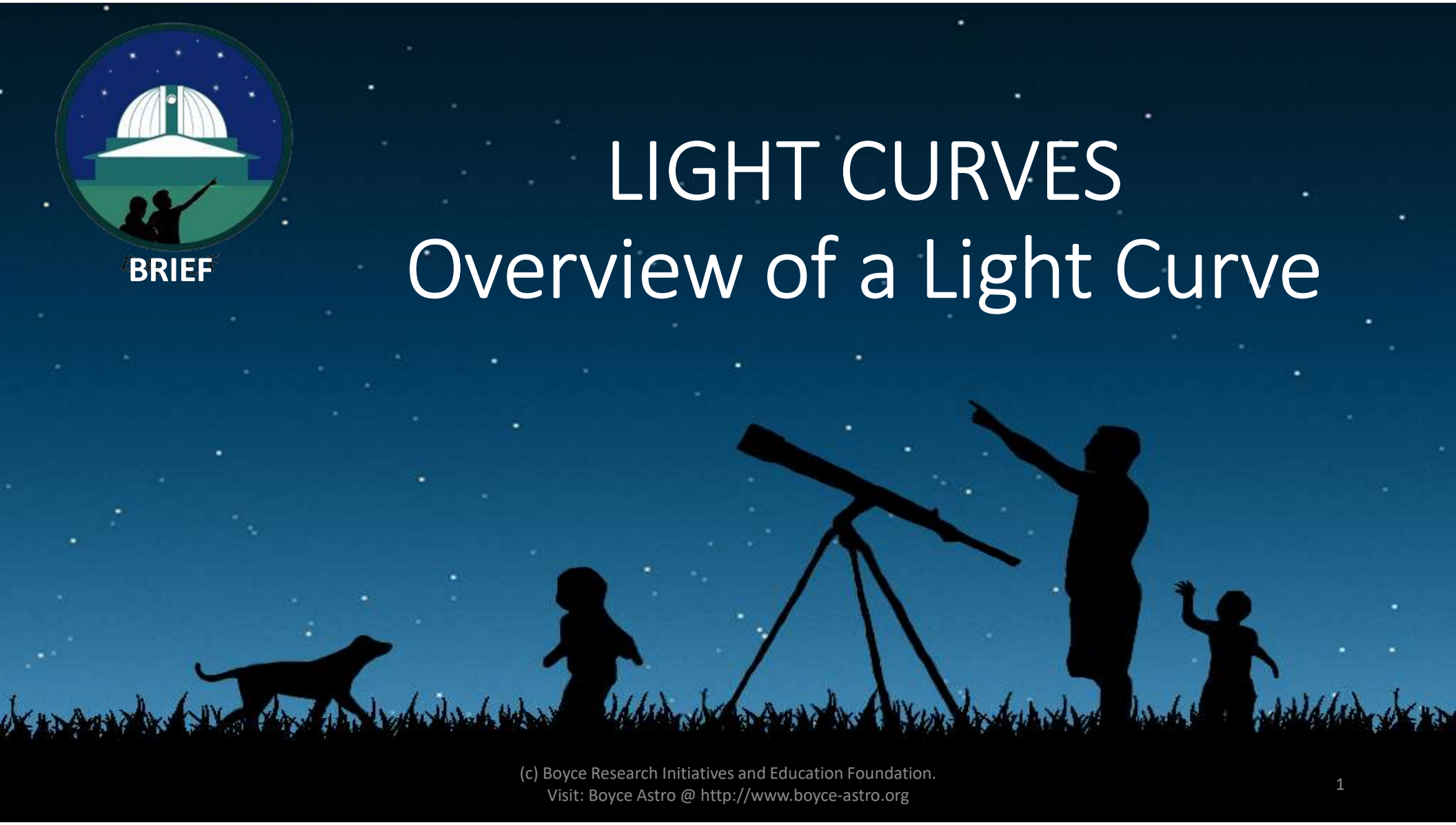
BRIEF

LIGHT CURVES
Overview of a Light Curve



Overview

Photometry is used to determine a light curve. In essence, this is a curve plotting the light output of an object over time. Each image will contain stars of a certain magnitude at that moment. A series of images are taken, the magnitudes are measured, and they are plotted over a period of time. The resultant variations of magnitude over time produce a light curve, or a phase.

