



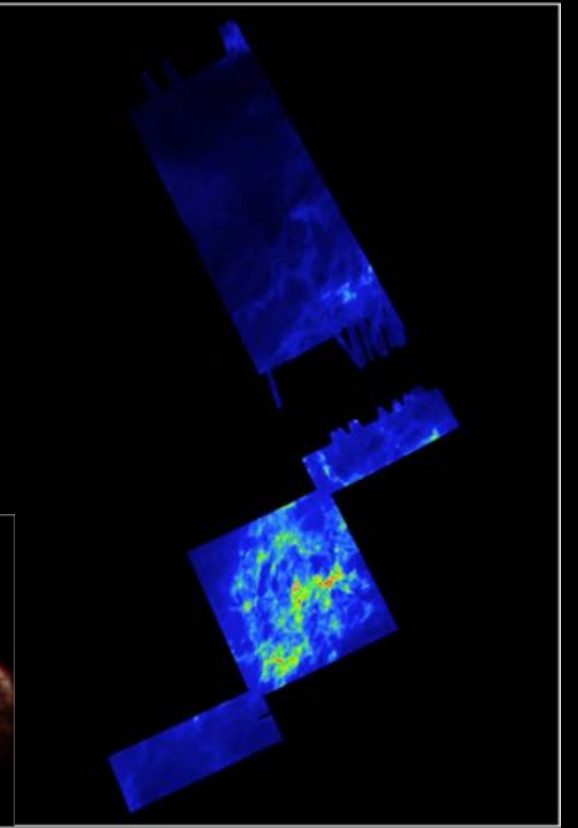
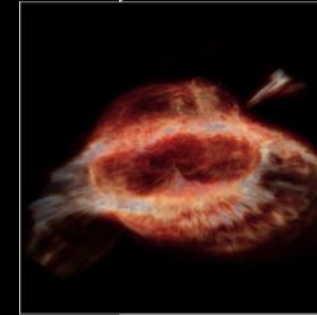
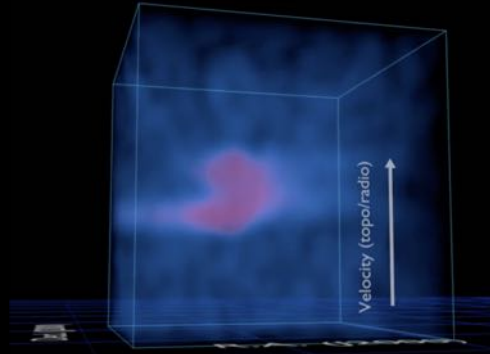
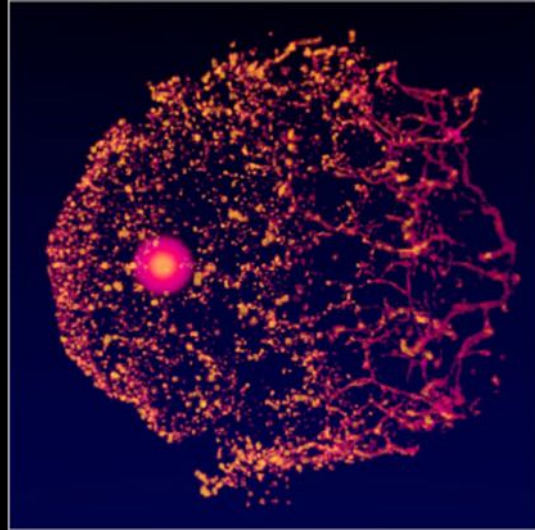
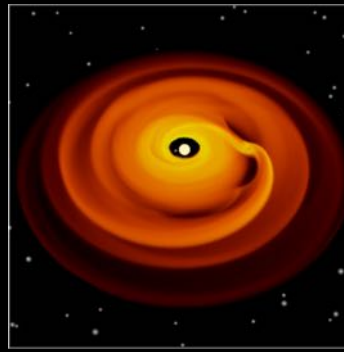
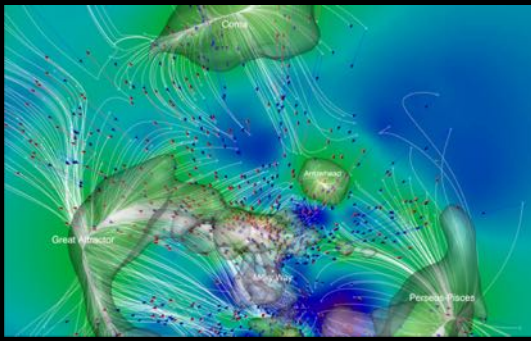
3D Data Visualization in Astrophysics

Dr. Brian R. Kent

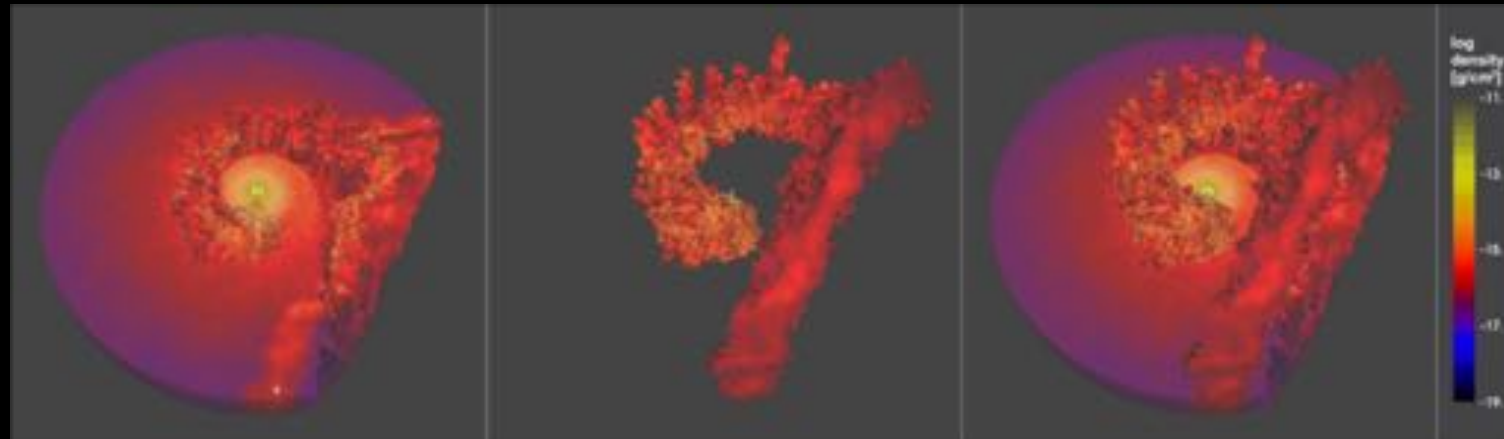
National Radio Astronomy Observatory

<http://www.cv.nrao.edu/~bkent/blender>





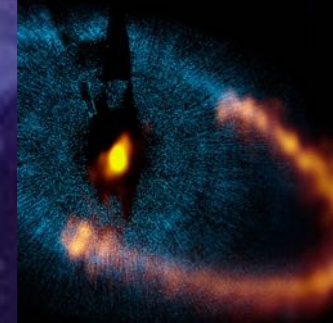
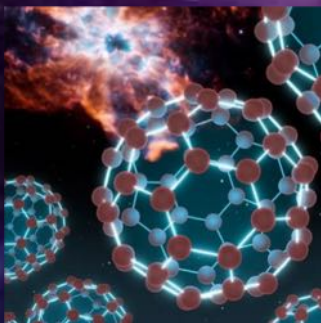
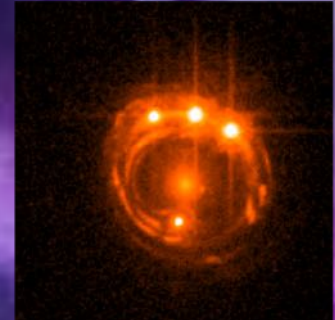
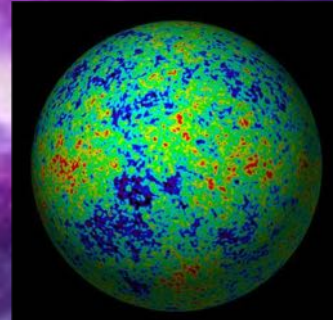
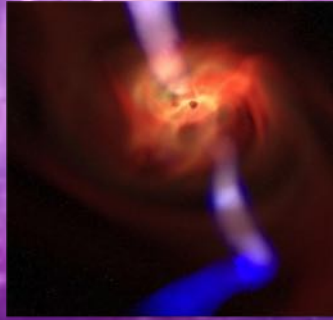
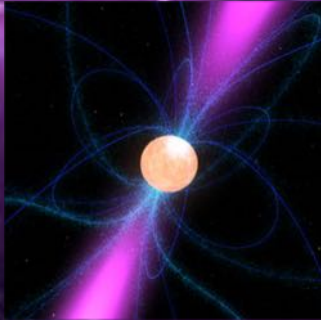
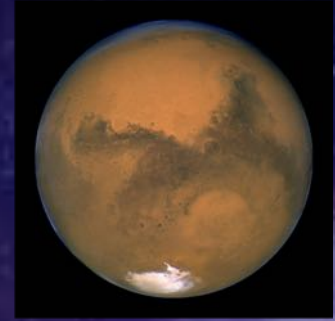
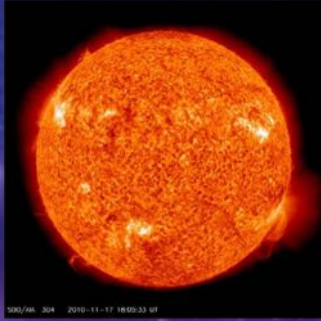
<http://iopscience.iop.org/journal/1538-3873/page/Techniques-and-Methods-for-Astrophysical-Data-Visualization>



Overview

- What we want to get out of 3D data visualization
- Types of visualizations when rendering 3D graphics
- How we can leverage *Blender* for 3D viz
- Examples

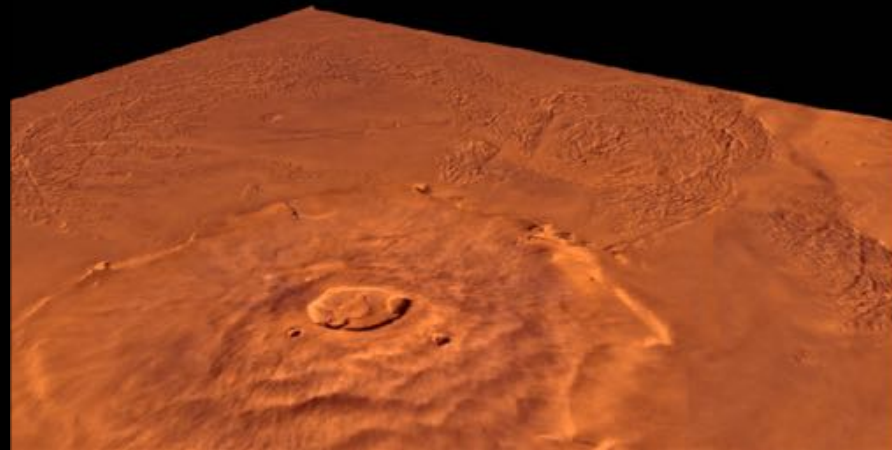
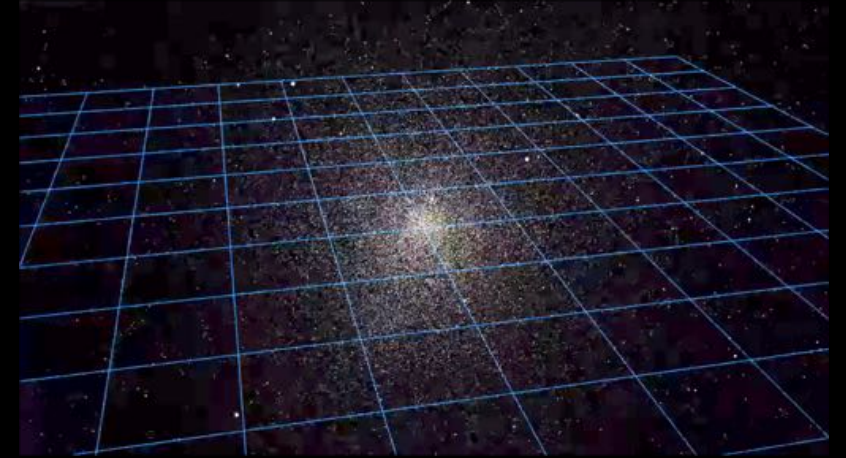
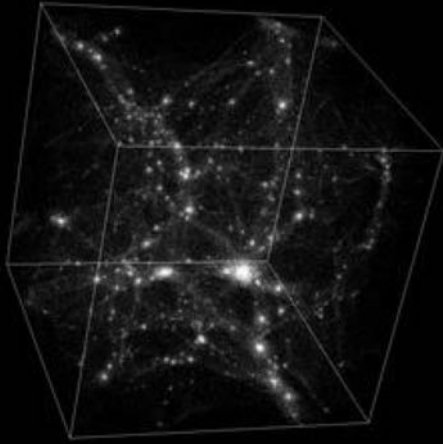
Astrophysical Phenomena



