”) code
  - Spaces around
    - operators
    - equal sign in assignment
  - Space after comma
  - Descriptive variable names
- Be clear, not clever

Which one has an error?



```
F=-((C*A*d)/2)*(mag(r.vel)**2)*norm(r.vel)=Ftot*2-mag(r.vel)**2

F = -(C * A * d) / 2 * mag(r.vel)**2 * norm(r.vel)

F_air = -(C * Area * diam) / 2 * mag(rocket.vel)**2 * norm(rocket.vel)
```

Why notebooks, ever?

- Mix of explanatory text and coding
- Provide easy-to-modify template
- Include or link to additional resources

Why not notebooks, year 1?
General

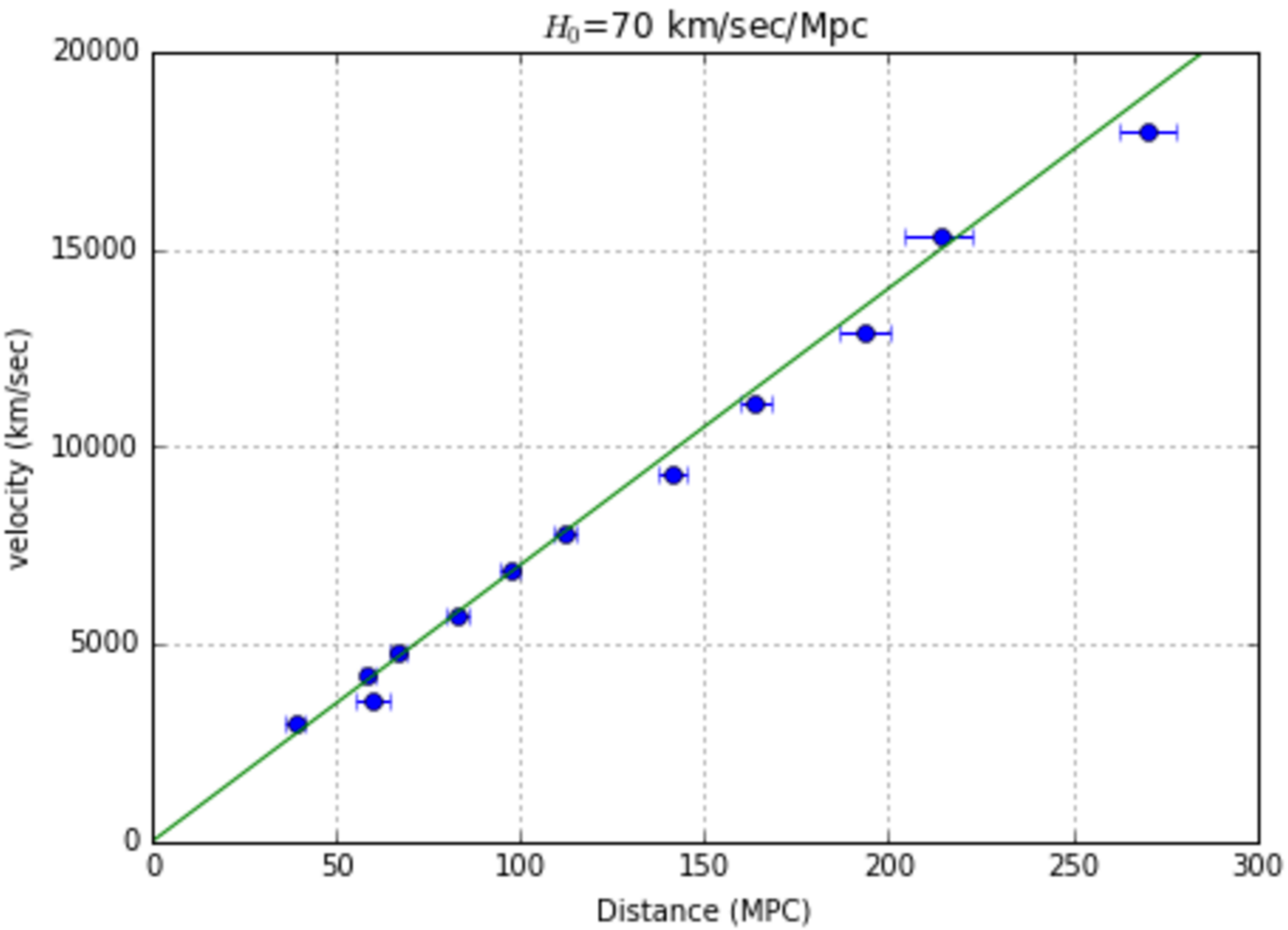
- Jupyter install can be tricky
  - Multiple kernels, configuration paths
- Several steps to launch
- Need to save files locally…
  - …then lose them,
  - or have campus delete them,
  - or forget to email them, or…
- **Demo: out-of-order execution**
- Execute all (or re-execute)

Why not notebooks, year 1?
vpython-jupyter

- Jupyter evolves *very* rapidly
  - Notebooks first demoed Scipy 2014
  - Jupyter announced summer 2015
- Not infrequent breakage because of Jupyter
  - Better recently
- Occasional misbehavior if code is in several cells.

