Advanced Lab 2: Final Project Proposal

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1 Project Description

My final project for Advanced Lab 2 will involve analyzing the nature of dwarf galaxies, globular clusters, and unclassified satellites within the Milky Way galaxy, the Andromeda galaxy, and others within the local field up to 3 Mpc. Specifically, I will look at their dynamical mass-to-light ratios as a measure of their dark matter content. I will then compare observed local volume dwarfs to simulated data of dwarfs created by the EDGE (Engineering Dwarfs at Galaxy's Edge) hydrodynamical simulation suite.

In astrophysics, the mass-to-light ratio Υ is a quotient between the total mass of a large spatial volume (usually a galaxy) and its luminosity. Like many astrophysical measurements, this is calculated relative to the Sun as a standard baseline given by the equation below.

$$\Upsilon_\odot = \frac{M_\odot}{L_\odot} \tag{1}$$

The mass-to-light ratios of galaxies are helpful measures of dark matter content, since most of the matter content of galaxies does not reside within stars. A higher mass-to-light ratio suggests a larger dark matter domination within the galaxy.

The EDGE Simulation suite is a cosmological hydrodynamical simulation that selects dark matter halos in the early universe to resolve at high resolutions once they evolve to the present day (see Figure 1). These low-mass dark matter halos host traditional dwarf galaxies as well as globular clusters. At the tail end of the galaxy formation spectrum, low-mass dwarfs are particularly sensitive to galaxy formation physics, including the process by which dark matter seeds structure development in the early universe [1]. The EDGE Simulation evolves dwarf galaxies from their initial formation through to the present day, as well as take into account the impact of gas and stellar physics on the interstellar environment [3]. Additionally, advances in EDGE simulation physics such as non-equilibrium cooling and heating models, radiative transfer and supernovae feedback, and updated element enrichment provide a highly beneficial environment with which to study the nature of dwarf galaxies and their halos [3].

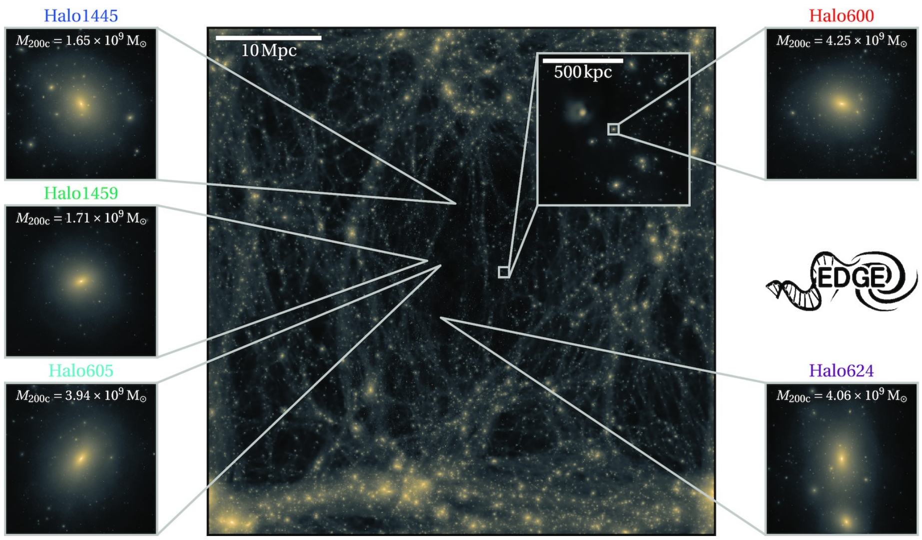

Figure 1: Depiction of EDGE Simulation selection of dark matter halo databases within a Cosmological void. Halo databases are selected for higher resolution re-simulation at a redshift of zero.[2]

2 Table of Project Parameters or Goals

Parameter	Source
Stellar Mass	Local Volume Database/Simulation Data
Luminosity	Local Volume Database/Simulation Data
Half Light Radius	Local Volume Database/Simulation Data
Line of Sight Velocity Dispersion	Local Volume Database/Simulation Data
Dynamical Mass	Calculated from Half Light Radius and Velocity Dispersion
Dynamical Mass-to-Light Ratio	Calculated from Dynamical Mass and Luminosity

3 Project Features or Steps

Include at least 3–5 things you plan to implement, simulate, or analyze. - Format using itemize or enumerate

- Step 1: Gather/calculate needed parameters from Local Volume Database.
- Step 2: Simulate dwarf galaxy parameters using EDGE
- Step 3: Conduct data and error analysis using simulated and observed local volume values
- Step 4: Visualize data analysis

References

[1] Oscar Agertz, Andrew Pontzen, Justin I Read, Martin P Rey, Matthew Orkney, Joakim Rosdahl, Romain Teyssier, Robbert Verbeke, Michael Kretschmer, and Sarah Nickerson. Edge: the mass–metallicity relation as a critical test of galaxy formation physics. *Monthly Notices of the Royal Astronomical Society*, 491(2):1656–1672, 10 2019.

[2] Matthew D. A. Orkney, Justin I. Read, Martin P. Rey, Imran Nasim, Andrew Pontzen, Oscar Agertz, Stacy Y. Kim, Maxime Delorme, and Walter Dehnen. EDGE: two routes to dark matter core formation in ultra-faint dwarfs. , 504(3):3509–3522, July 2021.

[3] Martin P. Rey, Ethan Taylor, Emily I. Gray, Stacy Y. Kim, Eric P. Andersson, Andrew Pontzen, Oscar Agertz, Justin I. Read, Corentin Cadiou, Robert M. Yates, Matthew D. A. Orkney, Dirk Scholte, Amélie Saintonge, Joseph Breneman, Kristen B. W. McQuinn, Claudia Muni, and Payel Das. Edge: The emergence of dwarf galaxy scaling relations from cosmological radiation-hydrodynamics simulations, 2025.