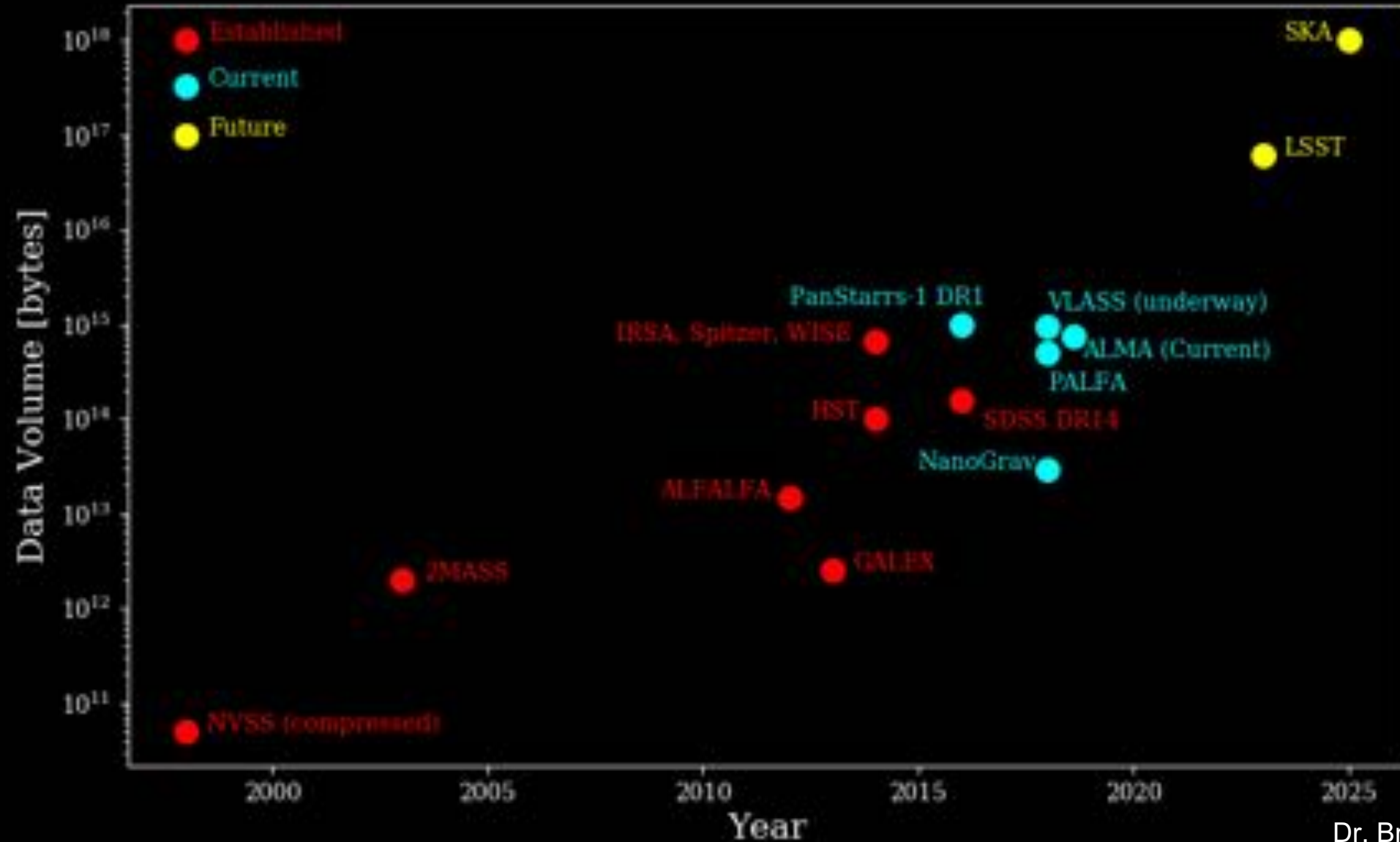
What do we want when visualizing our data in 3D?

- Effectively display a discovery, principle, data characteristics, or parameter space
- Show a data perspective not otherwise seen
- Collapse a high N phase space into a 3D animation
- Visuals for EPO

Types of Data in Astronomy



Data Volumes in Astronomy



3D Graphics Software



MAYA



3DS MAX



HOUDINI

3D Graphics, Python, and Astronomy

I use a non-traditional package called Blender to render different forms of astronomical data - catalogs, data cubes, simulations, etc.



What is Blender?



Blender is:

- 3D graphics software for modeling, animation, and visualization
- Open-source
- a real-time 3D viewer and GUI
- A Python scriptable interface for loading and manipulating data

