Chapter 13: Using a Light Curve to Identify Celestial Objects

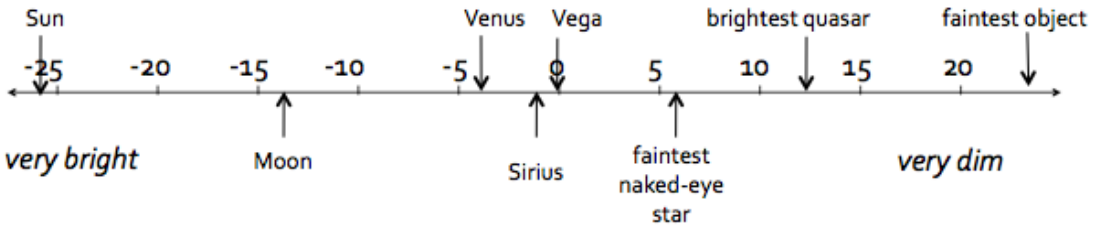
Student Worksheet

Objective: Determine the nature of a mysterious object by interpreting its constructed light curve.

Engage: What can you think of that changes in brightness over time? Give one or two examples. Now—try to imagine the shape of a graph with the brightness for these examples plotted on the y-axis and the time plotted on the x-axis. Then sketch a graph for each object that shows brightness vs. time .

Introduction: In astronomy the brightness of objects can be understood by using the magnitude system. The magnitude scale ranges from the brightest end -26.5, a value given to our sun, to the dimmest objects visible to the Hubble Space Telescope at about positive 28. The magnitude scale is logarithmic, meaning it is compressed across a small numerical span to hold a scale in which the brightest objects are hundreds of thousands of trillions of times brighter than the dimmest. It would be pretty clunky to say the sun has a magnitude of zero and the faintest object has a magnitude of 4.9×10^{20}. -26.5 to +28 is much more manageable. See Figure 1 for more benchmark magnitudes.

Figure 1 Benchmark Magnitudes



Some celestial objects have a magnitude that varies with time, or a distinct shape to their *magnitude vs. time* graph. By looking at a graph of the magnitude vs. time we can identify patterns and determine the type of object much easier than when looking at a table of data.

Celestial objects with variable brightness include Cepheid variable stars, eclipsing binaries, and type 1 supernovae. Below, you will find a definition and a sample light curve for each.

Example 1:
A **Cepheid variable** is a star that has a brightness that changes periodically over the course of a few days. This is due to the star actually changing size. These stars have such a close relationship between their brightness and their period of brightening and dimming that they can be easily identified and used to calibrate distances to distant objects. Figure 2 shows a sample of the changing brightness of a Cepheid Variable:

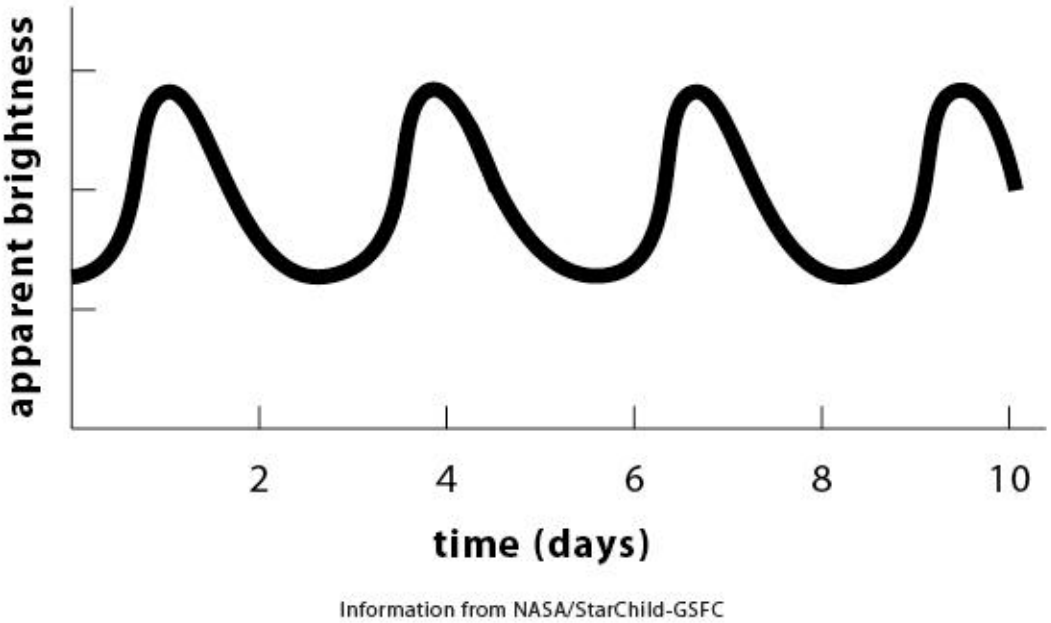


Figure 2: Cepheid Variable Light Curve

Example 2:

An **eclipsing binary** system of stars also has a pattern of changing brightness over time. Many stars in the night sky are in binary or multiple star systems. Figure 3 shows how the brightness changes when one star passes in front of the other.