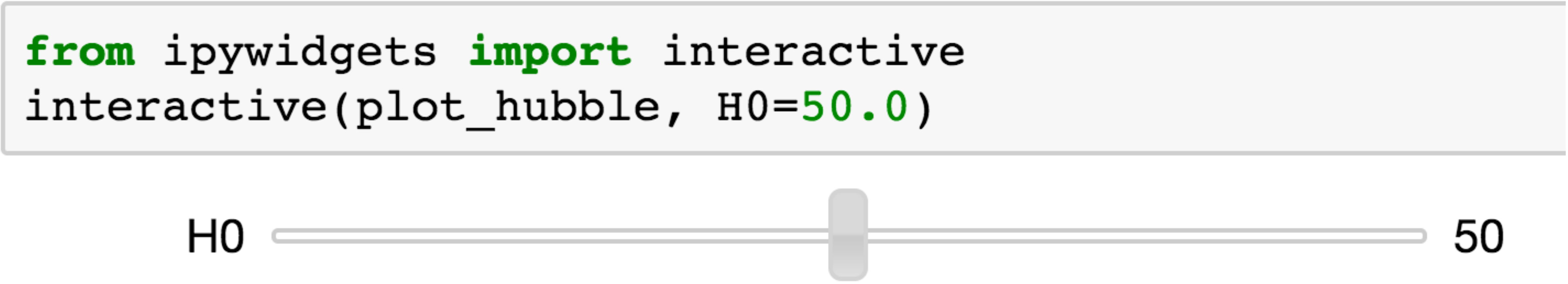
Jupyter widgets

- Static plot



Jupyter widgets

- Added this code, got interactive slider:

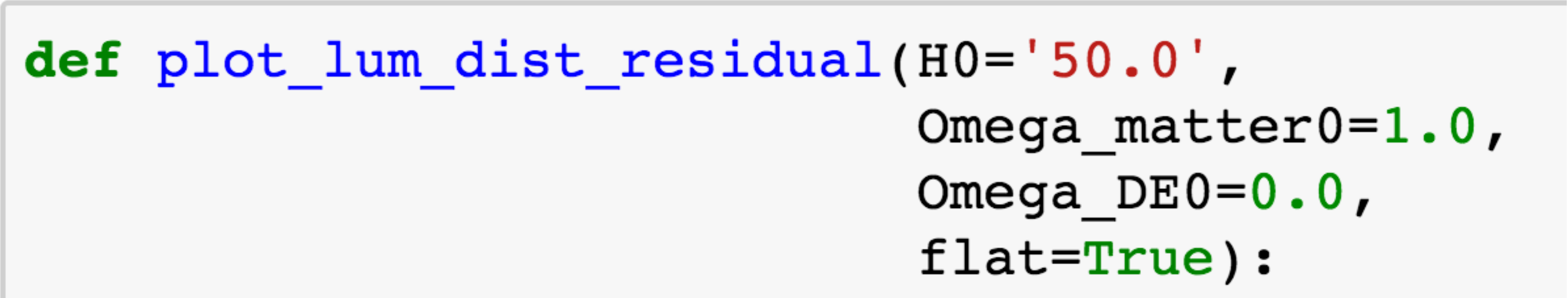


```
from ipywidgets import interactive
interactive(plot_hubble, H0=50.0)
```

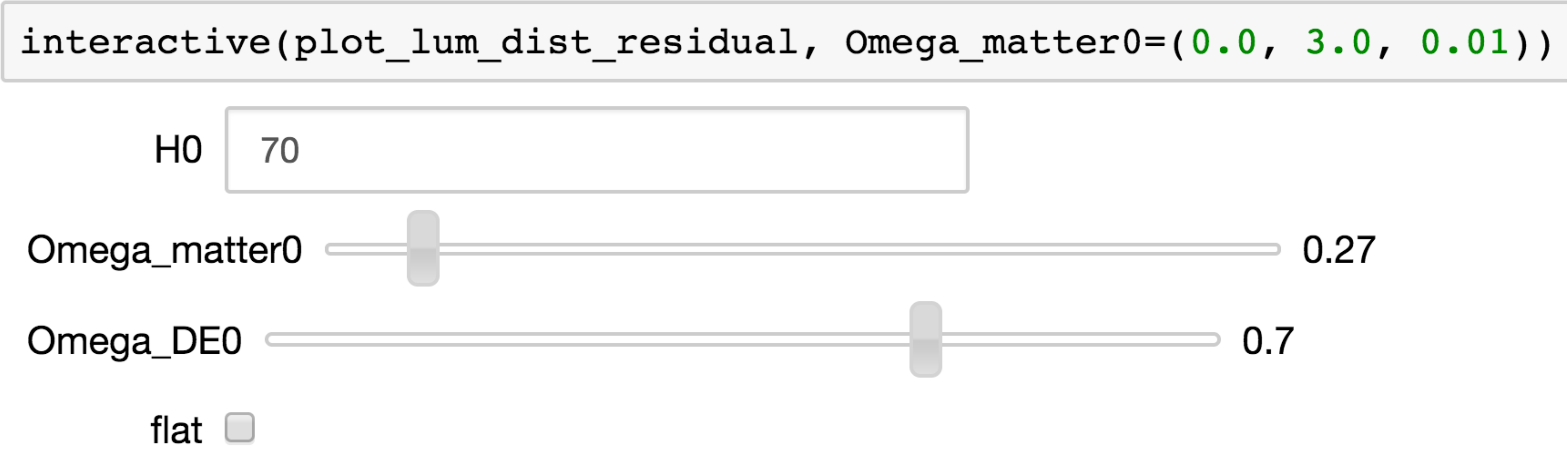
H0 50

Jupyter widgets

- Another example:



```
def plot_lum_dist_residual(H0='50.0',
                           Omega_matter0=1.0,
                           Omega_DE0=0.0,
                           flat=True):
```



```
interactive(plot_lum_dist_residual, Omega_matter0=(0.0, 3.0, 0.01))
```

