

# The AAS WorldWide Telescope

Peter K. G. Williams (CfA, AAS)  
@pkgw • <https://newton.cx/~peter/>

Hotwiring 6 – 2019 Aug 20

Chris Wiseman, NASA

# **The future of science is on the Web.**

---

Datasets are getting too big to move  $\Rightarrow$  *remote access* is key.

Collaborations are bigger, more dispersed.

Fortunately, industry is pouring billions of dollars into the problem of building rich interfaces to remote assets: the Web browser.

Side benefit: systems built for scientific users can be adapted for public outreach relatively easily.

*Time-domain science is an especially good fit for the Web: not just speed and agility, but standardization.*

# Lots of exciting work is happening in this space!

Jupyter Notebooks are innovative not just because of their user experience, but because they are delivered *through the browser*.

This is driving a long overdue Web-ification of astronomical data visualization tools.

Notebooks also provide a paradigm for remote computation — cf. NOAO DataLab, LSST Science Platform, etc.

The image displays two overlapping Jupyter Notebook windows. The background window shows a 'Welcome to the Jupyter Notebook Server' page with a warning box and instructions for running code. The foreground window is titled 'Exploring the Lorenz System' and contains the following content:

**Exploring the Lorenz System**

In this Notebook we explore the [Lorenz system](#) of differential equations:

$$\begin{aligned}\dot{x} &= \sigma(y - x) \\ \dot{y} &= \rho x - y - xz \\ \dot{z} &= -\beta z + xy\end{aligned}$$

This is one of the classic systems in non-linear differential equations. It exhibits a range of complex behaviors as the parameters  $(\sigma, \beta, \rho)$  are varied, including what are known as *chaotic solutions*. The system was originally developed as a simplified mathematical model for atmospheric convection in 1963.

```
In [7]: interact(Lorenz, N=fixed(10), angle=(0.,360.),
                sigma=(0.0,50.0), beta=(0.,5), rho=(0.0,50.0))
```

angle: 308.2  
max\_time: 12  
 $\sigma$ : 10  
 $\beta$ : 2.6  
 $\rho$ : 28

The plot shows a 3D visualization of the Lorenz attractor, a complex, chaotic system of trajectories in a three-dimensional space, rendered in various colors.

<https://jupyter.org/>

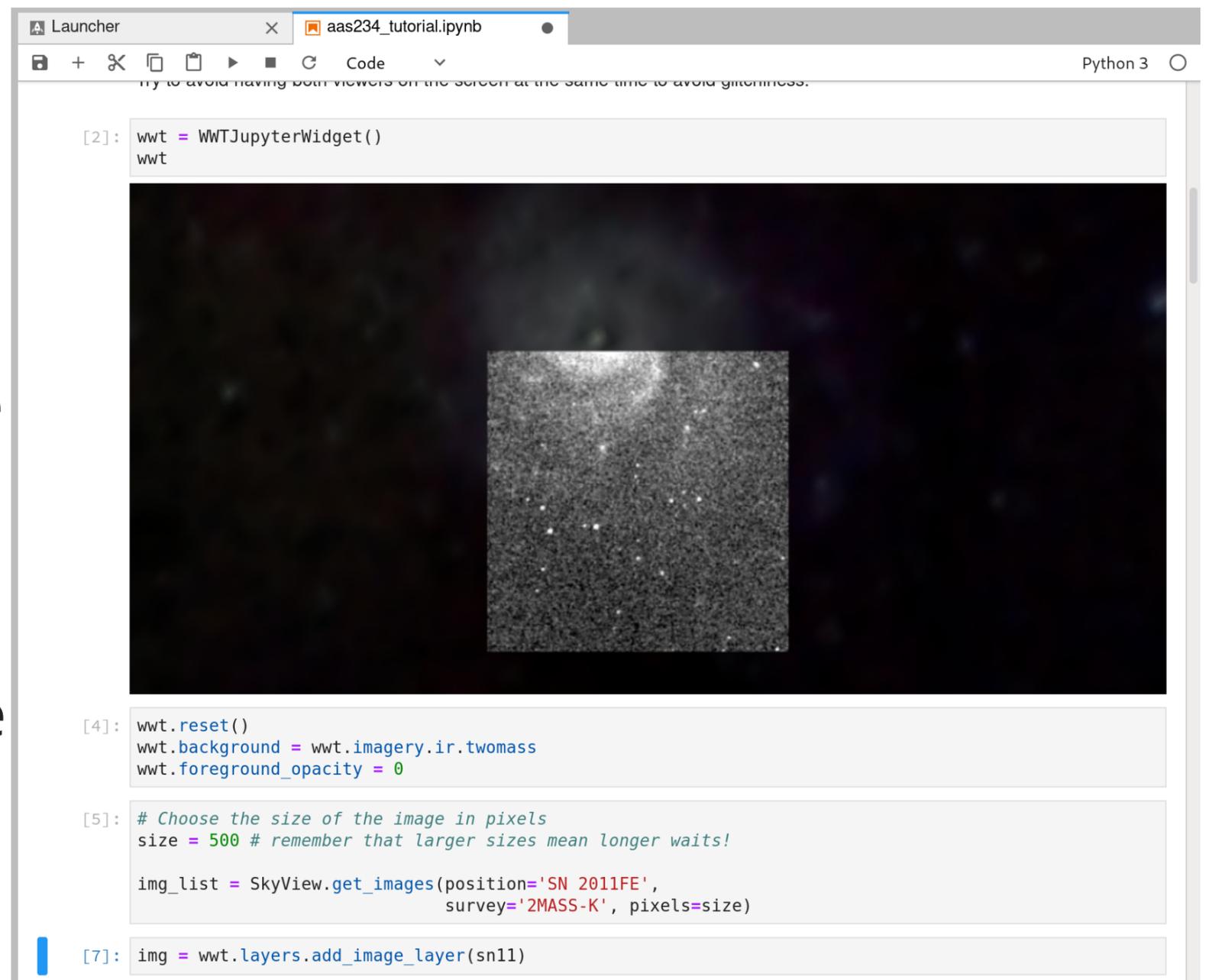
# The AAS WorldWide Telescope is a platform for Web-based image data sharing and exploration.