<http://www.blender.org>

Publications

Kent 2013

<http://adsabs.harvard.edu/abs/2013PASP..125..731K>

Kent 2015

<http://iopscience.iop.org/book/978-1-6270-5612-0>

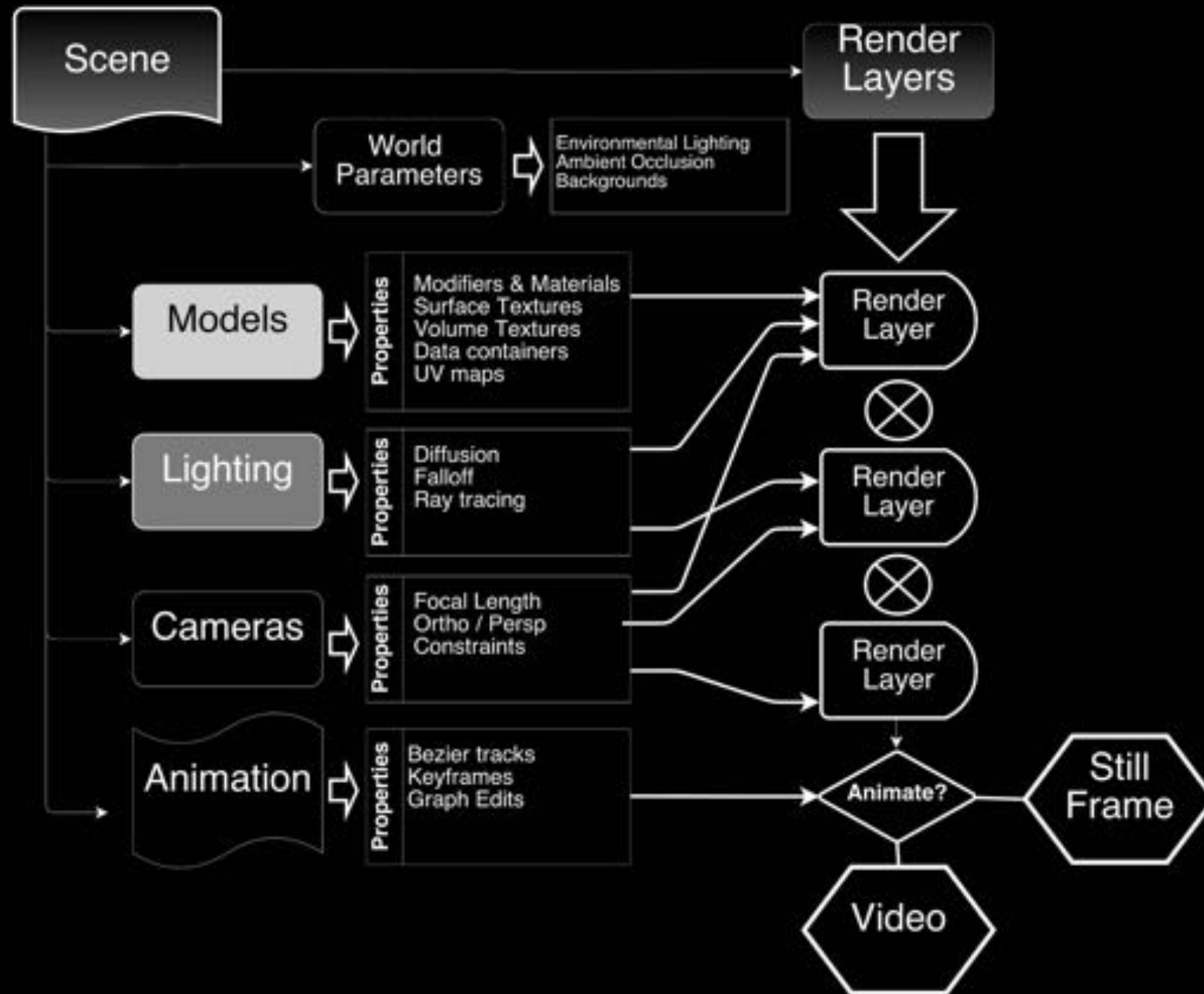
Kent 2017

<http://adsabs.harvard.edu/abs/2017PASP..129e8004K>

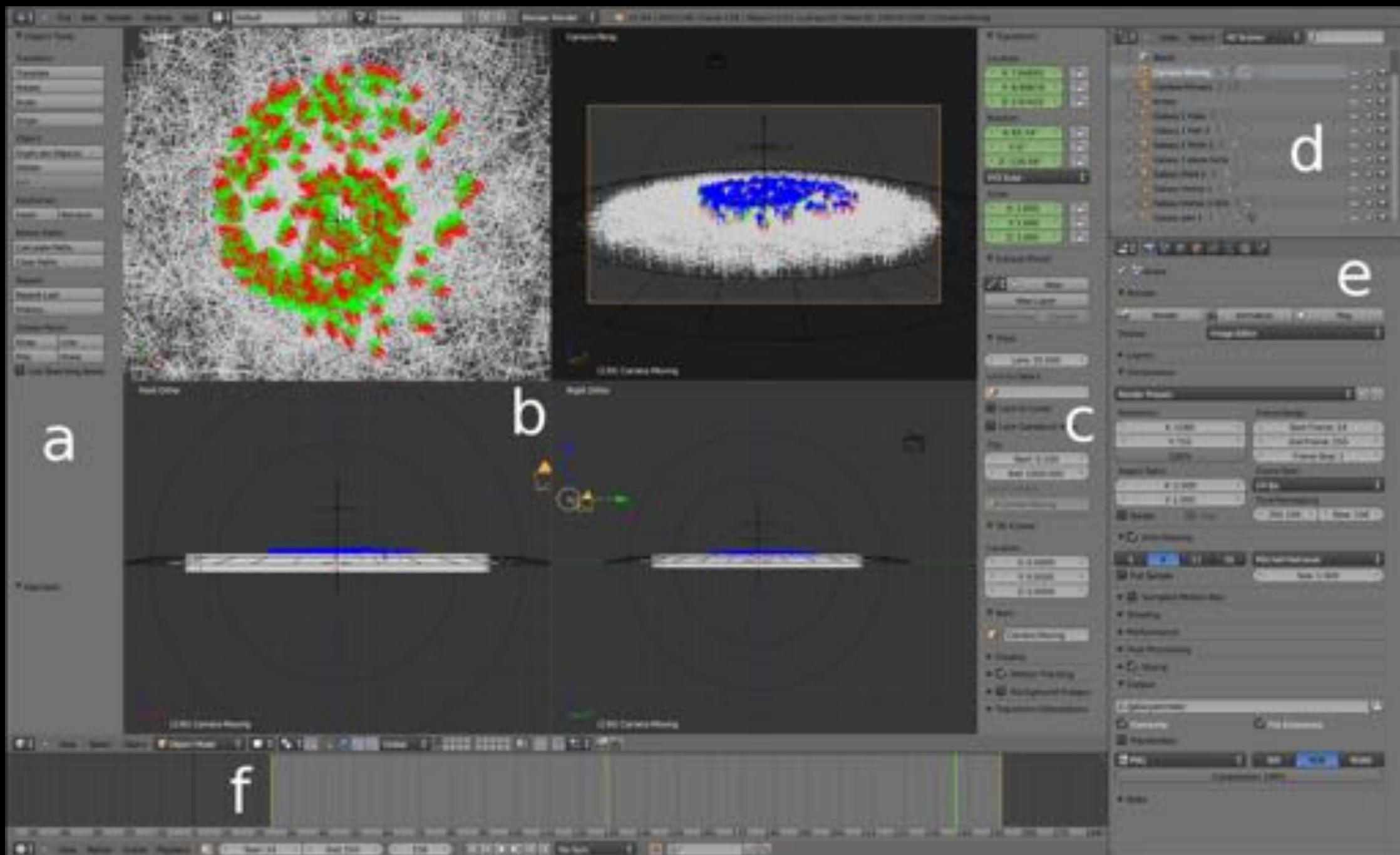
Elements of 3D Graphics

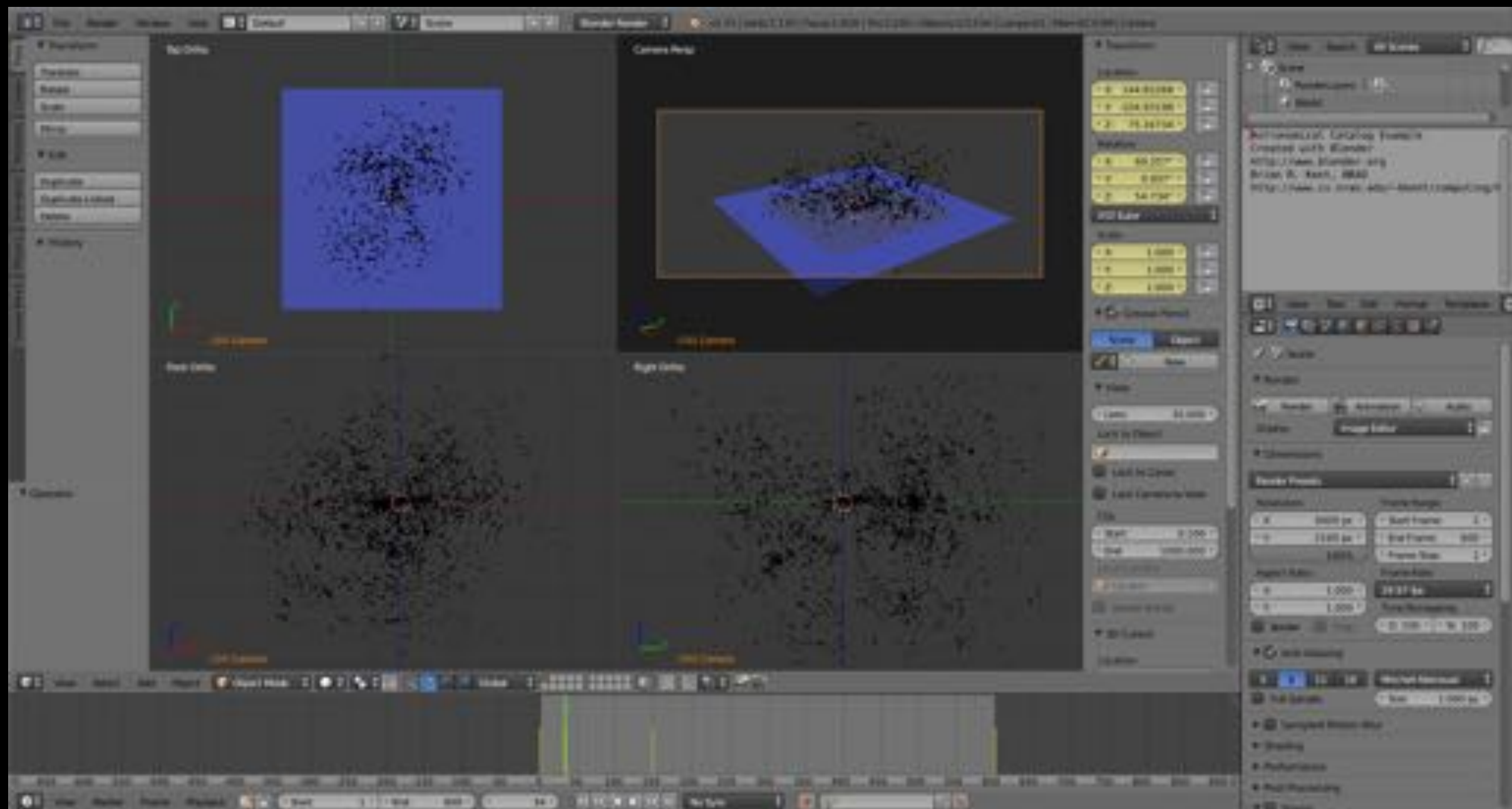
We need to consider:

- Models - physical or data containers?
- Textures - 2D, 3D, and projections?
- Lighting - illumination of data - physical or artistic
- Animation - How will the model move and change?
- Camera control - lens selection, angle, image size, and movement and tracking
- Rendering - backend engine choice
- Compositing - layering final output

