VISUALIZATION FOR PUBLIC OUTREACH

FIGURE 1:
Cosmological simulation from John Wise, soon after the first generation of stars appeared. Filaments of dense cool gas are blue-white; gas heated and ionized by ultraviolet light from new stars is orange-to-white; clouds of heavier elements synthesized in early stars and released when they explode as supernovae are paler yellow; clusters of young stars are white dots.

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EXECUTIVE SUMMARY

CADENS (The Centrality of Advanced Digitally ENabled Science) is a National Science Foundation-supported project to increase digital literacy and inform the public about computational and data-enabled scientific discovery. CADENS invites scientists in diverse fields to submit their data to the artists and technologists of the Advanced Visualization Laboratory, who then create data-driven visualizations of scientific phenomena for dome productions and documentaries that are seen by hundreds of thousands of people. In 2015-16 the CADENS team used Blue Waters in processing data and creating animations for two major productions. "Solar Superstorms" is a full-dome planetarium documentary featuring simulations on multiple scales of solar magnetism and its influence on Earth and of early-universe star formation. The flat-screen production "Super Tornado: Anatomy of a Mega-Disaster" looked at two storms that created multiple strong tornadoes.

Work is ongoing on a third production, aimed at understanding what the Dark Energy Survey and Large Synoptic Survey Telescope will reveal, with Blue Waters being used to analyze two early-universe cosmological simulations from Michael Norman and Brian O'Shea.

INTRODUCTION

Digital tools and methods are increasingly central to science, engineering, and scholarly research, but many people still envision research as exclusively using analog tools such as microscopes and telescopes. The NSF-supported CADENS project aims to increase public understanding of the crucial role digital tools and techniques play in research across a wide range of fields, while also sharing the latest research results with wide audiences.

METHODS & RESULTS

In order to bring cutting-edge scientific research to life for large audiences of all ages, we create clear and visually appealing animations from large physical simulation data provided by our collaborators. The CADENS team visualized the first generations of stars ionizing the early universe (simulations conducted on Blue Waters by John Wise and by Michael Norman and Brian O'Shea), a solar storm impacting the Earth's magnetosphere (simulation by Homa Karimabadi et al.), and a system of tornadoes that struck El Reno, Oklahoma, in 2011 (simulation conducted on Blue Waters by Leigh Orf).

For the cosmological simulations, we used the astronomical analysis/visualization package yt [1], which supports both OpenMP and MPI parallelism. We relied on a then-experimental version of yt's volume-rendering feature, which was being reinvented at the time, and are grateful to Matthew

Turk, Sam Skillman, and other yt developers for their critical assistance. We created full-dome imagery of several quantities (gas density, temperature, metallicity, stars) and combined them.

With Karimabadi's magnetosphere simulation, we again could use yt, this time to trace magnetic field lines perturbed by the incoming solar coronal mass ejection.

We have also experimented with running the commercial animation software Houdini on Blue Waters. Houdini is a backbone of our image production system, with a high-quality renderer, a rich set of data-flow-based processing operators configured via a graphical interface, and our own group's scientific data reader plugin. We currently use Houdini on a dedicated visualization cluster, but it would be valuable to allow Houdini rendering to operate with Blue Waters data directly. Initial results were promising, and we hope to further develop this capability.

WHY BLUE WATERS

We work with simulation data from collaborators who compute on Blue Waters. The resultant datasets are often so large that they can't readily be moved elsewhere.

Blue Waters staff were very helpful when technical problems arose, whether with negotiating the system-installed Python, getting usable performance reading large memory-mapped files, or acquiring statistical data on jobs we had run.

NEXT GENERATION WORK

As CADENS and future public outreach projects continue, we anticipate working with science collaborators who will use larger computing environments to solve larger problems. There will be a need to visualize their results, and we expect to need a future Track-1 system for at least some of that work.

PUBLICATIONS AND DATA SETS

Super Tornado: Anatomy of a MegaDisaster, available via Amazon Prime, Hulu, IMDB, and YouTube.

Solar Superstorms, available in fulldome format for museums and science centers via Spitz Inc.

Solar Superstorms, alternate expanded flat-screen version broadcast by TVF International.

Solar Superstorms, available via Amazon.com, Amazon Prime, DirectTV, Hulu, and YouTube.

Rivers of Energy Inside the Sun 4K, YouTube.

When A Solar Storm Engulfs Earth, Hulu and YouTube.

FIGURE 2:
Visualization of Leigh Orf's simulation of the tornado that struck El Reno, Oklahoma, on May 24, 2011, showing cloud water, cloud ice, and cloud rain. This was an attempt at a realistic treatment of the data, since these variables are what would be visible to the naked eye when watching the tornado. To indicate the storm's scale, the ground floor is a grid of 1km squares.