H0: 70

Omega_matter0: 0.27

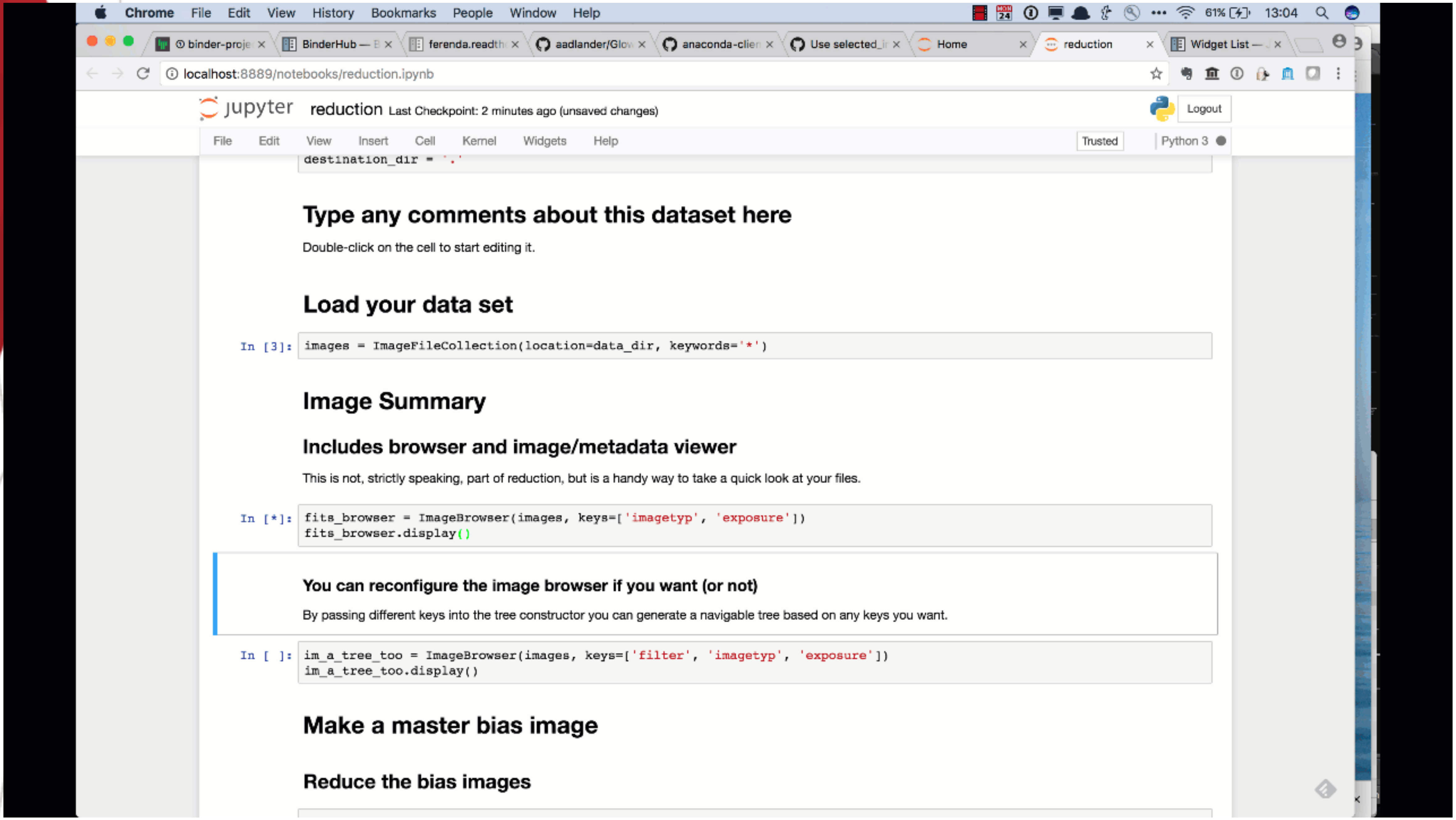
Omega_DE0: 0.7

flat □

Jupyter widgets

- Cosmology notebook is at:
  https://github.com/mwcraig/jupyter-notebook-intro/
- More complicated widgets
  - reducer, python package for calibrating (reducing) astronomical images
  - reducer.readthedocs.io

reducer


Chrome File Edit View History Bookmarks People Window Help
localhost:8889/notebooks/reduction.ipynb
jupyter reduction Last Checkpoint: 2 minutes ago (unsaved changes)
Logout
File Edit View Insert Cell Kernel Widgets Help
Trusted
Python 3

```
destination_dir = '.'
```

Type any comments about this dataset here

Double-click on the cell to start editing it.