(It's also a lot of other things, but this is what I'm focusing on today.)

Its basis is an embeddable JavaScript *WebGL engine* that renders imagery in the context of a 4D simulation of the known universe.

The *pywwt* package provides a Python interface and makes it easy to embed WWT in a Jupyter notebook.

WWT was built from the ground up to stream large datasets over the Web efficiently and with a smooth user experience.



```
Launcher x aas234_tutorial.ipynb Python 3
try to avoid having both viewers on the screen at the same time to avoid glitchiness.

[2]: wwt = WWTJupyterWidget()
      wwt

[4]: wwt.reset()
      wwt.background = wwt.imagery.ir.twomass
      wwt.foreground_opacity = 0

[5]: # Choose the size of the image in pixels
      size = 500 # remember that larger sizes mean longer waits!

      img_list = SkyView.get_images(position='SN 2011FE',
                                     survey='2MASS-K', pixels=size)

[7]: img = wwt.layers.add_image_layer(sn11)
```

**Demo 1:**  
**36,000 × 36,000 HSC**  
**image ([link](#))**

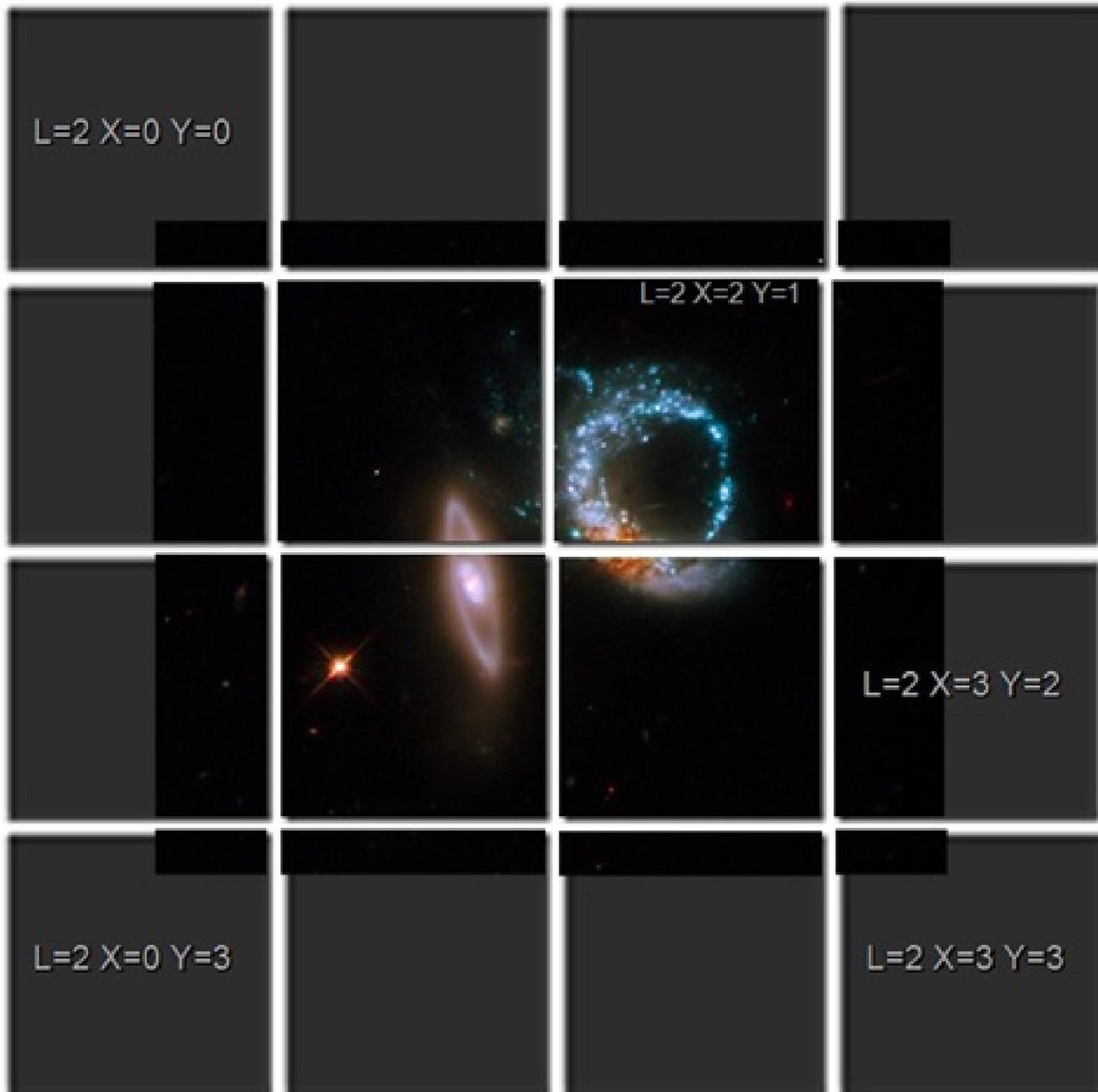
<http://localhost:8888/> (local-only demo)

**Demo 2:**  
**HSC image in WWWT “web  
client” ([link](#))**

[http://www.worldwidetelescope.org/webclient/default.aspx?  
wtml=http://newton.cx/~peter/files/toasty3/online.wtml](http://www.worldwidetelescope.org/webclient/default.aspx?wtml=http://newton.cx/~peter/files/toasty3/online.wtml)

# None of this works without data standards.

---



