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Dynamics of the Local Group

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ABSTRACT

This is a very early draft consisting mostly of placeholders and preliminary ideas. I only pushed it to GitHub so that I wouldn't lose it.

1. INTRODUCTION

The simulation of Milky Way–M31–M33 orbital evolution was described previously (Marel et al. 2012). That paper included an extensive analysis of both N-body simulations and semi-analytic orbit integrations. The present study uses data from the same N-body simulation to carry out further computational analysis.

2. DATA

Data from one N-body simulation in (Marel et al. 2012) was supplied in text-file format by one of the original authors. This included position and velocity data for each particle at the current epoch ($t = 0$) and 800 future timesteps. For ease of analysis, this was all transferred to the open source database PostgreSQL[1] (approximately 1.35 billion records). The same database was used to store computed summary data during the analysis.

Particle counts for each time point are shown in Table 1 and total masses in Table 2.

The coordinate system is approximately centered on the Milky Way at $t = 0$. The center of mass (CoM) of all particles in the system is not fixed over time, moving at an average of (35.9, -26.7, 27.5) km/s with some minor fluctuations due to numerical approximations. In contrast, the total angular momentum of the system is very small at all time points.

3. SOFTWARE

The work in this report was carried out in Python using standard package. Full details are available online[2]

4. RESULTS

4.1. *Trajectories*

Refer to Figure 1

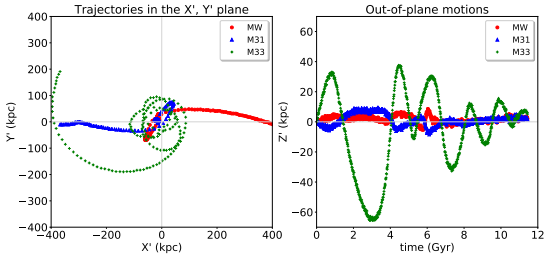

Figure 1. Trajectories of each galactic center of mass in (left plot) and perpendicular (right plot) to the X',Y' plane. Points are at ?? Gyr intervals.

4.2. *MW-M31 Close approach*

4.2.1. *Inclinations*

TODO Relative rotation axes of disks

4.2.2. *Tidal tails and bridges*

TODO identify, trace history, trace fate

4.2.3. *Velocity dispersion*

Refer to Figure 2

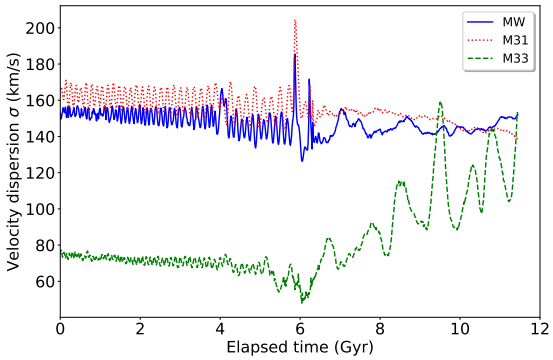

Figure 2. Velocity dispersion of disk particles from each galaxy over time.

4.3. *MW-M31 merger remnant*

TODO shape - how to get principal axes? boxiness?
Refer to Figure 3

4.3.1. *Rotation*

TODO phase diagram

[1] http://www.postgresql.org

[2] Code https://github.com/colinleach/400B_Leach
documentation https://400b-leach.readthedocs.io

Table 1. Particle counts

Galaxy	DM Halo	Disk	Bulge	Total
MW	250,000	375,000	50,000	675,000
M31	250,000	600,000	95,000	945,000
M33	25,000	46,500	0	71,500
Local Group	525,000	1,021,500	145,000	1,691,500

Table 2. Aggregate masses ($M_\odot \times 10^{12}$)

Galaxy	DM Halo	Disk	Bulge	Total
MW	1.975	0.075	0.010	2.060
M31	1.921	0.120	0.019	2.060
M33	0.187	0.009	0.000	0.196
Local Group	4.082	0.204	0.029	4.316

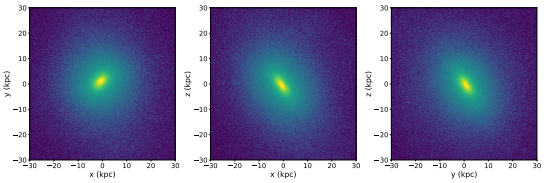

Figure 3. Luminous star density of the MW-M31 remnant in three orthogonal projections.

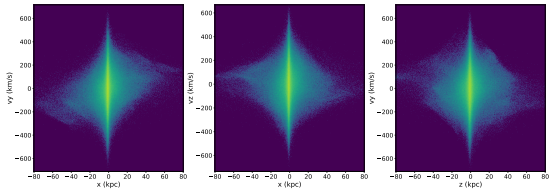

Figure 4. Phase diagrams of the MW-M31 remnant.

Refer to Figure 4

TODO alignment between particles of different origin?

REFERENCES

Marel, R. P. v. d., Besla, G., Cox, T. J., Sohn, S. T., & Anderson, J. 2012, The Astrophysical Journal, 753, 9, doi: 10.1088/0004-637X/753/1/9

Toomre, A., & Toomre, J. 1972, The Astrophysical Journal, 178, 623, doi: 10.1086/151823