Astronomy 330 / Galaxies

Problem Set 5

Due: Friday 03 December 2010

Problem 1. (a) Convert km/s into kpc/Gyr. **(b)** Come up with an astronomically or astrophysically relevant scale for the speedometer on your car that keeps the units of the same order of magnitude as the current values. (Extra credit: mass produce these and sell them to GM or Ford.)

Problem 2. Use the virial theorem (and other simplifying assumptions) to derive an expression for the fundamental plane of elliptical galaxies.

Problem 3. In this problem you will start to work out some simple relations for how disks like the Milky Way's might have been heated through diffusion. For boundary conditions assume: (i) Stars are born in a gas layer characterized by a vertical velocity dispersion σ_b and exponential scale-height z_b; the stars initially share these phase-space attributes; these properties are independent of radius within the disk. (ii) The disk is characterized by a radial mass surface-density distribution, Σ, that is exponential with a scale length of h_R and constant in time. (iii) After stars are born they are heated by a diffusion process involving a variety of massive objects, e.g., giant molecular clouds, spiral arms, globular clusters, and satellite galaxies and dark halos. (iv) Today, the disk is characterized by a vertical distribution that is exponential, with scale-height h_z constant with radius. (v) The disk can always be treated as a system in dynamical equilibrium.

- **(a)** Derive an expression relating the radial trend of σ_z *today* with radius [$\sigma_z(R,t_0)$], where t_0 is the age of the galaxy disk today. Comment on how the radial trend is related to, or differs from that of Σ.
- **(b)** Derive an expression which describes the evolution of $\sigma_z(R,t)$ for disk stars given the boundary conditions above and the unknown parameters of diffusion.
- **(c)** Use these results to derive constraints on the radial trend of the disk-heating coefficient, **n**, with radius assuming a fixed heating time-scale, τ_H.
- **(d)** Repeat (c), but instead solving for τ_H assuming fixed **n**.
- **(e)** Assume that τ_H is given by the dynamical time-scale of the disk (at each radius). For a disk like the Milky Way, what are the values of τ_H and **n** at $R/h_R = 1$ and 3 for $t_0 = 10$ Gyr. How does this change if $t_0 = 6$ Gyr? For $t_0 = 3$ Gyr? What do the differences or similarities in **n** tell you about the diffusion process in the disk?

Problem 4. Do Problems 4.6, 4.7, 7.1, 7.8, 8.1, and 8.2 in Sparke & Gallagher (these are all connected).