Ast 7939: Exoplanets (Fall 2008) Homework Set #1

1. According to Kepler's third law, the orbital period and semi-major axis are related by, $G (M_* + m_{pl}) P^2 = 4\pi^2 a^3$, where G is the gravitational constant, $M_*$ is the mass of the host star, $m_{pl}$ is the mass of the planet, P is the orbital period, and a is the semi-major axis (the mean star-planet separation). If P is measured in years, and a is measured in AU, and masses are measured in solar masses, then $G = 4\pi^2$. Assuming a planet travels on a circular orbit, derive an expression for the amplitude of radial velocity variations in the host star due to the perturbations of the host planet. Use Kepler's third law to eliminate the semi-major axis in favor of the orbital period and masses.

2. For each of your host stars, what is/is known about the:

a. Typical precision of published radial velocity measurements?

b. Expected radial velocity "jitter" (see Wright 2005 PASP 117, 657, if not mentioned in your discovery paper)

c. Number of published radial velocity observations?

d. Time between the first and last published radial velocity observations?

e. Rotation rate and/or rotational velocity?

f. Extent of stellar activity?

g. Stellar mass?

h. Stellar radius?

i. Typical precision of published photometric observations?

j. Time between successive photometric observations?

3. For each of your planets, what is/would be* the:

a. Orbital period?

b. K, the radial velocity amplitude (of the host star due to each planet in isolation)?

c. Percent decrease in brightness of host star if/when the planet were to transit (neglecting limb darkening)?

d. Probability of the planet transiting the host star (assuming that orbital planets are oriented randomly as viewed from the Earth)?

* = For example, if one of your planets is 51 Pegasi b, then you could look up the observed orbital period and radial velocity amplitude. However, since the planet that is not known to transit the star, you could not use an observed planet radius. Instead, you could estimate the radius, perhaps based on the radius of a similar planet or perhaps by making a reasonable assumption for the density.

4. Based on the above data, is there a significant chance that the "detection" of any of your "planets" could in fact be due to measurement errors or astrophysical noise sources? If so, what other lines of reasoning can be used to substantiate or discredit the planet candidate? Is there a significant chance that any of the planets in your multiple planet system might actually transit their host star (as seen from Earth)? Explain your reasoning.

5. After searching for your discovery paper in ADS, you can use the citations "C" link to find subsequent papers that cite the discovery paper. Have any such papers have led to revisions in the physical or orbital parameters of your planets? If so, has the size of these revisions been comparable to what would have been expected based on the previously published uncertainty estimates?