Astronomy 475/575: Homework 3

Problems 1–2 are to be completed by all students. Problem 3 is intended for graduate students. Others are free to attempt, but not required to do so.

1. Assume that the solar system as we know it now was formed out of a disk with a mass of 0.05 $M_\odot$. Assume that 1% if this disk consisted of solid matter, and the rest consisted of gas. Assume further that the gas disappeared after 5 Myr. If we change the following, how would the resultant planetary system differ from ours (for example, in terms of planet masses, orbits, or compositions)?

   (a) If we increased the total disk mass by a factor of 10?

   (b) If we increased the percentage of solids to 10%?

   (c) If we allowed the gaseous disk to survive for 50 Myr?

   (d) If the gaseous disk disappeared in 1000 yr?

2. Take the current planet Neptune, with $a \approx 30$ AU, $R \approx 2.5 \times 10^9$ cm, $M \approx 10^{29}$ g.

   (a) Calculate the Hill radius of Neptune.

   (b) Assume that 100% of Neptune's current mass was accreted from planetesimals within its feeding zone, and that the current mass of Neptune is equal to the isolation mass. Compute the mass surface density within the feeding zone.

   (c) Using $v_{\rm esc}/v = 10$ =constant, determine the time for Neptune to attain its current mass (v is the random velocity of planetesimals and $v_{\rm esc}$ is the escape velocity for the growing Neptune).

   (d) If Neptune formed at $a = 10$ AU, how would your answers change?

3. Compute the minimum size a meteorite must have in order to impact the surface of the Earth. You will need to make reasonable assumptions about the density, composition, and scale height of Earth's atmosphere, as well the density and velocity of the meteor. (*Hint: Derive the stopping time for the meteor as it passes through Earth's atmosphere.*)