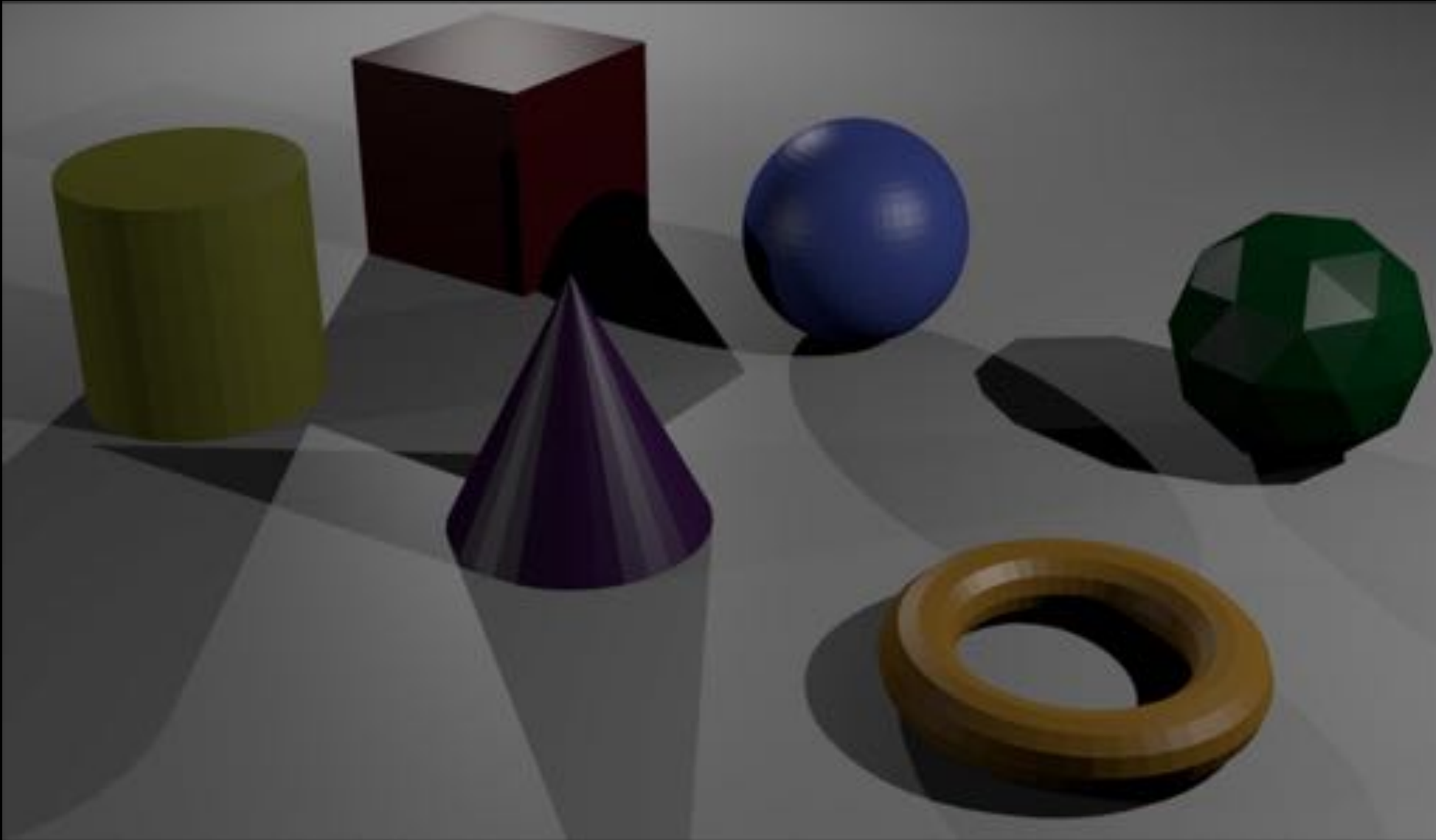


Lights, Camera, Action: The Blender Interface

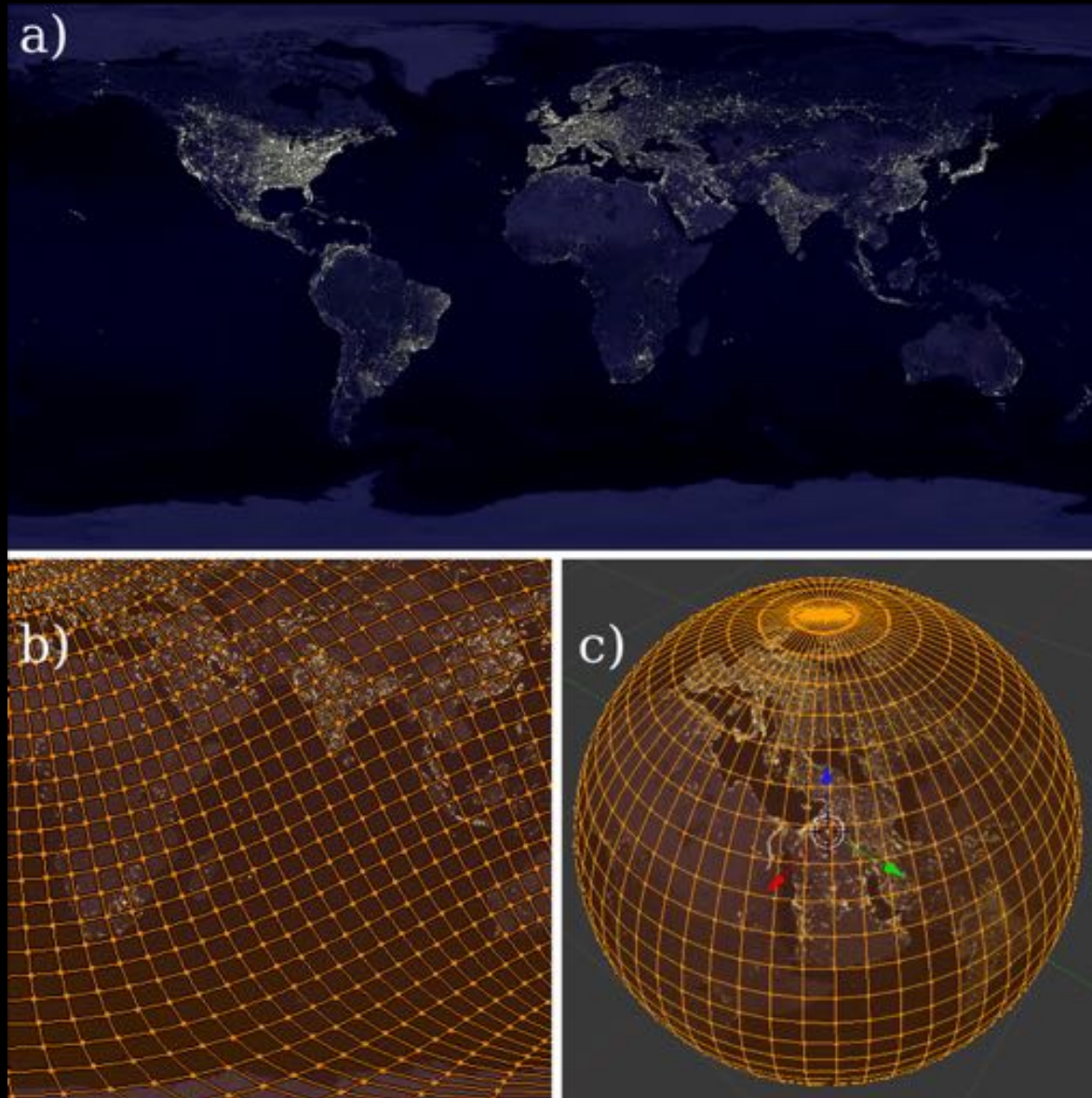


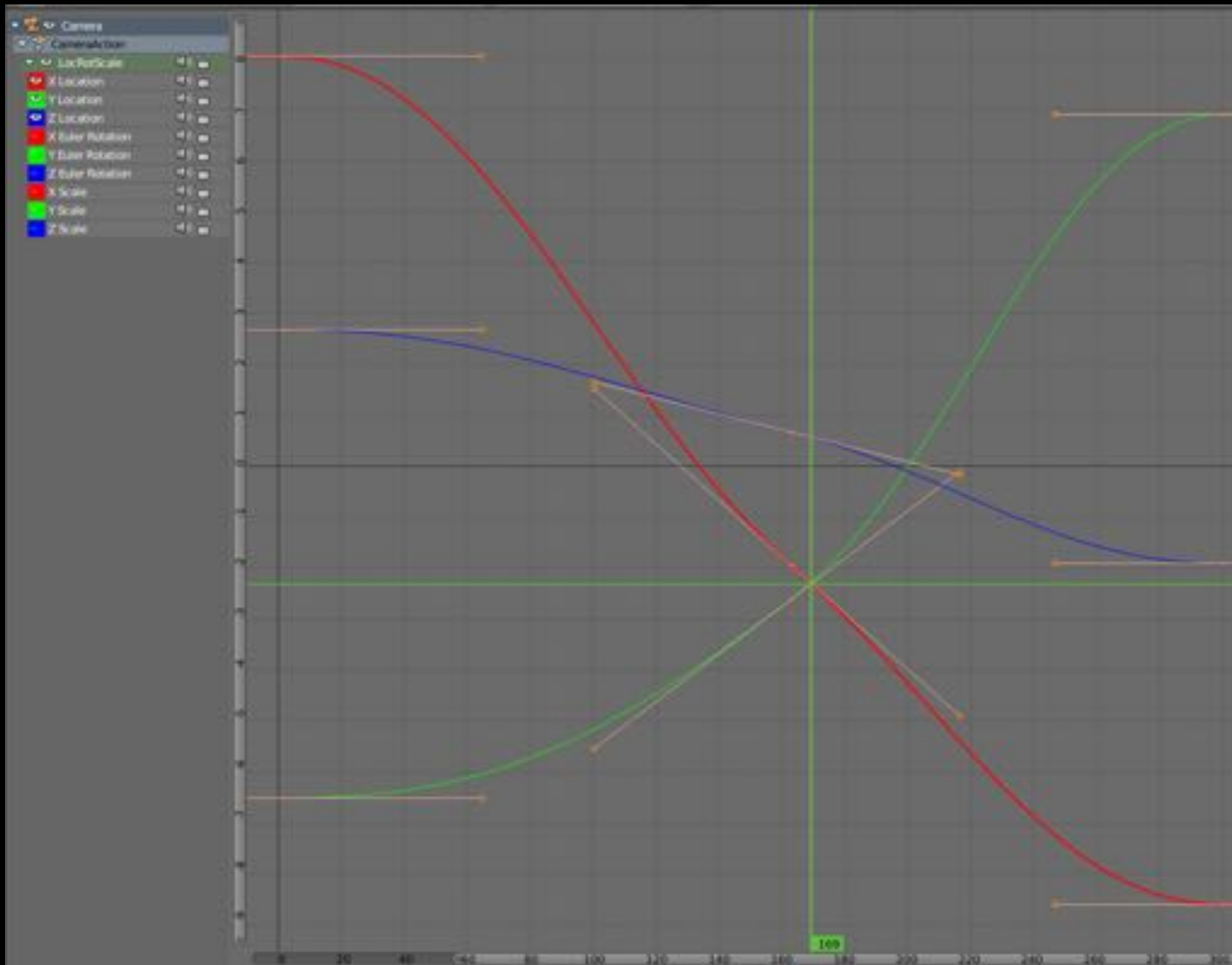


Modeling - basic shapes and containers

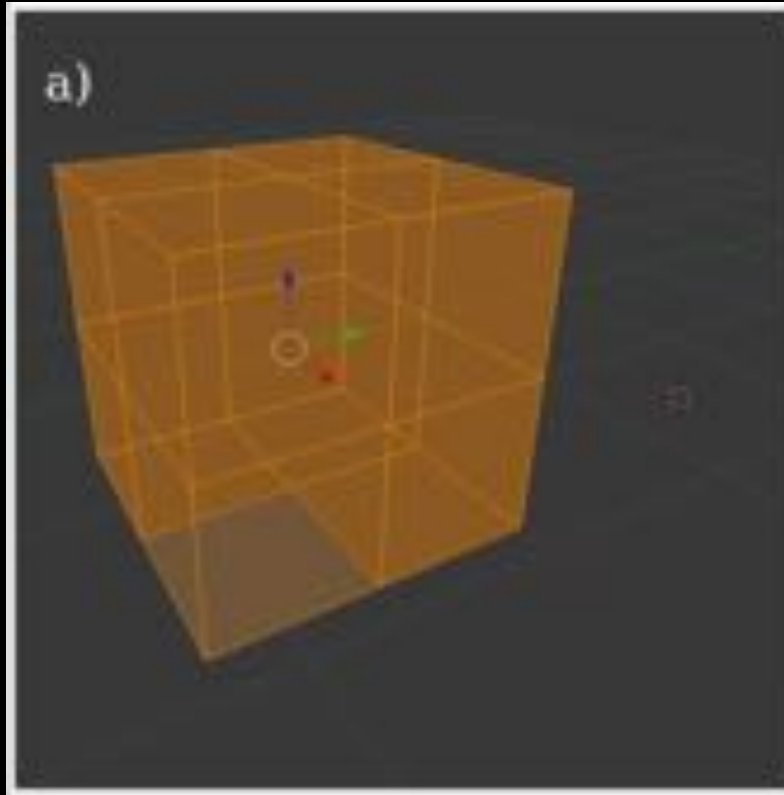


Texturing and Mapping

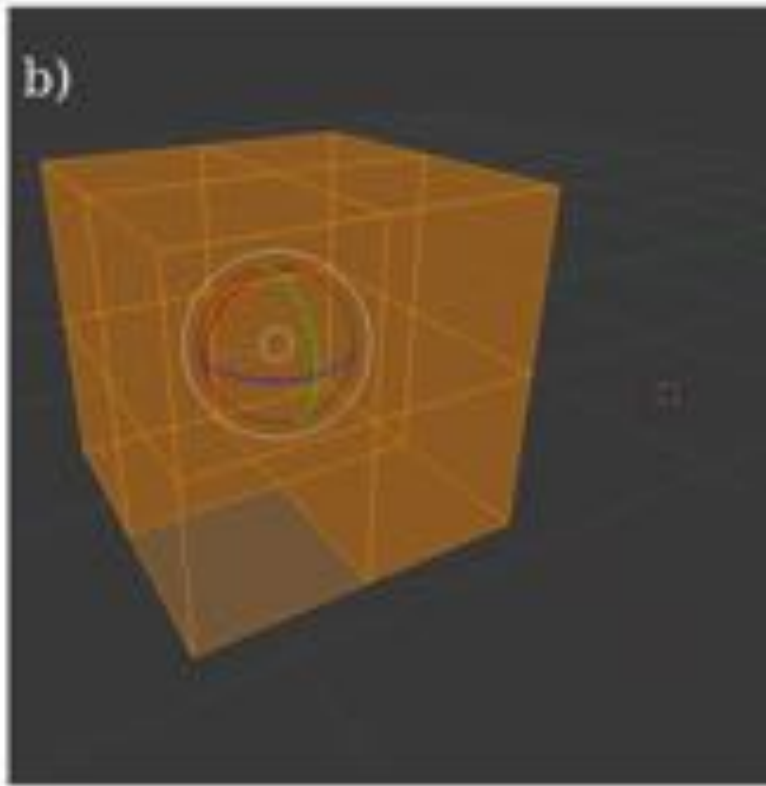




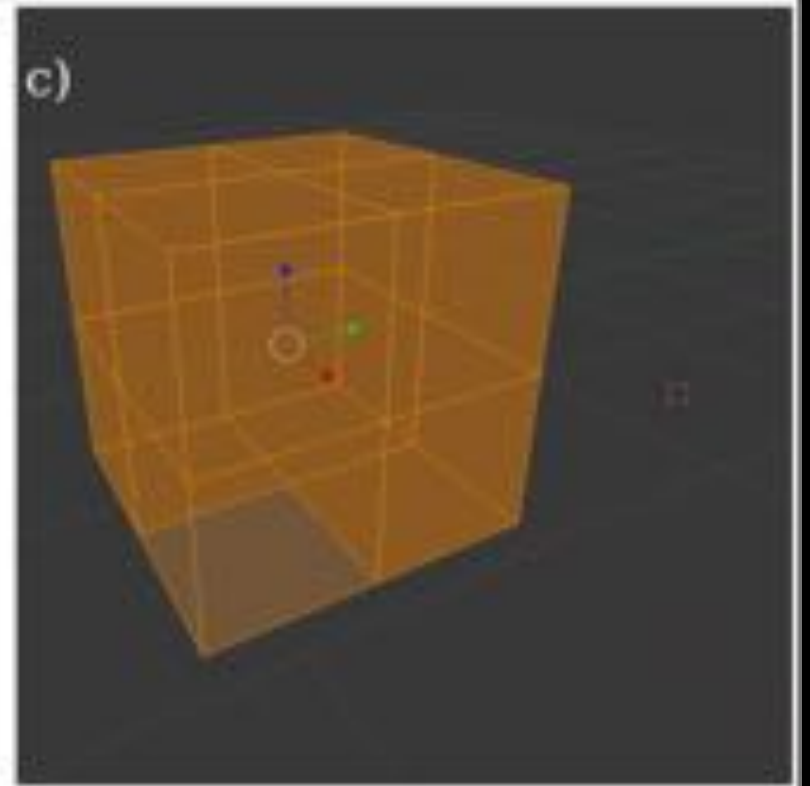
Blender controls



Translation

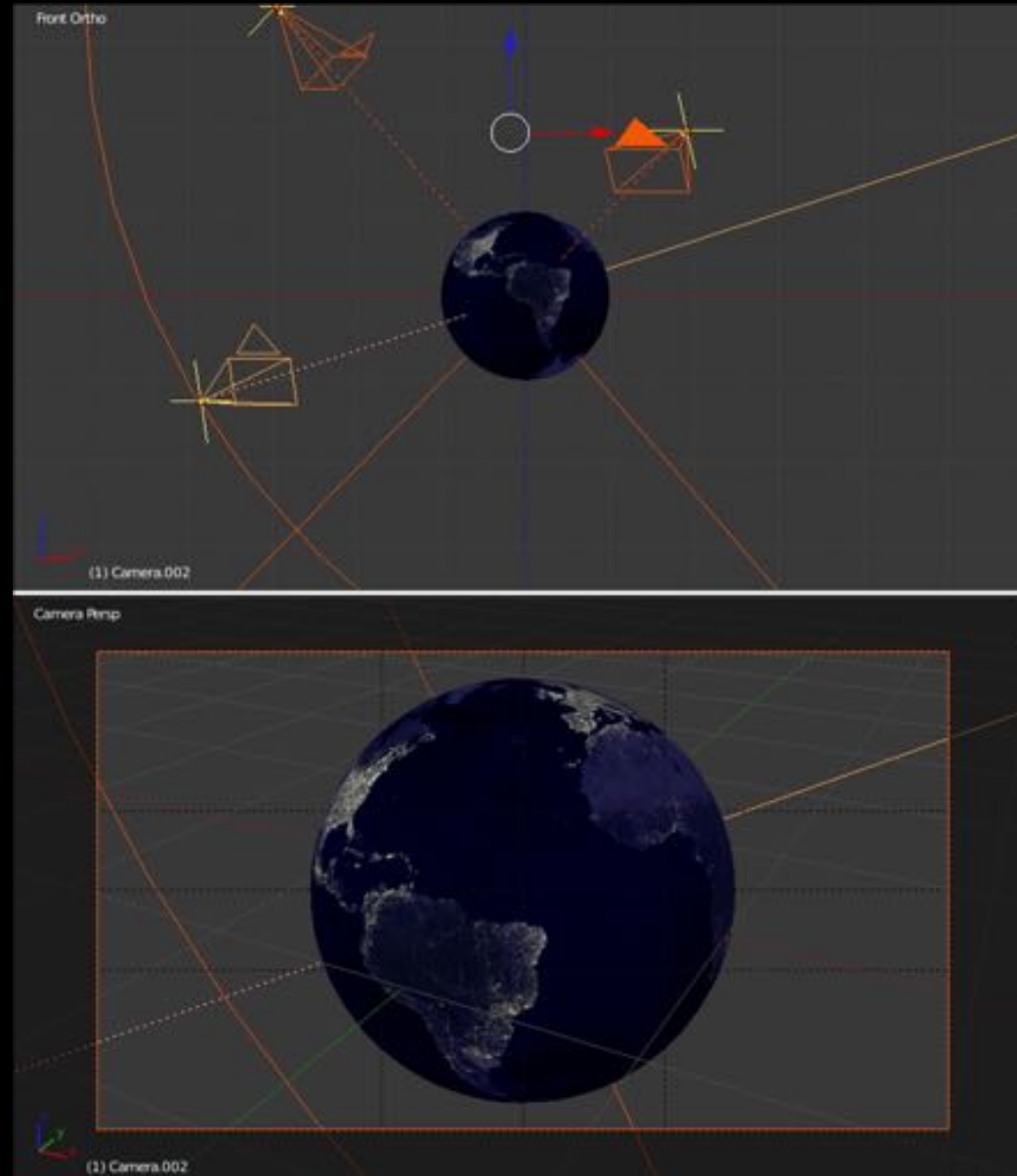