Load your data set

```
In [3]: images = ImageFileCollection(location=data_dir, keywords='*')
```

Image Summary

Includes browser and image/metadata viewer

This is not, strictly speaking, part of reduction, but is a handy way to take a quick look at your files.

```
In [*]: fits_browser = ImageBrowser(images, keys=['imagetyp', 'exposure'])
        fits_browser.display()
```

You can reconfigure the image browser if you want (or not)

By passing different keys into the tree constructor you can generate a navigable tree based on any keys you want.

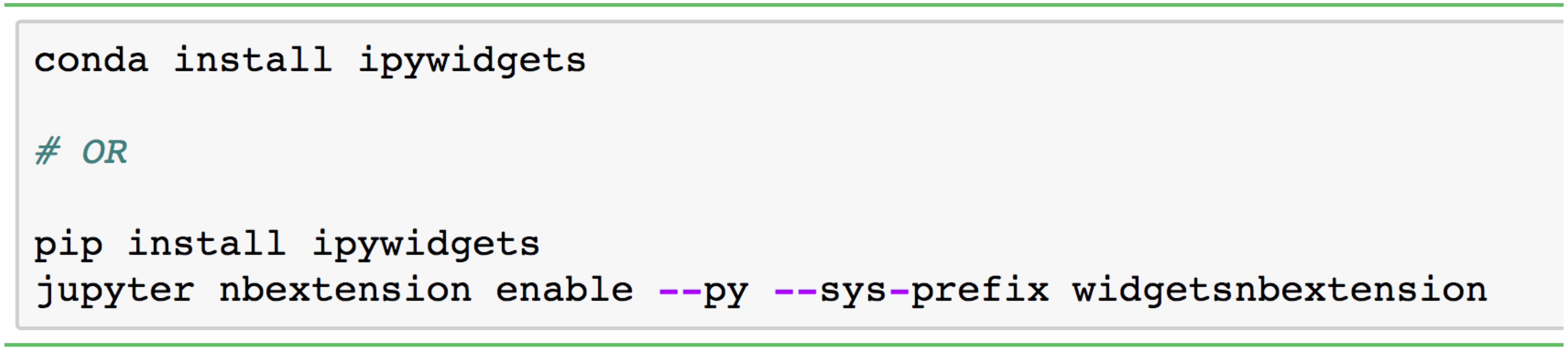
```
In [ ]: im_a_tree_too = ImageBrowser(images, keys=['filter', 'imagetyp', 'exposure'])
        im_a_tree_too.display()
```

Make a master bias image

Reduce the bias images

Jupyter widgets: resources

- Install: package name is ipywidgets



```
conda install ipywidgets

# OR

pip install ipywidgets
jupyter nbextension enable --py --sys-prefix widgetsnbextension
```

- Tutorial video: https://youtu.be/eWzY2nGfkXk
- Tutorial materials: https://github.com/mwcraig/scipy2017-jupyter-widgets-tutorial
- Documentation: http://ipywidgets.readthedocs.io

