Draft version March 25, 2020
Typeset using LaTeX default style in AASTeX63

ASTR400B Research Assignment 2

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1. INTRODUCTION

In the MW-M31 merger, stars will undergo large changes in their orbital characteristics and likely never return to the environment that birthed them. In the N-body results of (van der Marel et al. 2012a), it is possible to tag galaxy particles which have characteristics similar to our local environment in M31 and follow them through the merger to discover what shared fate we may have. By following these particles, we can generate a statistical array of futures including ejection from the system, capture by a satellite, and changes in orbital radius and eccentricity.

The next major change to our local environment is the MW-M31 merger and so all characteristics of the merger are relevant to our understanding of not only the future of our galaxy but of other galaxies that are currently going through or settling from a similar merger. The presence of massive elliptical galaxies is best explained by the repeated merging of other galaxies like ours. By studying the dynamics of such a system, it could be possible to recover useful stellar population statistics and a kinematic history in evolved systems rather than assuming a population formed solely in the modern host.

It is known that M31 has a COM velocity vector that intersects with the MW (van der Marel et al. 2012b) and will eventually undergo several tidal interactions before settling into a new merger product. Because M31 is near enough that individual stars can be resolved, it is possible to match the galaxy with an N-body model to extract specific rather than general information from a simulation. By running the N-body simulation through the merger, likely characteristics of the merger product can be determined such as the mass profile, the rotation curve, and the stellar density. Other galaxies in the local group such as M32, the SMC, and the LMC are often left out of simulations of mergers as their masses individually are less than even M33 and their current trajectories send them away from the merger zone (Kallivayalil et al. 2006; van der Marel et al. 2012a).

It is not well established whether stars ejected from their host come from the edge of the galaxy or if the tidal forces reach deep enough to dredge up stars more tightly bound. Studying the fate of stars with the same orbital characteristics as our sun sheds light on how far into the MW the merger may reach. The night sky as seen from Earth will change not only due to M31 growing larger on the sky, but also due to the Earth's new location in the merger system. It is possible our solar system will be ejected and the night sky may eventually be a view of the aftermath of the provided figure.

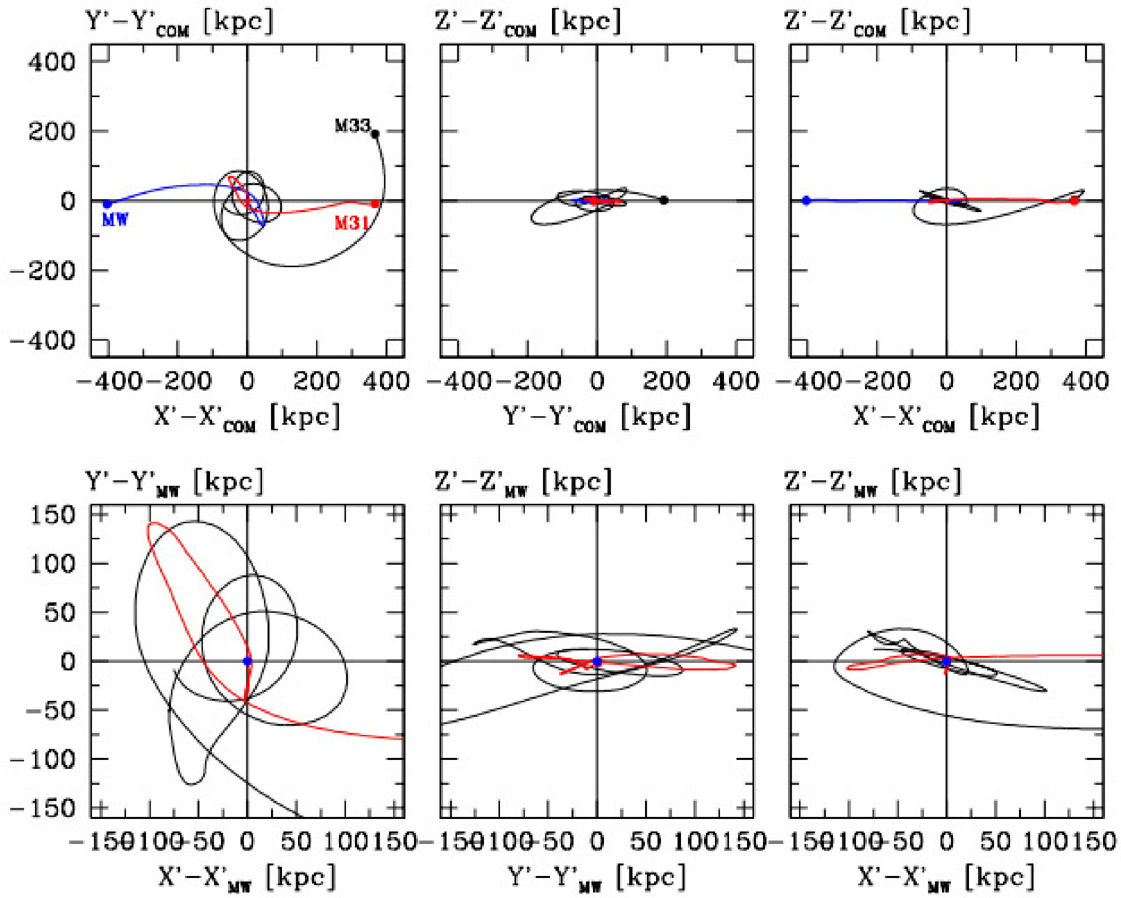


Fig. 2.— Orbital evolution of the COM of the galaxies MW, M31, and M33, calculated with N-body simulations for the canonical model discussed in Section 3. Each row shows three orthogonal projections of the trigalaxy cartesian (X',Y',Z') system. The quantity shown along the vertical axis is listed at the top left of each panel. Top row: wide view fixed on the COM of the system. Bottom row: central view fixed on the MW. The MW is shown in blue, M31 in red, and M33 in black. Initial positions are shown with a dot. The MW and M31 merge first. M33 settles into an elliptical, precessing, and slowly-decaying orbit around them, in a plane that is close to the M31-MW orbital plane.

