

# Homework - 6 Astronomy 400 B

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## 1 Questions

### 1. How many close encounters will the MW and M31 experience in the future?

Milky Way and M31 experience 2 close encounters. On the 3<sup>rd</sup> – and final – encounter both the galaxies finally match.

### 2. How is the time evolution of the separation and relative velocity related?

When the distance between two galaxies is the minimum, the relative velocity between two galaxies is the maximum. When the galaxies are separated by the maximum distance, the relative velocity of the two galaxies is the minimum. This is due to the inertia of the two bodies. When they are far away, they start attracting each other due to gravitational law and start coming close. When they come to the closest distance, they have the maximum velocity and then due to inertia, they keep moving. Now, the gravitational force keeps decelerating the two bodies and then they start moving again, but in opposite directions.

### 3. When do M31 and the MW merge? (you might need to zoom in on the plot - try a log y-axis). What happens to M33's orbit when they merge?

Both these galaxies merge at roughly  $t \sim 6.5$  Gyrs. When Milky Way and M31 merge, M33 is at the apocenter, i.e., it is closest to the Milky Way, and therefore to M31 as well. After that, M33 keeps on oscillating between the apocenter and pericenter.

### 4. BONUS: What is roughly the decay rate of M33's orbit after 6 Gyr (ratio of the difference between two successive apocenters and the orbital period; you don't need to be precise). If this rate is constant, how long will it take M33 to merge with the combined MW+M31 remnant if it is at a distance of 75 kpc?

Approximately, after 6 Gyrs, the period of oscillation for M33 galaxy is  $\sim 1.25$  Gyrs and the decay of the apocenters is  $\sim 6$  kpc. Thus, the decay rate for M33's orbit is  $\tau_{decay} = \frac{6}{1.25} = 4.8$  kpc per Gyr. Given that the distance to M33 from remnant of Milky Way and M31 merger is 75 kpc, we can get the time of merger of M33 as  $t_{merge} = \frac{75 \text{ kpc}}{\tau_{decay}} = 15.63$  Gyrs.

Thus, after Milky Way and M31 merge, it will take around 15 Gyrs more years for M33 to merge.