ASTR 400B: Homework 6

Due on March 6, 2020

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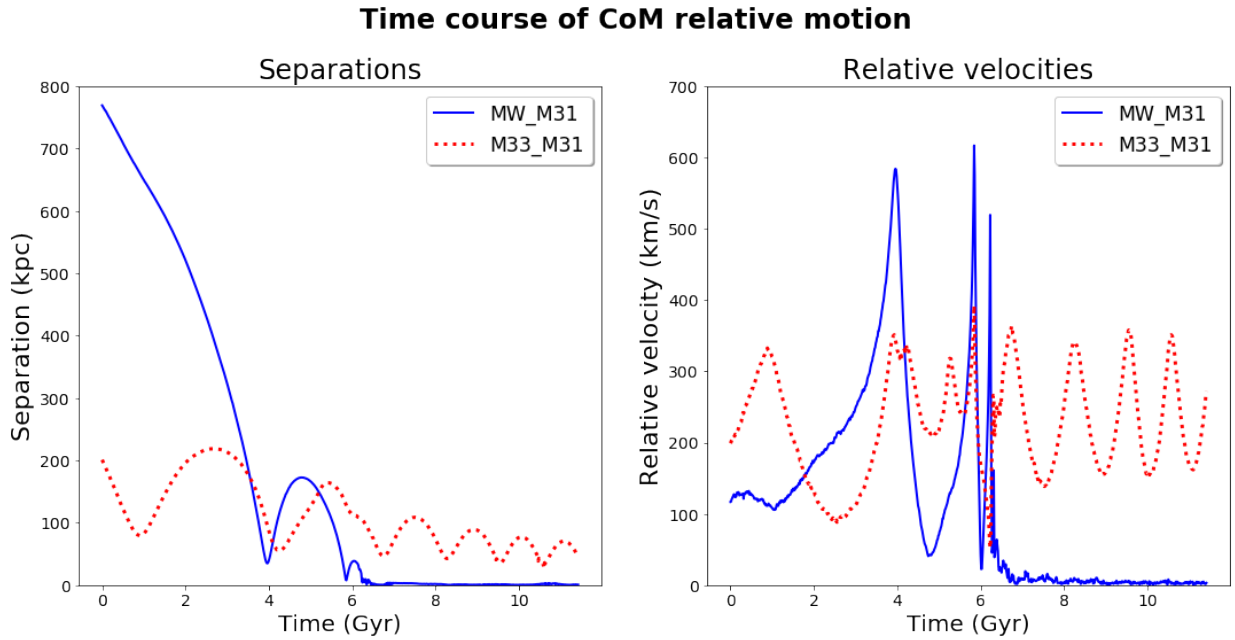
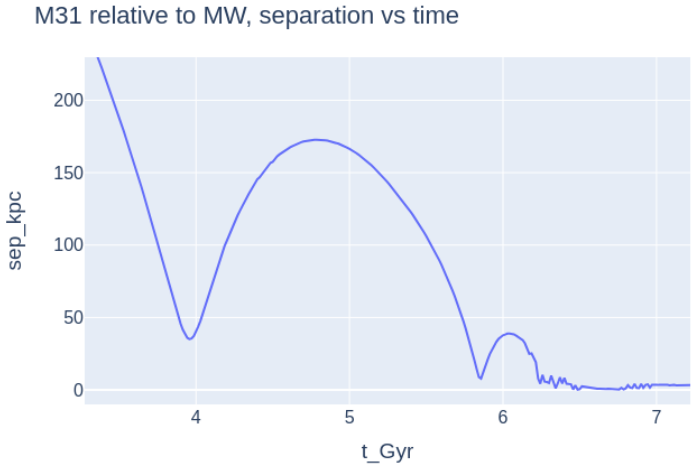
Calculations are in ./OrbitCOM.ipynb, this is just a summary.

1) CoM Relative Motion Plots



2) Close Encounters and Merger, MW-M31

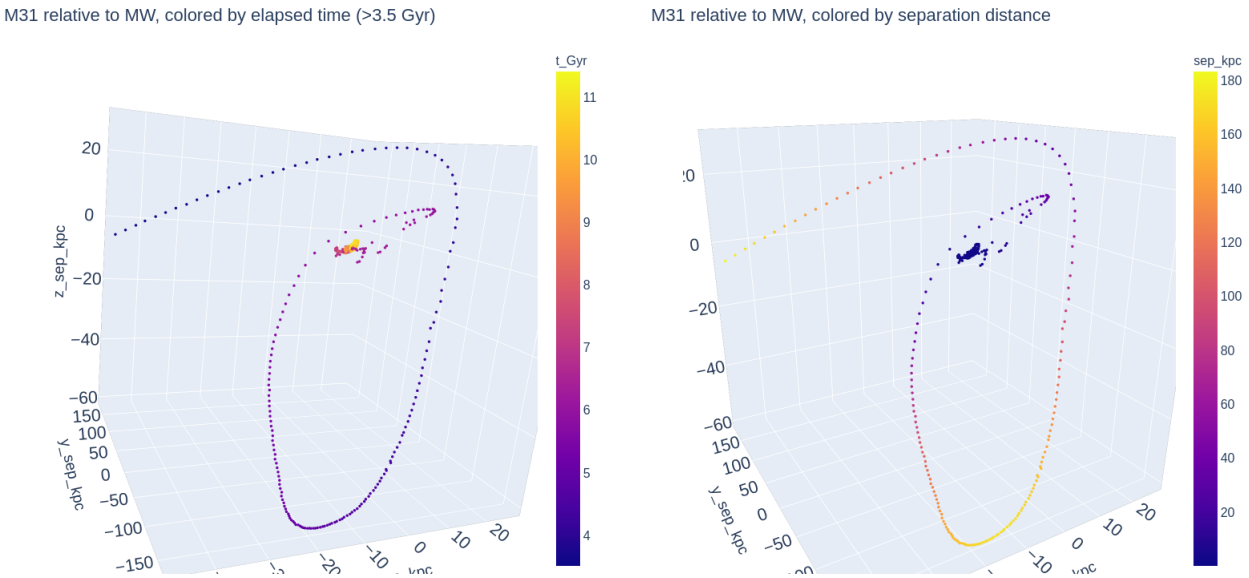
This is a bit hard to see in the graphs above (left subplot, blue line). For better mouse interactivity it was redrawn in Plotly:



