Print Name ____________________________ Period _________ Date _________________

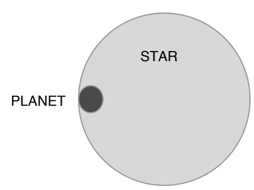
CA2 2A.9: Detecting Exoplanets: Lab

Purpose: To characterize a planetary system based on the light curve of a star with a planet that eclipses it.

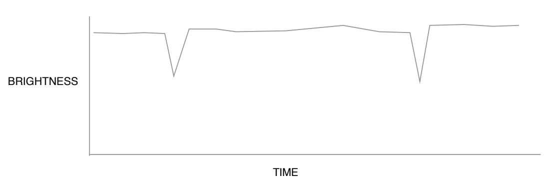
Equipment needed: Light curve of a star data, graph paper, calculator

Background: The data you are about to investigate is based on data obtained by NASA's Kepler mission. The Kepler mission looks at a fixed location in space and takes many repetitive pictures. The light curves of thousands of stars are measured. Then when an interesting star is found, such as a star with an **exoplanet** orbiting it, the data is analyzed further to determine the characteristics of the planet.

When a planet is lined up with the earth and its star, it will eclipse the light of the star and make the star slightly dimmer, as shown in the drawing.



As a result, brightness measurements, calibrated against standard stars, will show a small dip in the brightness of a star as shown in the light curve below.



The data in this activity is from the publicly available data published by the Kepler mission. You will plot the data and determine whether or not there is a companion that eclipses the star, and then answer some questions about it.

The Data

The data table is *very* long. Robotic telescopes can collect vast amounts of data. Part of the task astronomers face is how to manage so much data.
In the table, the elapsed time has been adjusted to start on the first day of the observation (day 0). The brightness data was **normalized** (reduced in proportion to have a maximum of 1.0), but for this exercise it has been multiplied by 100 to avoid having so many data points be decimal values.

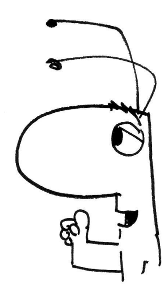


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Table 1. Light curve data

Time (days)	Brightness (normalized)
0.634368	100.8
1.002187	100.9
17.273821	100.2
22.586712	73.7
37.462719	100.1
45.288914	100.0
45.697592	100.1
46.576248	100.0
48.497029	100.0
48.721801	100.0
59.633422	100.1
63.536247	99.9
80.557337	99.9
80.639071	100.0
80.966004	100.1
81.211205	74.6
88.546756	100.0
92.817296	100.0

The star is identified as a spectral class K dwarf star, Kepler ID kplr007620844. For more information about the star in a technical sense, go to this website http://archive.stsci.edu/kepler/data_search/search.php and enter the number 007620844 in the Kepler ID field.

Procedure

1. Use the graph grid provided to plot the data. *Plot time on the x axis and brightness on the y axis*. Label these on the axes.

2. Identify on the graph and in the data table where the curve falls significantly below 100. Circle these points on the graph. On what days of the experiment did the graph fall in brightness significantly?

3. How many days elapsed between the two dimming events? ________

4. Is it possible that there were other eclipsing events between or beyond the two you can see, on other days? How do you know?

5. How many planets are indicated by this limited data set, and how do you know?

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CA2 2A.9: Detecting Exoplanets: Lab

Using the Data to Investigate the Planet

This next section is designed to use your knowledge about planets gained in Volume 1 of this workbook, to reach conclusions about this particular exoplanet.

6. Convert the orbital period of the planet in days to seconds. Show your work.

7. Look at the Stellar Spectral Types table in the appendix and find out what the mass of a typical K-dwarf star is. It will be expressed as a range of solar masses.

8. Use the maximum value of the mass for the next step. Convert the maximum mass into kilographs by using this conversion factor: 1 solar mass = 2 x 10^{30} kg.

9. Now, using Newton's version of Kepler's third law, derived in volume 1 and shown here, calculate the orbital radius of this unknown exoplanet.

$$r^3 = \frac{Gm_1P^2}{4\pi^2}$$

10. Compare this value to 1 AU, the distance of earth to the sun. 1 AU = 150 x10^9 meters.

11. Propose a name for this new planet.