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ASTR 400B

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## ASTR 400B – HW 7 Question Responses

### **1. How do the plots compare?**

The plots are quite similar in the beginning but differ significantly after 1.5 Gyr. The analytical position plot only oscillates once for several oscillations in the simulation position plot. The same goes for the velocity plots, with the analytical plot only oscillating once for several oscillations of the simulation plot. It seems that the simulation solution can vary on significantly shorter timescales ( $\sim 0.5$  Gyr) while the analytical solution oscillates on longer timescales ( $\sim 10$  Gyr).

### **2. What missing physics could make the difference?**

The analytical solution does not account for the presence of the Milky Way (MW). The Milky Way interacts with both M31 and M33 so the 2-body problem being solved in the analytical solution is really a 3-body problem. The addition of another body with the same mass as M31, which is 10x greater than M33, will significantly influence the position and velocity of M33 with respect to its initial role as a satellite of only M31.

### **3. The MW is missing in these calculations. How might you include its effects?**

In a broad sense, one would have to extend these calculations to account for the Milky Way as a third body. One might include these effects by again modeling M33 as a point mass, but instead of just calculating its acceleration vector with respect to the center-of-mass (CoM) of M31, one could calculate its acceleration vector with respect to the CoM of the entire system. As the Local Group approaches each other and M31 and the MW merge, M33 will no longer solely orbit the CoM of M31. So, the calculations could again be conducted with two bodies, but the two bodies might be M33 and the common CoM of the MW, M31, and M33.