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Dwarf galaxies as probes of dark matter

ROSEMARY WYSE, Johns Hopkins University

The retinue of dwarf satellite galaxies that surrounds the Milky Way galaxy include some of the faintest stellar systems known. The low masses in ordinary baryons contrasts with their gravitational masses derived from analyzes of the motions of their member stars: the spread in internal velocities implies a total mass that can be up to several orders of magnitude larger. These dwarf galaxies are apparently the most dark-matter dominated systems in the local Universe and offer an unprecedented opportunity to determine the density profile of the dark matter on small scales, where the physics of the dark matter candidate is expected to be manifest. These are the only systems where we have/can find dark matter localized at relatively high density, without accompanying complex high-energy baryon physics. They are therefore ideal (potential) probes of possible dark matter self-annihilation/decay processes. Defining their mass profiles is clearly critical to the interpretation of any signal in high-energy particles or photons. The necessary experiment is to obtain and analyze the velocities of member stars as a function of distance from the center of the dwarf galaxy. Our ability to carry out this experiment is limited by several factors, including the fact that we can only measure one component of the velocity, the faintness of the systems means that it is not trivial to observe the required statistically significant sample of stars, and the velocity amplitudes are sufficiently small that the required precision challenges the best instruments. I will review the state-of-the-art, focusing on constraining the mass profile. I will also discuss other aspects of these intriguing systems that distinguish them from simple star clusters. I will describe the evidence, from the properties of their stellar populations and chemical element abundance distributions, that these are ancient galaxies, plausibly the earliest bound structures to have formed in the Universe.