

## CADENS NSF PROJECT: DIGITAL LITERACY, DATA VISUALIZATION, AND THE CINEMATIC PRESENTATION OF SCIENCE

**Allocation:** Illinois/300 Knh

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### EXECUTIVE SUMMARY

The Advanced Visualization Lab (AVL) continues work on the NSF-funded CADENS project (The Centrality of Advanced Digitally ENabled Science, ACI-1445176). The AVL co-produced and rendered visualization scenes for the recently released science documentary, “Seeing the Beginning of Time.” We have used Blue Waters for processing data as well as rendering scenes in 4K monoscopic, stereoscopic, and dome formats. A few technological byproducts of this work include a new pipeline for rendering on Blue Waters called Blurend and an open-source cinematic scientific visualization tool called Ytini.

### RESEARCH CHALLENGE

The AVL produces cinematic scientific visualizations for public outreach. Cinematic visualization is an especially accessible form of science communication because it leverages a powerful and familiar visual language established by Hollywood films. Creating production-quality renderings of supercomputer datasets that are both cinematic and scientifically accurate is challenging. There are many existing tools for cinematic animation (Houdini, Maya, 3DS Max, Blender, etc.) and many tools for scientific visualization (yt, ParaView, Partiview, VisIt), but few tools exist at the intersection of cinema and science.

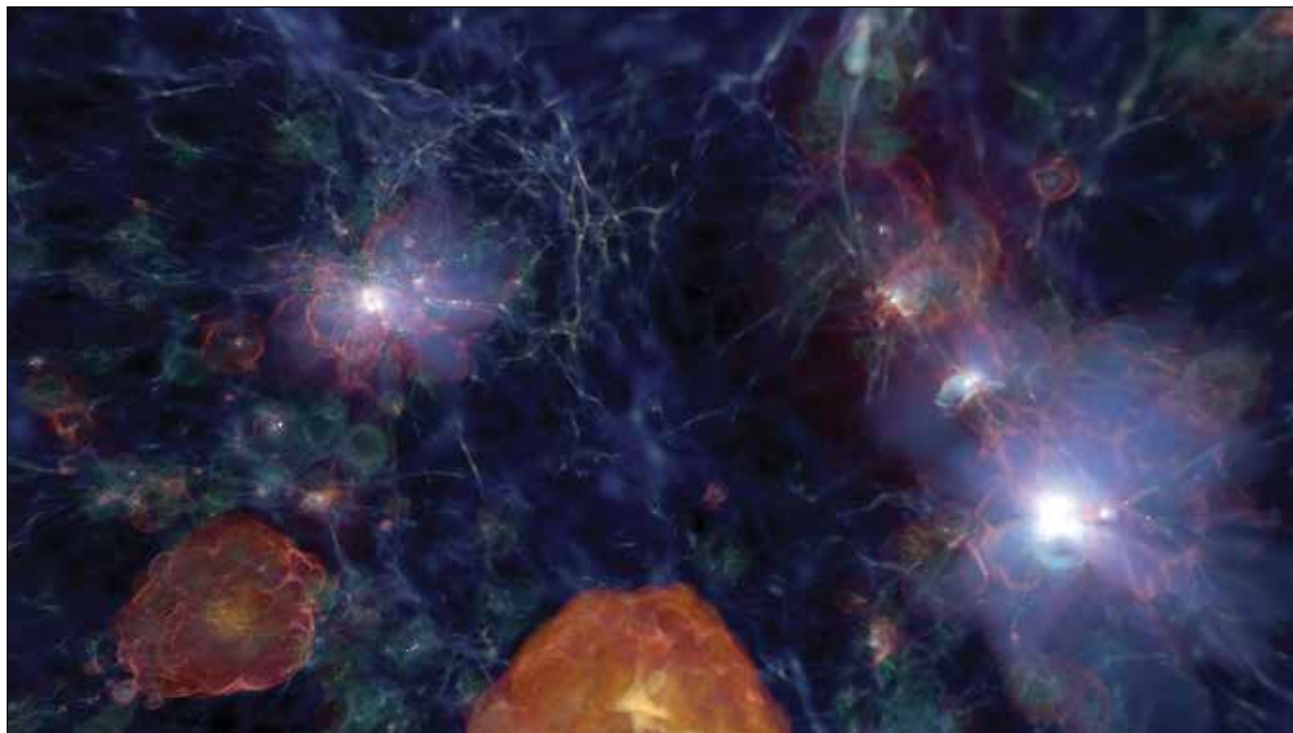


Figure 1: A visualization of the Renaissance simulations [1] done by the Advanced Visualization Lab. The universe 400 million years after the Big Bang.

