4th year physics 05.10.2022

Exercises week 2 Autumn semester 2022

Astrophysics III : Stellar and galactic dynamics <u>Exercises</u>

Problem 1:

The surface density of our Galaxy's disk is $\sim 50\,\mathrm{M}_\odot/\mathrm{pc}^2$ and its thickness is $\sim 500\,\mathrm{pc}$. Given that its mass is $\sim 1/45$ of the total mass of our Galaxy ($M_{\mathrm{tot}} = 2 \times 10^{12} M_\odot$), estimate its radius and its mean density. Given that the Sun is at $R_{\mathrm{sun}} = 8\mathrm{kpc}$ from the Galaxy center and that its rotation period is 220 Myr, estimate the mass inside a sphere of R_{sun} .

Problem 2:

For a galaxy cluster and for a galaxy, estimate the ratio between the volume of the N components and the total volume of the system. Consider a mean radius of $R_{\star} = 10^6$ km for the stars.

Problem 3:

For a galaxy cluster and for a galaxy, estimate the ratio between the volume of the tube travelled by one of the component during $t=10^{10}$ years and the total volume of the system. Consider a mean radius of $R_{\star}=10^{6}$ km for the stars.

Problem 4:

Estimate the gravitational influence radius R_G for a galaxy moving within a galaxy cluster and for a star moving within a galaxy.

Problem 5:

Assuming that the disk of galaxies are (uniformly) randomly oriented, what fraction will be seen face-on (say under 10°) between their axis of symmetry and line of sight? What fraction are seen edge-on, 10° between their equatorial plane and the line of sight?

Problem 6:

Estimate the relaxation time of the following systems, assuming that all stars are solar type ones :

- 1. An open cluster (typical radius : ~ 2 parsecs, typical velocity ~ 0.5 km s⁻¹, mass ~ 300 M_{\odot}).
- 2. A globular cluster (typical radius : ~ 3 parsecs, typical velocity ~ 6 km s⁻¹, mass $\sim 2 \times 10^5$ M_{\odot}).
- 3. A dwarf spheroidal galaxy (typical radius : ~ 500 parsecs, typical velocity $\sim 10~\rm km\,s^{-1},~mass \sim 10^7~M_\odot$).

$\underline{\text{Problem } 7}$:

Discuss briefly, why the relaxation time of a system will increase with the number of members assuming the size is held constant. (This will also help with the next problem.)