Rotation



Scaling

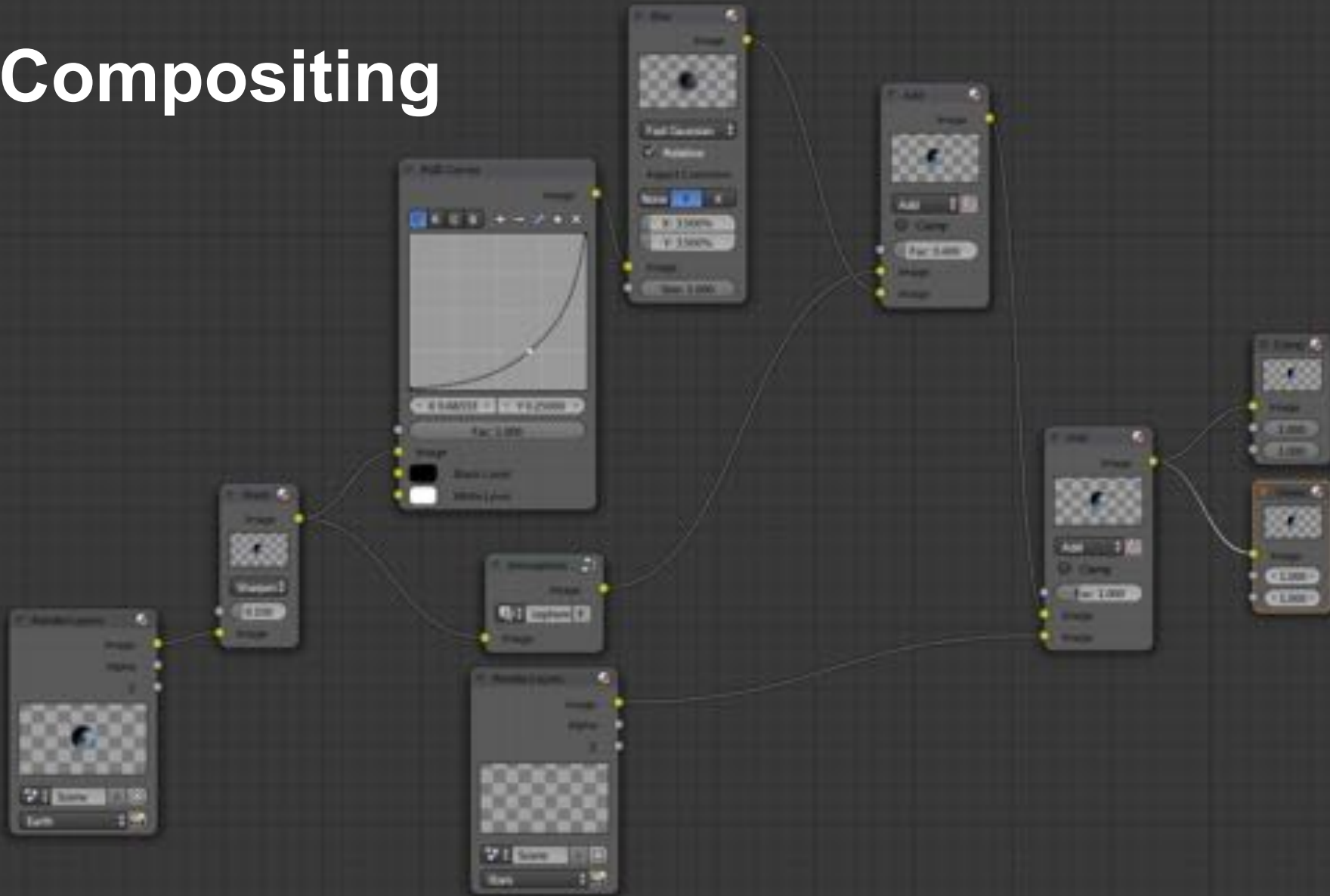
Camera Control and Movement

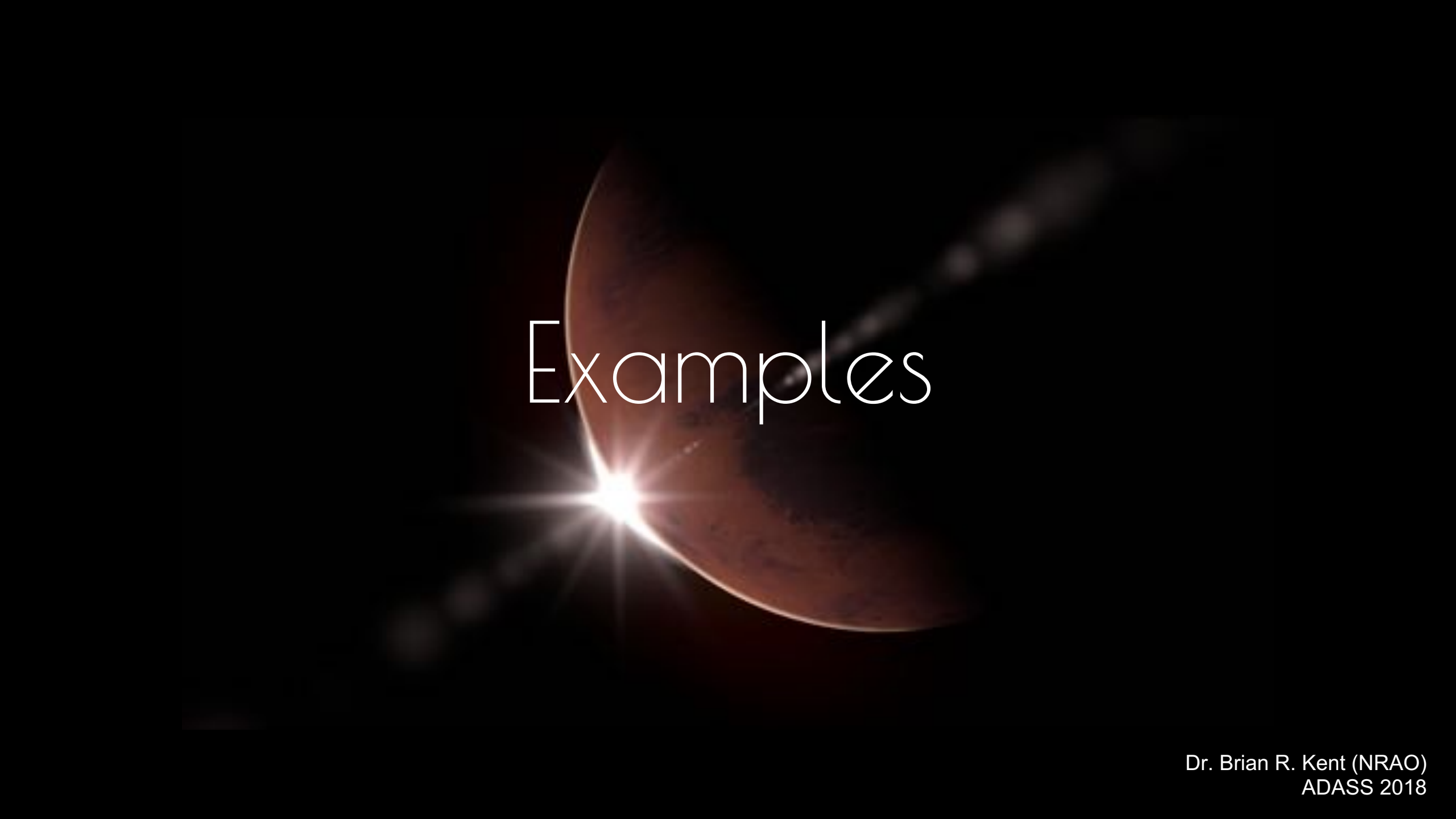


Rendering Engine

- Blender (included)
- Cycles (included)
- Yafaray (open source ray tracing engine
<http://www.yafaray.org/>)
- Luxrender (http://www.luxrender.net/en_GB/index)
- Octane (<http://render.otoy.com/>)
- Renderman (<http://renderman.pixar.com/view/renderman>)