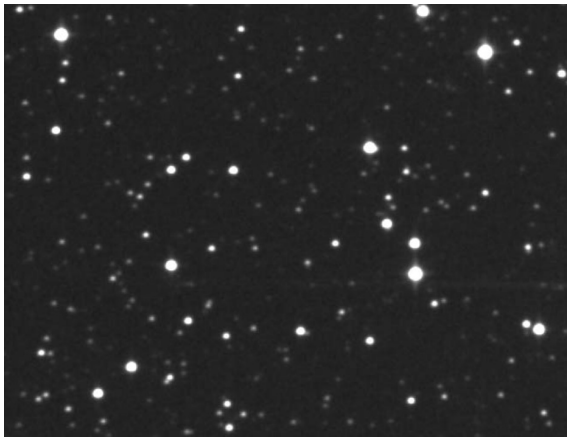
However, a single light curve does not determine, by itself, a period. This requires multiple light curves that together reveal a period, or a varying period as the case may be.

The reasons for magnitude variations, amplitude variations, and/or period variations gets to the heart of why we study photometry.

The following slides will outline examples of light curves.

Overview of a Light Curve

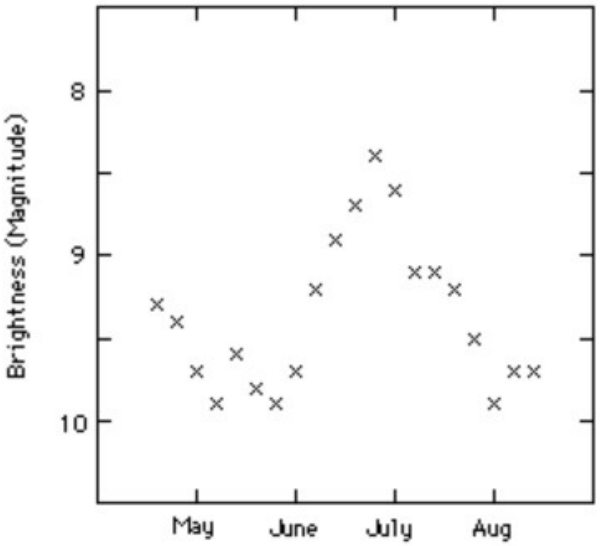
How a Light Curve is Developed:



Take a CCD image of the area of interest repeatedly night after night for a period of time.

Date	Brightness (Magnitude)	Date	Brightness (Magnitude)
April 21	9.2	June 20	8.7
April 27	9.3	June 26	8.3
May 3	9.7	July 2	8.6
May 9	9.9	July 8	9.1
May 15	9.6	July 14	9.1
May 21	9.8	July 20	9.2
May 27	9.9	July 26	9.5
June 2	9.7	Aug 1	9.9
June 8	9.1	Aug 7	9.7
June 14	8.8	Aug 13	9.7

Use software to measure the brightness of the object of interest over time: Minutes, hours, days, months, etc.

