

## Astrophysics IV : Stellar and galactic dynamics

Exercises**Problem 1 :**

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

**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  $R_\star = 10^6 \text{ km}$  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  $R_\star = 10^6 \text{ km}$  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  $10^\circ$ ) between their axis of symmetry and line of sight? What fraction are seen edge-on,  $10^\circ$  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 :  $\sim 2 \text{ parsecs}$ , typical velocity  $\sim 0.5 \text{ km s}^{-1}$ , mass  $\sim 300 \text{ M}_\odot$ ).
2. A globular cluster (typical radius :  $\sim 3 \text{ parsecs}$ , typical velocity  $\sim 6 \text{ km s}^{-1}$ , mass  $\sim 2 \times 10^5 \text{ M}_\odot$ ).
3. A dwarf spheroidal galaxy (typical radius :  $\sim 500 \text{ parsecs}$ , typical velocity  $\sim 10 \text{ km s}^{-1}$ , mass  $\sim 10^7 \text{ M}_\odot$ ).

**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.)