Cosmological Hydrodynamic Simulations and Its Spin-off runs for exploring Formation and Evolution of Galaxies and Clusters in Early Universe

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Horizon Run 5 (HR5) is a cosmological hydrodynamical simulation which captures the properties of the Universe on a Gpc scale while achieving a resolution of 1 kpc. This enormous dynamic range allows us to simultaneously capture the physics of the cosmic web on very large scales and account for the formation and evolution of dwarf galaxies on much smaller scales. To model galaxy formation, we choose the sub-grid physics of radiative heating/cooling, reionization, star formation, supernova feedback, chemical evolution tracking the enrichment of oxygen and iron, the growth of supermassive black holes and feedback from active galactic nuclei (AGN) in the form of a dual jet-heating mode. For this simulation, we implemented a hybrid MPI-OpenMP version of the RAMSES code, 'RAMSES-OMP', specifically designed for modern many-core many thread parallel architectures. For the post-processing, we extended the Friends-of-Friend (FoF) algorithm and developed a new galaxy finder PGalF to analyze the big data outputs of this simulations. The simulation successfully reproduces various observation result and can be identified cosmological structures at a wide range of scales, from filaments with a length of several cMpc, to voids with a radius of ~ 100 cMpc. Moreover, this simulation provides a large amount of statistical samples of Lyman-alpha emitters and protoclusters which are important to understand the structure formation history of early universe. This is expected to be an invaluable asset for the interpretation of current ΛCDM cosmology and upcoming deep surveys of the Universe. On the back of a remarkable achievement of this, we have done a follow-up study which has 2 times larger volumes than before and is expected to complementary to the world largest narrow band imaging survey, ODIN (One-hundred-square-degree Dark energy camera Imaging in Narrow band). Moreover, we have finished to run a state-of-the-art simulation which has similar cubic volumes but 2 times higher resolution than a previous largest cosmological simulations, such as TNG300.

References

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