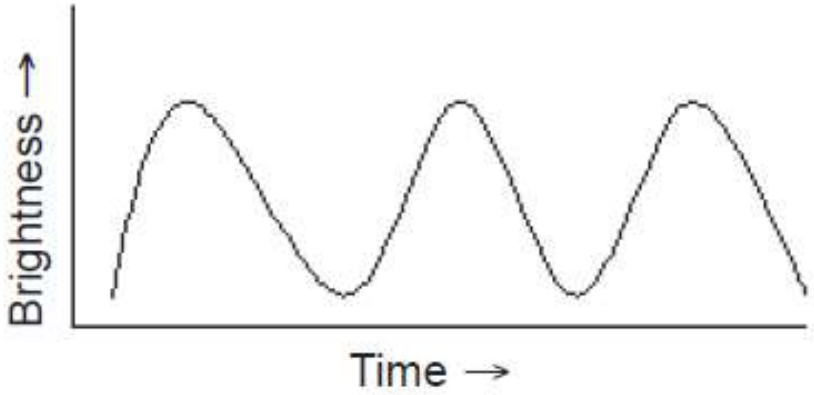


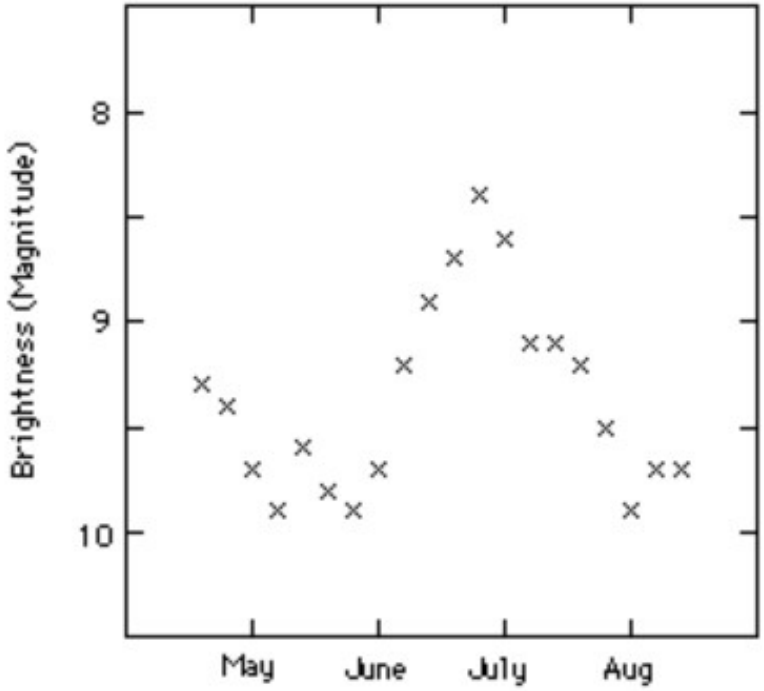
Plot the data into a graph.

What is Overview of a Light Curve

Light Curves are simply graph's of **brightness** (Y axis) vs. **time** (X axis). Brightness increases as you go up the graph on the Y axis and time advances as you move to the right on the X axis.

In this example, the light curve shows that the star began at a brightness of 9.2 and progressively dims until there is a slight rise in mid-May. From June to July the magnitude increases. Afterwards it falls again.





What is Overview of a Light Curve

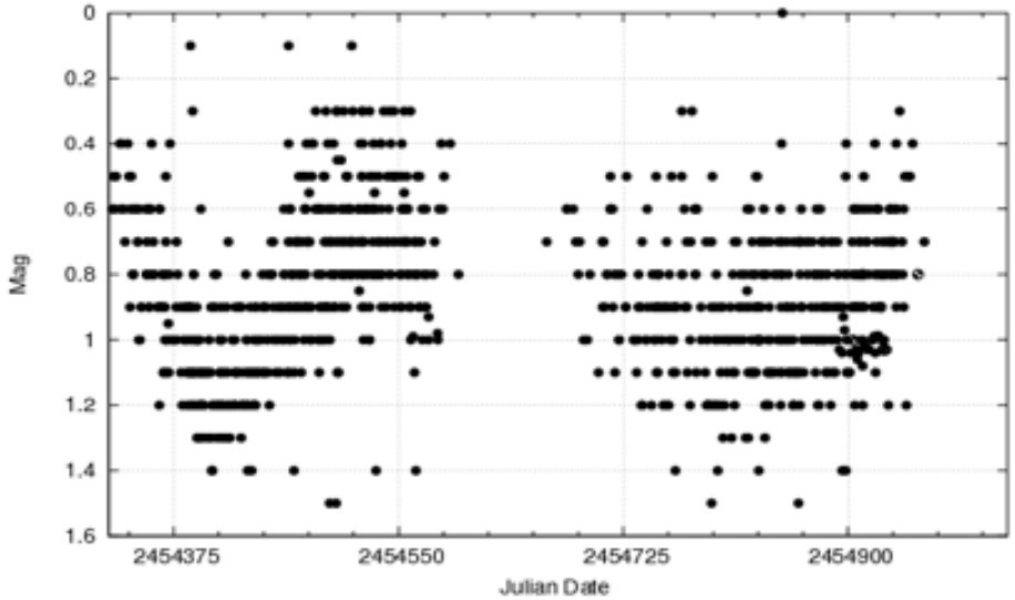
From an AAVSO example: the case of Betelgeuse