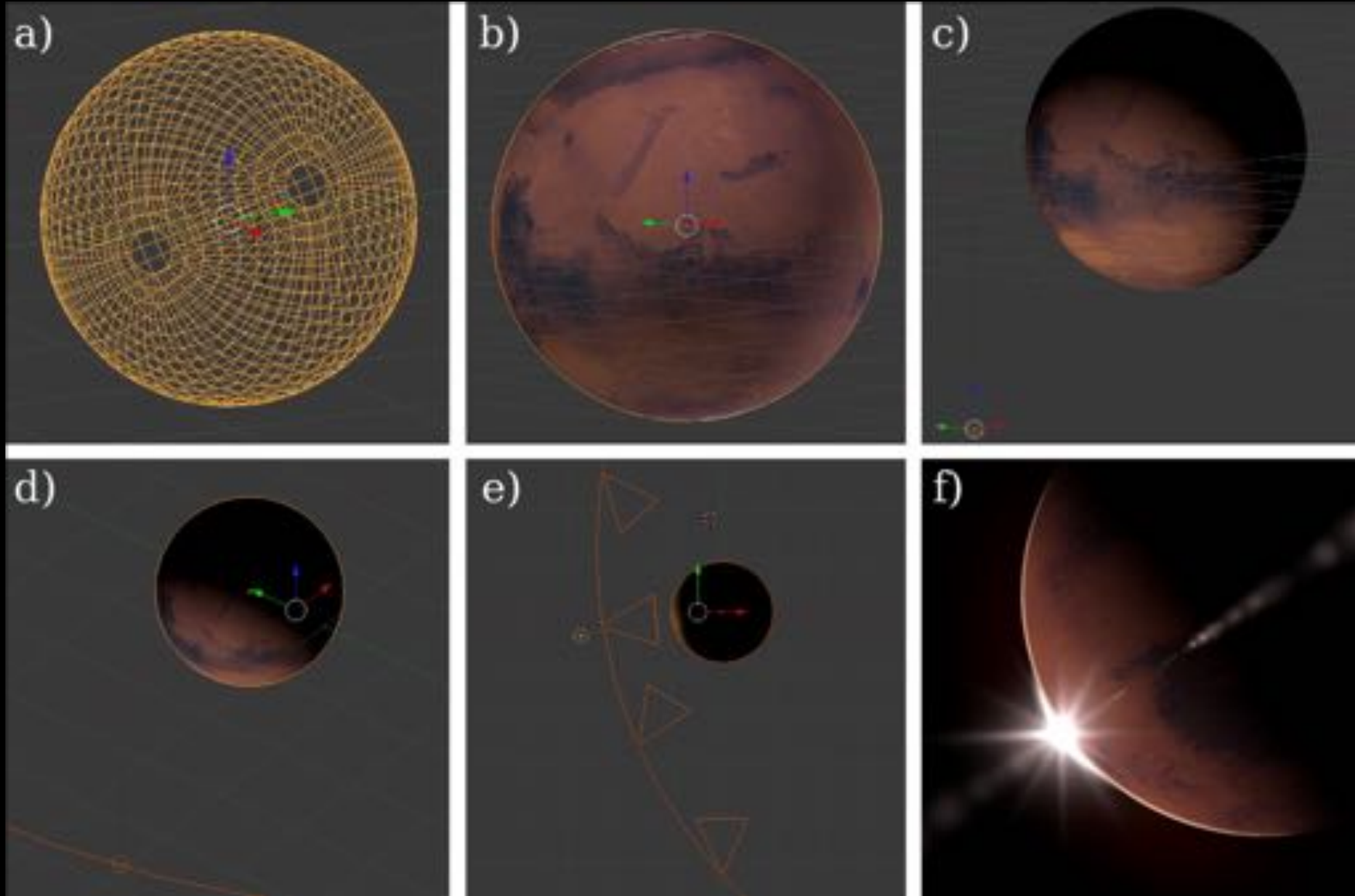
Compositing



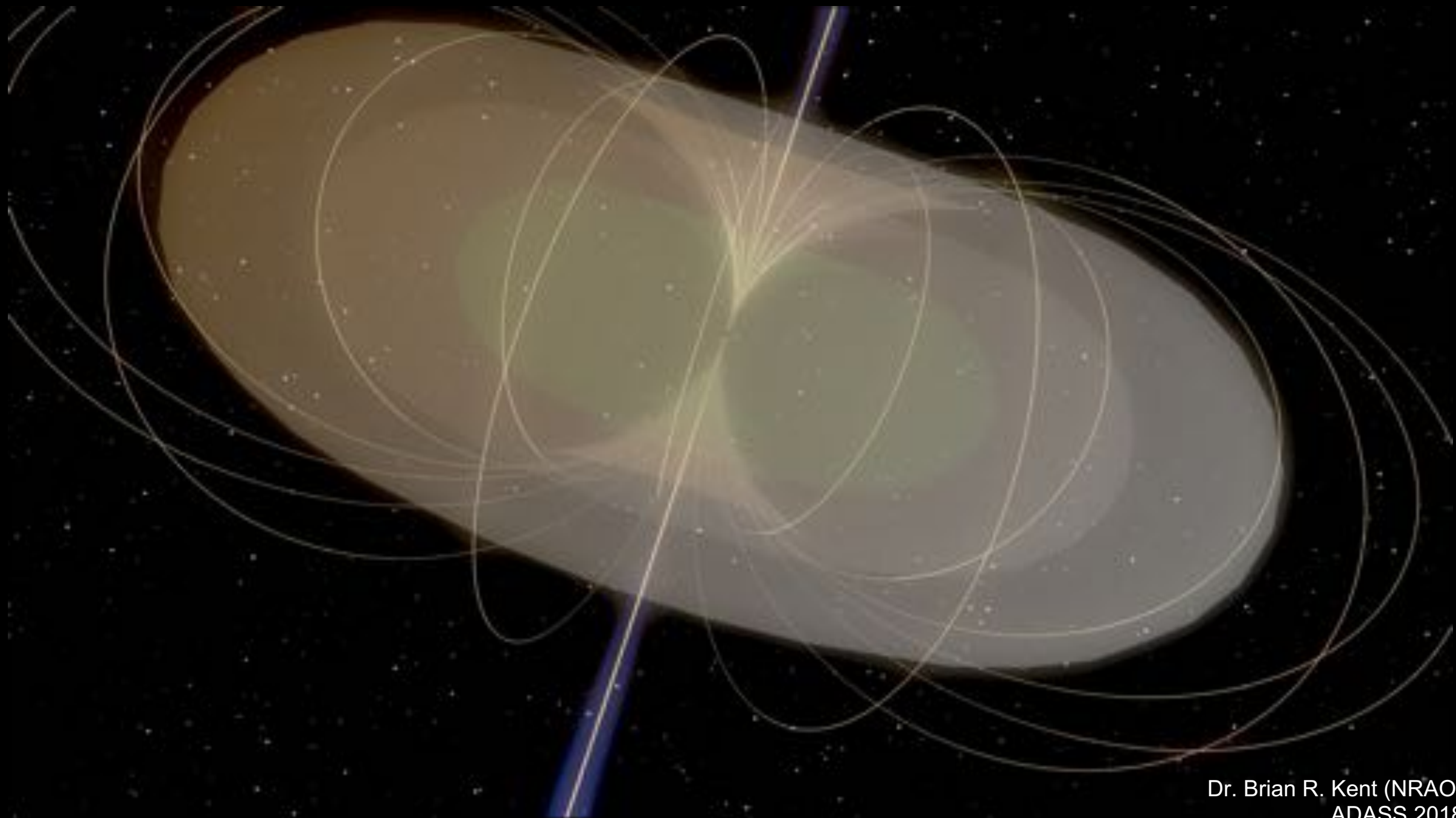


Examples

Rendering and Compositing







Data Cubes

- Gridded data can come from telescopes or simulations
- Radio telescopes produce grids that cover...
 - Two sky coordinates (RA and Decl.)
 - Frequency (Z - the doppler shifted velocity)
- These cubes can show the dynamics of galaxies, planetary disks, and large scale structure formation of clusters
- HCN Comet Lemmon – Cordiner et al...

<https://www.youtube.com/watch?v=RDUVZ9MIW2I>

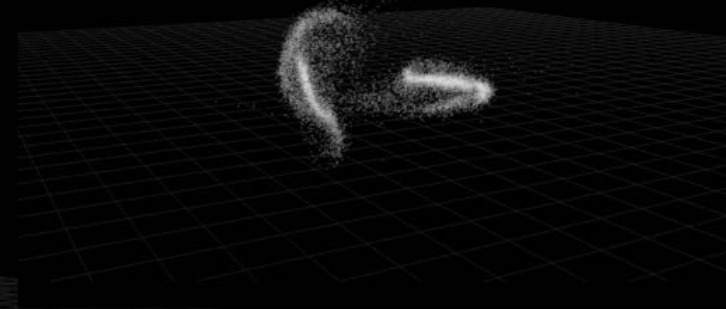
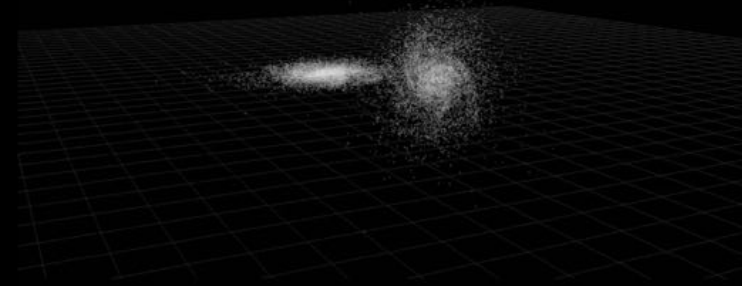
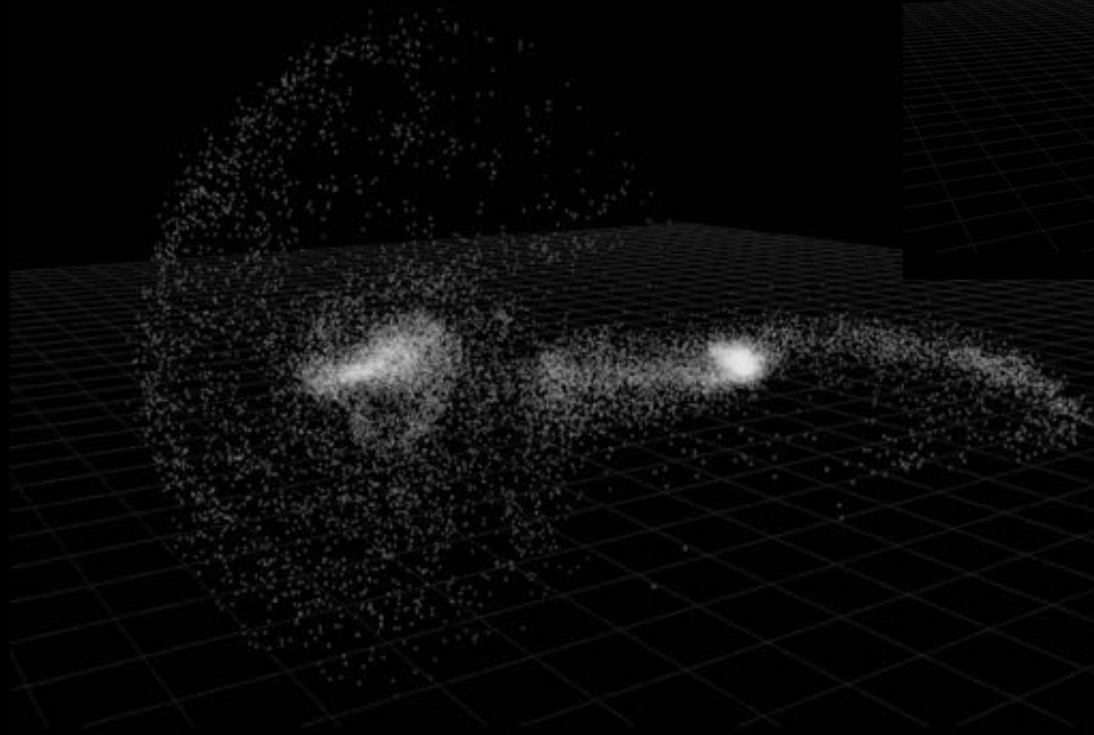
Data Cubes