How many close encounters do we expect? It depends a bit on definitions:

- at 4.8 Gyr there is a relatively benign encounter
- just after 6.0 Gyr there is a closer and more disruptive encounter, after which the galaxies barely separate
- merger happens at about 6.2 Gyr (a *very* close encounter?)

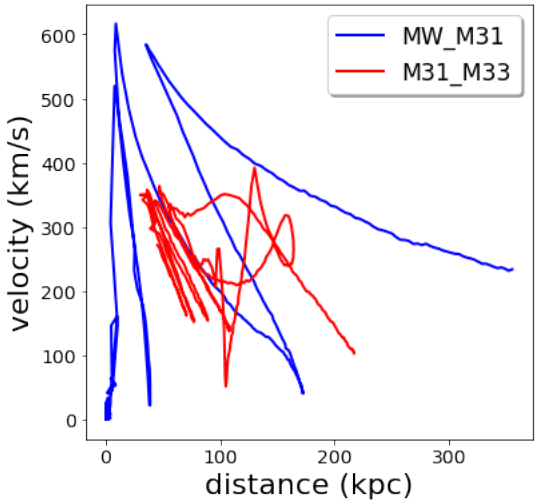
What do these look like in 3D? This definitely needs to be viewed in the browser, from many directions, but these are two attempts to make a static visualization:



In both cases, points are plotted at 1 Myr intervals, starting from 3.5 Gyr. In the left plot they are colored by elapsed time, in the right plot by separation. It's complicated...

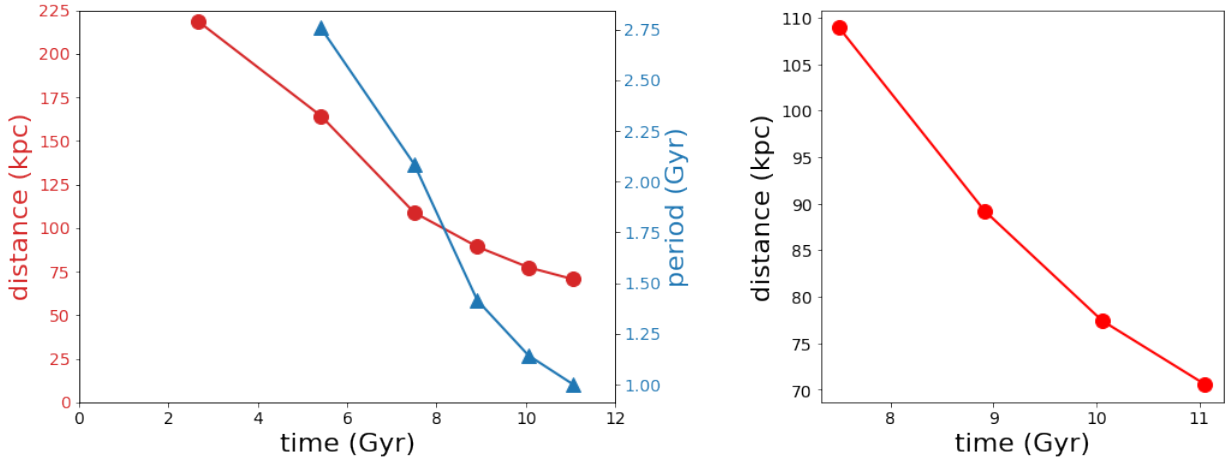
3) Separation vs Velocity

The overall trend is for higher relative velocities at smaller separations, somewhat like a Keplerian orbit of high ellipticity. However, it's not nearly as simple in this case. Points are plotted in time order, starting on the right at about 2.8 Gyr:



4) M33-M31 Merger

The galaxies reach apocenter at [2.657, 5.414, 7.50, 8.914, 10.057, 11.057] Gyr. Separation falls monotonically at successive orbits (red curves) and unsurprisingly so does the orbital period (blue curve).



The decay is non-linear, but by extrapolation from the last two points we can estimate 6.8 kpc/Gyr as an upper bound. From a 75 kpc separation, merger would take a further 11 Gyr (i.e. 22 Gyr from the start of the sim). A linear fit to all the apocenters beyond 6 Gyr gives a faster decay, with merger happening after about 6-7 Gyr.