Studying M33's Orbit Around M31

1 Orbit of M33 Around M31

The plot is attached in the Jupyter Notebook titled "Homework 7" for reference along with the code used to generate it.

2 Interpreting the Plots

The two plots illustrate how M33 moves around M31 over 10 billion years. The top plot tracks M33's position along the x, y, and z axes, while the bottom plot shows its velocity components.

Key observations:

- The x-position (red) steadily decreases, meaning M33 is moving closer to M31 in that direction.
- The y-position (green) initially decreases but then rises significantly after about 8 Gyr, indicating a major shift in motion.
- The z-position (blue) gradually decreases, meaning M33 is moving downward relative to M31.
- The velocity components show noticeable changes around 8 Gyr, particularly in the y and z directions, suggesting an orbital disturbance.

3 Limitations of the Model

While this simulation provides insight into M33's orbit, it lacks several key physical effects that could significantly impact its motion:

- **Dynamical Friction:** M33 should experience drag as it moves through M31's dark matter halo, gradually slowing it down.
- **Tidal Forces:** M31's gravitational pull should stretch and distort M33, which could alter its orbit.
- **M33's Extended Structure:** The model treats M33 as a point mass, but in reality, its distributed mass could change how it moves.

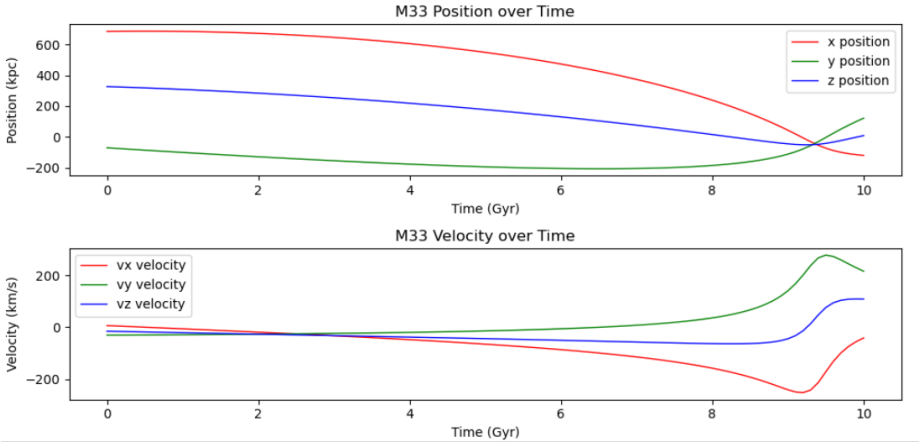

Figure 1: Figure 1: M33's position and velocity over time as it orbits M31. The top panel shows the x, y, and z components of M33's position in kiloparsecs, while the bottom panel displays the corresponding velocity components in kilometers per second. Both plots are derived from numerical integration of M33's orbit using the Leapfrog method over a 10 Gyr period.

- **The Milky Way's Influence:** The simulation assumes only M31 and M33 interact, but the Milky Way's gravity could also play a role in shaping the orbit.

4 Ways to Improve the Model

To get a more accurate representation of M33's orbit, we could enhance the model by:

- Including the Milky Way's gravitational effects to create a more complete three-body system.
- Refining M31's gravitational model to better account for its halo, disk, and bulge.
- Adjusting the initial conditions to factor in M31's motion within the Milky Way's potential.
- Adding orbital decay effects due to dynamical friction.

Implementing these improvements would help create a more realistic simulation of M33's movement as well as its interactions with surrounding galaxies.