Astrophysics III : Stellar and galactic dynamics

Exercises

Problem 1 :

Write down the Cartesian components of the acceleration at a point $\vec{r}$ occurring due to the presence of N particles of mass m_i situated at coordinates $\vec{r_i}$.

Problem 2 :

Using the results of Problem 1, derive a formula to calculate the circular velocity generated by this N body system.

Problem 3 :

Apply the formula from Problem 2 to calculate the rotation curve for a point-mass, Plummer sphere, homogeneous sphere and a Miyamoto-Nagai disk.

Implement them in their respective python files and verify your formula (start by implementing the point-mass).

Problem 4 :

Create a galaxy from a Plummer bulge, exponential disk and a NFW halo using vc_galaxy.py. Verify that the sum of the rotation curve for each component is identical to the one derived from the total potential.

Problem 5 :

For the galaxy generated in Problem 4, compare the contribution of each component to the vertical force (F_z) in the direction of the galactic disk, at a radius equal to that of the sun ($\sim$ 8 kpc). What about when the halo is the dominant contributor to the gravity of the galaxy ?

Problem 6 :

Demonstrate that a Keplerian potential generates elliptical orbits.