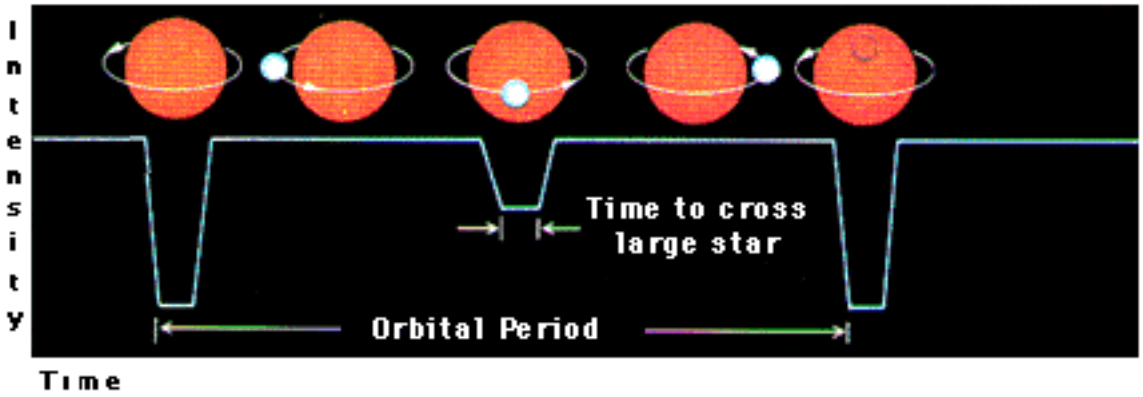


Figure 3 NASA/GSFC

The light curve of an eclipsing binary star system would look like the graph in Figure 4 below.

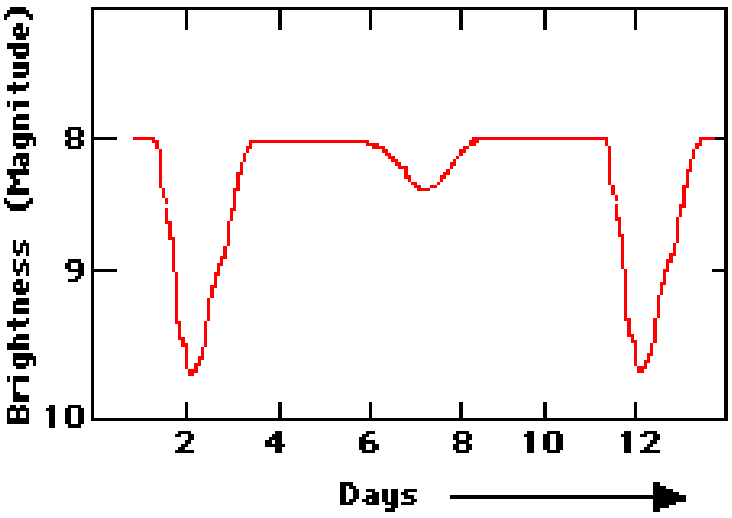


Figure 4 Eclipsing Binary Star System Light Curve NASA/GSFC

Example 3:

The final type of light curve we will look in this activity is that of a supernova. A supernova is the result of the death of a very massive star. As you can see in Figure 5 below, its light curve is marked by a rapid increase in brightness that drops off rapidly after a few days and then more slowly over the course of about one year. This is a **type 1 supernova**.

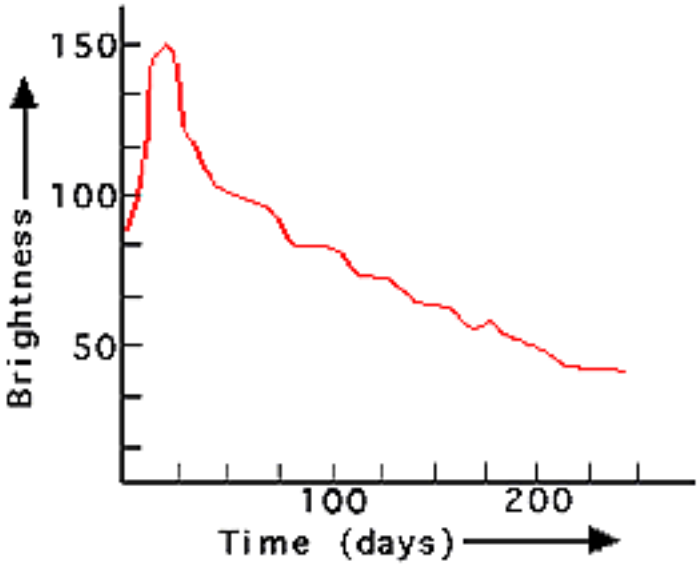


Figure 5 Supernova Light Curve NASA/GSFC

Your Task:

You can see that each of the three example light curve graphs shown above is simply a plot of the *apparent magnitude versus time* measured in days. In this activity you will be given two sample data tables to plot as light curves in order to determine which of the above type of celestial object is represented.

Procedure:

1. Plot Data Table 1 on graph paper with time (in days) on the x-axis, and apparent magnitude (no unit) on the y-axis. Do this as large as possible on your graph paper. Make sure your x- and y-axes are labeled and that your graph has a title.

2. Repeat for Data Table 2.

3. Review the 3 example light curves and choose which example is illustrated by each data set.

Data Table 1

Day	Apparent Magnitude
1	7.9
2	6.3
3	7.9
4	8.0
5	8.0
6	8.1
7	8.2
8	8.0
9	8.0
10	8.0
11	10.0
12	8.0

Data Table 2

Day	Apparent Magnitude
0.5	4.4
1.0	3.5
1.5	3.6
2.0	3.9
2.5	4.1
3.0	4.3
3.5	4.5
4.0	4.5
4.5	3.5
5.0	3.6
5.5	3.9
6.0	4.2

Conclusion:

1. Name another astronomical object or group of objects that would exhibit a light curve. Sketch what the light curve might look like. What information might it tell us?

2. What is a non-astronomical object that has a light curve? Hint: Think of something in your everyday life.

Extend:

- Research one of the objects listed in the table of magnitudes at the start of the introduction.
- Why does the magnitude system have such an odd scale: -26.5 to +28? What is the history of this system that keeps it from beginning at zero.
- Who was Henrietta Leavitt? What did she have to do with Cepheid Variables?
- What is the difference between a type 1 and a type 2 supernova? Which is used to help astronomers calculate distance?