Ay 124 – Final (Observational Part)

Posted on Friday, March 13 – Due by 5 pm on Wednesday, March 18 (directly to the TA)

Note:

You have up to 2 hours to do this part, and it counts for 35% of your final exam grade. Then you have up to 3.5 hours to do the theoretical part, which counts for 65%. You can do them in any order, with a break in between. Please mark your exams with the start and end times.

The Rules:

Closed book, closed notes, etc. No collaboration. You cannot discuss the exam with anyone, until everyone in the class has turned in their test.

Good Luck!

Ay 124 – Final Exam (Observational Part)

1. [9 points] Assume that both mass and light density in Galaxy's disk are distributed as:

$$\rho(r,z) = \rho_0 \, exp(-r/a) \, exp(-z/h)$$

where the scale height is h = 300 pc, and the scale length is a = 4 kpc. Assume that at $R_\odot$= 8 kpc, the mean number density in the Galactic plane is 0.1 stars/pc^3; an average star mass of 0.3 $M_\odot$, and an average luminosity of 0.1 $L_\odot$.

a. What is the implied luminosity and mass density in the center of our Galaxy? What is the corresponding mean separation between stars there? [2 pts]

b. Compute the total luminosity and mass of the disk. [3 pts]

c. Assuming that the bulge and the stellar halo together have the same mass and luminosity as the disk, compute the total absolute magnitude in the *V* band of our Galaxy, assuming that its integrated spectrum is of a G type. [2 pts]

d. Assuming that the average luminosity of our Galaxy over its lifetime of about 12 Gyr is twice the present luminosity (which you just computed), what is the total amount of energy radiated away by our Galaxy so far? [2 pts]

2. [11 points] Assume the disk mass computed in problem above, rotating with a constant circular speed of V_c = 220 km/s, and having the velocity dispersion of 30 km/s in each coordinate.

a. Compute the total kinetic energy of the Galactic disk. [3 pts]

b. What is the ratio of the kinetic energy in the rotational and random components? [1 pt]

c. Compute the angular momentum of the disk, due to the rotation alone. [3 pts]

d. Assume that the bulge has the same mass as the disk, no rotation, and a velocity dispersion of 120 km/s in each coordinate. What is its total kinetic energy? [2 pts]

e. Add up the kinetic energies of the disk and the bulge, and assume our Galaxy to be in the virial equilibrium. What is its estimated binding energy? How does it compare with the total radiated energy you computed at the end of the previous problem? [2 pts]

3. [15 points] Explain briefly more than a paragraph, but less than a page each):

a. Define the concept of stellar populations. What are the relevant physical parameters? Give a brief quantitative description of the stellar populations in our Galaxy, and list some specific membership. [3 pts]

b. What is the Eggen, Lynden-Bell, & Sandage picture of the formation of our Galaxy, and what are the more modern developments? List some observational arguments for and against the stellar halo formation in a single free-fall time. [3 pts]

c. Compare the kinetic energies of stars in a disk galaxy which correspond to the random and ordered (rotation) motions; compare that with the ratio of disk scale heights and scale lengths. What can you say about the importance of mergers for galaxy disks? [3 pts]

d. Which dynamical processes are important for the evolution of the Galactic disk, open clusters, globular clusters? Give quantitative estimates of the relevant physical quantities for each. [3 pts]

e. What is the gravothermal catastrophe (core collapse), why does it happen, and in which systems it is (or is not) important? How can it be arrested and reversed? Mention at least two distinct situations in which core collapse plays an important role. [3 pts]