Colliding Galaxies

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1. Overview

This project aims to simulate the collision of two galaxies using the restricted three body problem with the aim of analysing the resulting formations.

In the simulation, each galaxy has a central core mass with the stars being modelled as massless test particles. The properties of each galaxy are based on those of the Milky Way and the Andromeda galaxy (M31) so properties of the galaxies can be taken from the literature.

2. Simulation

The galactic core interactions are initially simulated using a black box integrator from the Scipy package with an initial separation of $600\ kpc$. The stars are then generated randomly around each core initially in stable circular orbits. The stars are then simulated interacting with each core using the Runge-Kutta method (4th order). The Taylor method was initially used to compute the stellar interactions due to its greater speed however it was not accurate enough over the required timesteps.

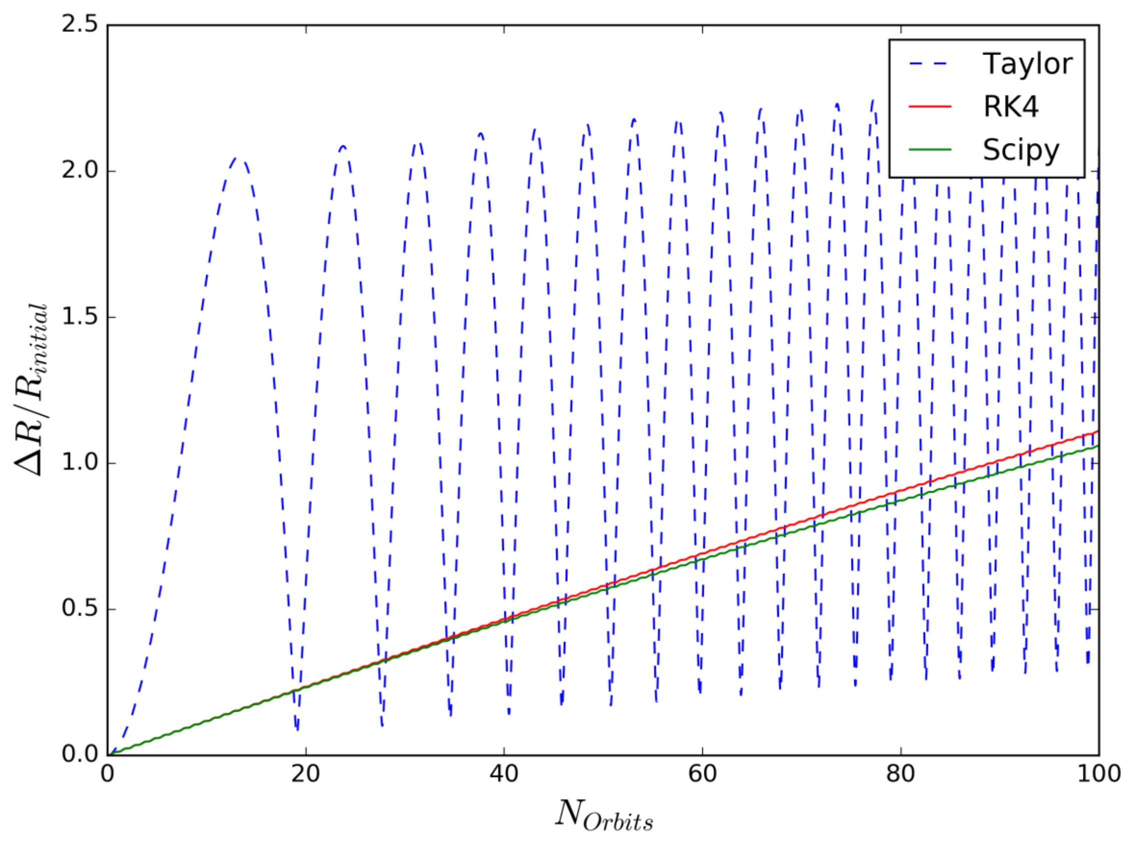

Fig. 1: The accuracy of each integrator using a star in an analytically known circular orbit around a galactic core. The total number of time steps used was 10^6.

Fig. 1 shows how chaotic the Taylor result is, RK4 and the Scipy are very similar in their results.

3. Softening Length

In reality, the entire mass of a galaxy is not centred in a single point particle. To improve the realism of the simulation, an adjustment can be made to the gravitational potentials of the galactic cores which introduces a softening length term.[1]

$$\boldsymbol{F}(\boldsymbol{r}) = -\frac{GM_1M_2\boldsymbol{r}}{(\boldsymbol{r}^2+\epsilon^2)^{\frac{3}{2}}} \qquad (1)$$

Equation (1) shows how the force acting between the gravitational cores is adjusted for the softening length term. This has the effect of putting an upper limit that can be experienced by the two masses and stops the force tending to infinity at small values of $\boldsymbol{r}$.

References

[1] Softening in N-Body simulations