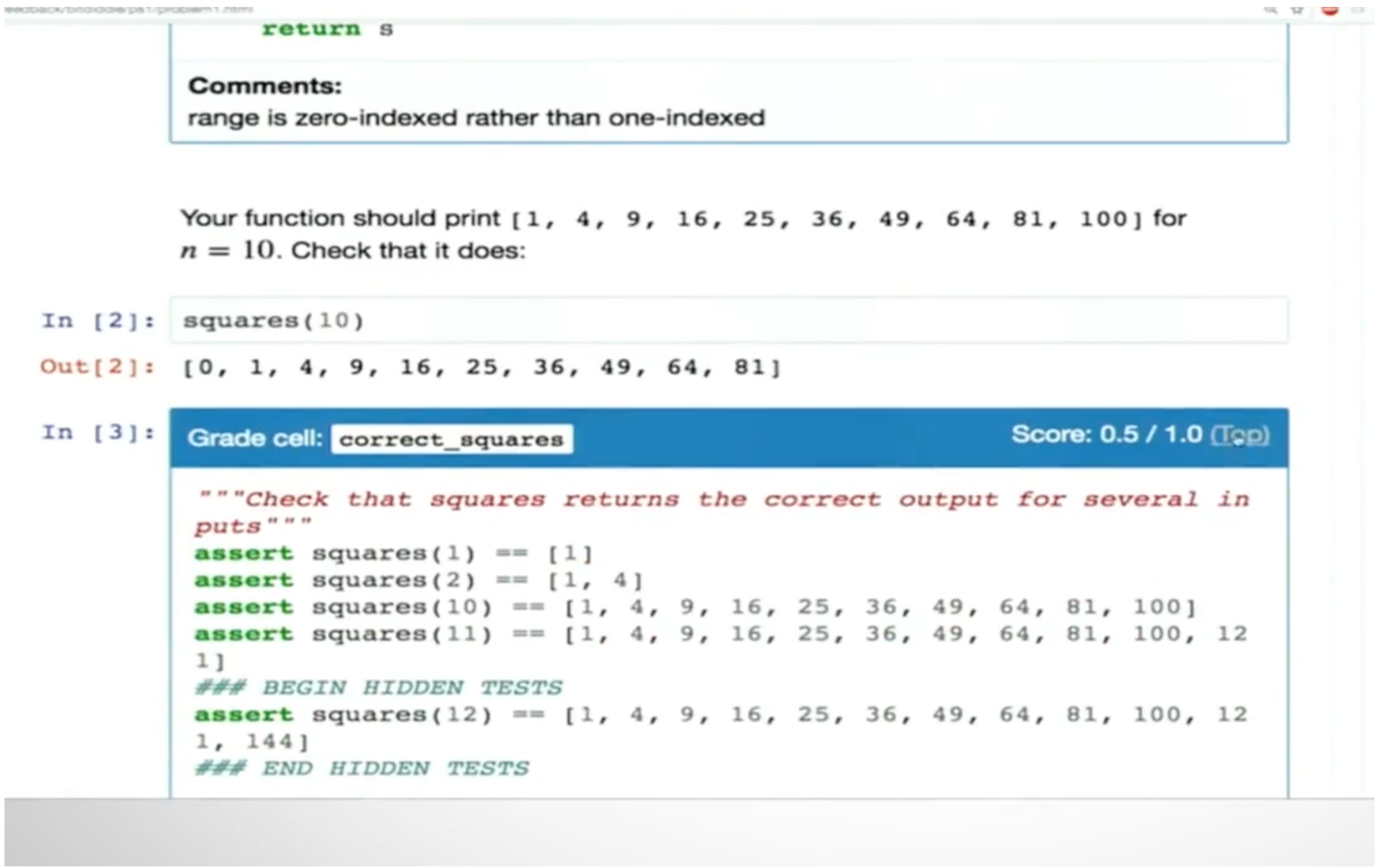
widgets

- Where to get help (gitter.im):

https://gitter.im/jupyter-widgets/Lobby

nbgrader

- Can use to distribute, collect, markup, and (maybe) auto-grade notebook cells.



eedback/bitdiddle/ps1/problem1.html

```
        return s
```

Comments:

range is zero-indexed rather than one-indexed

Your function should print `[1, 4, 9, 16, 25, 36, 49, 64, 81, 100]` for $n = 10$. Check that it does:

```
In [2]: squares(10)

Out[2]: [0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

```
In [3]:
```

Grade cell: `correct_squares`   Score: 0.5 / 1.0 (Top)

