Problem Set #2: The Milky Way Disk

Due: Monday, September 28 by 5pm to Dickinson 104

1. *Extragalactic Astronomy and Cosmology*, Problem 2.2
2. The International Astronomical Union (IAU) recognized values for the Galactocentric radius and velocity of the Sun are R_0=8.5 kpc and v_0=220 km s^{-1}. Using these values, show that it takes the Sun about 240 Myr to complete one orbit around the Galactic center (this period is sometimes called a "Galactic Year").
3. As we talked about in class, the vertical stellar distribution in the disk (for both the thin and thick disk) is well-modeled by an exponential. The *radial* distribution of stars is also well modeled by an exponential. Taken together, Equation 2.35 describes the density of stars at any radius R and at any height z:

$$n(R,z) = n_0\left(e^{-|z|/h_{\text{thin}}} + 0.02e^{-|z|/h_{\text{thick}}}\right)e^{-R/h_R}$$

   The constant of proportionality n_0 is just going to be the stellar density at the disk center midplane (i.e. at R=0, z=0). Assume h_{thin}=325 pc, h_{thick}=1.5 kpc, h_R=3.5 kpc.
   a. For the disk at the Galactic location of the Sun (R=8.5 kpc, z= 30pc), the stellar density is ~0.2 stars/pc^3. Use this information to determine n_0.
   b. Use Gnuplot (or your favorite non-Excel, non-Desmos plotting software) to plot how the stellar density falls as one goes out both radially (within the disk midplane) and vertically (at the Galactic radius of the Sun). Your x-axes should be a multiple of scale lengths/heights (i.e. "1 scale height, 2 scale heights, etc") and your y-axes should be an actual number for stellar density. Make sure to label your axes appropriately.
   c. Looking at your plots for (b), how many scale lengths/heights do you think are a good estimate for the "size" of the stellar disk?
4. Problem Set 1, revisited. Refer to the table you created in Problem Set 1. Consider what it would require to observe a volume-limited sample of galaxies complete to an absolute magnitude of M_B=-12. You would, according to column 7, need to catalog and obtain redshifts for every galaxy in your survey down to m_B=22. That is, you'd need to observe a magnitude-limited sample of galaxies to m_B=22. Note that this *is* possible observationally; our telescopes and detectors are able to work that faint. Using the attached table, recompute the numbers in columns 3-5 of the table for a magnitude-limited sample complete to m_B=22 (you *don't* need to show your work here and are welcome to use a tool like Excel to make this easier). How many galaxies would you need to observe in total in order to allow you to include the 1264 galaxies with M_B=-12? Assume that you can obtain spectra (for redshifts) of 200 galaxies per night (this would be *very* ambitious on a traditional spectrograph). How long would it take you to obtain redshifts for your entire sample? Now do you understand why volume-limited samples are virtually impossible to obtain? Comment. Finally, use Google to find how many spectra the Sloan Digital Sky Survey can observe on one "plate" (one pointing of the telescope). Do you understand why SDSS was a game changer?

M_B	ϕ	Distance – D [Mpc]	Volume – V [Mpc^3]	Number Mag. Limited	Number Vol. Limited	m_B
(1)	(2)	(3)	(4)	(5)	(6)	(7)
-10.0	0.2528					
-12.0	0.1264					
-14.0	0.0632					
-16.0	0.0316					
-18.0	0.0158					
-20.0	0.0042					
-22.0	0.000016					