PAP301 Seminar in Particle Physics and Astrophysical Sciences
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Evaluating the agreement of cosmological simulation galaxies and observed relations

Galaxies are dynamically bound structures that consist of gas, stars, and central supermassive black holes (SMBHs) embedded in dark matter (DM) halos. An open question is to understand how these structures have formed and evolved, and a powerful tool to tackle the question of galaxy formation and evolution is cosmological simulations. Hydrodynamical cosmological simulations follow the evolution of the Universe over a large range of scales from hydrodynamical equations of gas all the way to large-scale dark matter structures.

Since studying the results of cosmological simulations helps to better understand all processes related to galaxy formation and evolution, producing realistic galaxies is crucial. Simulations still need to compromise regarding resolution, computational cost, and small-scale physics even though both computing power and numerical methods have largely improved over recent years. Thus, constant improvement of the simulations is needed in order to achieve even more realistic models of the Universe.

This work focuses on evaluating if galaxy properties produced in a cosmological KETJU-simulation agree with observed relations. The KETJU-code is an extension to a widely used numerical simulation code GADGET. The main purpose of KETJU is to accurately solve small-scale SMBH binary dynamics. Having such a specific focus, galactic properties from cosmological simulations have not been explicitly analyzed before. Now, this is done by comparing the simulation galaxies to observed relations.

I use data produced by a cosmological simulation starting from the very early universe, at redshift z=50. During the evolution to current time z=0, the galaxy group in the simulation volume goes through multiple mergers and significant evolution. From the comparisons of tens of simulation galaxies to observed relations, we see that our simulation galaxies are realistic in most of their properties. They evolve as expected as the simulation progresses, although a trend of producing galaxies too efficiently can be found. Thus, we learn which aspects of the cosmological KETJU simulations could be improved even though simulation galaxies reproduce observed relations on the most part well.