```
"""Check that squares returns the correct output for several in
puts"""
assert squares(1) == [1]
assert squares(2) == [1, 4]
assert squares(10) == [1, 4, 9, 16, 25, 36, 49, 64, 81, 100]
assert squares(11) == [1, 4, 9, 16, 25, 36, 49, 64, 81, 100, 12
1]
### BEGIN HIDDEN TESTS
assert squares(12) == [1, 4, 9, 16, 25, 36, 49, 64, 81, 100, 12
1, 144]
### END HIDDEN TESTS
```

nbgrader

- Can use to distribute, collect, markup, and (maybe) auto-grade notebook cells.
- Run on your computer or a server
- Resources:
  - SciPy2017 talk by Jess Hamrick: https://youtu.be/5WUm0QuJdFw
  - Documentation: http://nbgrader.readthedocs.io/

binder

- Binder: runs server in the cloud
  - Set up github repository with
    - list of requirements
    - notebooks
    - any other files you want
  - Go to beta.mybinder.org, fill in form
  - Server created on the fly
  - Persists for a few hours…
  - …but not forever

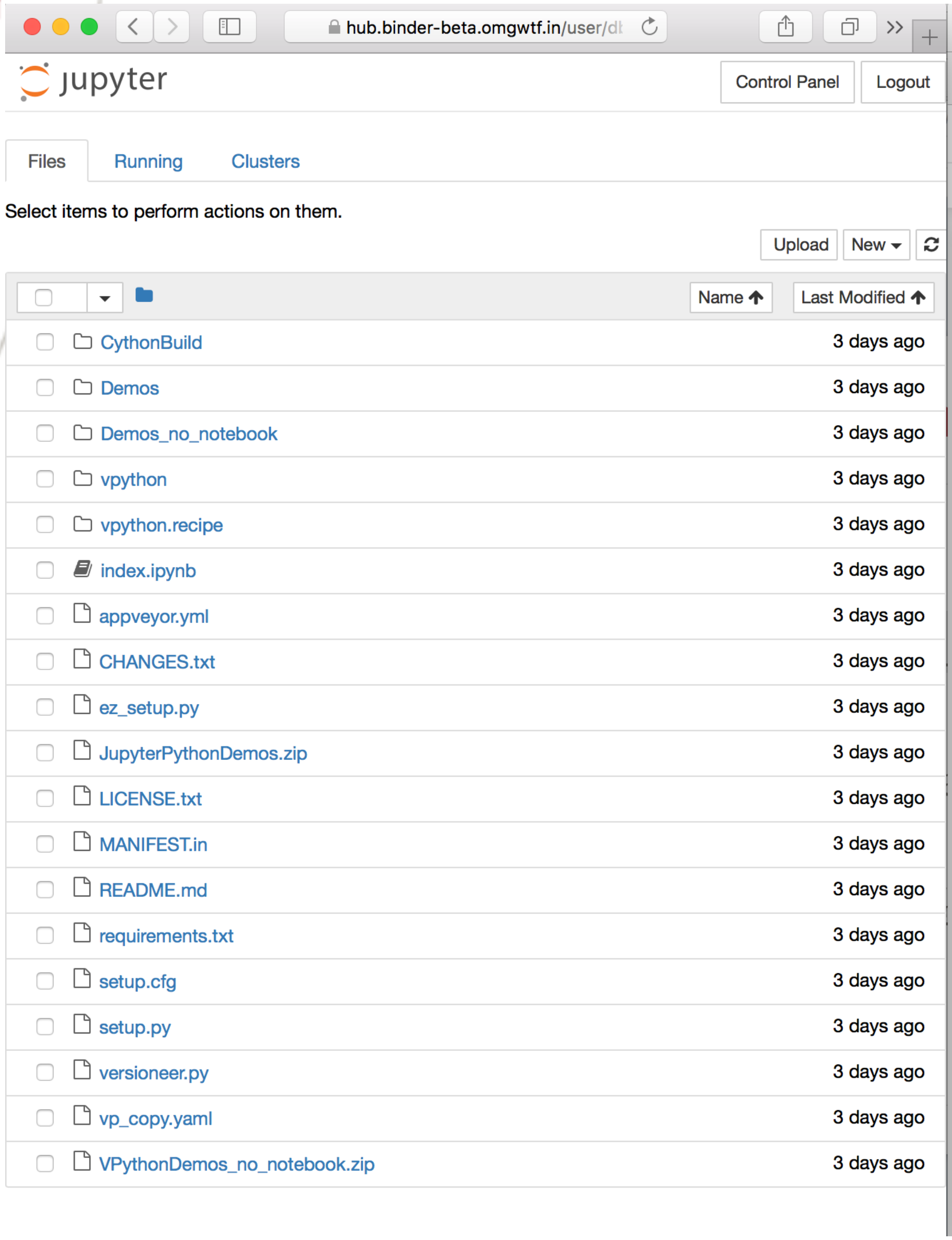
Binder: ±ives

- Positives
  - No local setup
  - Reliable for the last 3-4 months
    - Now officially supported by Jupyter
  - Can customize the installed packages
  - Can download notebooks
- Negatives
  - It can fail, usually at the worst possible time
  - Student work can be lost

Another drawback

Same URL

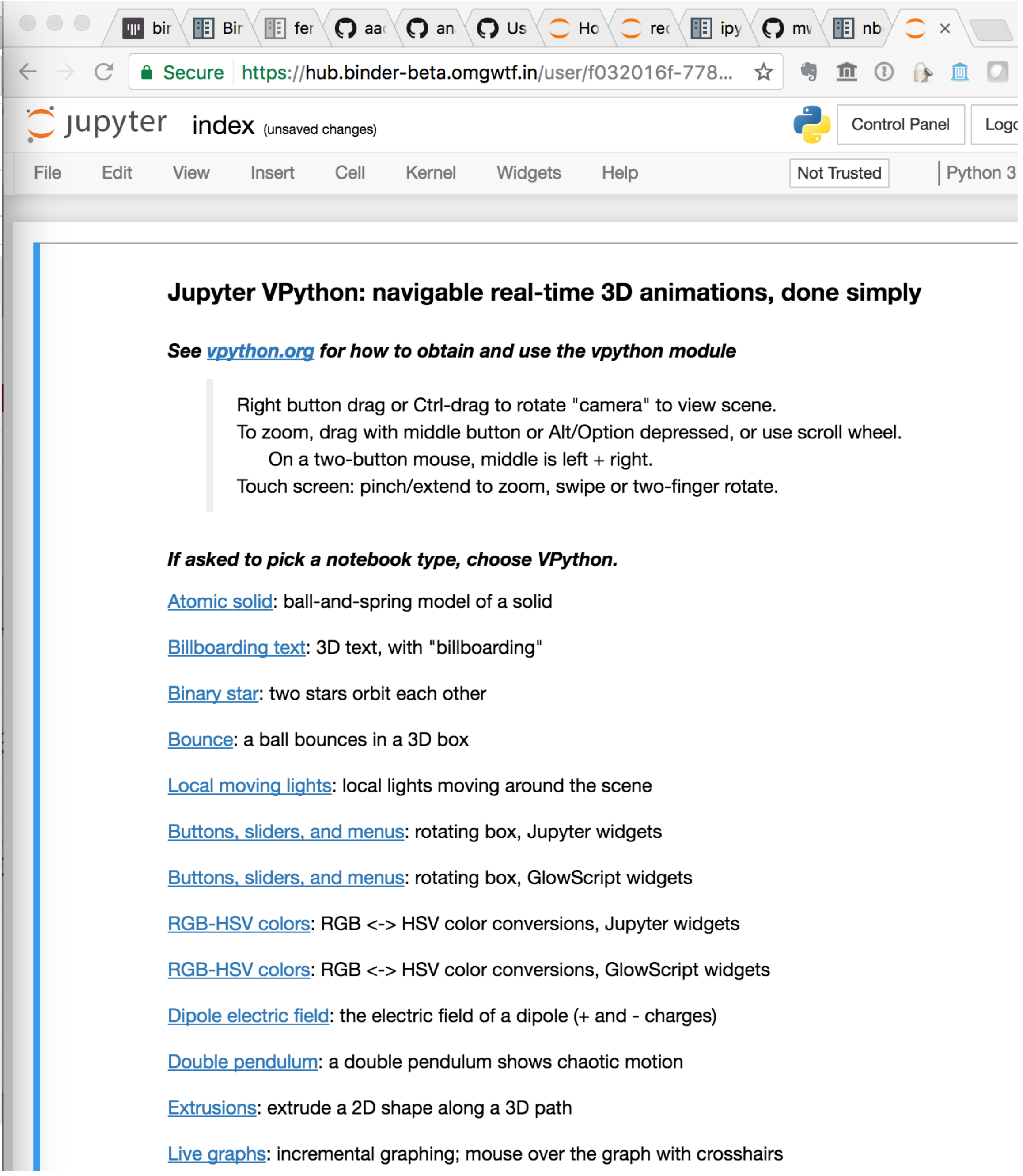
Safari



Select items to perform actions on them.

Name	Last Modified
CythonBuild	3 days ago
Demos	3 days ago
Demos_no_notebook	3 days ago
vpython	3 days ago
vpython.recipe	3 days ago
index.ipynb	3 days ago
appveyor.yml	3 days ago
CHANGES.txt	3 days ago
ez_setup.py	3 days ago
JupyterPythonDemos.zip	3 days ago
LICENSE.txt	3 days ago
MANIFEST.in	3 days ago
