Astronomy 253 — Group Problems 4
Friday, February 13

Do the problems on separate sheets of paper. Each group will turn in only one set of solutions. Make sure your solutions are clear enough that I can understand what you were doing and what you were thinking! You probably won't get through all of these problems in an hour; that is OK. Do all problems in order.

1. You observe a spiral galaxy which is nearly face-on. You observe a spot on this galaxy which is well outside the bulge, but still well within the visible disk. This spot has a V-band surface brightness of 20 magnitudes per square arcsecond.

   (a) At this spot in the galaxy, what is the V-band "surface luminosity" in units of $L_\odot/pc^2$? (I.e., how much light is emitted from one square parsec of the galaxy.) Note that the absolute magnitude of the Sun is about 4.8 in the V-band.

   (b) Sketch two pictures of this galaxy, one as observed face on, one as observed edge on. Shade the region where the light you're looking at is emerging from in both sketches.

   (c) Make a very rough estimate of the total mass of stars in one square parsec of this region the disk, integrated through the height of the disk.

   (d) Assume the stellar population is similar to that of the Solar Neighborhood. What is the total number of stars that is emitting the light you see from one square? (Hint: see figure 2.3 in your book.)

2. You observe the metallicity and v_z (the velocity perpendicular to the plane of the Galactic disk) of a large number of stars. If you plot $|v_z|$ vs. the metallicity for all of these stars, what trends might you expect to see, and why? Consider what you've read about vertical velocities (see Section 2.2.2 and Figure 2.8) and what we've talked about this week about metallicities. (Hint: there may be more than one thing contributing to this! If you come up with just one reason, ask Prof. Knop to provide you with an additional challenge.)

(Turn page over for more problems)

3. Suppose a spiral galaxy has a surface brightness profile as given by Equation 5.1 in Sparke & Gallagher. Suppose that this particular galaxy has $h_R = 5\,\mathrm{kpc}$.

   (a) At what distance from the center of the galaxy (in kpc) will the surface brightness drop to 1/2 of its central value?

   (b) What fraction of the "star mass" in this galaxy is closer to the center than this distance? (assume a constant mass-to-light ratio, a negligible bulge, and if you understand why it might be relevant, a constant vertical scale height).

   (d) Suppose this galaxy is at a distance of 15kpc. What is the angular separation you would observe between the center of the galaxy and a point at the distance from the center you calculated in part (a)?

   (e) If the central surface brightness observed is 15 magnitudes per square arcsecond, what surface brightness will you observe at the position you found in part (d)?

   (f) Make a sketch of μ vs. r, where mu is the surface brightness in magnitudes per square arcsecond, and r is the distance from the center of this galaxy in kpc.

4. Sparke & Gallagher problem 2.4. (**Hard!** But working through this one and thinking about what your result means could help you "get" what is going on with a mix of star ages and the evolution of the color of a system with a changing star formation rate.)