Secrets of the Dark Universe: Simulating the Sky on the Blue Gene/Q The Outer Rim Simulation

Joseph A. Insley, Salman Habib, Katrin Heitmann
Argonne National Laboratory
{insley, habib, heitmann}@anl.gov

***Abstract*—An astonishing 99.6% of our Universe is dark. Observations indicate that the Universe consists of 70% of a mysterious dark energy and 25% of a yet unidentified dark matter component, and only 0.4% of the remaining ordinary matter is visible. Understanding the physics of this dark sector is the foremost challenge in cosmology today. Sophisticated simulations of the evolution of the Universe play a crucial task in this endeavor.**

This movie shows a large simulation of the distribution of matter in the Universe, the so-called cosmic web, which evolved under the influence of dark energy. The simulation is evolving 1.1 trillion particles using HACC, a new computational framework developed to overcome the challenges posed by future supercomputing architectures. It is currently running on 32 racks of Mira, the Blue Gene/Q system at the Argonne Leadership Computing Facility. This work is described in further detail in an SC13 Gordon Bell Finalist paper [1]. The visualization was performed on Argonne's Tukey cluster.

I. Visualization

This dark matter simulation evolves 1.1 trillion particles using 262,144 processes. These particles are projected onto a regular grid of $10{,}240^3$ for visualization, resulting in a volume that is 3000 Mpc/h, or $1.3*10^{10}$ light-years, across. This animation shows the evolution of the Universe to a redshift of z=0.7, when the Universe was 7.4 billion years old. The data from one process is used to highlight the fine-grained details. The region shown is 50 Mpc/h, or $2.3*10^8$ light-years, across. This region is then compared to the data from a slab that is 10,240x10,240x800, showing the full domain in the X and Y dimensions, see Figure 1. This is followed by a fly-through of the slab at that snapshot in time, see Figure 2. The animation can be downloaded from: www.alcf.anl.gov/research/fl/flinternal/HACC/OUTER_RIM/hacc_outer_rim_L4225_evolve_scale_flythru_v01.mp4

Additional Authors

Argonne National Laboratory: Mark Hereld, Hal Finkel, Nicholas Frontiere, Kalyan Kumaran, Vitali Morozov, Michael E. Papka, Tom Peterka, Adrian Pope, Venkatram Vishwanath, Tim Williams; *Los Alamos National Laboratory:* David Daniel, Patricia Fasel; *Lawrence Berkeley National Laboratory:* Zarija Lukic.

Acknowledgment

This work was supported in part by the Early Science Program (ESP), a project of the Argonne Leadership Computing Facility (ALCF), a DOE Office of Science User Facility, aimed at preparing key applications for the architecture and scale of Mira, the 10 petaflop IBM Blue Gene/Q supercomputer which was installed in the ALCF in 2012, and went into production in early 2013.

This simulation and visualization were produced using resources of the ALCF at Argonne National Laboratory, which is supported by the Office of Science of the U.S. Department of Energy under contract DE-AC02-06CH11357.

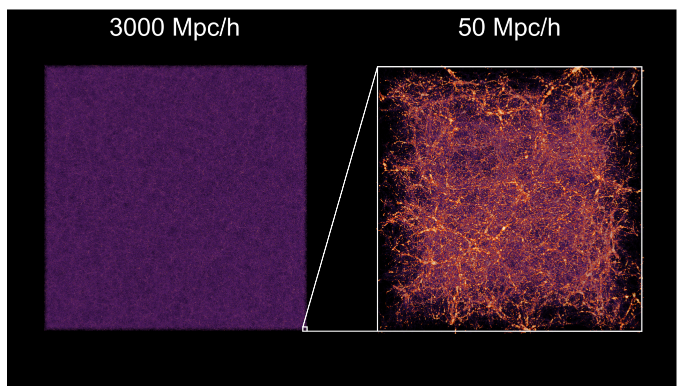

Fig. 1. Snapshot comparing the data from one process (right) to the data from a slab showing the full domain in the X and Y dimensions (left).

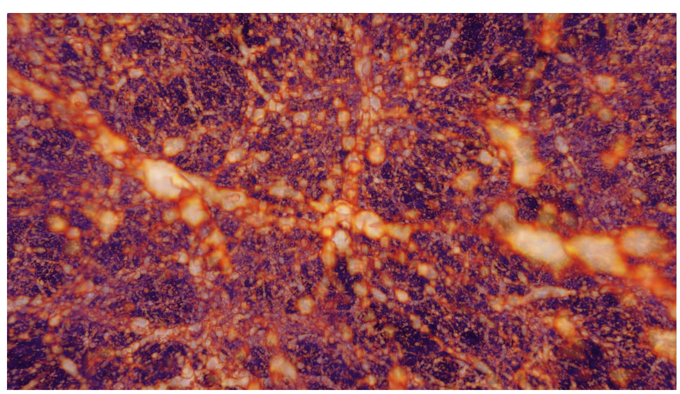

Fig. 2. Snapshot showing a close-up of a fly-through of a 10,240x10,240x800 slab of the volume, at redshift z=0.7.

REFERENCES

[1] Salman Habib, Vitali Morozov, Nicholas Frontiere, Hal Finkel, Adrian Pope, Katrin Heitmann, Kalyan Kumaran, Venkat Vishwanath, Tom Peterka, Joseph A. Insley, David Daniel, Patricia Fasel, and Zarija Lukic. Hacc: Extreme scaling and performance across diverse architectures. In *Proceedings of the IEEE/ACM International Conference for High Performance Computing, Networking, Storage and Analysis (SC 2013) [Gordon Bell Finalist]*, November 2013.