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Testing SIDM with Realistic Galaxy Formation Simulations

The nature of dark matter remains one of the most important questions in physics. Because of the tremendous overall successes of the Cold Dark Matter (CDM) model, dark matter has been assumed to consist of a massive, weakly-interacting particle. However, the effort to detect such a particle with experiment have not yet yielded conclusive evidence. Although the CDM paradigm has been successful at describing our Universe on large scales, it has faced challenges on small scales (inside of galaxies and in low mass galaxies)- which has yielded alternative models including Self-Interacting Dark Matter (SIDM). As such, astrophysical measurements represent a compelling means of directly studying the properties of dark matter- in particular, the imprint of dark matter model on dwarf galaxies and their baryonic matter. This project uses state-of-the-art computer simulations of dwarf galaxy formation to test galaxy formation in the LCDM framework and in the SIDM framework, in order to constrain the nature of dark matter.

More technically, the project will result in a suite of high resolution, state-of-the art simulations of galaxy formation within a SIDM paradigm. SIDM preserves the large-scale success of CDM, while opening up the possibility of altering the small scales in testable ways using galaxy observations. We use the N-Body+SPH code ChaNGa to run a series of simulations: (1) "zoom" simulations of individual dwarf galaxies in order to test whether CDM or SIDM can reproduce the diverse range of rotation curves observed in real galaxies and (2) "zoom" volumes that contain dozens of dwarfs from 1000 solar masses to 10^9 solar masses in order to directly compare the observed shapes of galaxies with those predicted in CDM vs SIDM. Analytic models have shown that an SIDM model with an interaction cross-section of ~3 cm^2 g^-1 can reproduce the full range of galaxy rotation curves. The project tests this model across a range of galaxy simulations for the first time.

Primary frontier topic

Theory Frontier

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