

A visualization of the cosmic web, showing a complex network of dark matter filaments and galaxy clusters. The filaments are depicted as thin, blue, thread-like structures that form a web-like pattern across the image. Bright, orange and yellow clusters of galaxies are scattered throughout, particularly concentrated along the filaments. The background is a deep, dark blue, suggesting the vastness of space.

Visualizing Astronomy

How do we learn stuff from large datasets?

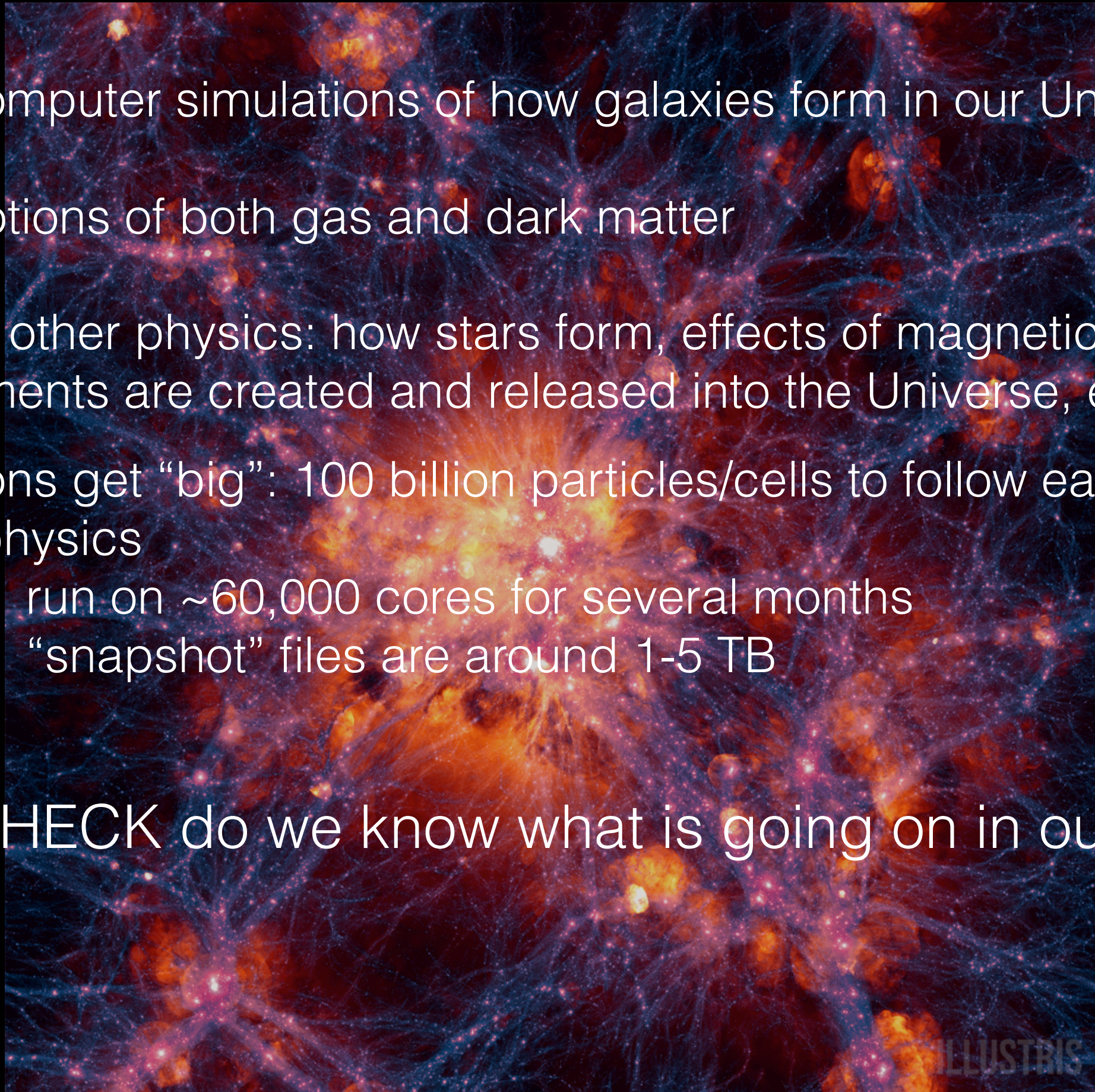
Jill P. Naiman
NSF+ITC Fellow, CfA

Collaborators: Matthew Turk, Kalina Borkiewicz, A.J. Christensen, Donna Cox, Stuart Levy, Bob Patterson, Jeffrey Carpenter

Big Data in My Own Work: The Illustris Simulations

- ◆ Super computer simulations of how galaxies form in our Universe
- ◆ Track motions of both gas and dark matter
- ◆ Includes other physics: how stars form, effects of magnetic fields, how elements are created and released into the Universe, etc
- ◆ Simulations get “big”: 100 billion particles/cells to follow each with its own physics
 - run on ~60,000 cores for several months
 - “snapshot” files are around 1-5 TB

How the HECK do we know what is going on in our data?



Big Data in Observational Data too

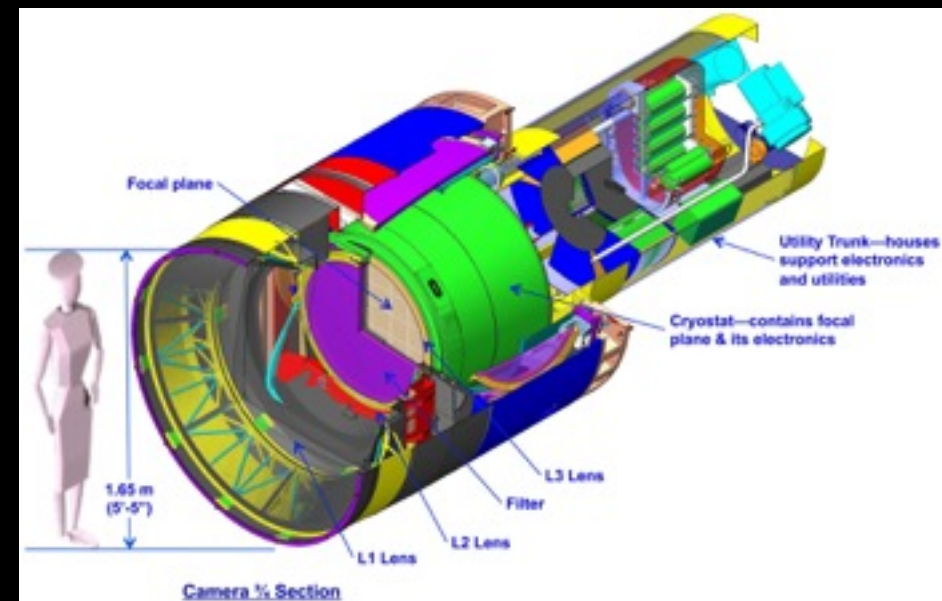
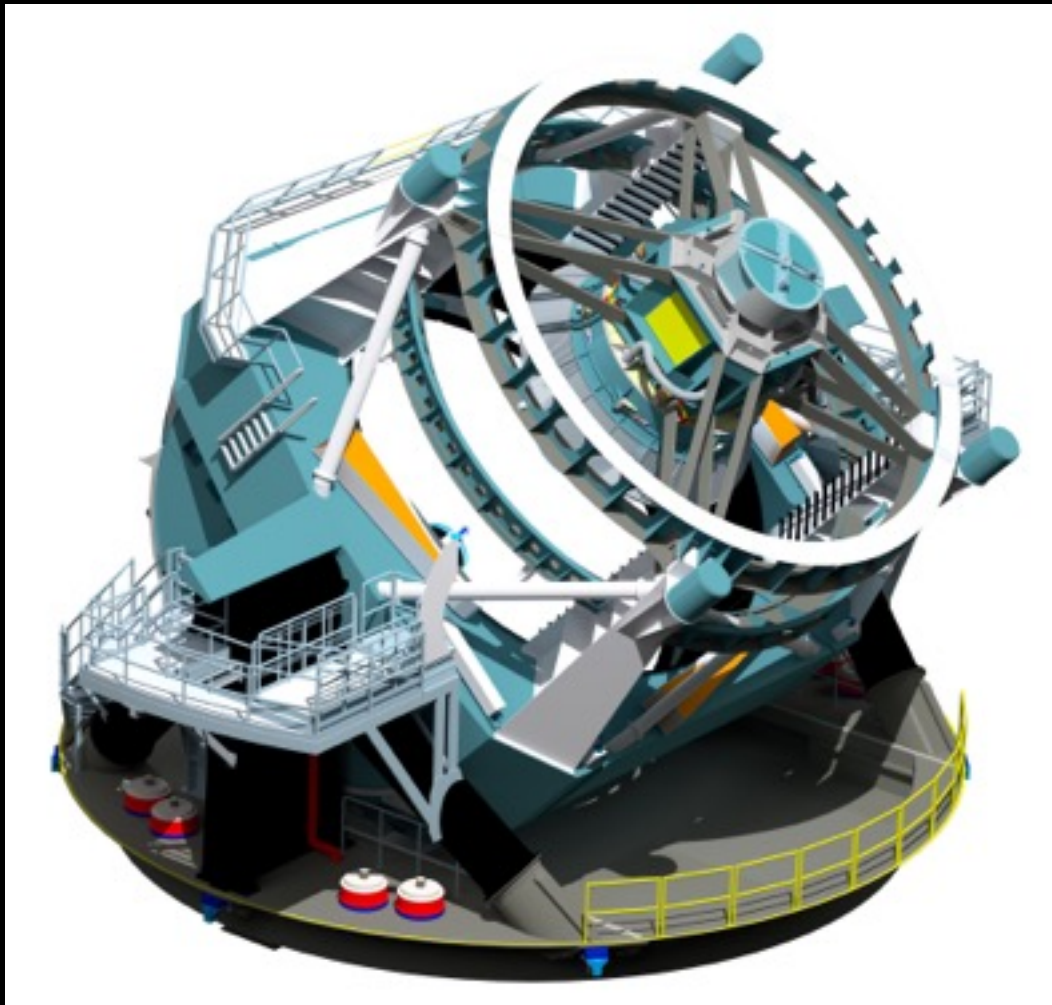
New instruments
=
more data

LSST: 200PB/decade expected

Sloan Digital Sky Survey (SDSS): ~120TB

Dark Energy Survey (DES): ~200GB/night,
~PB in last decade.

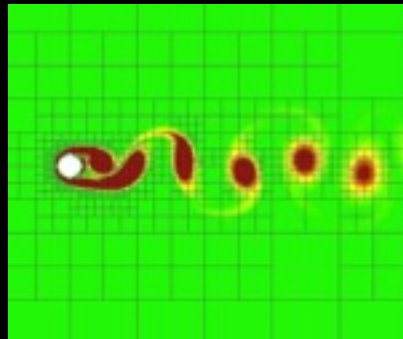
Square Kilometre Array (SKA): 1000 PB per year
expected



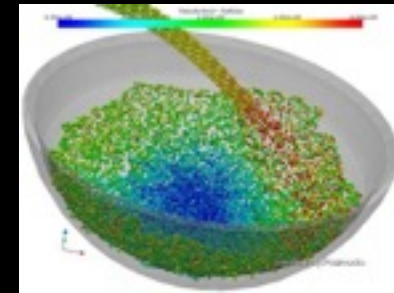
GIGANTIC camera with 3.2 gigapixels

Workflow of a Typical Computational Astrophysicist

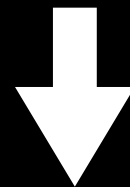
(AMR)



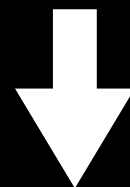
(SPH)



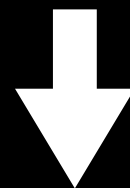
Pick a code for your physics problem.



