Visualizing Scientific Graphics for Astronomy and Astrophysics

Brian R. Kent[1], National Radio Astronomy Observatory (NRAO)

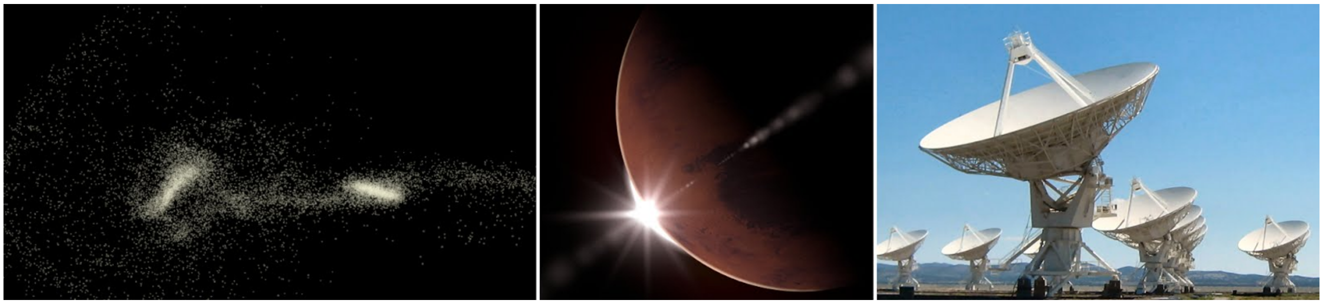

Figure 1: N-body simulations of colliding galaxies, planetary surface maps, and the NRAO Very Large Array

1. Introduction

The combination of astronomy and computational sciences plays an important role in how members of the astronomical community visualize their data. Larger detectors in the optical/IR, increasing bandwidth in radio interferometers, and large N astrophysical simulations drive the need for visualization solutions. These visualization purposes include exploring the dynamical phase space of data cubes, surface mapping, large catalogs, and volumetric rendering. The use of 3D computer graphics in the movie, television, and gaming industry has led the development of useful computer algorithms for optimizing the display of complex data structures while taking advantage of new hardware paradigms like GPU processing. Melding the exciting scientific results with state of the art computer graphics cannot only help with scientific analysis and phase space discovery, but also with graphics for education and public outreach. The visual impact of astronomy cannot be understated - for both the community of scientists and how to present to the public with higher accuracy our results.

We present a practical overview for astronomers to the capabilities of the 3D graphics program Blender. We take the approach of describing the features that will be of interest to various parties in astronomy - for both research visualization and presentation graphics. We aim to describe methods of data import, modeling, texturing, lighting, rendering, and compositing for astronomy.

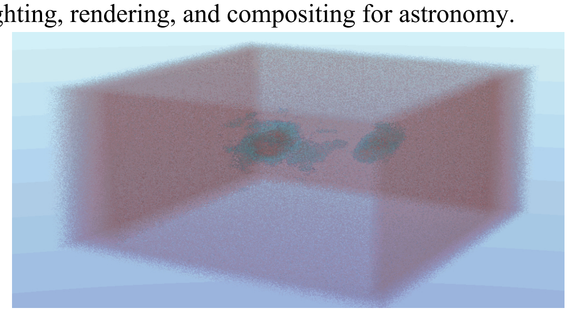

Figure 2. Galaxy dynamics visualized with data obtained from the Very Large Array Radio Telescope.

2. Visualizing the Universe

Data cubes and galaxy dynamics

Data obtained with the NRAO Very Large Array radio telescope (Figure 1) allows astronomers to study the dynamics of galaxies in 3D. The data cube of a galaxy shown in Figure 2 is rendered by mapping the Doppler shifted frequency of neutral hydrogen. This allows astronomers to measure both the amount of gas and the rotation of the galaxy [Walter et al. 2008].

N-body simulations

This example of a galaxy simulation was generated with GADGET-2 [Springel 2005]. Each large spiral disk galaxy has 10000 disk particles and 20000 halo particles with Milky Way scale lengths and masses. The simulation is run for approximately 1100 timesteps for a total simulation runtime of 2 billion years. We read in the particle x, y, z coordinates as single vertex with a small Gaussian halo as its texture. The snapshot file for each timestep is keyframed as one frame in the animation. In addition, a Bézier curve can be added to the scene as an object path [Farouki 2012]. The camera can then be flown along the curve as the galaxy interaction progresses (Figure 1).

Planetary surfaces

We explore the utility of UV mapping - taking astronomical surface map projections onto 3D objects for display and analysis. The examples that will be shown are from the Mars Global Surveyor TES [Christensen et al. 2001]. Each map file is given in a simple cylindrical projection. We use a high resolution UV-sphere mesh with 2048 surface polygons, which gives a good balance between resolution and rendering time (Figure 1).

References

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[1] http://www.cv.nrao.edu/~bkent/ bkent@nrao.edu

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