3D Data Visualization in Astrophysics

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

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Data Volumes in Astronomy

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3D Graphics Software

- Maya
- 3DS Max
- Blender
- LightWave 11
- Cinema 4D
- Pixar's RenderMan
- 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

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Publications

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

Kent 2015

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

a)

b)

c)
Blender controls

Translation

Rotation

Scaling
Camera Control and Movement
Rendering Engine

- Blender (included)
- Cycles (included)
- Luxrender ([http://www.luxrender.net/en_GB/index](http://www.luxrender.net/en_GB/index))
Compositing
Examples
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…
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/](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
408 MHz  NASA SkyView or Montage (Berriman et al.)
Google Spatial Media Module
360 Panoramas (Kent 2017)

Education and public outreach

Thomas Madura

Benedikt Diemer and Isaac Facio

NRAO NINE Program

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PASP Special Issue
Contribute to Volume 2!

Interesting in learning more?

Book and tutorials available at:

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

https://www.youtube.com/VisualizeAstronomy

Twitter: @VizAstro