README.md	3 days ago
requirements.txt	3 days ago
setup.cfg	3 days ago
setup.py	3 days ago
versioneer.py	3 days ago
vp_copy.yaml	3 days ago
VPythonDemos_no_notebook.zip	3 days ago

Chrome



Jupyter VPython: navigable real-time 3D animations, done simply

See vpython.org for how to obtain and use the vpython module

> Right button drag or Ctrl-drag to rotate "camera" to view scene.
> To zoom, drag with middle button or Alt/Option depressed, or use scroll wheel.
> On a two-button mouse, middle is left + right.
> Touch screen: pinch/extend to zoom, swipe or two-finger rotate.

If asked to pick a notebook type, choose VPython.

Atomic solid: ball-and-spring model of a solid

Billboarding text: 3D text, with "billboarding"

Binary star: two stars orbit each other

Bounce: a ball bounces in a 3D box

Local moving lights: local lights moving around the scene

Buttons, sliders, and menus: rotating box, Jupyter widgets

Buttons, sliders, and menus: rotating box, GlowScript widgets

RGB-HSV colors: RGB <-> HSV color conversions, Jupyter widgets

RGB-HSV colors: RGB <-> HSV color conversions, GlowScript widgets

Dipole electric field: the electric field of a dipole (+ and - charges)

Double pendulum: a double pendulum shows chaotic motion

Extrusions: extrude a 2D shape along a 3D path

Live graphs: incremental graphing; mouse over the graph with crosshairs

Binder example

- Try vpython:

  https://goo.gl/m36eWz

- Try observational astro:

  https://goo.gl/RG4uLg

binder

- where to get help: on gitter.im:

  https://gitter.im/binder-project/binder

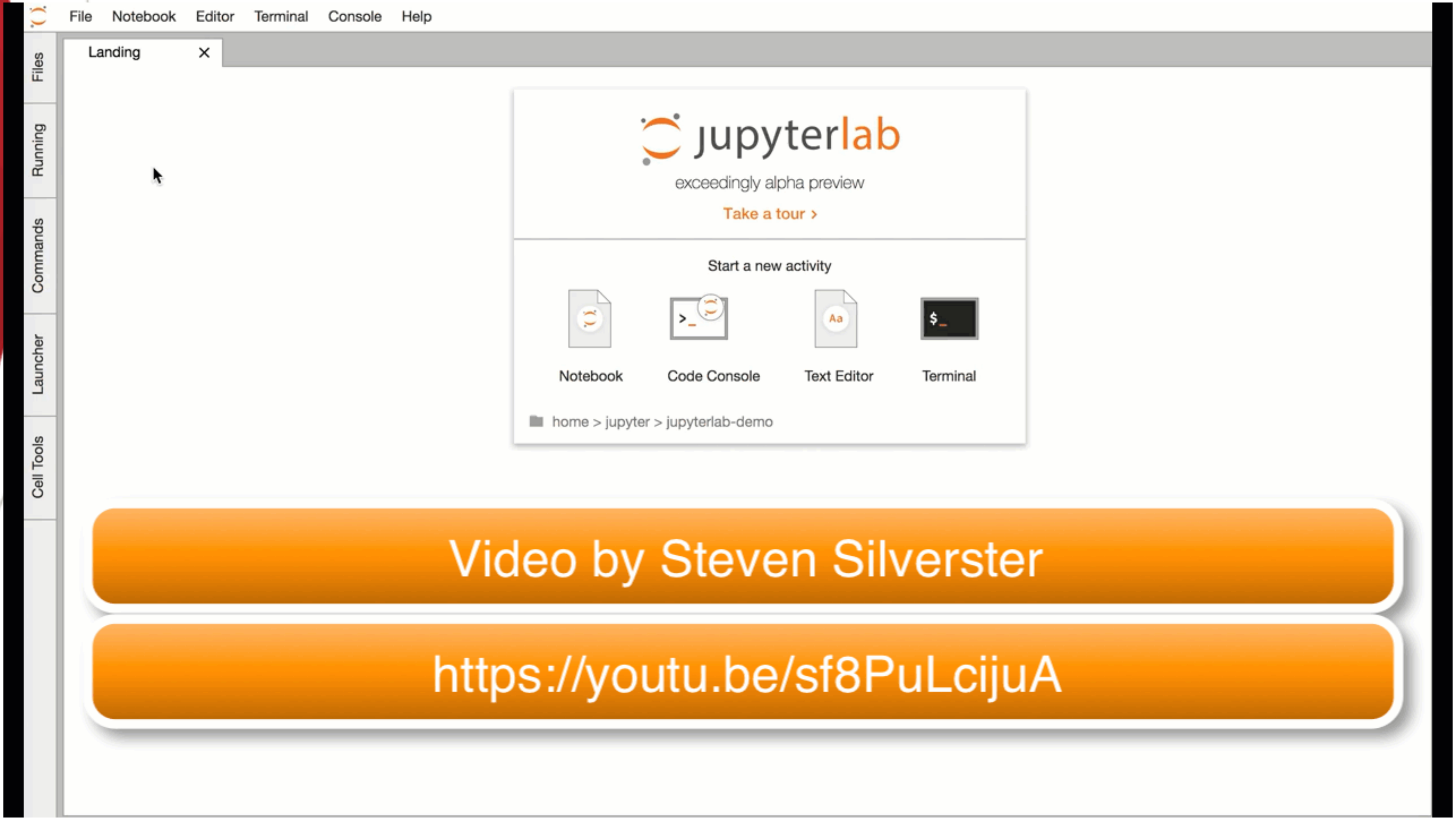
tmpnb.org

- Creates short-term server in cloud
