Draft version March 20, 2025
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Galactic Mergers and Evolution: Stellar Density and Sersic Profile Development Due to Tidal Forces

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1. INTRODUCTION

The topic proposed for my research assignment is to investigate how the surface density profiles of MW and M31 evolve during their galactic merger. Both galaxies have a disk and bulge region with its own surface density. When MW and M31 merge within the next seven billion years, these two regions will interact with each other and combine. The dynamical forces, namely the tidal forces, will influence the result of this merger and the ongoing evolution of the two galaxies.

Density is a property of a galaxy that influences many different phenomena related to galactic evolution (P. Torrey et al. 2012). By observing the surface density of the galaxies as they merge over time we can learn about how galactic mergers influence evolution. With how old the universe is, it is difficult to see the whole picture that is galactic evolution. A galactic merger can hopefully allow us to see how a galaxy evolves in a shorter amount of time. We can also learn what type of galaxy is formed from the merger of MW and M31 by analyzing its surface density.

We know that after MW and M31 merge, the merger remnant will have a significantly larger radius that the original galaxies (R. P. van der Marel et al. 2012). With this, the surface density after the merger should follow a distribution similar to a de Vaucouleurs profile (A. Brooks & C. Christensen 2016). This means that the new elliptical merger remnant will have its density scale with the radius to the power of a quarter (outside of 1 kpc from the centre). Figure 1 shows the particles originating from MW and M31 respectively after the merger. It can be seen that the shape of the merger remnant consisting of MW and M31 should be elliptical when viewed face on.

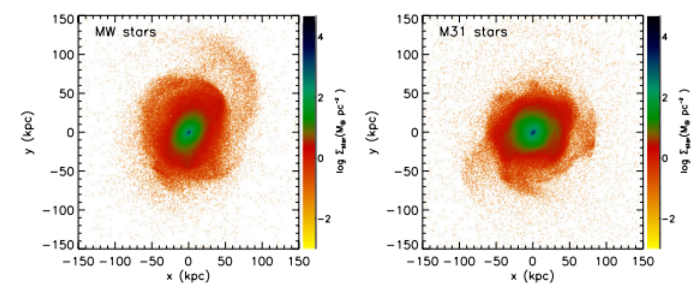

Figure 1. The distribution of particles at the end of the N-body simulation (t = 10 Gyr). Scale colour used to represent surface mass density. The centre of mass of each galaxy is at the highest-density position in its particle distribution (R. P. van der Marel et al. 2012).

There are several questions relating to the evolution of the surface density profiles during the galactic merger. A very good question is how will the forces acting on the galaxies during the merger change their surface density profiles. Hopefully, by analyzing the way the galaxy surface density changes throughout this interaction and compare it to the initial densities and the density of the merger remnant, we can learn more about how galactic mergers and their density profiles impact galactic evolution. There is also the question of how the merger will impact the form of the two galaxies. As aforementioned, the merger remnant should be elliptical. The shape and density of the merger remnant could help us learn how to more easily identify other similar merger remnants. In the same vein, something must happen to the spiral arms of MW and M31 as the galaxies go from a spiral classification to an elliptical merger remnant. The tidal

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forces acting on the spiral arms cause them to evolve in such a way that the arms lose their definition during the merger.

2. PROPOSAL

2.1. *This Proposal*

The question I will be answering is how the surface densities of the disks and bulges of MW and M31 evolve over the course of the galactic merger.

2.2. *Methods*

In order to answer this question, I will have to complete a number of steps using the merger simulation. In general, I will look at surface density profiles at various times for both MW and M31. As stated in the previous subsection, I will look at both the evolution of the disk (i.e. particle type 2) and the bulge (i.e. particle type 3). I would like to analyze the two galaxies at specific points in time. I will look at the initial conditions (i.e. snapshot 000), the first close encounter at four gigayears (i.e. snapshot 280), the time they separate after that encounter at five and a half gigayears (i.e. snapshot 385), the time they merge at six and a half gigayears (i.e. snapshot 455), and some time after the merger to see if there are any changes (i.e. snapshot 700). These values were found using Figure 2 to look at the separation between MW and M31 during the galactic merger. At these times, I will calculate the Sersic profile for each galaxy and find the associated Sersic index that fits best. To do this, I will need to first compute the centre of mass of each galaxy for the given snapshot. I will need to do this for both particle types so that I can then find the surface density for both the disk and the bulge. With the surface densities, I can then calculate the Sersic profiles using the luminosity and effective surface brightness. By over-plotting the surface density profile and sersic profile, I can determine which Sersic index is most accurate.

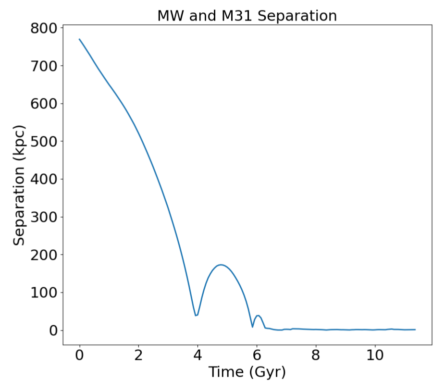

Figure 2. Plot showing the radial separation between the centre of mass of MW and M31 in kpc at a given time in Gyr.

2.3. *Hypothesis*

I expect to find that the Sersic index at the end of the merger to be four. This would fit with the merger remnant being elliptical in shape. It is also likely that the Sersic indexes will vary between particle type as well as snapshot number. This is due to the the bulge and disk having different surface densities.

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