The X and Y-axis is formatted as described above.

This light curve spans approximately 2 years worth of observations. IMPORTANT: durations of light curves vary from seconds to years.

There are many observations for a given date as the AAVSO receives reports from many different observers.

Not all measurements are the same. This variation is called scatter.



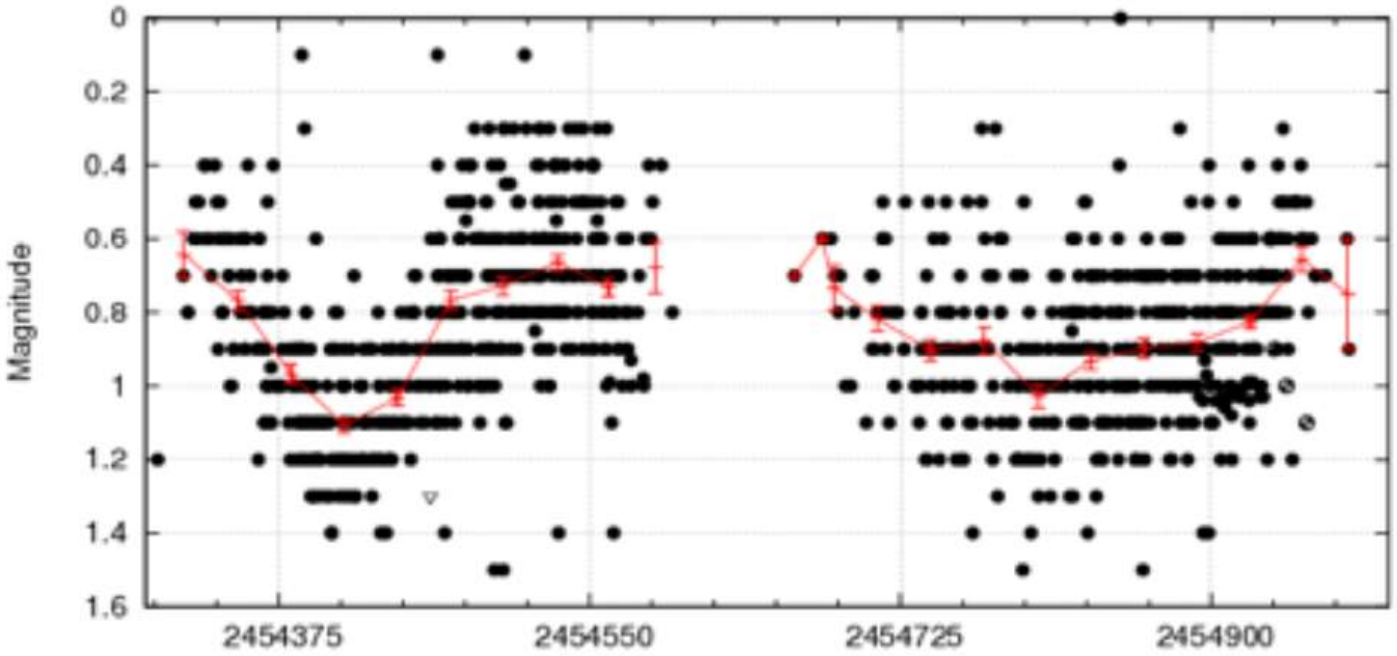
SOURCE: AAVSO

What is Overview of a Light Curve

Through statistics, the scatter is used to acquire a light curve.

