Name:_____ April 21, 2014

Algebra II/Trig: Exoplanets

1 The Kepler Telescope

The **Kepler Observatory** is a telescope designed to find exo-planets, which are planets outside our solar system. It looks for **transit** dips in the light of a star that happen when the planet passes in front of the star

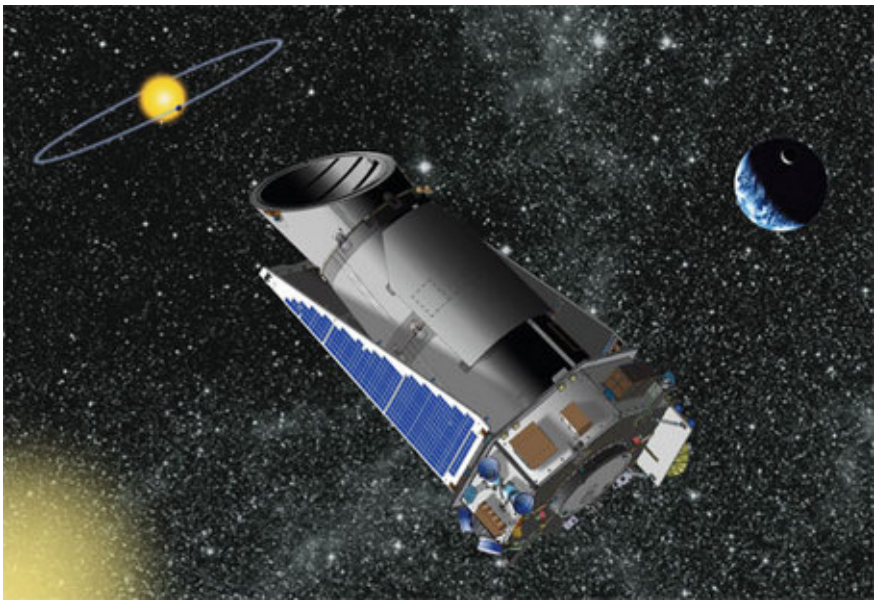

Figure 1: The Kepler Telescope observing a planet outside our solar system.

Kepler is designed to find planets like Earth that could potentially support life.

2 Planetary Transit

A **transit** happens when a planet orbits in front of a star, partially blocking some of the light from the star. By measuring how much light was blocked for how long, astronomers can determine how long a year is on an exo-planet, and how fast the planet is orbiting its host star.

