Astronomy 253, Spring 2004
Problem Set 3

Due Friday, April 2

Those problems marked "[**solo**]" you must do on your own, without talking to anybody else other than the instructor. On all other problems, you may discuss the problems with anybody, though of course the final solution you present must be your own.

1. [**solo**] Briefly describe the primary evidence for the existence of dark matter in spiral galaxies like the Milky Way.

   It turns out that there is evidence that there is as large a fraction, or a greater fraction, of dark matter within clusters of galaxies. Clusters, however, do not show an ordered rotation. What observations would lead to the conclusion of dark matter in clusters? Be sure to describe the quantities that would be measured, and give some indication how they would be measured. Also be sure to clearly state which of these quantities are either too large or too small compared to what you would expect if there *weren't* dark matter.

2. Repeat the analysis of the timescale for a strong encounter. However, instead of figuring out when two stars collide, figure out how often gas molecules collide. Assume a typical interstellar density (one particle per cubic centimeter), and assume gas at 80 Kelvin. Make whatever other assumptions are necessary and reasonable. Is the timescale you calculate for collisions between gas molecules "long" or "short"? Justify your assertion by comparing to other timescales of relevance.

3. *Sparke & Gallagher*, problem 3.2 (page 98).

. . . Continued on reverse. . .

4. An astronomer observes three blobs of gas in the plane of the Galaxy. Each blob of gas is at a measured galactic longitude l and has a measured radial velocity V_r in the Local Standard of Rest (where a positive velocity means it's moving away from us, and a negative velocity means it's moving toward us). He measures for each object:

Blob	l	V_r (km/s)
A	23.8°	89
B	-26.6°	-98
C	111.7°	-68

(a) Derive an expression for R, the distance of a blob from the center of the Galaxy, in terms of known quantities. Known quantities include R_0, the distance of the Sun from the center of the Galaxy; $V = V_0$, the velocity of an object relative to the Galaxy (assumed to be the same everywhere in the galactic disk); and the measured quantities l and V_r.

(b) Derive an expression for d, the distance from the Sun to the observed blob of gas, in terms of the known quantities from (a) and R.

(c) For the three blobs given, evaluate and tabulate all possible values of R and d. Use $R_0 = 8$ kpc and $V = V_0 = 220$ km/s.

(d) Sketch a schematic diagram of the Galaxy, as seen by an observer looking down on the plane of the Galaxy. Indicate the position of the Galactic Center, the Sun, and the possible positions of each of the three blobs on this diagram.

(e) Look at Figure 2.18 on page 80 of S&G; think about where each of your blobs fall on this diagram, and what insight this gives you about the physical location of gas plotted at different places in this figure. (There is nothing to write for this section, but if you don't do the proper pondering our Thought Police will find out and fail you out of Vanderbilt.)