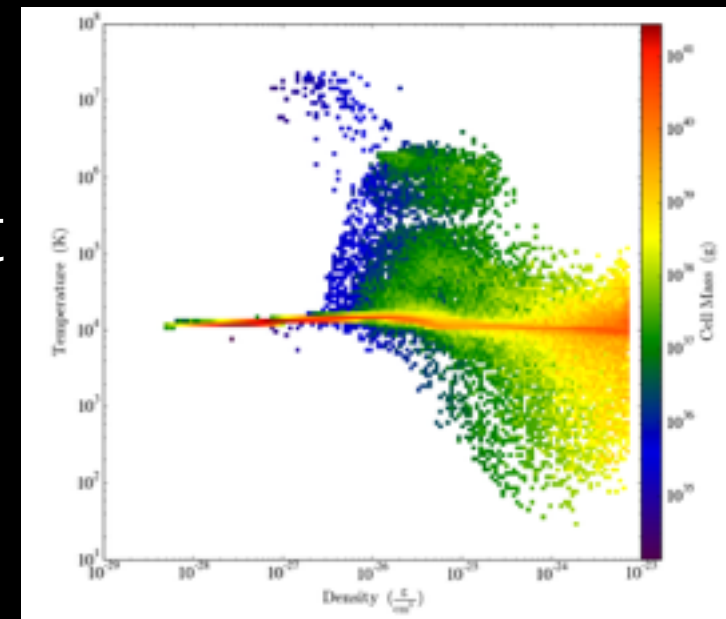
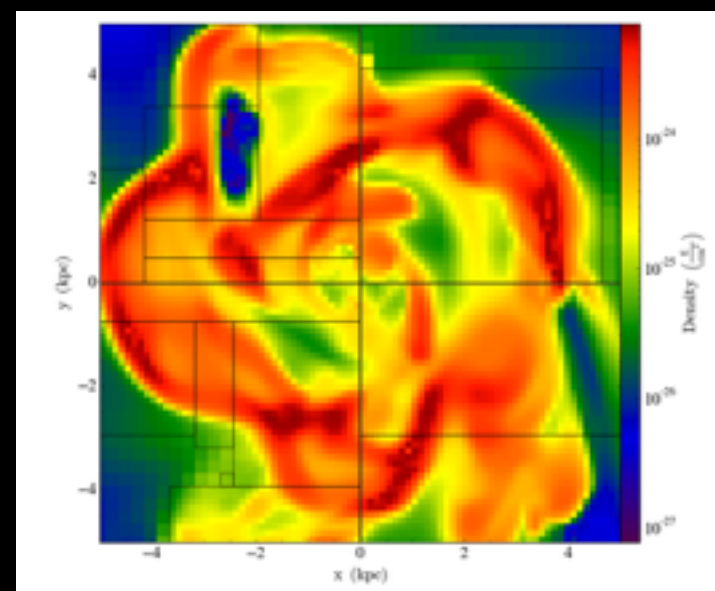
Add physics: (how stars form, supernovae feedback, how elements are created/destroyed, sources of material/heat external to your simulation domain...)



Send to supercomputer... and wait



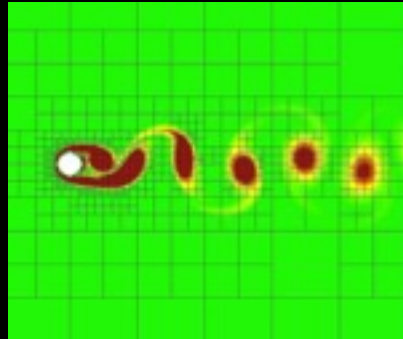
Visualize and Analyze



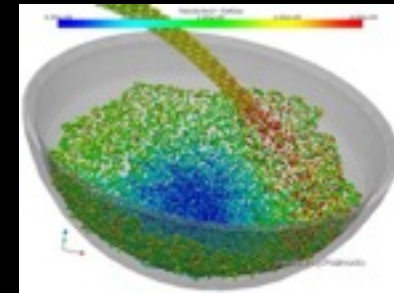
Usually special program for the specific AMR/SPH code, or **yt**

Workflow of a Typical Computational Astrophysicist

(AMR)



(SPH)



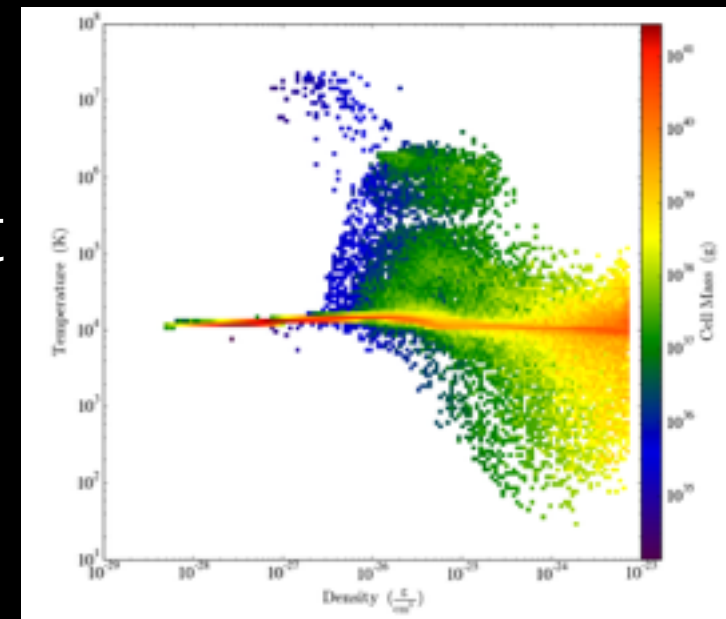
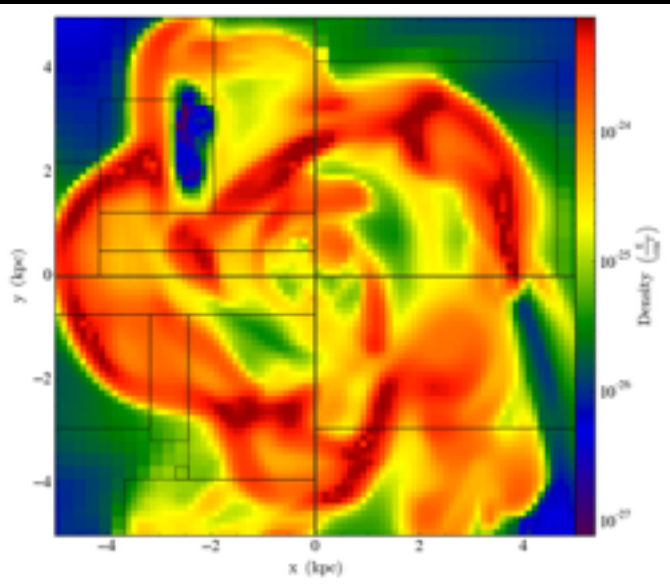
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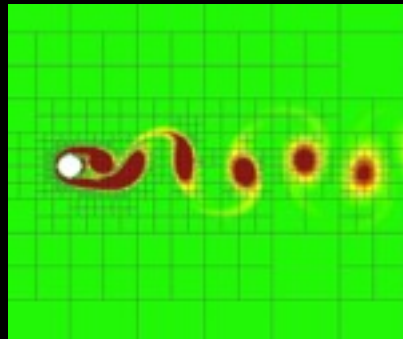
Visualize and Analyze

Make a super cool movie

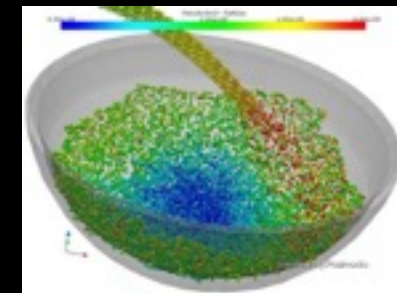


Workflow of a Typical Computational Astrophysicist

(AMR)



(SPH)



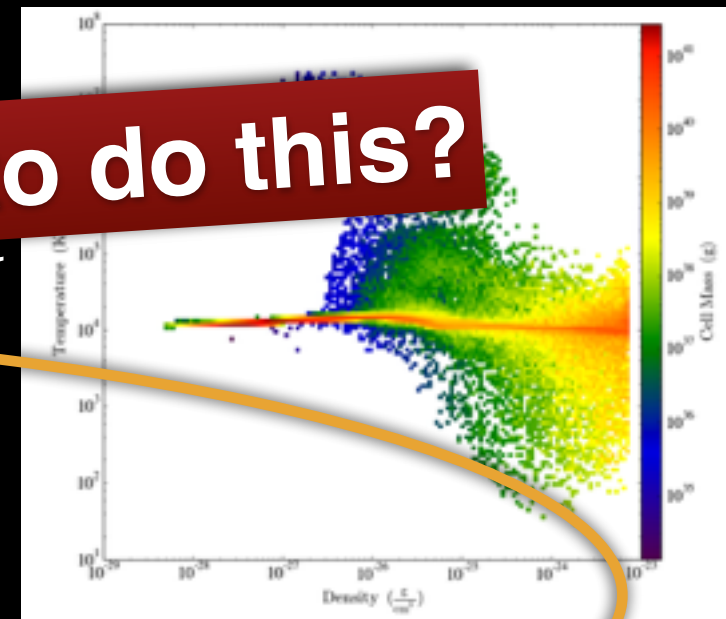
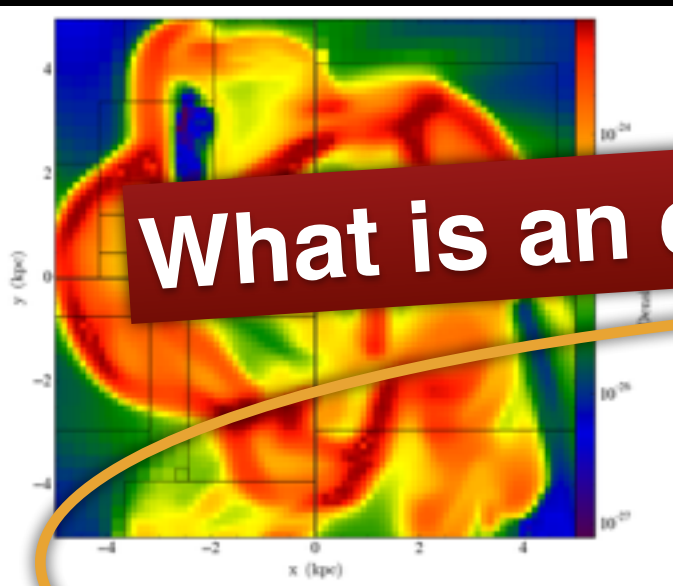
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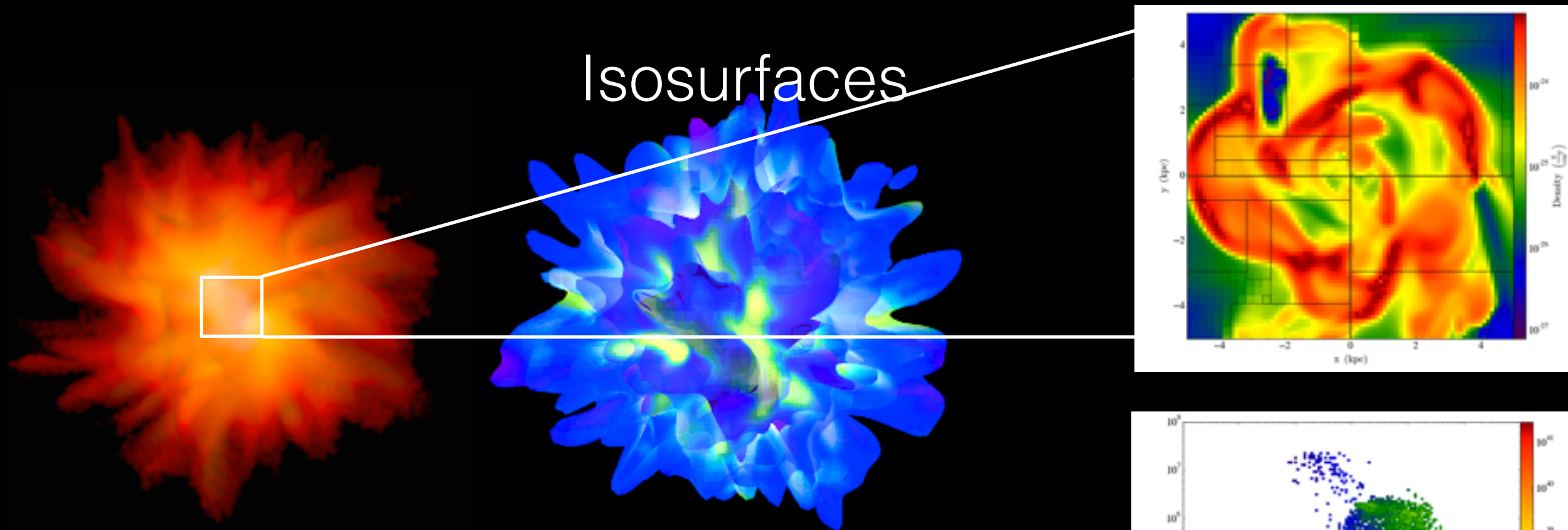
What is an effective and intuitive way to do this?