3 Light Curve

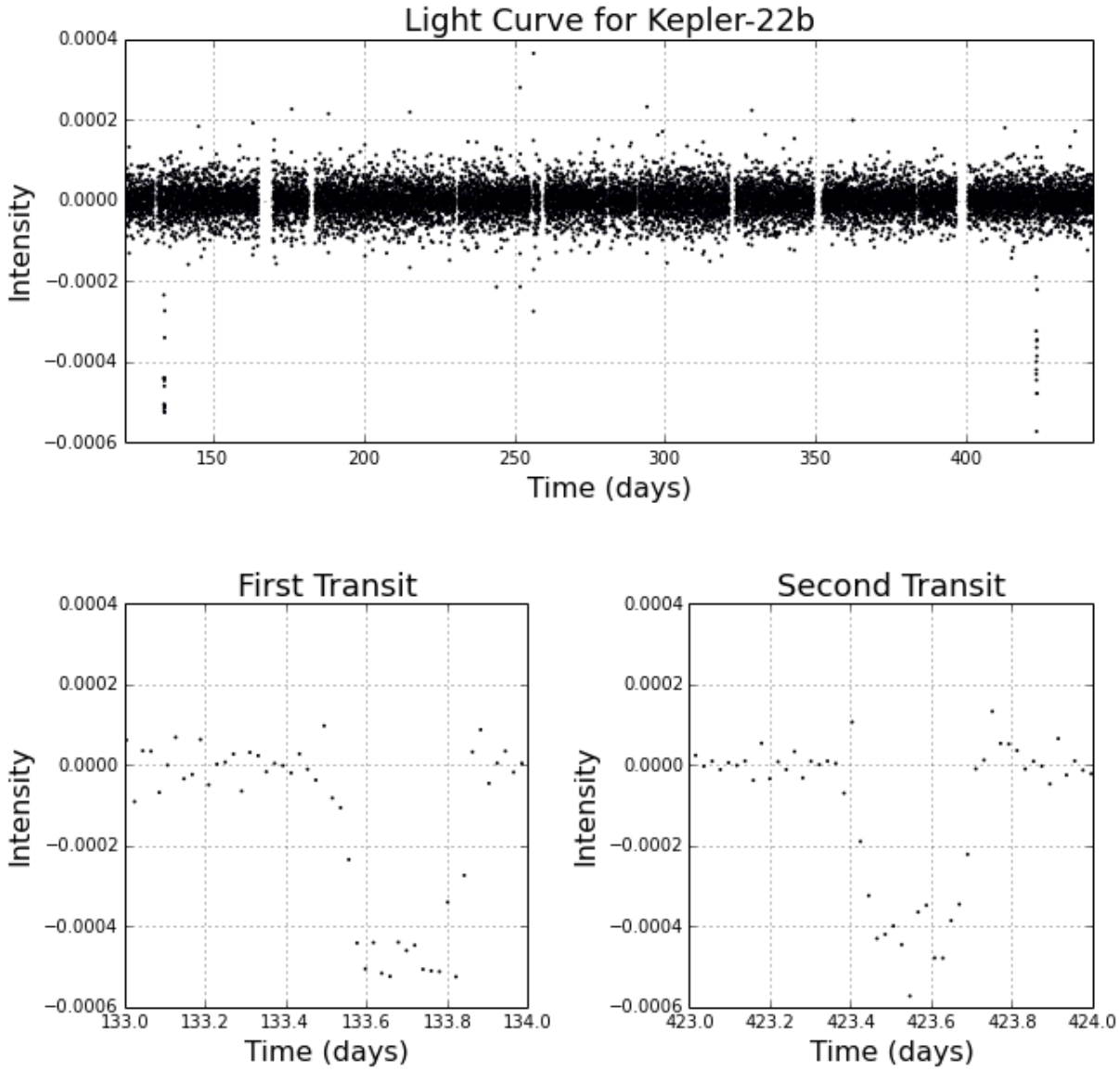

Figure 2: Kepler data for a potential planet called Kepler-22b

4 Kepler's Third Law

Kepler's Third Law reads

$$\frac{T^2}{d^3} = \frac{4\pi^2}{GM}$$

where:

- T is the length of a year on the planet, in days,
- d is the distance from the planet to the star in kilometers,
- M is the mass of the star in solar masses and
- G is the gravitational constant.

Question 1

Rewrite Kepler's Third Law, solving for the distance, d:

Question 2

From the data on the previous page, how long is a year on Kepler-22b?

Question 3

If $G = 1 \times 10^{21}$ and the star has a mass of $M = 0.97\ M_\odot$, how far is the planet from its star?

5 Is it habitable?

To find out if a planet is habitable, we need to know if the average surface temperature can support liquid water. To do that, we use an equation that compares the temperature of the star to the temperature of the planet:

$$T_{\text{planet}} = \left(\frac{(1-\alpha)R_{\text{star}}^2}{4d^2}\right)^{1/4} T_{\text{star}}$$

where:

- R_{star} is the radius of the star,
- T_{star} is the temperature of the star, and
- α is the **albedo** of the planet.

The **albedo** is a measure of how reflective a planet is to starlight.

Question 1

Based on what you know from physics, what colors absorb light? Which colors reflect light. What do you think would make a planet reflect more light?

Question 2

Let's assume that $R_{\text{star}} = 6.8 \times 10^5 km$, $T_{\text{star}} = 5518K$, and $\alpha = 0.29$. What is the average temperature on Kepler-22b?

Question 3

Is it possible that liquid water (and therefore life) can exist on Kepler-22b?