### METHODS & CODES

To create visualizations for the science documentary “Seeing the Beginning of Time,” the AVL primarily used the commercial visual effects tool Houdini and the scientific analysis and visualization Python package yt. We have created middleware and a pipeline that uses both of these tools, called Ytini. We have run Ytini on Blue Waters to convert raw data into Houdini-compatible OpenVDB sparse volume data files. Further, we have created a Python tool called Blurend for preparing Houdini scene files for rendering on Blue Waters.

### RESULTS & IMPACT

We have rendered the following sequences on Blue Waters:

- “First Light in the Renaissance Simulations” [1] in 4K stereoscopic format
- “First Light in the Renaissance Simulations” [1] in 4K dome format
- “El Reno 2011 Tornado” [4] in 4K dome format
- “Large Synoptic Survey Telescope Model” [6] in 4K monoscopic format

We processed data on Blue Waters for the following sequences:

- “Cosmic Bubble Bath” [2] for the 4K documentary “Seeing the Beginning of Time”
- “Formation of the Moon” [5], for our work-in-progress dome show

“Seeing the Beginning of Time” is currently available for streaming on Amazon Prime, where it is rated 4.3/5 stars.

AVL’s new tool, Ytini, has significantly optimized our pipeline by allowing us to read many scientific data formats using the Python package yt. This has cut out weeks of development time from our visualization process. Ytini is an open-source project, making it easier for both artists and scientists to make their own cinematic scientific visualizations. Files and tutorials are distributed through [www.ytini.com](http://www.ytini.com).

### WHY BLUE WATERS

We are currently using Blue Waters to prepare data for import into the commercial visual effects tool, Houdini, where we can create cinematic treatments of the data. Converting a particular dataset from particles to a Houdini-compatible Adaptive Mesh Refinement-like volumetric format took about four days on our local cluster. It would have been incredibly difficult to iterate at this time scale. Running the same script across nodes on Blue Waters took four hours.

Additionally, we have created a new pipeline for preparing Houdini scene files for rendering on Blue Waters, resulting in a new software tool called Blurend. We used this tool to render several sequences for “Seeing the Beginning of Time” as well as a tornado simulation [4] in dome format.

Several of our scientific collaborators used Blue Waters to run their simulations and create large datasets residing there. It was



Figure 2: A dome rendering of a tornado simulation [4], done by the Advanced Visualization Lab.

is more productive and save valuable time to be able to work with their data in situ on the Blue Waters filesystems rather than transfer large amounts of data to specialized visualization systems.

### PUBLICATIONS AND DATA SETS

Naiman, J., K. Borkiewicz, and A. Christensen, Houdini for Astrophysical Visualization. *Publications of the Astronomical Society of the Pacific*, 129:975 (2017), DOI:10.1088/1538-3873/aa51b3.

Borkiewicz, K., A. Christensen, and J. Stone, Communicating Science Through Visualization in an Age of Alternative Facts. *SIGGRAPH Conference on Computer Graphics and Interactive Techniques*, Los Angeles, Calif., July 30–August 3, 2017.

Cox, D., et al., First Light in the Renaissance Simulation Visualization: Formation of the Very First Galaxies in the Universe. *Supercomputing, Scientific Visualization Showcase Submission*, Denver, Colo., November 12–17, 2017.

Cox, D., et al., Milky Way Analogue Isolated Disk Galaxy Visualization. *Supercomputing, Scientific Visualization Showcase Submission*, Denver, Colo., November 12–17, 2017.

“Seeing the Beginning of Time,” science documentary directed by Thomas Lucas (50 minutes). Long-form web distribution via Amazon Prime.