Visualize and Analyze

Make a super cool movie

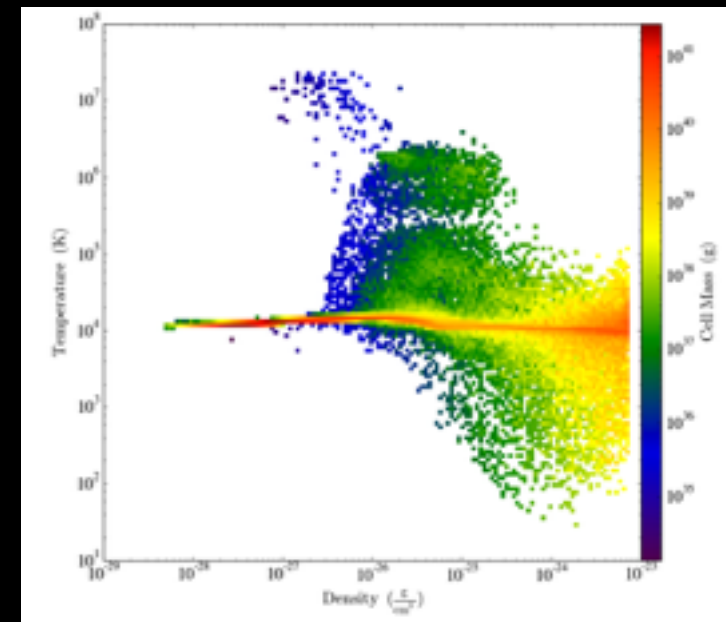


Searching for Fast, Intuitive, Open Access Visualization in the Land of Big Datasets



Requirements to implementing this workflow

- low latency
- fast access to remote data
- both stunning visuals AND analysis capabilities



Ease of handing data over to large studios vs. giving early career scientists tools for their own visualization tools.

Combining Visualization and Analysis

... where we are

Viz and analysis packages written for scientists

IDL

yt

astropy

VisIt

ParaView

Vapor

Glue

Misc Python packages
(I'm sure I'm missing your
favorite!)

High-end 3D modeling, volume rendering, Visual Effects, etc

Maya

Blender

Houdini



Websites with 3D

Capabilities:

Sketchfab

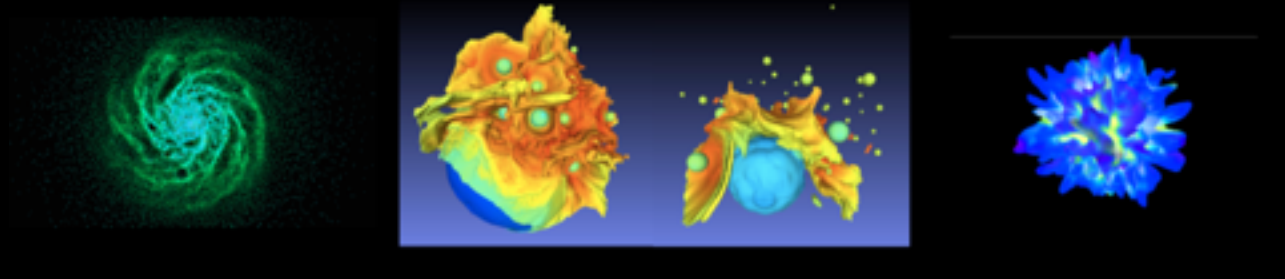
Thingiverse

Google Sketchup

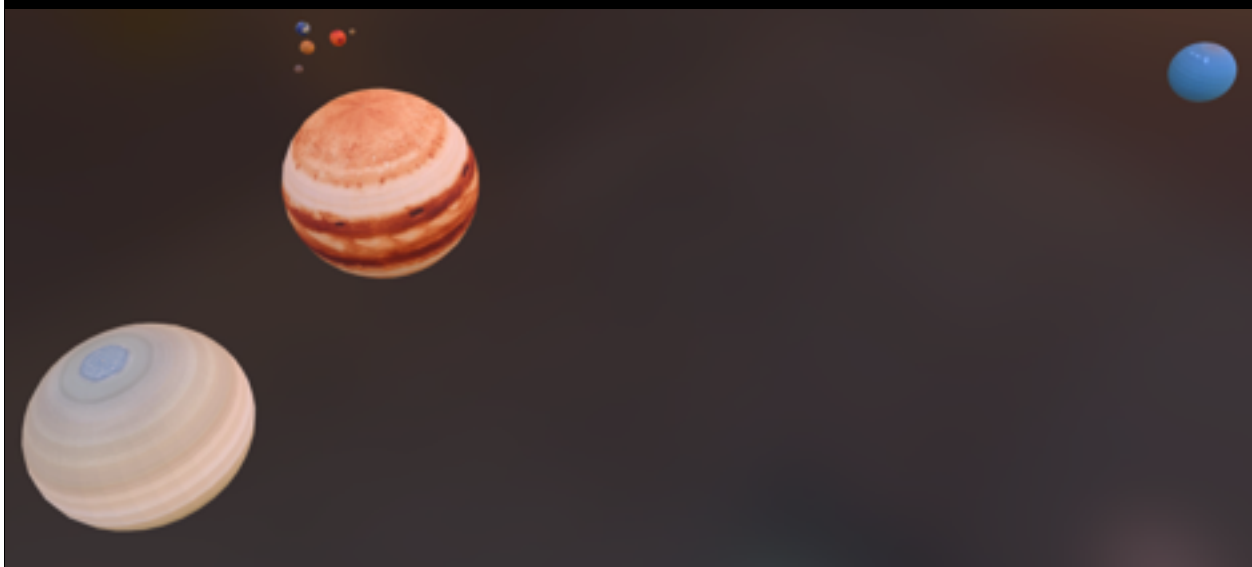
Combining Visualization and Analysis

... a collection of fun things as a place to start...

