<u>ASTR 3710: Problem Set #2</u>

(due in class Thursday October 3rd)

1. The website http://exoplanets.org/table maintains a list (the "Orbit database", ignore the "Kepler" and "other" data tables for now) of extrasolar planets with well-determined orbital properties:

   (a) Consider planets with "masses" (these are mostly M.sin(i), for the reasons discussed in class) between 0.2 and 5 Jupiter masses, and semi-major axes greater than 0.5 AU. Plot the distribution of eccentricity for these planets, and determine the mean and median eccentricity.
   (b) Split the sample above into high mass and low mass subsamples, choosing the dividing line such that there are equal numbers of objects in both. Plot the eccentricity distribution for the two samples.
   (c) Do you think the eccentricities of high mass extrasolar planets are significantly different from low mass extrasolar planets? Justify your answer (statistical reasoning here would be good, but is not required).

2. Suppose the angular momentum associated with Jupiter's orbit was instantaneously transferred to the Sun. *Estimate* how fast the Sun would rotate.

3. Consider a protoplanetary disk extending from r_{in} to r_{out}, with a surface density profile $\Sigma = \Sigma_0 r^{-1}$.

   (a) Write down an expression for the specific (per unit mass) binding energy of gas in the disk at radius r, accounting for both kinetic and gravitational terms.
   (b) By integrating over the disk surface (remember there is more area at large radii), determine the total binding energy of the disk. This is the amount of energy that would need to be added to the gas to unbind it from the star and move it to infinity.
   (c) If the surface density at 1 AU is 10^3 g cm^{-2}, r_{in} = 0.1 AU, and r_{out} = 100 AU, evaluate the binding energy numerically.
   (d) Suppose the disk absorbs ¼ of the radiation emitted by the star, which you can assume has a Solar luminosity. How long would it take before the disk absorbs enough energy to, in principle, become unbound.
   (e) Comment on your result in light of what we know about protoplanetary disk lifetimes.