Astrophysics III : Stellar and galactic dynamics

Exercises

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 ($M_{\rm tot} = 2 \times 10^{12} M_\odot$), estimate its radius and its mean density. Given that the Sun is at $R_{\rm sun} = 8$kpc from the Galaxy center and that its rotation period is 220 Myr, estimate the mass inside a sphere of $R_{\rm sun}$.

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

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.)