AstroBlend

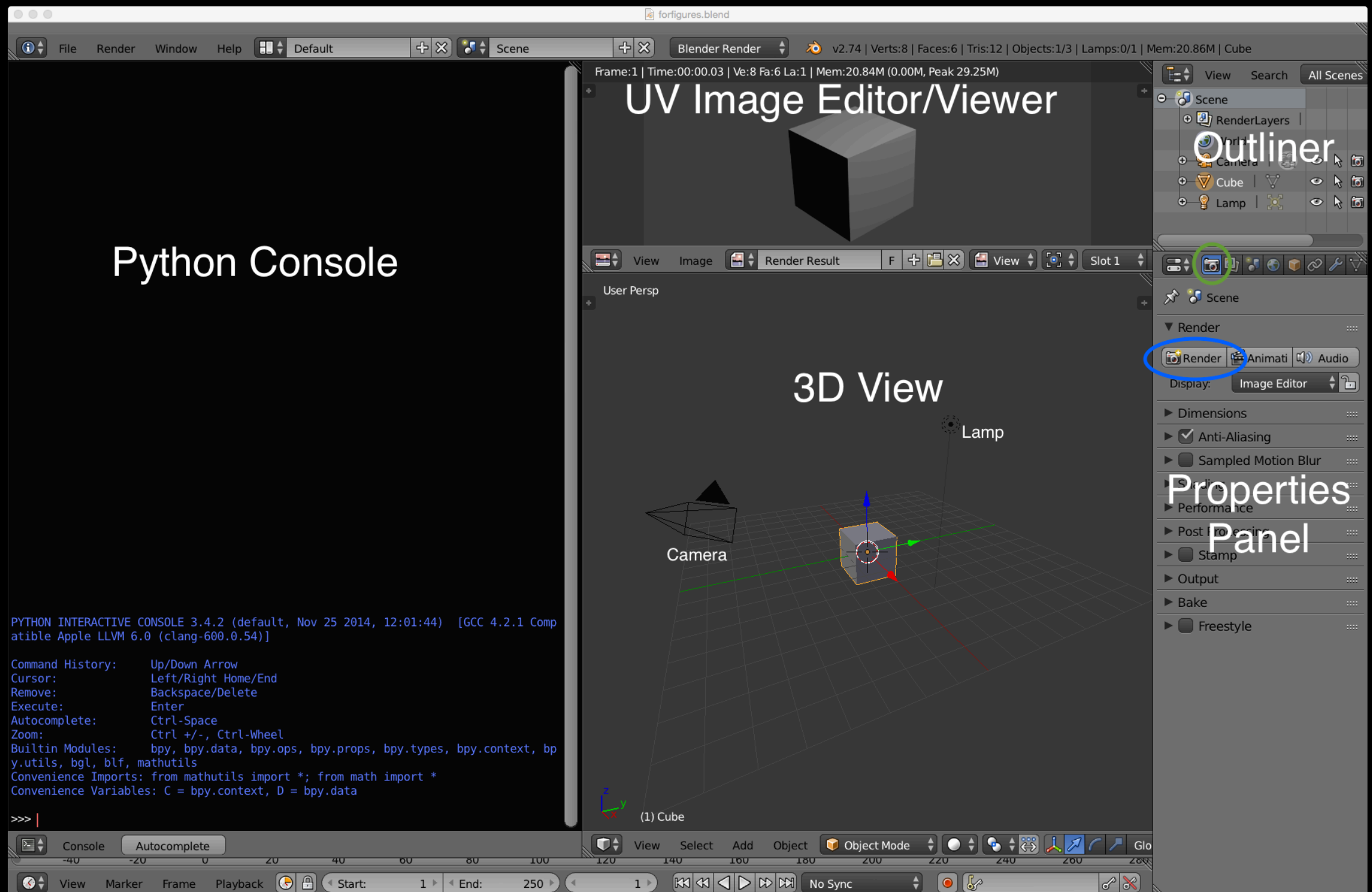


Sketchfab



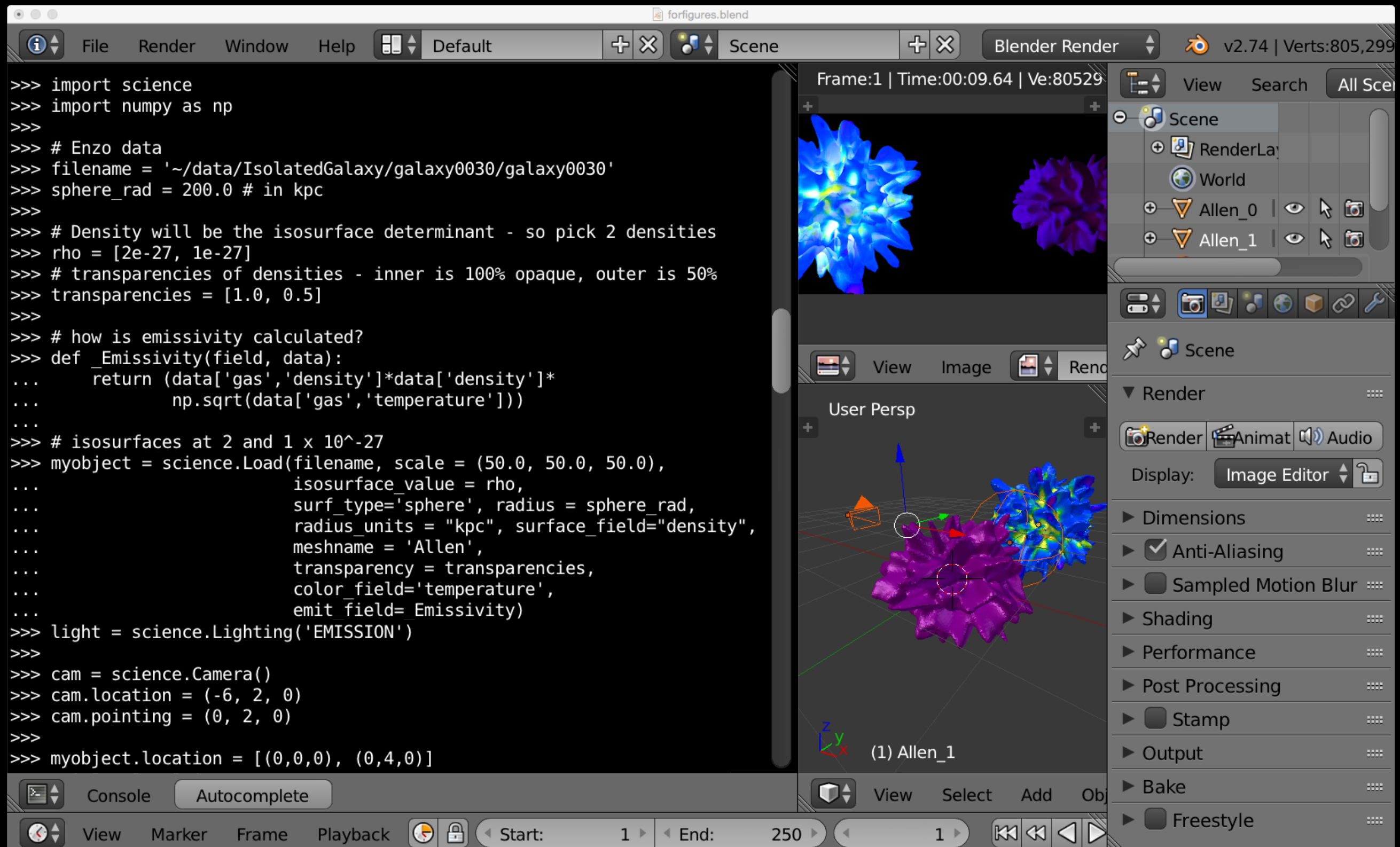
AstroBlend

www.astroblend.com



AstroBlend

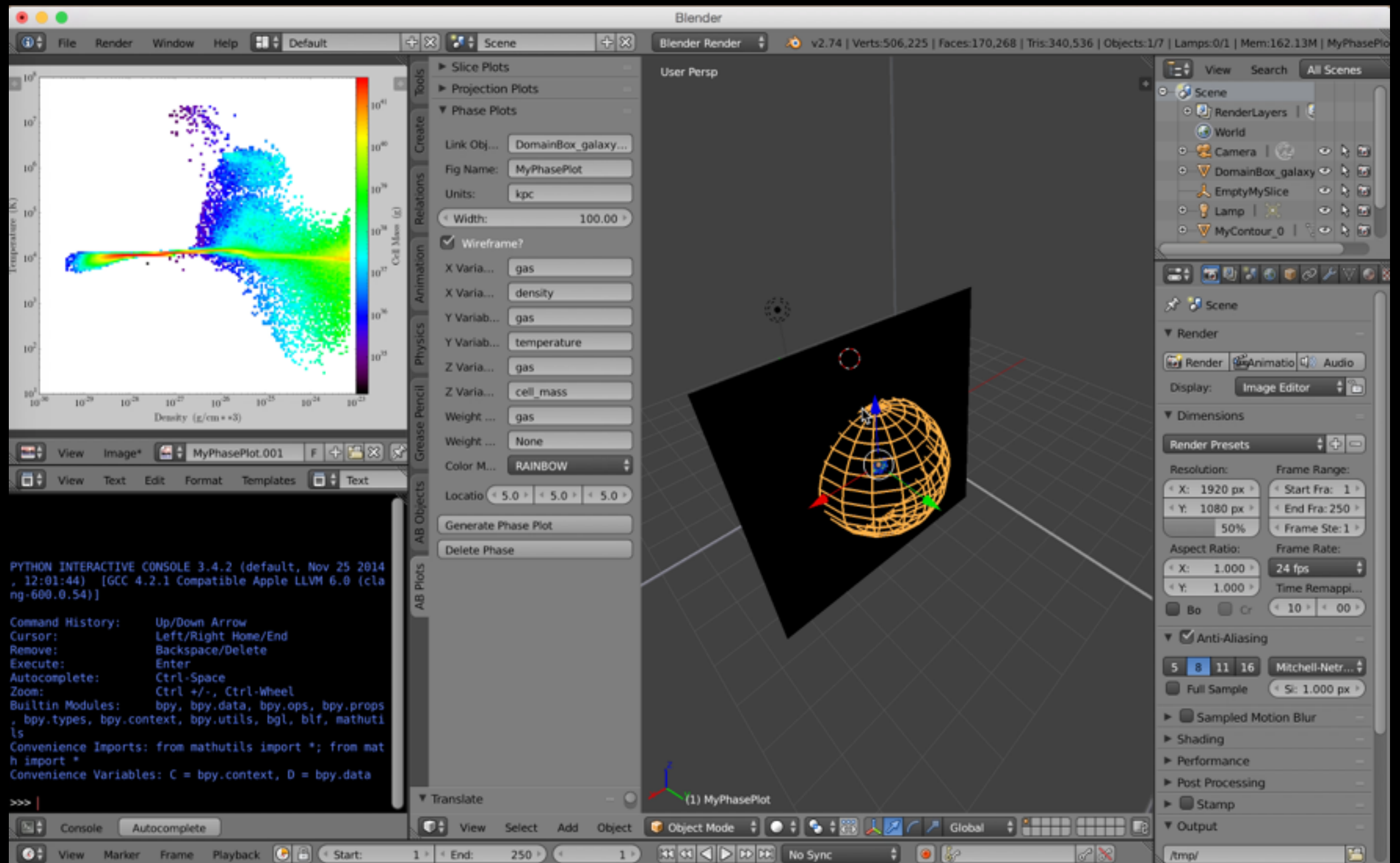
www.astroblend.com



Naiman 2016

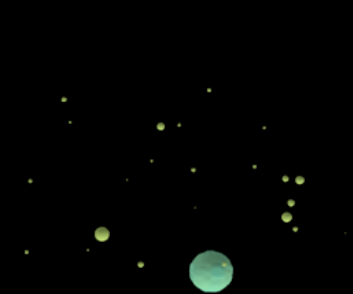
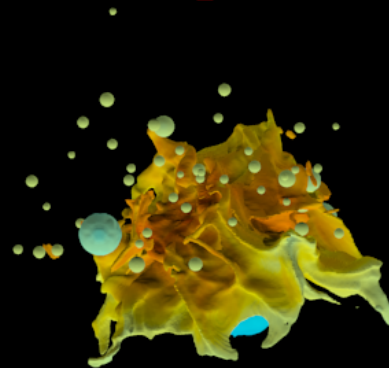
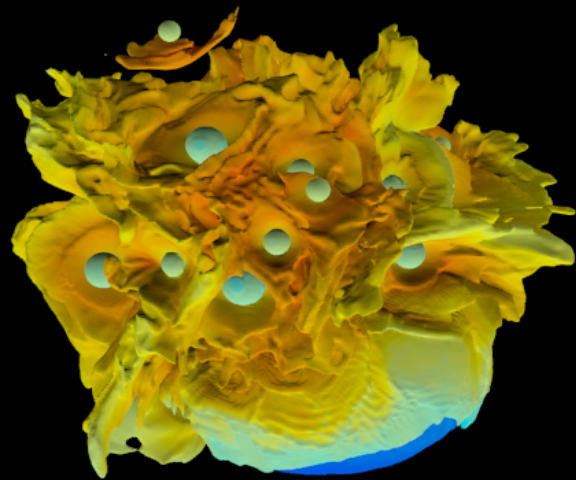
AstroBlend