- short-term means after ONE minute of inactivity the server dies
- Useful for quickly viewing a notebook

tmpnb ±ives

- Positives:
  - Always works
  - Can upload your own notebooks
    - only to the temporary workspace
- Negatives:
  - Time limit of a few minutes
  - Very limited
    - upload space
    - memory

Coming soon: Jupyter Lab



Video by Steven Silverster

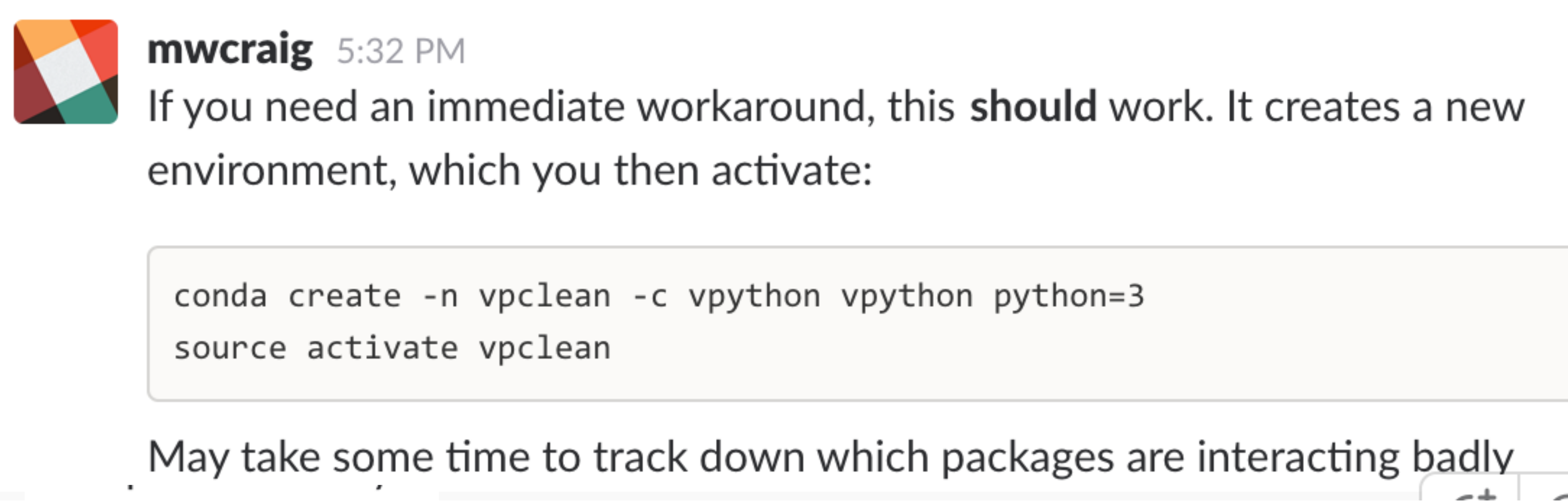
https://youtu.be/sf8PuLcijuA

Jupyter Lab links

- Project home: https://jupyterlab-tutorial.readthedocs.io/
- Screencast on which video here was based: https://youtu.be/sf8PuLcijuA
- Short talk about Jupyter Lab: https://youtu.be/X8zPuBu22Y4?t=44m30s
- Longer talk about JupyterLab: https://youtu.be/dSjvK-Z3o3U

environment

- A Python environment is a workspace separate from your main Python install.



mwcraig 5:32 PM

If you need an immediate workaround, this **should** work. It creates a new environment, which you then activate:

```
conda create -n vpclean -c vpython vpython python=3
source activate vpclean
```

May take some time to track down which packages are interacting badly

💃 💃 💃

(celebrating)

🎉 2

Conclusion

- Expect rapid evolution of
  - Jupyter
  - *Internals* of interface between vpython and Jupyter
  - The "best" option for post-freshman work
- Jupyter notebooks are here to stay
- anaconda is the Python distribution to use

Recommendations

- glowscript.org as introduction
- Use anaconda or miniconda
- Python 3
- vpython in
  - Spyder, or
  - VIDLE/terminal,
  - or atom/terminal
- Jupyter notebook for more advanced work

Slides, lists of resources

- https://github.com/mwcraig/aapt-2017
- aka: goo.gl/nVbrme