Research Assignment 2

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1 Introduction

The topic I have chosen is the MW+M31 Stellar Major Merger Remnant: Stellar disk particle distribution/morphology. More specifically, I want to find out what the final stellar density profile for the combined system after merging looks like. The first thing I would like to do is compare the distributions of the stellar particles of MW and M31 so that I can have a better idea of how many stars I will be working with. This will give me a good idea of how much mass I'm working with. Since the amount of light we see will change dramatically during and after the merger, I will need to compare my result to several Sersic profiles to see if one would fit my result. This will tell me if the predictions for elliptical galaxies are accurate.

Understanding galaxy mergers, as well as galaxy evolution as a whole, helps us better understand how the universe became what we see today, and can even gives us some insight as to what the early universe (just after the Big Bang) might have looked like. Sersic profiles, which are the measure of a galaxy's light intensity with respect to the distance from the center of that galaxy, are one of our best tools in seeing if our theories actually match our observations. If they do match, then that means that the predictions that we make about the future stages of galaxy evolution are accurate and can be trusted, including the result of the simulation for this project.

As far as our current level of understanding of galaxy mergers, we actually learned quite bit over the years, especially when it comes to major mergers between two giant galaxies like the Milky Way(MW) and Andromeda(M31). For decades now, it was obvious that the tidal structures, known as 'tails', that we see in merger remnants are the result of interacting tidal forces between two disk galaxies. [1] This is important because so much material can be ejected into these 'tail' structures that in can become bound structures and form smaller dwarf galaxies. This in turn, will greatly affect the morphology and particle distribution of the final remnant. The number of tails depends entirely on how much mass there is between the colliding galaxies. When is comes to major mergers, such as the one in our simulation, the tails will be extremely long, curved, and binary, [2] so we should expect to see such structures within our merger remnant. It should look something similar to the following Figure 1.

Figure 1: True-color ESO optical image of the prototypical merger NGC 7252with, to the right, a NRAO/VLA HI map superimposed.

We're also sure that the final remnant will be an elliptical, considering that the current theory is that elliptical galaxies mostly form through mergers.

Despite our current knowledge, there are still unanswered questions we have regarding stellar disc distribution/morphology. According to Querejeta et al, there are intermediate mergers that are not present in their database. This is important because studies show that intermediate encounters and multiple minor mergers may have been as relevant for the evolution of some galaxies, such as S0 galaxies. [3] This begs the question: What would our models and simulations look like if we were to include these intermediates? What parameters would have to be adjusted in order to accurately create them? There are also more general unanswered questions, such as, How did the first galaxies form?, and How did we get the galaxies we see today? Better understanding the morphology and distribution of a future galaxy merger may shed some light on the answers, if only a little. If we're able to accurately predict this, then we can work backwards and figure out where and how the current galaxies formed.

2 Proposal

2.1 What specific question(s) will you be answering

The questions I will be answering are the following: 1) What is the final stellar density profile for the combined system? 2) Is it well fit by a Sersic profile? 3) Does it agree with predictions for ellipsoidal galaxies? 4) What is the distribution of stellar particles from M31 vs. the MW? Are the profiles different?

2.2 How will you approach the problem using the simulation?

First and for most, I will need to find the mass profiles of each galaxy, then of the merger remnant using the code from Lab 5. Afterwards, I can use the code from Lab 6 to find the density profiles what should look like, and once I do I can go about finding a Sersic profile with a reasonable fit. Finally, I'll make a density contour map of both the MW and M31 in order to compare the distribution of stellar particles of the galaxies and see if they're different or not.

2.3 Include at least one figure that illustrates your methodology.

Figure 2 below shows the surface brightness profile vs the distance to the mass centroid of two galaxies. In other words, it's an example of a Sersic profile of galaxy mergers, and I will want something that resembles the left side.

2.4 What is your hypothesis of what you will find? Why do you think this will occur?

Because this collision will be between two galaxies with roughly the mass, I expect to see a distribution of stellar particles that show two main tails coming from the remnant. According to the paper written by Duc, "...major mergers between spiral galaxies are long..., curved and binary. A main tail and a counter-tail are formed from each colliding galaxy. At the post-merger phase, the two counter-tails have already dis-appeared; remain the two main tails." [2] And since I know what kind of shape the remnant will more or less have, I have a good idea of how much light should be at a given distance, so I can find a more accurate Sersic profile fit. This also tells me that the stellar distributions of the particles for the MW and M31 should be about the same, since they're about the same mass, and therefore should exhibit the same behavior.

References

[1] Hernquist Barnes, J.E. and L.E. Formation of dwarf galaxies in tidal tails. *ApJL*, 1992.

[2] Pierre-Alain Duc. What collisional debris tells us about galaxies. *ASPC*, 2013.

[3] T. Tapia A. Borlaff C. Rodríguez-Pérez J. Zamorano M. Querejeta, M.C. Eliche-Moral and J. Gallego. Formation of s0 galaxies through mergers. *A&A*, 2015.

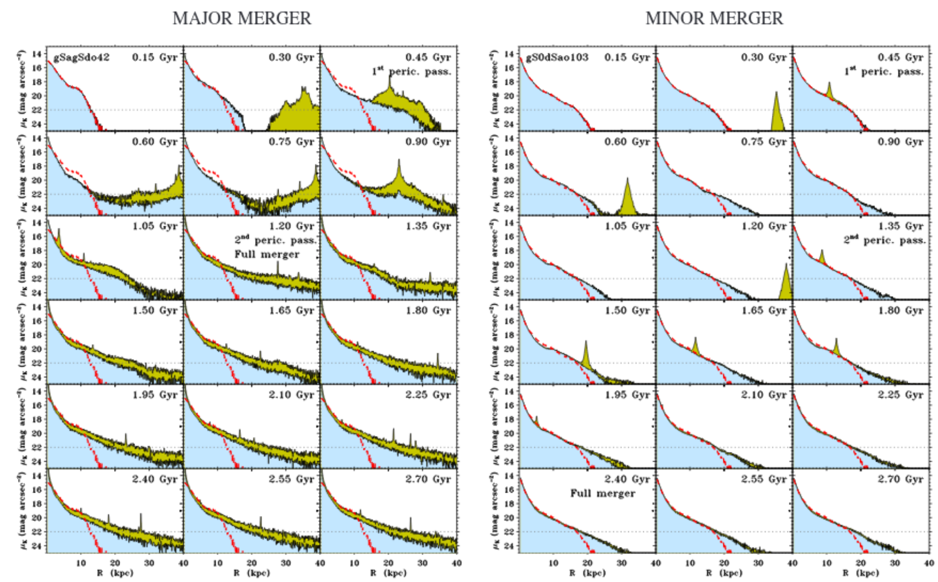

Figure 2: Time evolution of the surface brightness profiles of the stellar material in two models that result in an S0-like remnant, centred on the mass centroid of the most massive (primary) progenitor at each time.Left panels: For the major merger gSagSdo42.Right panels: For the minor merger gS0dSao103. The contribution of the stellar material of each progenitor to the total profile at each time is marked with a different colour (blue: primary progenitor;green: secondary progenitor). We have plotted with red dashed lines the original surface brightness profile of the primary progenitor in all panels, to stress that minor merger events essentially preserve the profile, whereas major encounters completely rebuild the bulge and disc profiles in the remnants out of material from both progenitors. The limiting surface brightness that we consider is shown with a horizontal dotted line. We also indicate the first and second pericentre passages, as well as the moment when the full merger is reached.