www.astroblend.com

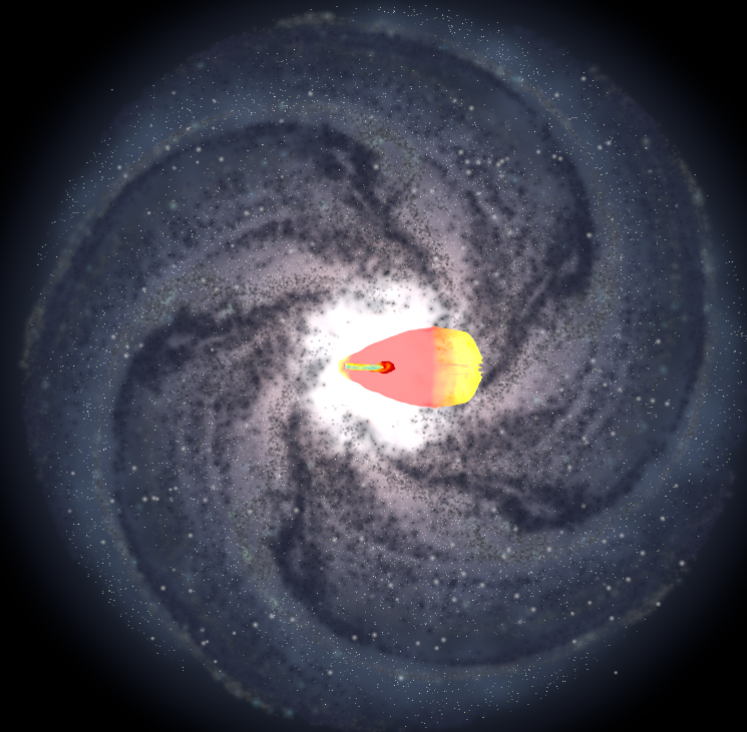


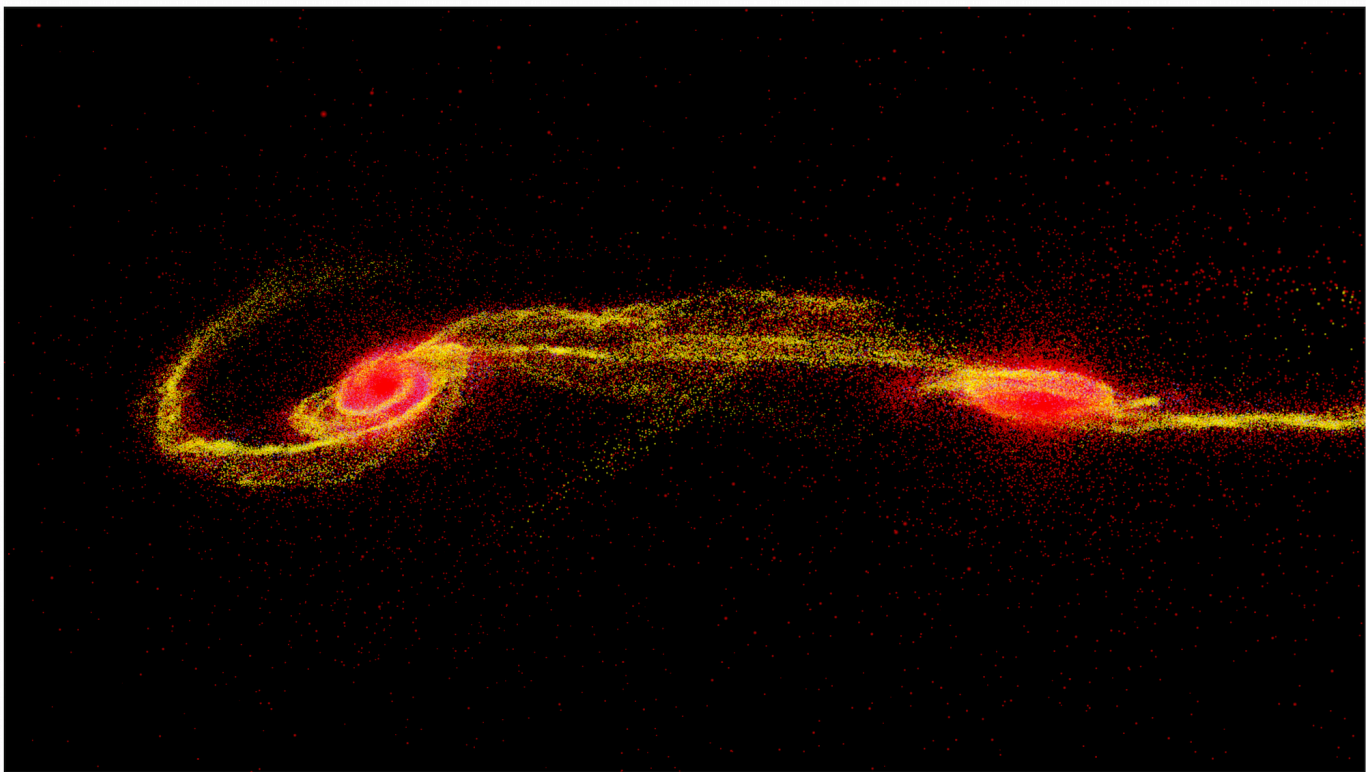
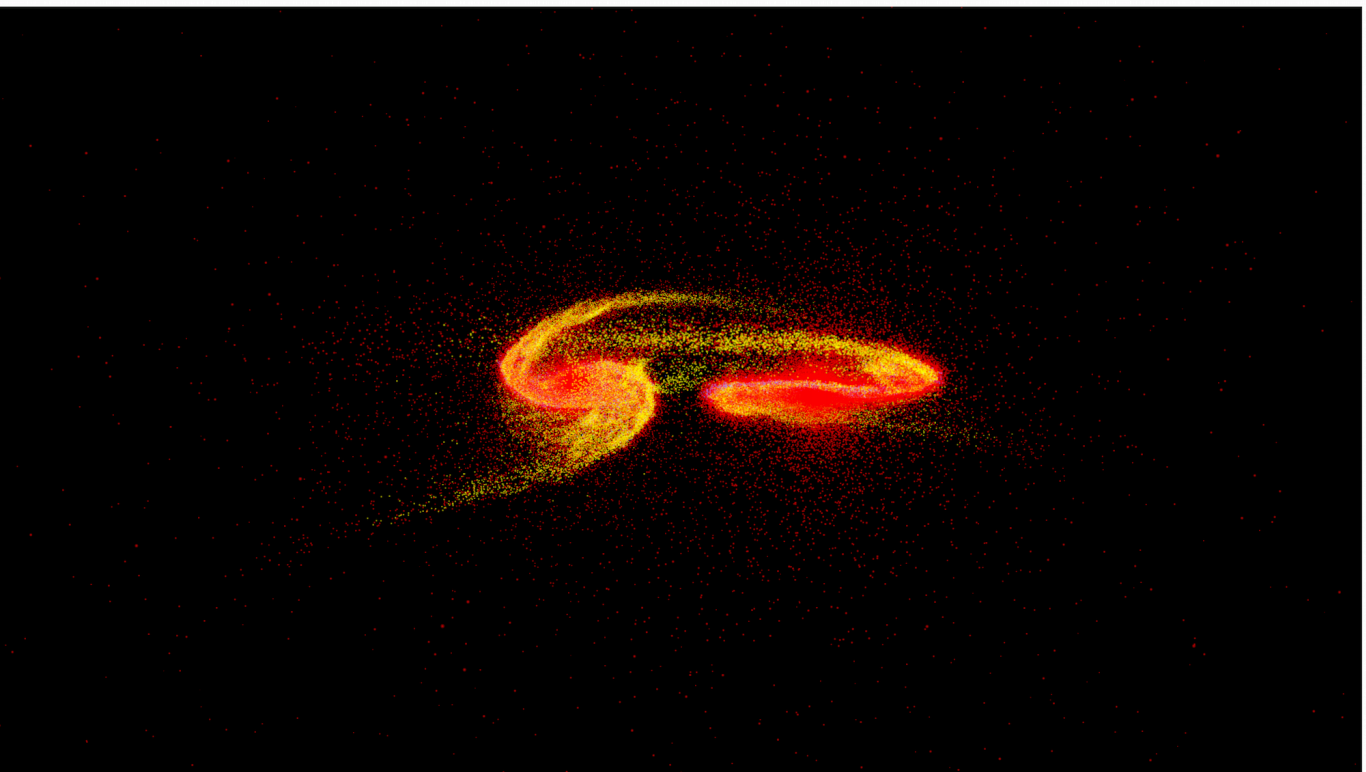
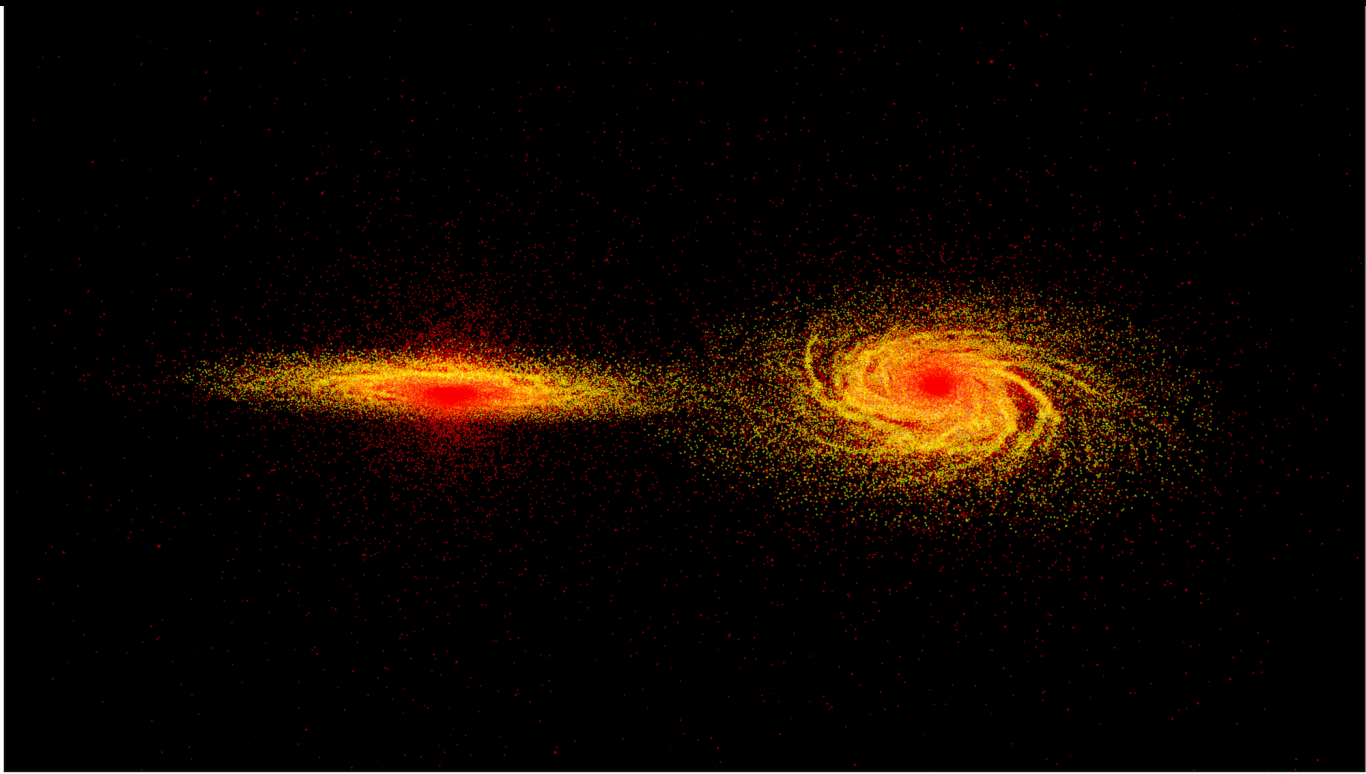
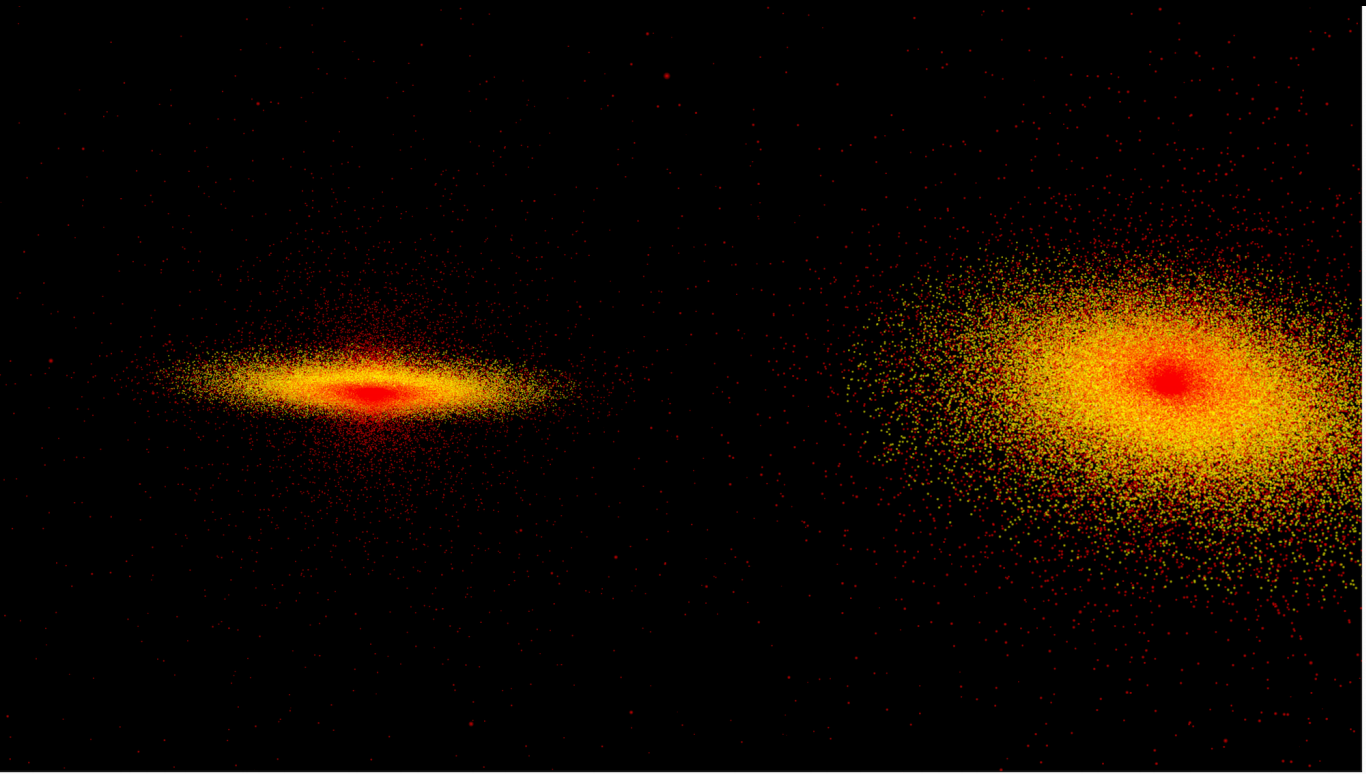
Analysis plots are made to be interactive Naiman 2016

