

Astro 730—Homework 2
Due in Class February 18, 2008
Galactic Structure & Structure of Galaxies

Readings:

1. An excellent introduction to the astrophysics underlying much of stellar Galactic astronomy is contained in the proceedings of the Saas-Fee advanced course, “The Milky Way as a Galaxy”. This book is on reserve in the Woodman Library. You should read Chapter 7-7.6 by Ivan King (now emeritus faculty UC Berkeley) for perhaps the best available introduction to the collisionless Boltzmann equation.
 - a. What are the assumptions under which the collisionless Boltzmann equation can be applied to a stellar system?
 - b. Why is the Milky Way the only galaxy where we can observationally test our understanding of the application Boltzmann equation to stellar dynamics? What do we need to measure to gain this understanding?
 - c. Explain why figure 7.2 indicates that orbits can behave in ways that differ from the expectations of the quasi-ergodic approximation. (Hint: How would this figure look for an orbit that was quasi-ergodic?)
 - d. (*Extra*) Discuss the implications of King’s statement at the bottom of section 7.4 that something like a third integral exists. In particular does this have implications for the number of orbit families that might exist in the Milky Way disk?

2. Show why the Galactic rotation curve is best known for radii of about 3-8 kpc.
 - a. Show how measurements of Oort’s A and B constants allow us to find the circular velocity of the Sun, V_0 .
 - b. What are the issues for finding the rotation curve for $R < 3$ kpc and for $R > R(\text{sun}) > 8$ kpc?
 - c. The mass of the Milky Way (and other galaxies) can be estimated from the HI rotation curve, usually using $M_T = V_c^2 R / G$. What are the limitations of this technique? How does this approach demonstrate the presence of “dark matter” in our Galaxy?
 - d. Show how studies of the velocity dispersions and densities of stars can be used to determine the local mass surface density of the Galactic disk. How would the results be biased if we did not allow for the possibility that 2 disks are present—e.g. if we assumed that thick disk stars actually were part of the thin disk? Explain how this type of study can be used to constrain whether dark matter exists in the Galactic disk? (*Extra*: You might think about what would happen if in galaxy disks only the HI component of contain the dark matter. There is some observational evidence for this possibility. As a challenge see if you can find a discussion of this in the literature by giving one or two references.)

3. As a professional astronomer you should know how to draw plans of the Milky Way as seen from the side and above and label the major components and note their relevant spatial scales (this is a favorite short prelim question).
 - a. Try your hand at drawing the total mass density versus radius from $1-10^5$ pc on a log-log plot. Note what form of matter dominates at the various radii. Briefly explain how you made your plot. (*Extra:* Briefly discuss the implications of this plot for models of galaxy formation.)

4. Classify the galaxies M60, M81, M101, M104, NGC3104, NGC3190, NGC3338, NGC4214, NGC4636, NGC4643, NGC4565, NGC5033, NGC5162, and NGC5701 on the standard “Hubble” system using the Sloan Digital Sky Survey images on the web at
 - a. How do these galaxy types compare with those in images of the Coma and Perseus galaxy clusters (and also the NGC5919 can help)? What might this imply regarding the relationship between the local densities of galaxies and galaxy structures? (*Extra:* How does the case of NGC1129 fit with your conclusions?)
 - b. Now consider Seyfert’s Sextet, Stephen’s Quintet, and the galaxy cluster Abell 2151 (from a catalog of galaxy clusters made by astronomer George Abell using the then relatively new photographs from Palomar Sky Survey under taken with the 1.2-m Schmidt telescope). How does this fit with your ideas?
 - c. Consider a pure S0 disk galaxy (no bulge) and an E0 elliptical galaxy, which are at the same distance with the same optical colors and apparent magnitudes. Furthermore this pair of galaxies is similar in size in that the elliptical galaxy’s R_{eff} is equal to the radial scale length of the S0 system’s disk scale length of α^{-1} . How do the total stellar masses of these two galaxies compare? Their stellar densities? (*Extra:* New galaxies can be made by merging two pre-existing stellar systems. Do you think that the S0 could be made from a merger of 2 E0 galaxies? Explain.)