- Density maps of the nearby Universe can be created on regularly spaced grids.
- The results of these surveys allow to study not only the density of galaxies in 3D, but also the effects of gravity in the same regions of space...
- PSCz redshift catalog... (Saunders et al. 2000)

https://www.youtube.com/watch?v=3cuNT8_YEF0&t=2s

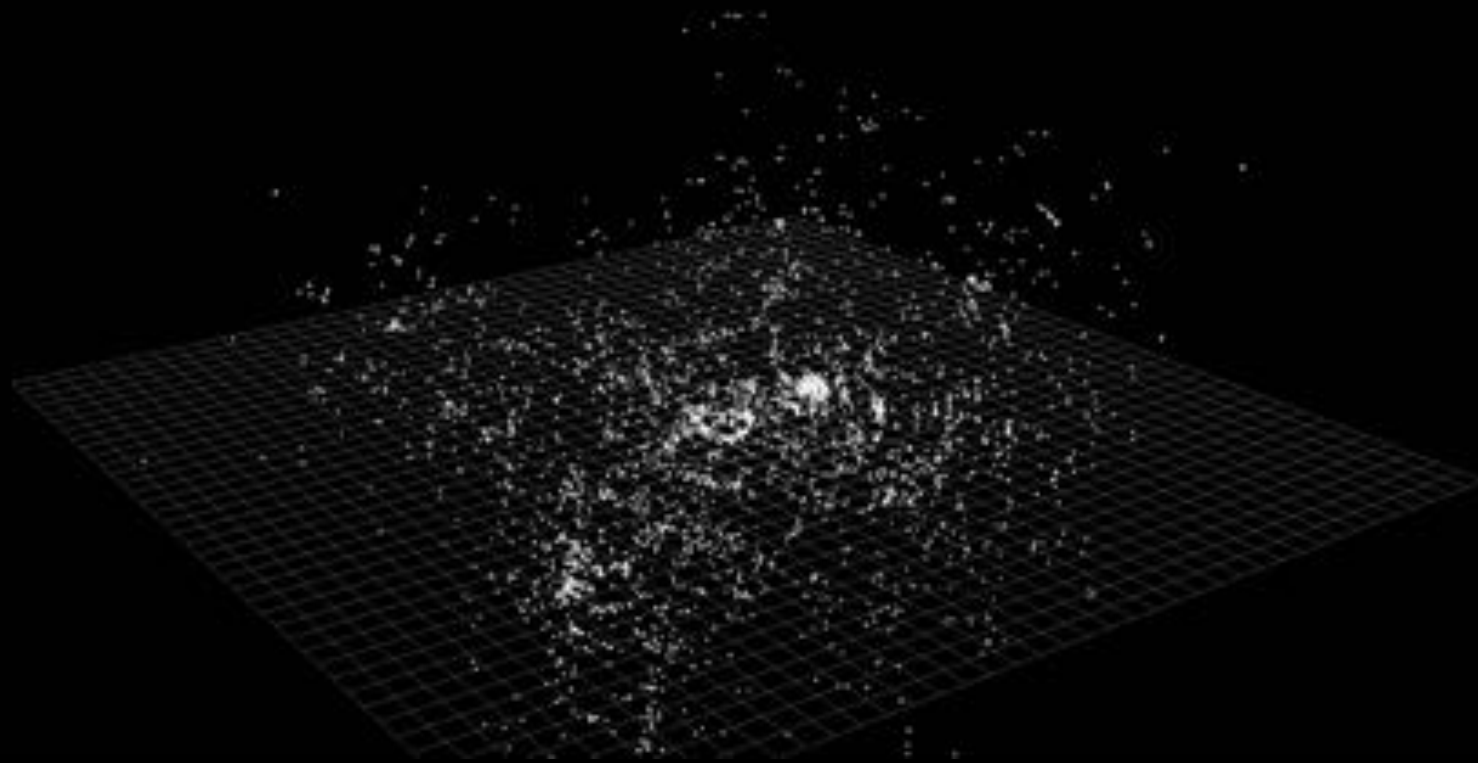
N-body Simulations

- Data generated from GADGET-2 (Galaxies and Dark Matter Interacting 2) N-body/SPH code
 - <http://www.mpa-garching.mpg.de/gadget/>
- 30,000 particles, 1100 snapshots run for 2 billion years
- Blender Python interface used to bring XYZ position data into the vertices of Blender objects
- Objects are “textured” with Halos.
- Each grid square is approximately 33,000 light years

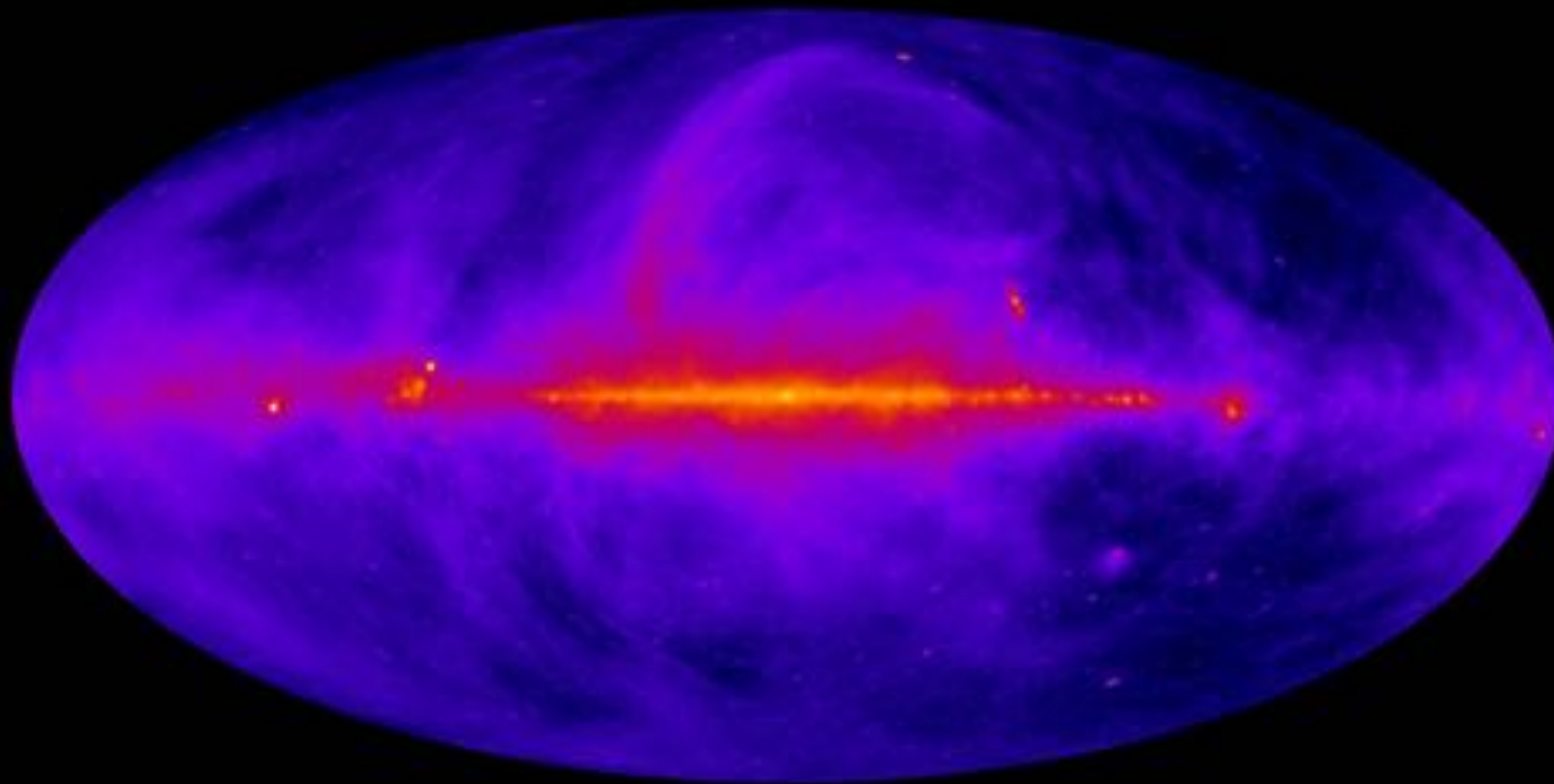


<https://www.youtube.com/watch?v=CPuVfiWLIHI>

Galaxy Catalogs



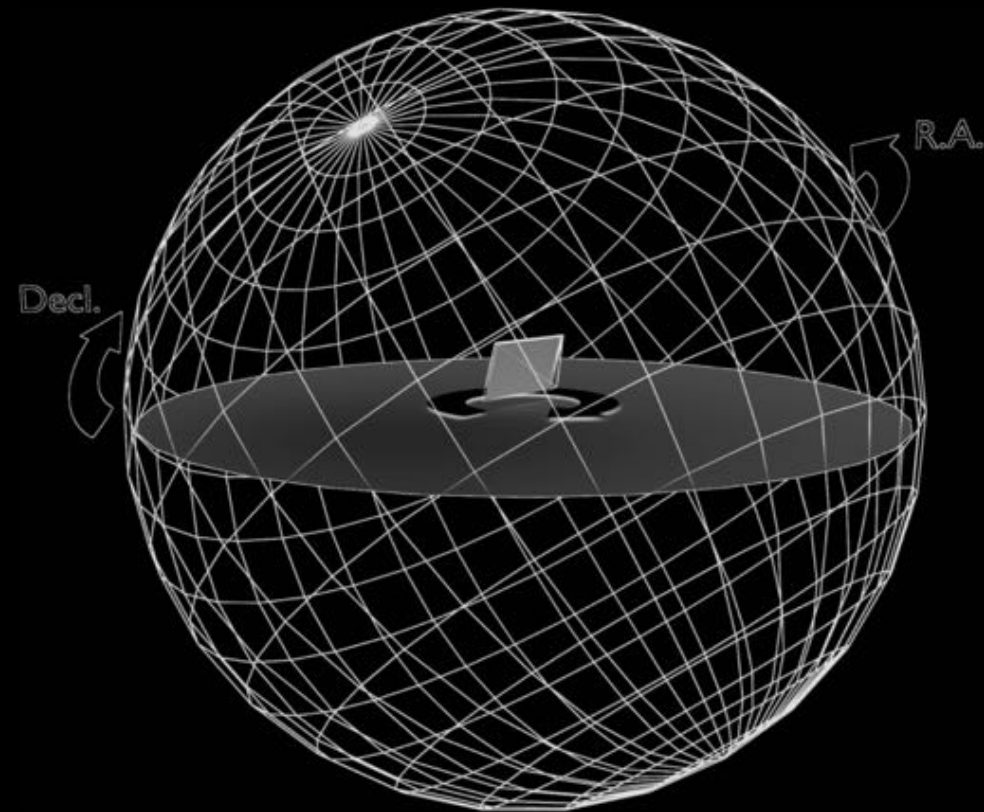
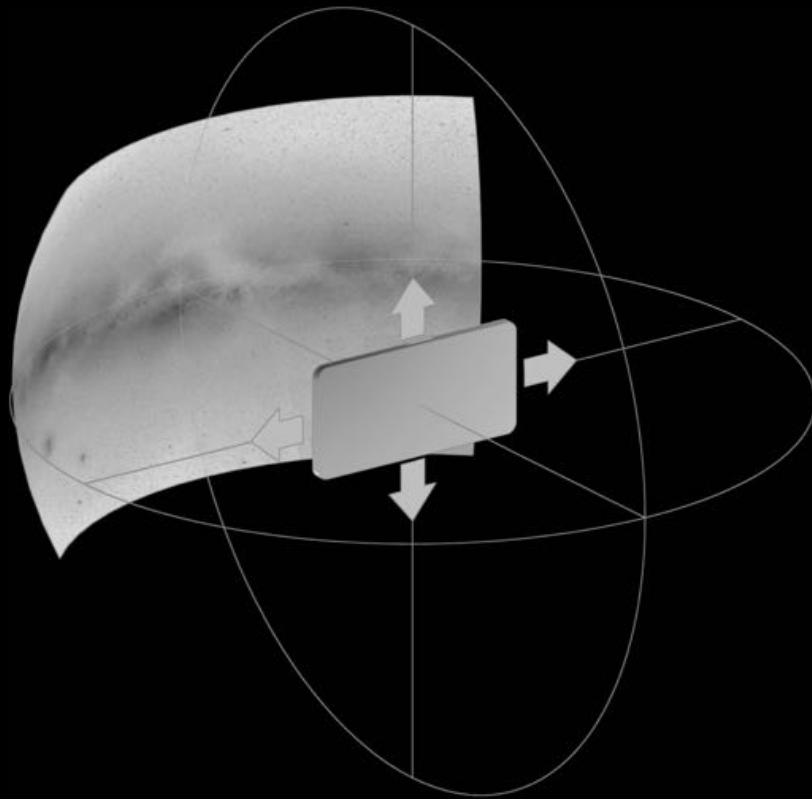
<https://www.youtube.com/watch?v=C3u2Gkdgxfw>