Figure and caption from (van der Marel et al. 2012a)

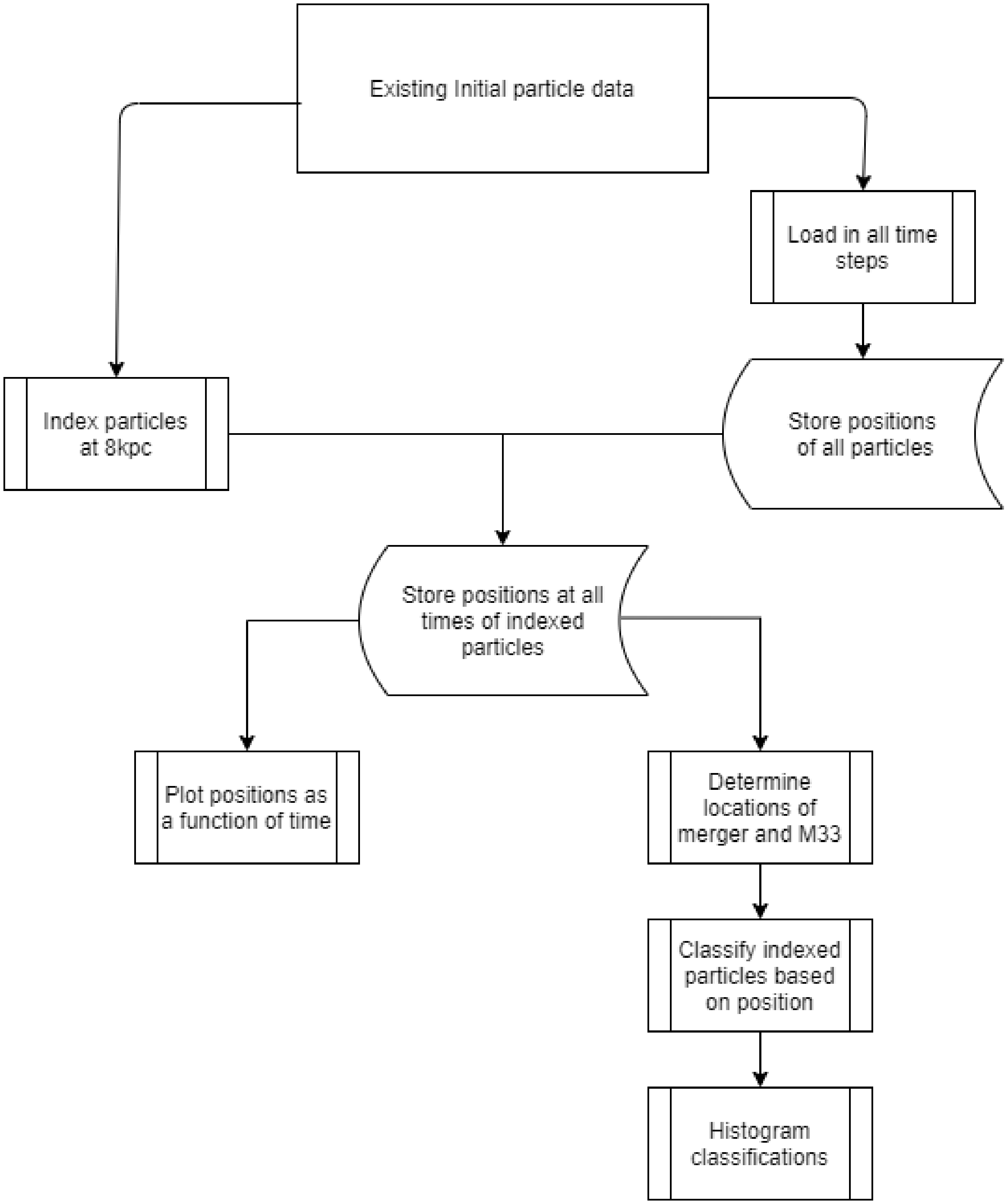
2. PROPOSAL

2.1. *Questions*

I aim to address the final fate of sun-like stars in M31 after the MW-M31 merger. Since there is an annulus of many particles close to the solar radius in M31, their different fates should mirror the possible futures of the sun. A probability distribution of futures can be created divided up into captures by M33, ejections, and stable but changed orbits around the merger product.

2.2. *Approach*

To approach this problem, code will need to be written to tag particles with velocities similar to the sun. By setting an index of these particles, it is possible to follow them through each time step and characterize their kinematics. Additionally, by determining the positions and velocities of every sun-like star at each time step, it can be determined whether the particle is captured by another galaxy or becomes unbound.



Flowchart of programming methodology.

2.3. *Hypothesis*

I believe a large fraction of sun-like stars will remain bound to the merger product while a smaller fraction will be herded by M33 and a negligible amount will be ejected from the system. Because sun-like stars are in the middle of a galaxy's disk, I believe the merger will change their orbital kinematics such that they are greatly perturbed but not ejected. While M33 is a small galaxy, it's gravitational cross-section is large and can lead to highly perturbed and ejected particles being dragged along in its wake as if being herded. Particles with enough velocity to be ejected and also on a trajectory which puts it out of M33's reach can be ejected entirely from the system but fulfilling both of these requirements is less likely than failing either.

REFERENCES

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