

Tidal Evolution of M33’s Dark Matter Halo

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1 INTRODUCTION

In roughly 4 billion years the Local Group will experience a catastrophic event. That event is when our own galaxy, the Milky Way (MW), will collide with our closest neighboring galaxy, Andromeda (M31). The collision of these two galaxies will produce immense changes to their own structure as well as any nearby satellite galaxies. The interest of this research paper focuses on the evolution of M31’s most massive satellite galaxy, Triangulum (M33). More specifically, the research will investigate the tidal evolution of M33’s dark matter halo. The primary physical features which are of great importance during it’s evolution are the changes to it’s internal dark matter profile and the mass loss of the dark matter halo.

The purpose of this research is to develop a better understanding of the evolution of dark matter in a dynamically changing universe. Astronomers strive to understand how dark matter behaves as it plays a very important role in the structure of our universe and especially how galaxies evolve. We’ve come to understand that a universe which is entirely composed of baryonic matter does not fit within our current observational data. Evidence suggests an unknown and highly elusive form of matter influences the ways in which galaxies behave. The primary evidence which leads to this conclusion is that the rotation curve of galaxies does not match previous dynamical models (Hoeneisen 2019). Astrophysicists suggest there exists a “hidden” source of matter which contributes to the orbital dynamics of the galaxy, dark matter. Our comprehension and investigation of dark matter produces a sort of trickle down affect. Observations of the rotation curves of galaxies suggest the presence of dark matter. Current theories attempt to predict how dark matter halos might influence the physical features of a galaxy. In turn, scientists are deeply interested in developing models of dark matter halos in hopes of constructing a more clear image of their behavior and we might detect them. To accurately build these models it is vital to reconstruct the exact environment in which the halo of interest exists within. This is of great importance because the dark matter halos of satellite galaxies can affect the For example, astrophysicists have ran simulations modelling the halo mass of MW & M33 which suggest their satellite galaxies greatly influence the final calculation of their mass (Patel et al. 2017). Thus, understanding the characteristics of M33’s dark matter halo after the galactic collision could provide insight into how the dark matter structure of the local group affects galaxy evolution.

The theoretical research investigating the interaction and tidal affects of M33 on it’s host halo, M31, have shed light on the importance of this system. As stated previously, astrophysicists have used simulations to calculate the theoretical mass of the dark matter halos of MW & M33. Using a Bayesian inference scheme which combines

8 *E. Patel et al.*

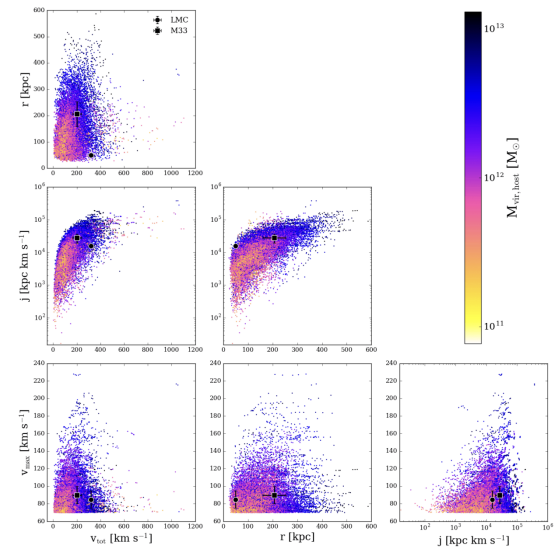


Figure 2. For all host-satellite systems selected from Illustris-Dark ($P(\theta)$), the distribution of the satellite subhalo properties (x) are shown for each pair of satellite parameters. All points are colored by the corresponding host halo virial mass (M_{vir}) to which they belong. The LMC’s properties are indicated by a black circle, while M33 is represented with a black square. These reference points indicate that host halos in Illustris-Dark do host massive satellite analogs with properties similar to that of the LMC and M33. Total orbital angular momentum (j^{orb}) suggests that M33 should reside in a higher host halo mass than the LMC, however, similar conclusions cannot be drawn for v_{max} , v_{circ} , and v_{tide} .

the satellite halo’s position, velocities, and specific orbital angular momenta, researchers concluded that the resulting host halo mass is more susceptible to bias when using measurements of the current position and velocity of the satellites, especially when satellites are at short-lived phases of their orbits (Patel et al. 2017). This conclusion was accentuated by the fact that researchers previously determined that simulations suggest M33 is completing it’s first orbit around M31 and is heading toward it’s pericentric approach (Patel et al. 2016). Thus, evidence is accumulating that points toward M33 having significant influence over the physical features of M31 and it’s dark matter halo in the coming future. Additionally, astrophysicists have created hydro-dynamical models of the interaction between M31 & M33 and have successfully reproduced characteristics observed in the system such as the spiral arm structure, stellar streams, and even a star formation burst (Semczuk et al. 2018). It becomes clear that ongoing research supports the fact that to better understand the nature of a galaxy’s dark matter halo it is necessary to account for the affects due to any massive satellite halos. Not only does the evidence suggest that the presence of a massive satellite halo will influence things such as the host halo mass but it also has the potential to

will create my own code. This is especially true of the Hernquist mass profile from homework 5.

2.3 Hypothesis

I believe that M33's dark matter halo will start with a semi-spheroidal shape with a Hernquist density profile. As the halo evolves, I think it will begin to exhibit an oblate shape as the gravitational pull from tidal disruption caused by it's host halo and MW approaching one another. This will inevitably cause the density profile to change in which the density will become more concentrated toward the combined MW & M31 dark matter halo. I believe the immense gravitational contribution from MW & M31 will change the shape an density profile of M33. If it does not change that could mean that M33 is outside of the range of the tidal affects of their collision.

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