Astronomy has done pretty well on this front historically. Other fields are jealous of FITS!

New standards are needed — or new commitment to existing standards is needed — to deliver smooth Web-based user experiences. Can't just ship gigabyte FITS files around!

WWT uses a projection called TOAST and a "tile pyramid" architecture. The python package *toasty* provides tooling for creating the necessary datasets.

# Demo 3: “drop-in” exploration with pywwt ([link](#))

<http://bit.ly/wwt-binder03>

# Demo 4: WWT as a data portal ([link](http://cxc.harvard.edu/csc2/wwt.html))

<http://cxc.harvard.edu/csc2/wwt.html>

# Here's a summary.

---

- The future of science is on the Web — we need rich interfaces to datasets that are far too large to ship around.
- The AAS WorldWide Telescope is a tool for efficient Web-based image data sharing and exploration.
- WWT can be used for one-off investigations, portals to whole data archives, and E/PO applications.
- Regardless of the technology you use, new data standards are needed to enable *efficient* remote data access.

*Thanks for your attention!*

Peter K. G. Williams • [@pkgw](#) • <https://newton.cx/~peter/>

*HTML talk info:* <https://tinyurl.com/htmltalk> • *Design credits:* Hakim El Hattab (“white” theme), Julieta Ulanovsky (Montserrat font), Steve Matteson (Open Sans font) • *Tech credits:* git, reveal.js, KaTeX, Firefox developer tools, d3.js, WWT

*Acknowledgments:* this work was supported by the American Astronomical Society. We'd all go nuts without ADS and CDS.