1 Finding exoplanets

Finding planets outside our solar system, also known as exoplanets, can be extremely difficult for a variety of reasons. One trick astronomers use to find them is the transit method. This can be seen in the diagram below. When a planet passes right in front of its star, it reduces the amount of light from that star that we receive (kind of like a very mini solar eclipse). We call the small "dip" in brightness the transit depth, which can be calculated using

$$\Delta F = \left(\frac{R_p}{R_s}\right)^2$$

where R_p is the radius of the planet and R_s is the radius of the star.

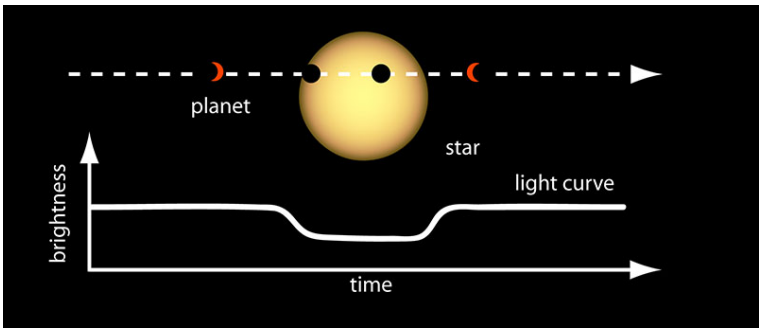

Figure 1: Transit of a planet across its star

For the following questions you will need to consider some useful equations:

Kepler's 3rd law:

$$P^2 = \frac{4\pi}{GM_s} r_p^3$$

where $G = 6.67 * 10^{-11}$N m^{2}kg^{-2}, P is the orbital period, and M_s is the mass of the star (assuming $M_s >> M_p$)

We can also relate the masses of the star and planet to their orbital radii and velocity:

$$M_s r_s = M_p r_p$$
$$M_s v_s = M_p v_p$$

where r is the orbital radius and v is the orbital velocity

1.1 Question 1

Astronomers are observing a transit with a star $M_s = M_\odot$ (where $M_\odot$ is the mass of our sun, $M_\odot = 1.99 * 10^{30} kg$) and radius $R_s = R_\odot = 6.96 * 10^8 m$. The transit depth is $\Delta F = 0.01$ and the time between transits is 52 days. The **star's** maximum velocity is measured to be 8km/s. (Yes! When large planets are in orbit around a star, the star can have an orbit as well.) Assume all orbits are circular and that we are looking at the system head on (ie. the planet passes across the largest diameter of the star).

1. To start, find the radius of the planet.

2. Next find the velocity of the planet around the star!

3. What is the total transit time (time it takes the planet to pass from one side of the star to the other

4. What is the mass of the planet?

1.2 Question 2

For this question we are going to discuss some more conceptual ideas regarding the transit method.

1. What would some limitations of the transit method be? Think of stated or implicit assumptions we have made in the previous problem to do our calculations.

2. How might the limitations of the transit method make the observation of exoplanets difficult? How might these limitations be overcome?

3. How could the transit method be used to find other properties of exoplanets?