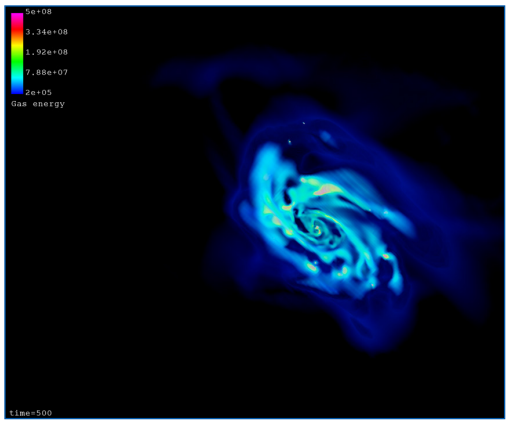
## Visualizing Simulations of Cosmology and Galaxy Formation

### Science Mission Directorate

According to the now-standard Lambda Cold Dark Matter (Lambda CDM) "double dark" theory, 95 percent of the universe's density is invisible dark matter and dark energy. Only 5 percent is ordinary matter, and about a tenth of that is the visible stars and gas in galaxies.

As part of the key challenge in astronomy to explain how the structures in today's universe formed within the Lambda CMD framework, our team is working to understand both the structure and distribution of dark matter halos, and the formation and evolution of galaxies within the dark matter cosmic web.

We are producing simulations of large volumes of the universe at resolutions high enough to follow the formation and evolution of all the dark matter halos that can host galaxies, including the merging of these halos. The halo merger trees form the basis for semi-analytic models (SAMs) that can follow the evolution of the entire population of galaxies.




Visualization of the cosmic web: an image, one billion light years across, of the final snapshot from the 8-billion-particle Bolshoi simulation, made with the Adaptive Refinement Tree (ART) code. *Anatoly Klypin, New Mexico State University; Stefan Gottloeber, AIP-Germany*

The Pleiades supercomputer at the NASA Advanced Supercomputing (NAS) facility has enabled us to run dissipationless and hydrodynamic simulations, in particular, our Bolshoi Gigalight-year simulations. Collaboration with NAS visualization experts has been crucial for visualizing and interpreting the results of these simulations to understand the evolving cosmos.

We have published results from a pilot project using new NVIDIA graphics processing units (GPUs) to greatly speed up parts of our radiative transfer calculations.

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