Software products employ advanced statistical methods to derive a median.

This median is noted in the image here as a red line averaging the measurements for a given epoch (time).

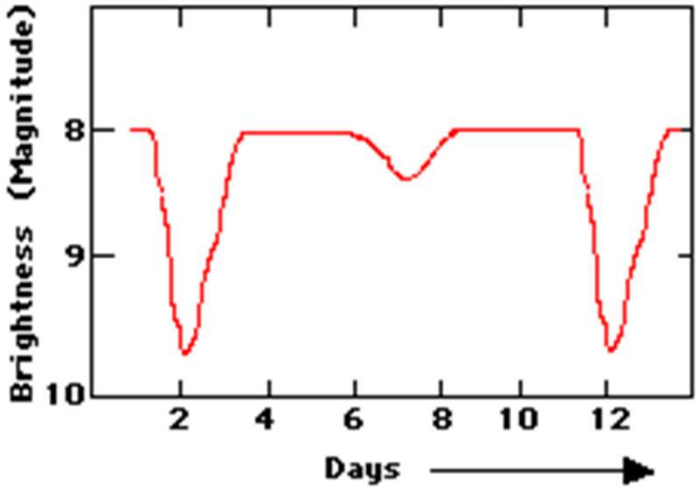


What can we learn from light curves

The record of changes in brightness that a light curve provides can help astronomers understand processes at work within the object they are studying and identify specific categories (or classes) of stellar events.

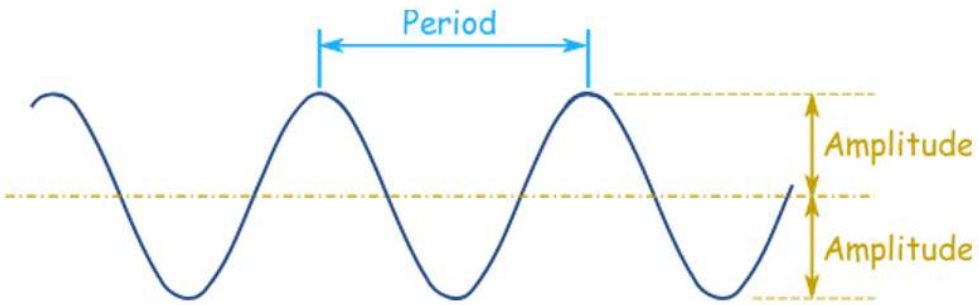
For a given set of objects (i.e. RR Lyraes, Exoplanets, Supernova, etc) we generally know what light curves look like.

When a new light curve is generated, it can be compared to those standard light curves to possibly identify the type of object being studied.



Description of a Light Curve

The light curve's record of the change in brightness over time provides clues to underlying processes causing the variation. Furthermore, the light curve can be compared to standard light curves to potentially identify the object of interest. The basic characteristics astronomers are looking for in a light curve are **ASP:**



Amplitude

Range/Full Amplitude: the difference between the maximum and minimum values of brightness on the y-axis.
If there is a sinusoidal light curve, amplitude can be defined as half of the range.

Shape

What is the shape of the light curve?
Are there features evident that characterize a particular type?