Density →

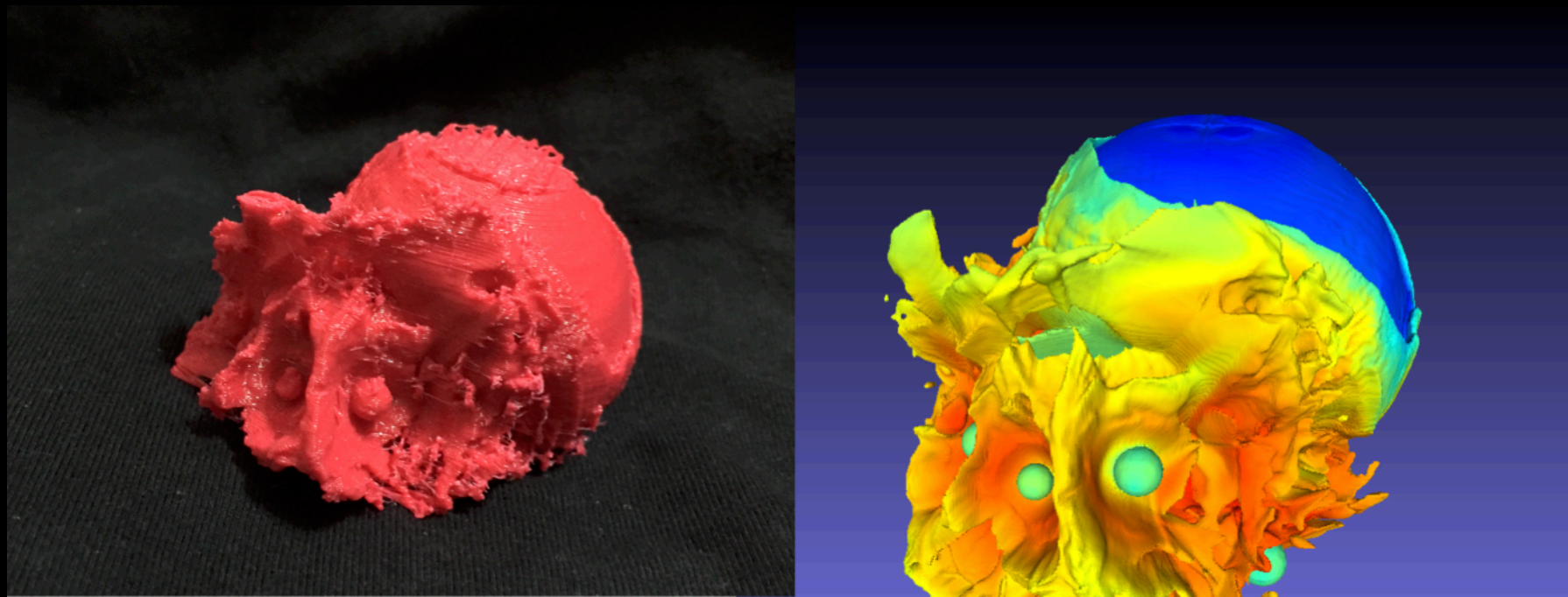


Soares-Furtado et al. in prep



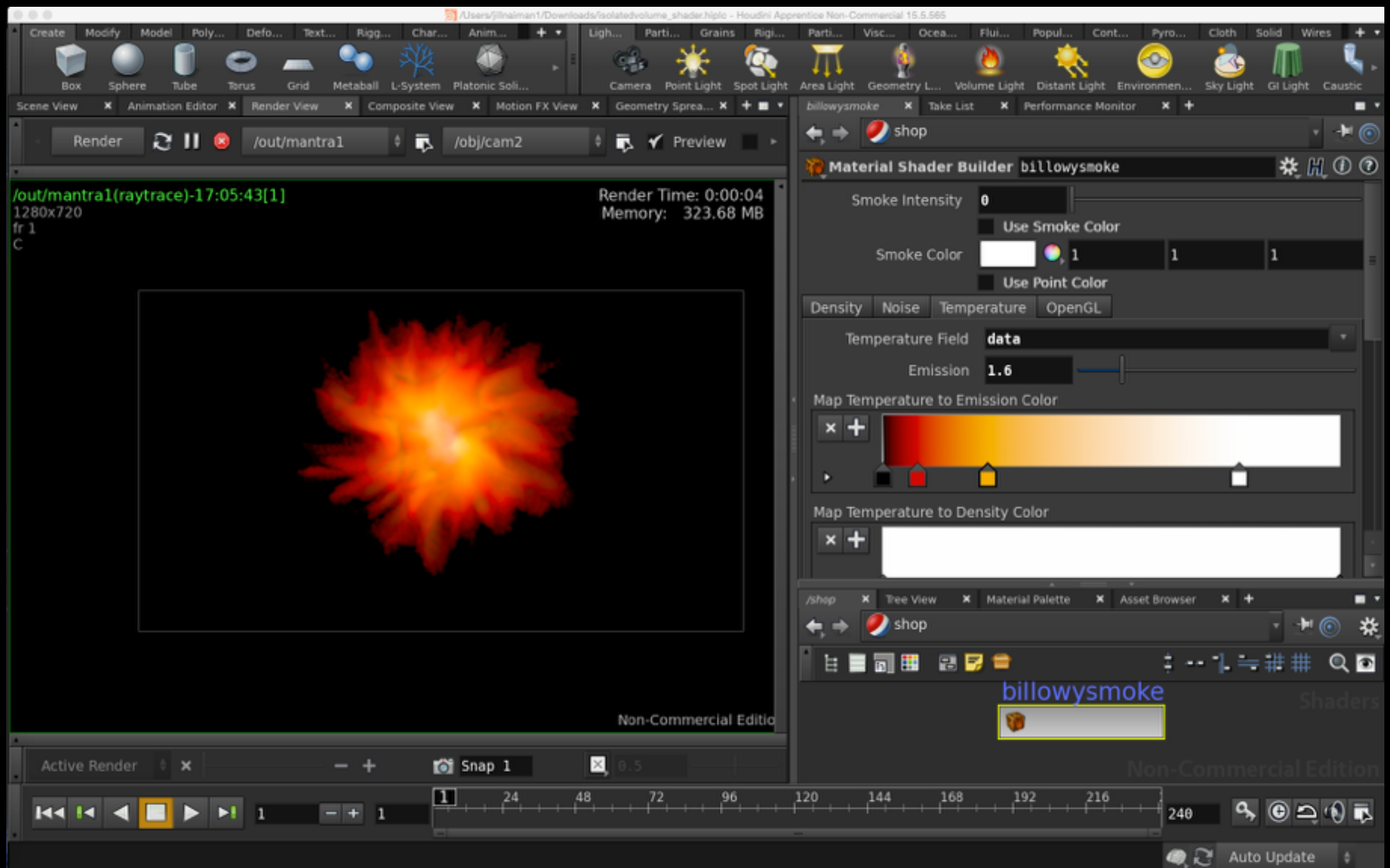


AstroBlend
www.astroblend.com

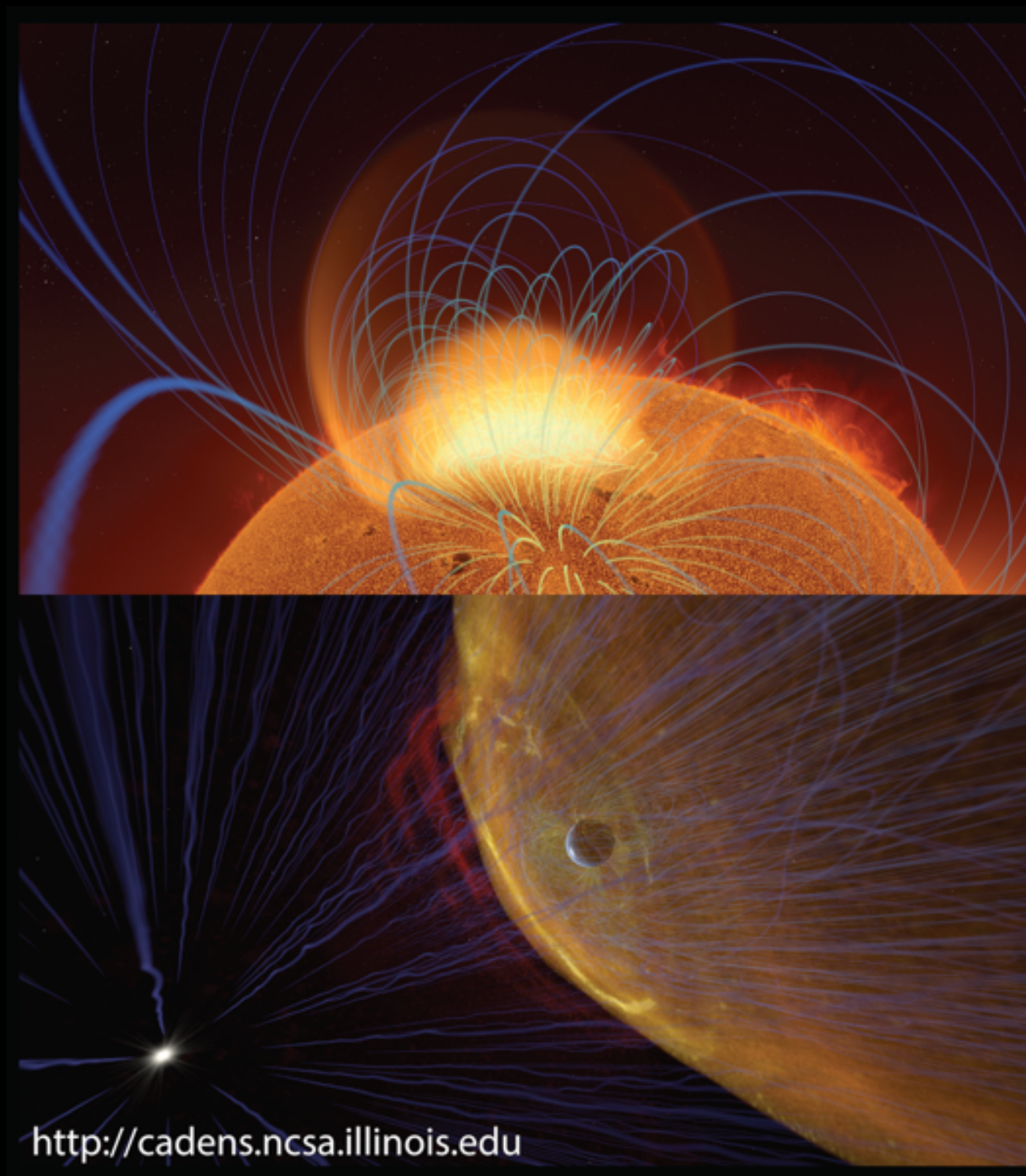


Code, Tutorials, Resources on the website and Bitbucket
Repo

Naiman 2016

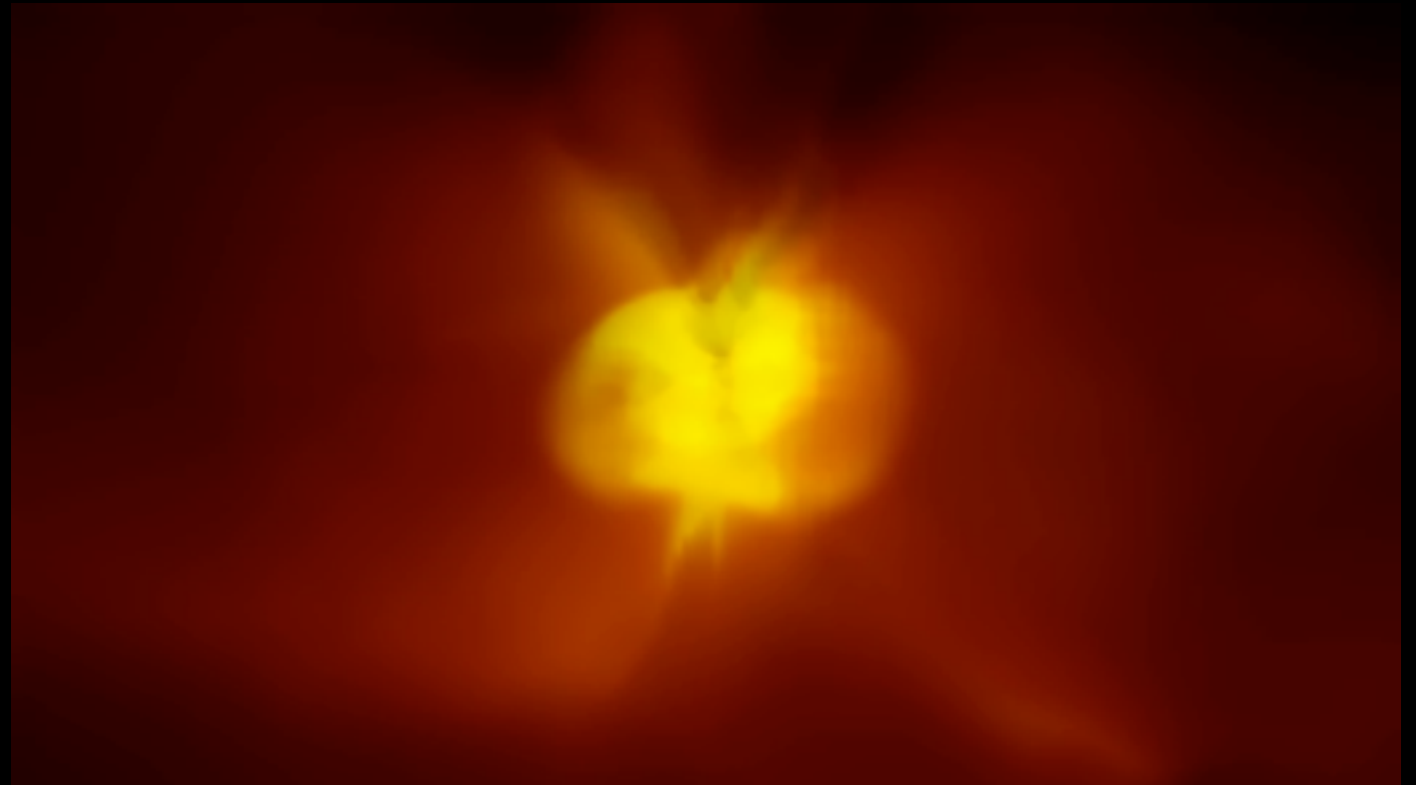
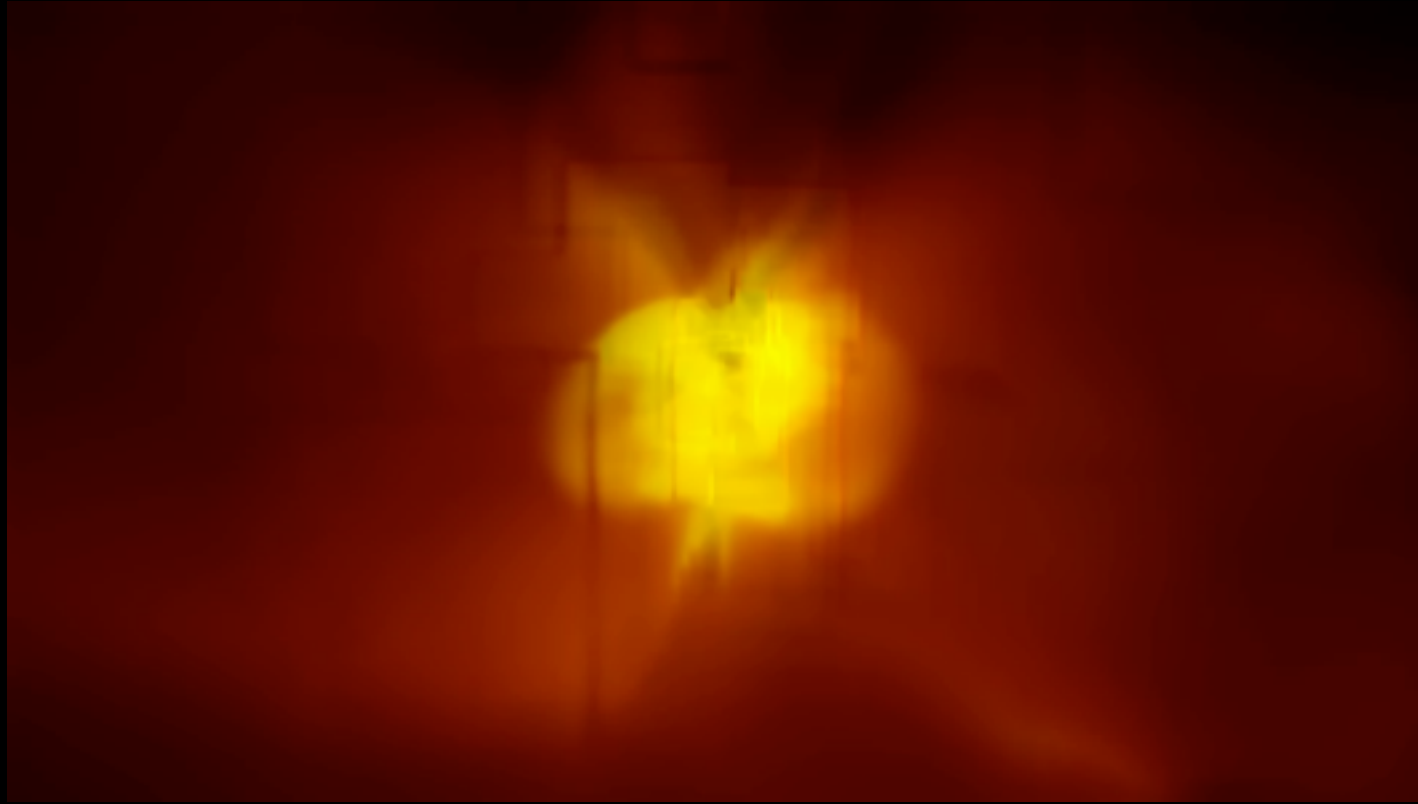


Ytini
www.ytini.com



<http://cadens.ncsa.illinois.edu>

Naiman et al. 2017



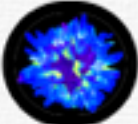
Sketchfab fun with Banneker/Aztlan Institutes

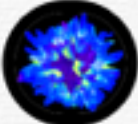
www.astroblend.com/ba2016

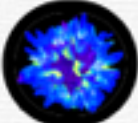
Some final thoughts on increasing access to science

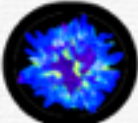
Computational Astrophysics and VisualizationHomeDays ▾

Day Pages: Astrophysical Visualization

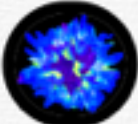
**Day 1**
Start to think about how to use visualization in your research, make some movies.

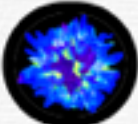
**Day 2**
Continue making some movies, starting thinking in 3D.

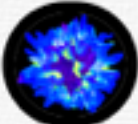
**Day 3**
Start thinking statically in 3D and start making some movies.

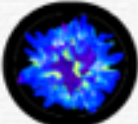
**Day 4**
A few thoughts to finish up, and resources to look into for more computational astronomy and visualization stuff.