408 MHz NASA SkyView or Montage (Berriman et al.)
Google Spatial Media Module

360 Panoramas (Kent 2017)

<http://iopscience.iop.org/article/10.1088/1538-3873/aa5543>

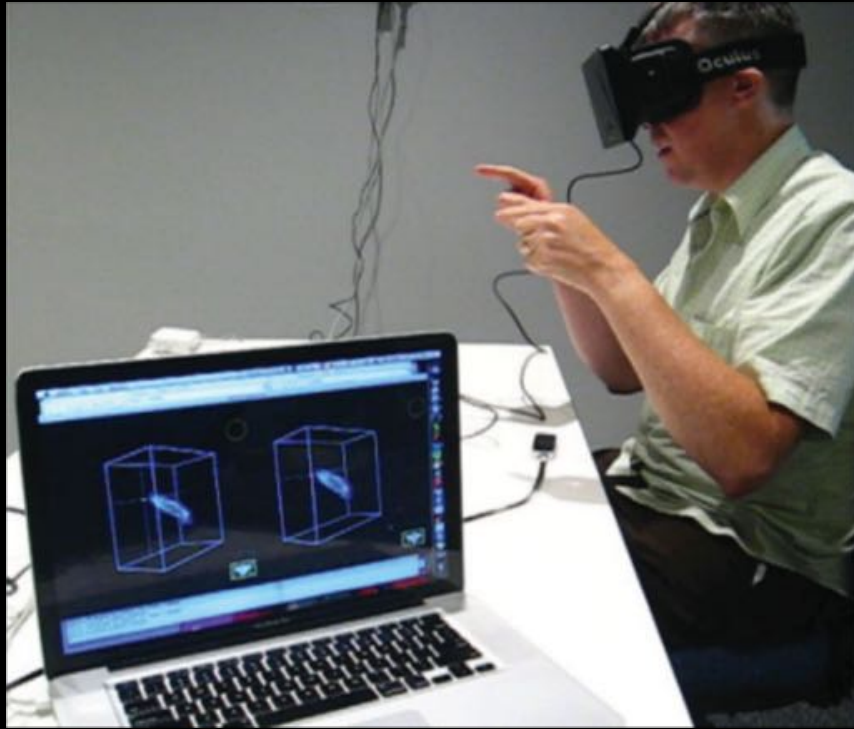




Tully et al. Extragalactic Distance Database

Dr. Brian R. Kent (NRAO)
ADASS 2018

<https://www.youtube.com/watch?v=vW93wkDqz54>

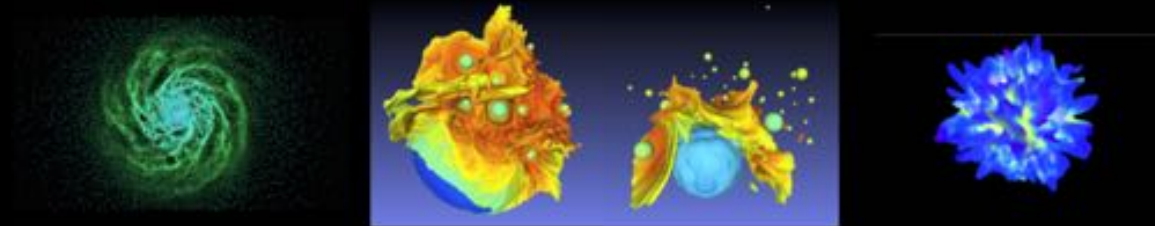


Fluke et al. 2018

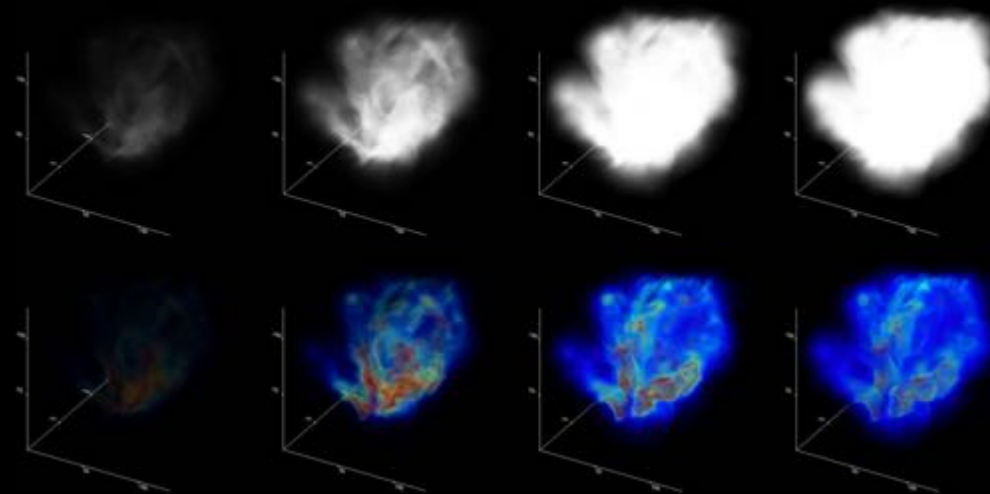


Vohl et al. 2017

AstroBlend



Jill Naiman et al.



Rhys Taylor et al.

Publications of the Astronomical Society of the Pacific, 129:058010 (11pp), 2017 May

Gárate

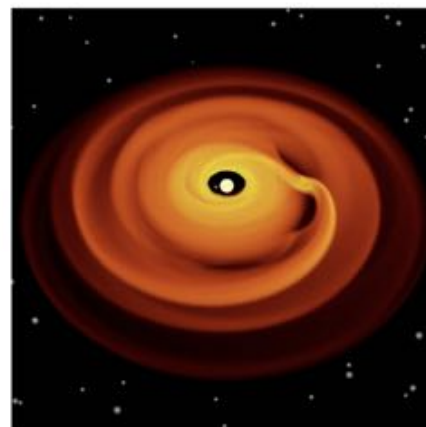


Figure 4. Protoplanetary disk with a massive planet carving a gap (S. Perez et al. 2017, in preparation). Simulation data provided by S. Perez using FARGO3D. The output was converted from an spherical grid as described in the Section 3.1. The image was post-processed to brighten the colors, and the halo points were added to emulate surrounding stars.
(A color version of this figure is available in the online journal.)

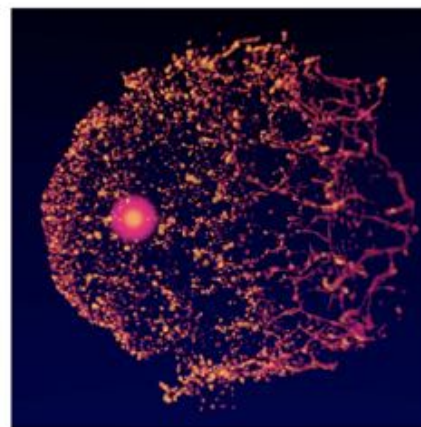


Figure 5. Stellar winds from a Wolf-Rayet star moving through the galactic center (Cuadra et al. 2008). Simulation data provided by J. Cuadra. The output was converted from an SPH simulation as described in Section 3.2. The image was post-processed to brighten the colors, and also the Blend Sky option of the World properties was used to add the background colors.
(A color version of this figure is available in the online journal.)

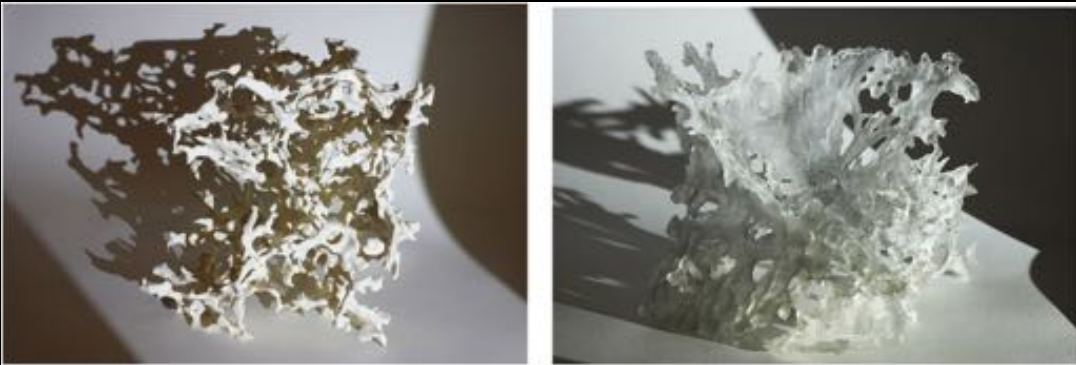
Matias Garate et al.

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ADASS 2018

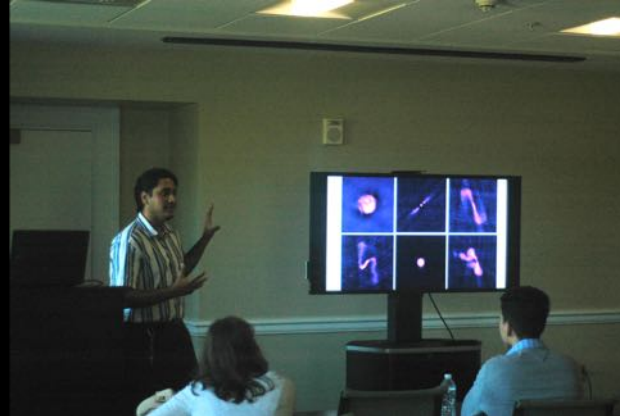
Education and public outreach



Thomas Madura



Benedikt Diemer and Isaac Facio



NRAO NINE Program

PASP Special Issue

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PUBLICATIONS	
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Special Issue: Techniques and Methods for Astrophysical Data Visualization	
Edited by Brian R. Kent	
	
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058005	LESSGalPy: Interactive Visualization of the Large-scale Environment Around Galaxies M. Argudo-Fernández, S. Duarte Puertas, J. E. Ruiz, J. Subirós, E. Verley, and G. Bergond
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ADASS 2018

Interesting in learning more?



Book and tutorials available at:

<http://www.cv.nrao.edu/~bkent/blender/>

<https://www.youtube.com/VisualizeAstronomy>

Twitter: @VizAstro

