Problems for lectures on the Milky Way (30/10/12 - 9/11/12)

1. What is the mean distance between disc stars?

2. If disc stars have vertical oscillations with frequency equal to the orbital frequency, what are their typical vertical speeds, given that the stellar disc has total thickness of 1 kpc? Look up the value of the frequency of vertical oscillations near the Sun. Why is this larger than the orbital frequency?

3. What is the mean number density of gas in the ISM?

4. About half the gas mass in the disc is in molecular clouds. Assuming each cloud has a mass of 10^6 M_sun, estimate the volume fraction of molecular clouds.

5. The total mass of dust is about 10^8 M_sun.

a) Assuming a reasonable mass per grain, estimate the number density of dust grains.

b) Assuming that the absorption cross-section for optical light is equal to the geometrical cross-sectional area of a grain, estimatethe mean free path for absorption. Then estimate the optical depths toward (i) Galactic centre; (ii) Galactic anti-centre; (iii) Galactic pole.

6. Given that the sun is at a distance of 8.5 kpc from the Galactic centre, and its circular speed is 240 km/s, estimate the mass of dark matter within the solar circle (assume that the dark matter distribution is spherically symmetric).

7. Assume that a globular cluster has mass equal to 10^5 M_sun, and radius 10 pc.

a) What is the mean number density of stars in the cluster? How does the mean distance between these stars compare with the distanceto the nearest star from the sun?

b) What is the rms velocity of stars? What is the crossing time of a star?

8. Repeat estimates of problem 6 for an Open Cluster of 10^3 stars in a region of size about a parsec.

9. Consider a "material" radial arm extending from a galactic radius of 4 kpc to 10 kpc at some initial time. Due to differential rotation, this hypothetical radial line winds up into a "material" spiral arm. Assuming a flat rotation curve, estimate the pitch angle of the spiral after 10^{10} yr.

10. Assume that a spiral density wave has coronation radius at 15 kpc. What is the relative speed between the sun and wave? Compare this relative speed with sound speed in (i) a molecular cloud at T= 10 K; (ii) HI gas with T = 100 K ?
