Understanding the Nature of Dark Matter Halo Mergers in Galaxy Formation

Science Mission Directorate

The material in the universe is dominated by dark matter that can only be detected through its gravitational wave signature on the vast range of astrophysical scales. Over the years, scientists have been able to create simulations of how miniscule density fluctuations of dark matter may evolve in an expanding universe. From such simulations, we have found that entire galaxies can materialize from these tiny density fluctuations, which form the cosmic scaffolding on which dark matter accumulates.

This project explores how Milky-Way-sized dark matter halos merge and evolve over cosmic time. Using two sophisticated codes, GASOLINE and GADGET2, the initial condition settings in the simulations are predetermined to result in the target halo sizes. We simulate numerous histories of dark matter mergers, in which two or more comparably sized dark matter halos merge and grow over cosmic time. The simulations produced are "cosmologically correct" scenarios that include the evolving structure and distribution of the ever-expanding dark matter, the behavior of gases, and star formation.

The supercomputing and visualisation facility at NASA's Jet Propulsion Laboratory enables us to meet the enormous numerical challenges in performing and analyzing these state-of-the-art simulations. Our simulation results can be compared with observations of actual galaxies obtained from NASA's Hubble, Spitzer, and WISE space telescope data.

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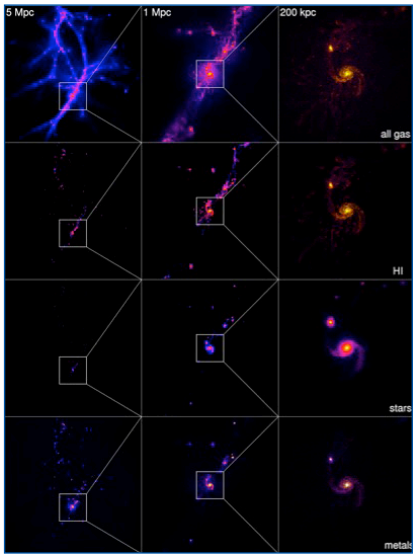

Image from a simulation showing the structure of a galaxy halo the size of the Milky Way, and the contents within it. Columns (from left to right) correspond to simulation box-sizes of 5 megaparsecs (Mpc), 1Mpc, and 200 kiloparsecs. Rows (from top to bottom) correspond to "all gas," all of the neutral hydrogen ("HI"), the distribution of all the stars, and gaseous elements heavier than helium. *Leonidas Moustakas, Kyle Stewart, NASA/JPL*