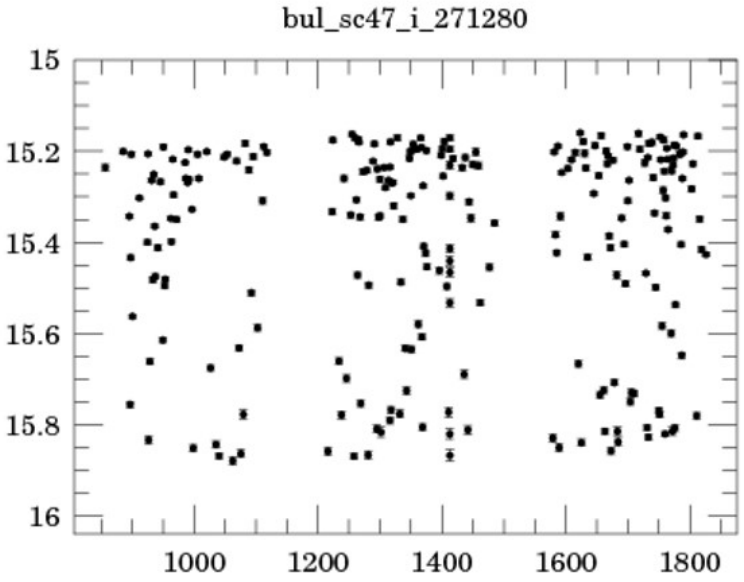
Period

Periodicity in a light curve refers to a repeated pattern at a regular interval
Is there a periodic pattern?
Is the periodicity consistent with some type?

What they Tell Us

Sometimes a light curve alone contains enough information to identify an object as a curve is evident in a short period of time. In other cases, phase plots are needed when the data is suspected to be periodic over longer periods of time.

Phase plots contain data that is “folded” to fit within a mathematically defined/determined period. These are often referred to as folded light curves.



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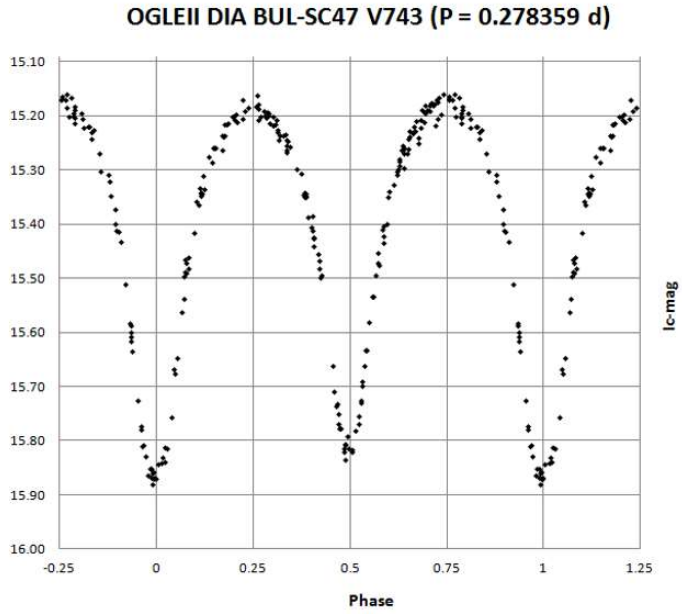
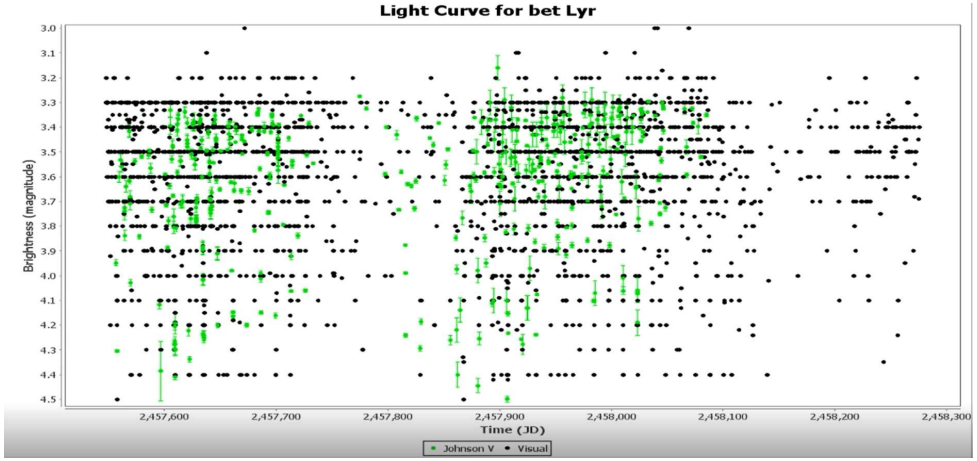
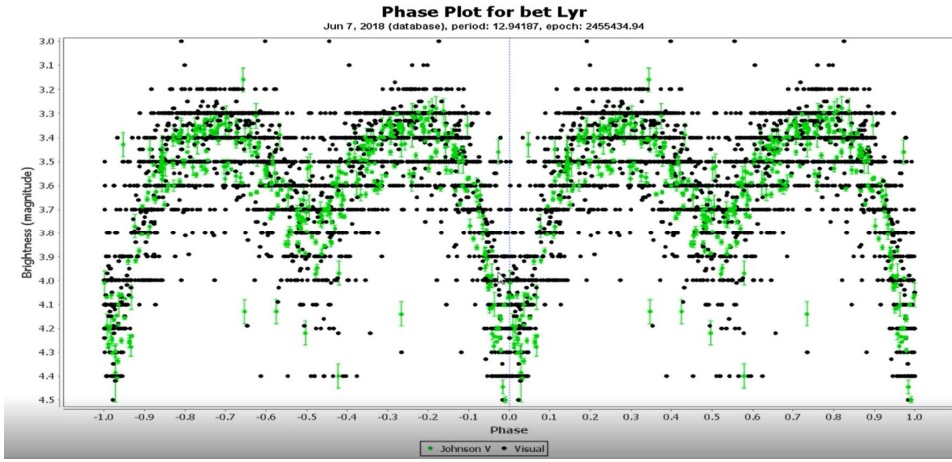


