HOMEWORK # 2, FRS 126, SPRING 2013

DUE FEB 20

1. Temperatures of planets (45 points)
We can compute the equilibrium temperature of the Earth can be calculated by assuming that it absorbs all the energy it receives from the Sun, and re-radiates it as a blackbody. This implies that the mean temperature at the planet surface, T_p, can be related to d, the planet's distance from the star, the star's temperature, T_* and the star's radius, R_*

$$T_p = T_* \sqrt{\frac{R_*}{2d}} \tag{1}$$

In this problem, you will derive the surface temperature of several planets. The data for the planets can be found on the web site: http://exoplanet.eu/catalog-transit.php The planets you should consider are:

- Kepler 9b
- HAT-P-2
- Kepler 33-f
- Corot-9b

Note that you will need to click on the planet name to get more information.

(a) Using the data on the web site above, calculate the equilibrium surface temperature for each of the planets listed above. You may ignore the effects of albedo and greenhouse effect on these planets (after all, we know absolutely nothing about their atmospheres!). (25 points)

(b) Is it possible that liquid water can exist on the surface of any of these planets, assuming that they have an atmospheric pressure similar to that of the surface of the Earth? Discuss. (10 points)

(c) Some of the planets have very eccentric orbits (i.e., with eccentricity more than 0.2). Discuss what effect this might have on any life that might exist on them, and the presence of liquid water. *Hint: The eccentricity of an orbit refers to how squashed it is. A perfect circle has an eccentricity of 0; the most flattened ellipse has an eccentricity of 1.* (10 points)

2. Inferring the Properties of a Transiting Planet (55 Points)
You read in next month's New York Times that Kepler has detected a planet around a Solar-type star (assume its mass, temperature and radius is the same as the Sun). The eclipses have a 300 day period and the maximum eclipse depth is 10^{-4} times the average flux. Follow-up observations find that the star's radial velocity, $v_{star} = 1$ cm/s.

(a) Estimate the radius of the planet (10 points)
(b) Estimate its distance from the star (10 points)
(c) Estimate the mass of the planet (15 points). Recall that for a circular orbit

$$v_{planet}^2 = \frac{GM_{star}}{r}$$

where r is the distance from the star and that conservation of momentum implies

$$M_{star} v_{star} = M_{planet} v_{planet}$$

(d) Estimate the mean density of the planet. Based on its mean density, speculate about its composition (hydrogen gas dominated [density $<< 1$ gm/cm^3],water [density $= 1$ gm/cm^3]), Earth-like, or Mercury-like) (10 points)
(e) Estimate the mean temperature of the planet. (10 points)