Day Pages: Computational Astrophysics

**Day 1**
Analytical and Numerical Solution of 2-Body Problem.

**Day 2**
More on the 2-Body problem.

**Day 3**
Different solvers, multi-planet systems.

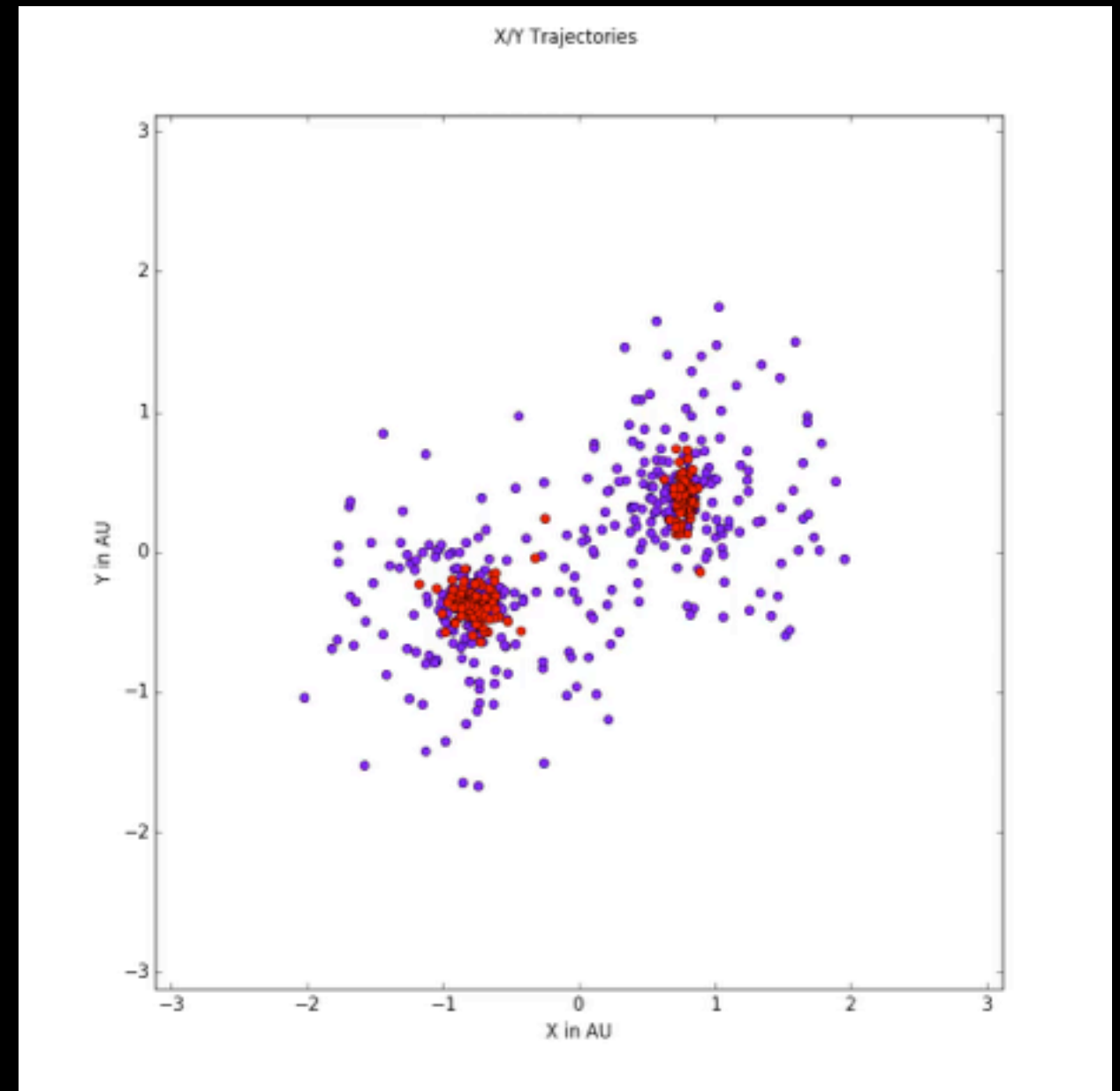
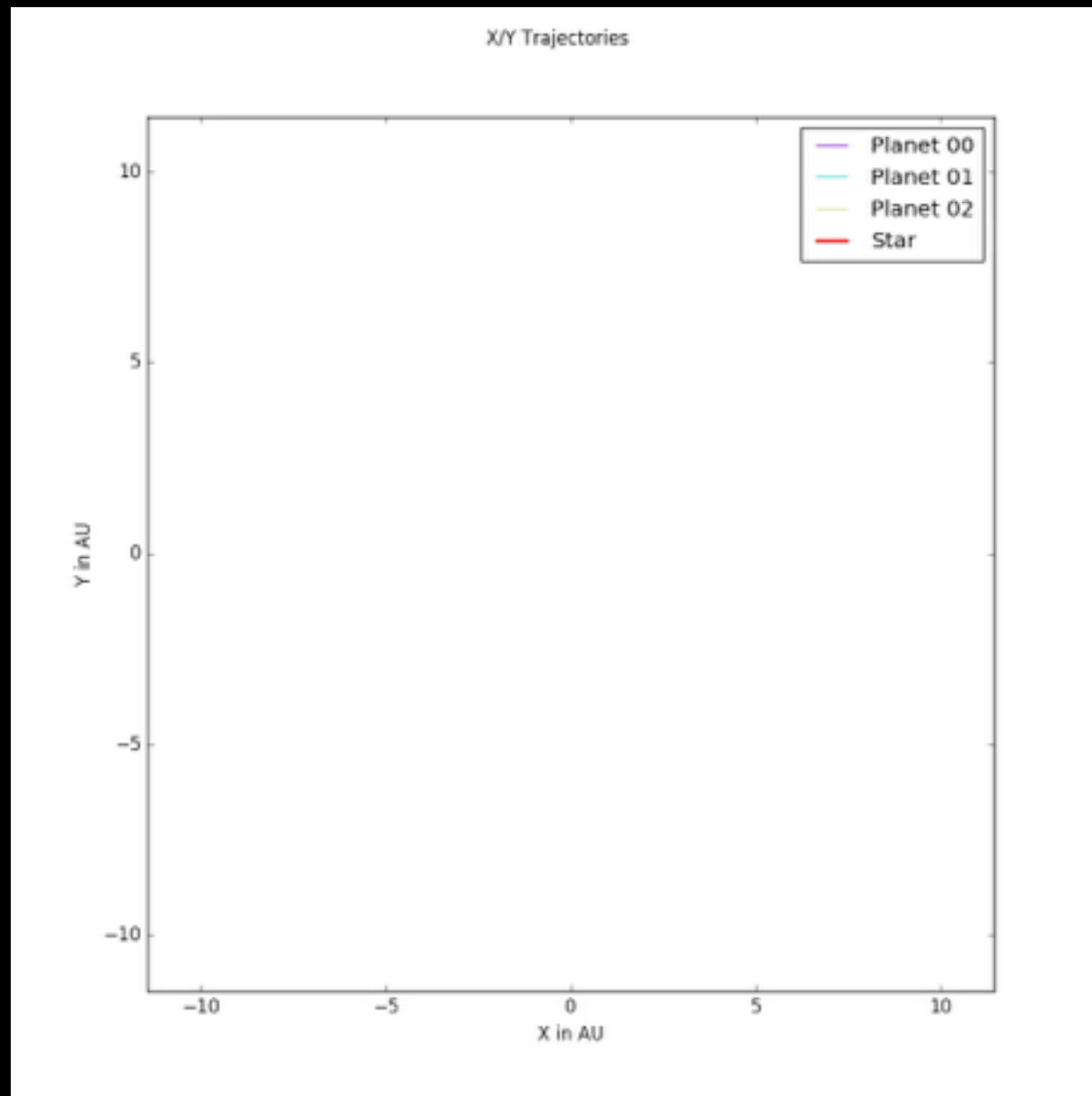
**Day 4**
The 3rd Dimension! Woo!

Second week - make 2D and 3D movies of the planetary systems and galaxies

First week - calculate orbits of planetary systems and motion of stars in merging galaxies

www.astroblend.com/ba2016

Some final thoughts on increasing access to science



Some final thoughts on increasing access to science

Moved on to:

3D Planets <https://skfb.ly/RyZo>

3D Galaxies <https://skfb.ly/QHwx>

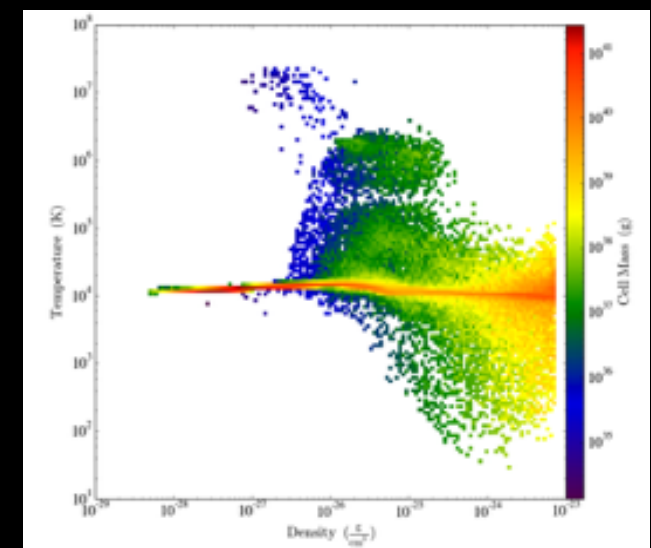
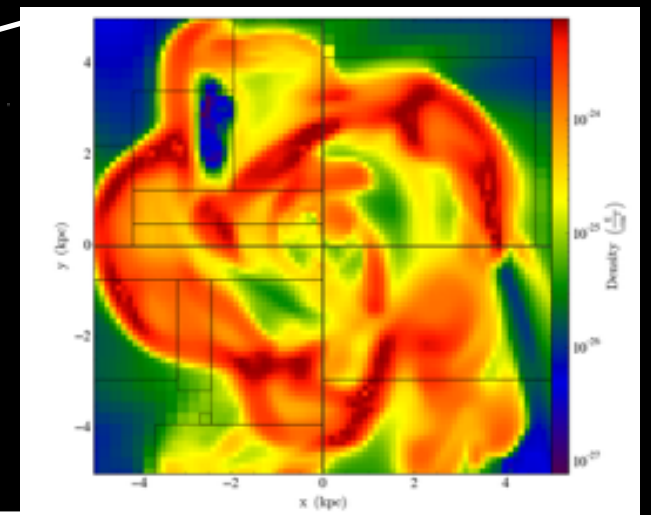
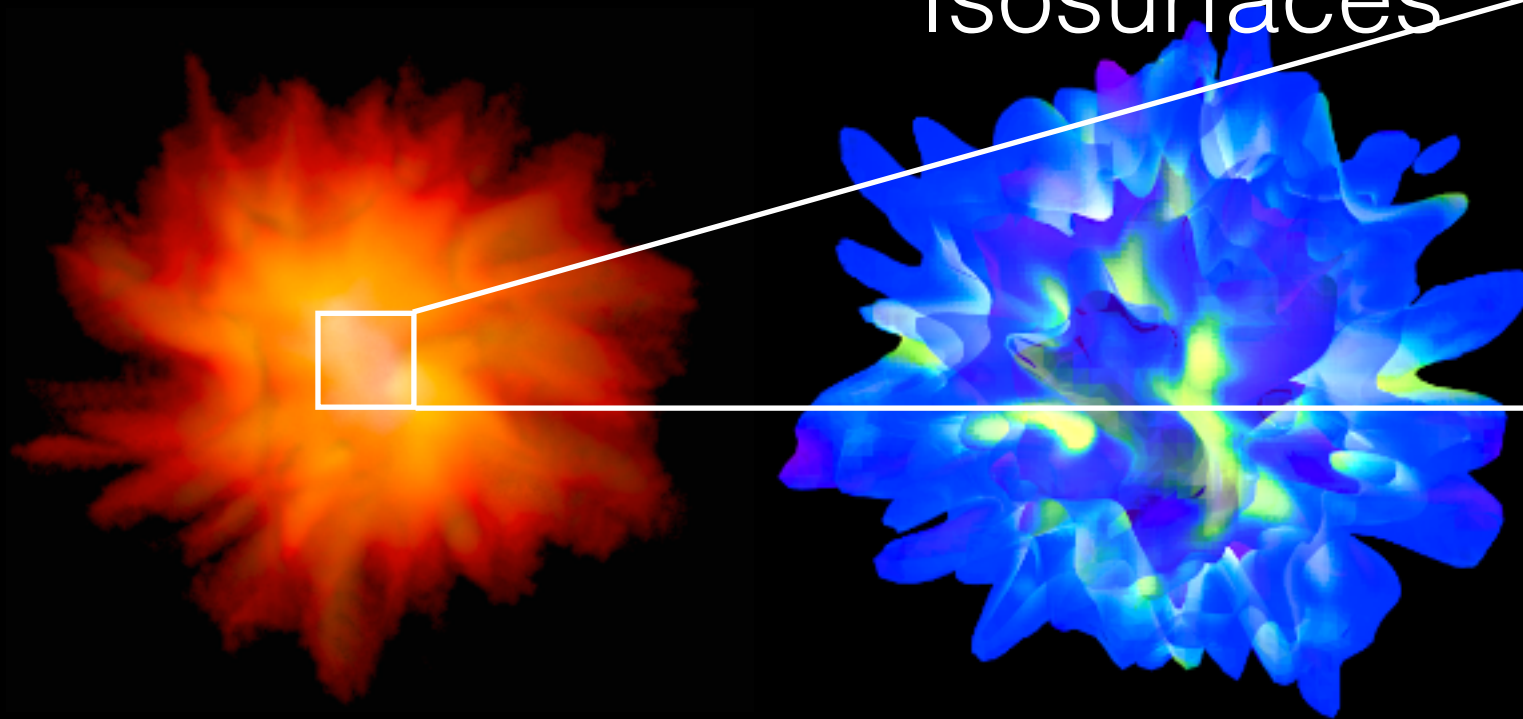
Where we go from here

Requirements to implementing this workflow

- low latency ← data preprocessing and AMR capabilities
- fast access to remote data ← some capabilities in yt to be fully utilized
- both stunning visuals AND analysis capabilities

fuller integration of yt into
Blender/Houdini (and Glue)

Isosurfaces



Thank you!

jill.naiman@cfa.harvard.edu

- ✦ www.astroblend.com
- ✦ <http://yt-project.org/>
- ✦ <http://bannekerinstitute.fas.harvard.edu/about>
- ✦ <http://www.ncsa.illinois.edu/>
- ✦ www.sketchfab.com/jnaiman
- ✦ www.ytini.com
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