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# Dark Matter Halo : the behavior under tidial forces in M33

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## 1. INTRODUCTION

The behavior of the dark matter halo in M33 due to the tidal forces caused by MW and M31 is yet to be understood. M33 is a spiral galaxy, third most massive member of the local group with the Milky Way (MW) and Andromeda (M31). It is believed that M33 is a satellite of M31 because it is gravitationally bound to the Andromeda galaxy. In detail, we will quantify and plot the evolution of M33's dark matter halo while it orbits the MW-M31 system. Specifically, I will study the change in M33's dark matter profile owing to mass loss from tides and quantify the mass loss rate as a function of time.

According to the definition from Willman & Strader (2012) a packet of stars hold together by more than baryon matter and gravitation define a galaxy. Baryon matter means gas and stars. So a galaxy also bound stars with dark matter. Galaxy evolution is defined by the modification of the morphology and/or the internal dynamics due to collision, star age or the super massive black hole in the center (Willman & Strader 2012)

Dark matter play an important role in galaxy formation and evolution. The depth of the potential well is increased by Dark Matter, which allow the galaxy to form stars by accretion of gas. Dark matter halo merge to form bigger structures, but as they merge, the smaller halo is not necessarily absorbed immediately and can become a sub-halo of the all structure (Delos 2019). This phenomenon is due to "Violent relaxation", defined from Lynden-Bell (1967) as a loss in the equilibrium of the system. The potential evolve due to a redistribution of the gravitational forces that makes the kinetic energy of the stars chaotic. By studying how the density profile of a satellite sub-halo of smaller size evolves due to tidal forces, we will be able to understand how dark matter mass loss impacts how galaxies are able to retain their baryonic matter. Since most of the mass comes from the dark matter halo, if it is tydaly removed, it is easier for the baryonic matter to escape. We would be able to predict how a subhalo merge with a larger Dark Matter halo by understanding the evolution of the mass profile of dark matter due to tidal forces. Figure 1 below shows the density profile of a Dark Matter Halo as a function of radius at different times. This study did not take into account the dynamical friction between the small sub-halo and the larger halo that merged together. We will also ignore friction in our analysis. In this figure we can see how the density profile of a Dark Matter halo is distributed without any tidal forces acting on it. This model will be helpful to compare the result we get under tidal forces and owing to mass loss. We know almost nothing about the behavior of Dark Matter except that even though we cannot see it, it interacts with normal matter via gravity. That property will allow us to predict the behavior of Dark Matter structure as the galaxies and halos merge during a collision using a simulation. Also, Wechsler & Tinker (2018) describes well how galaxies and dark matter halos are connected.

An important question in the field is how the growth and evolution of galaxies is connected to the growth and evolution of dark matter halos. Scientists think that the Baryonic matter has a direct impact in the density profile of dark matter halo (Grillo 2012).

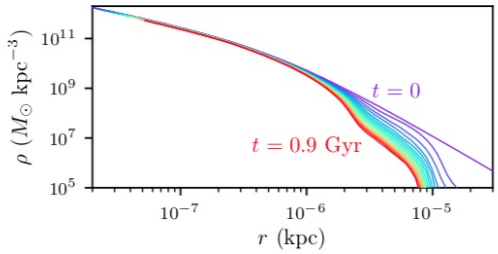


**Figure 1.** Delos (2019) Density Profile Evolution Of Halo as a function of radius at different times.

## 2. THIS PROJECT:

In this paper we will study the change in M33's dark matter profile owing to mass loss from MW and M31 tides and quantify the mass loss rate as a function of time.

We will be able to answer the connection of growth and evolution between the galaxy and the dark matter halo.

The galaxies are constantly changing under mass loss or gain. Analyzing how the density profile of the dark halo evolve over time owing to mass loss will describe the connection between dark matter halo and the galaxy

## 3. METHODOLOGY:

In this research, we will be answering the following questions :

- How does dark matter halo evolve over time due to the tidal forces from a collision of galaxies ?

To answer that question we will use the data we have on halo particles for M33 and MW-M31 and track how the density profile of M33's Dark matter halo evolve over time using a plot of density profile over time. We will need to use the center of mass class we created to keep track of the galaxies position and velocities.

I think the density of the halo should decrease until M33 collides with the new MW-M31 merger system and then the two halos will add their own Dark Matter to form a new more massive halo of Dark Matter.

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