

HOMEWORK PROBLEMS:

1. (100 points) The orbital speed of the Sun around the Galactic Center is  $220 \text{ km s}^{-1}$ , and the Sun is located at about 25,000 light years from the Galactic Center.

a.) If you were outside the Milky Way and observing it "edge-on" with a telescope, what would be the observed wavelength of the Doppler-shifted HI spectral line at the position of the Sun? Assume the Sun is moving directly away from you. The rest wavelength of the HI line is 21.12 cm.

[HINT: Must take care with significant figures!]

b.) Calculate the orbital period of the Sun around the center of the Milky Way.

c.) Calculate approximately how many times our solar system has orbited the center of our Galaxy since the Sun and planets formed.

[You need to know the age of the Earth and Sun for this, which you can look up.]

[...and you must show a calculation.]

d.) What is the mass of the galaxy inside the radius of the Sun's orbit (in units of solar masses)?

e.) Gas located 50,000 light years from the Galactic Center also has a circular orbital speed of  $220 \text{ km s}^{-1}$ . What is the total mass of the galaxy inside a radius of 50,000 light years (in solar masses)?

f.) Suppose that astronomers somehow determine the mass in stars and gas inside a radius of 50,000 light years to be  $2.0 \times 10^{10}$  solar masses. What is the total mass of Dark Matter in the galaxy, inside a radius of 50,000 light years? What fraction of the total mass is Dark Matter?

g.) If there were no additional mass in the Galaxy beyond the radius of the Sun's orbit, what would the orbital speed be at a radius of 50,000 light years?

[HINT: Use the ratio method to solve this problem! This is much easier than doing it out the long way!]