Light Curve Overview

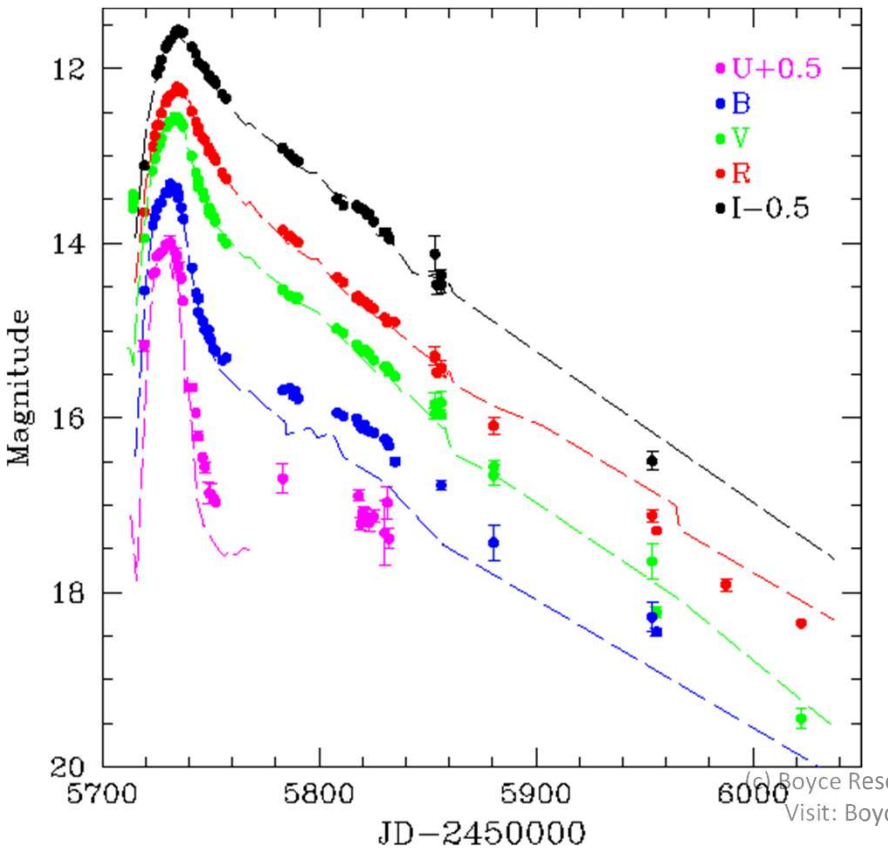
Software can be used to help discern a period pattern and develop a Phase Plot.

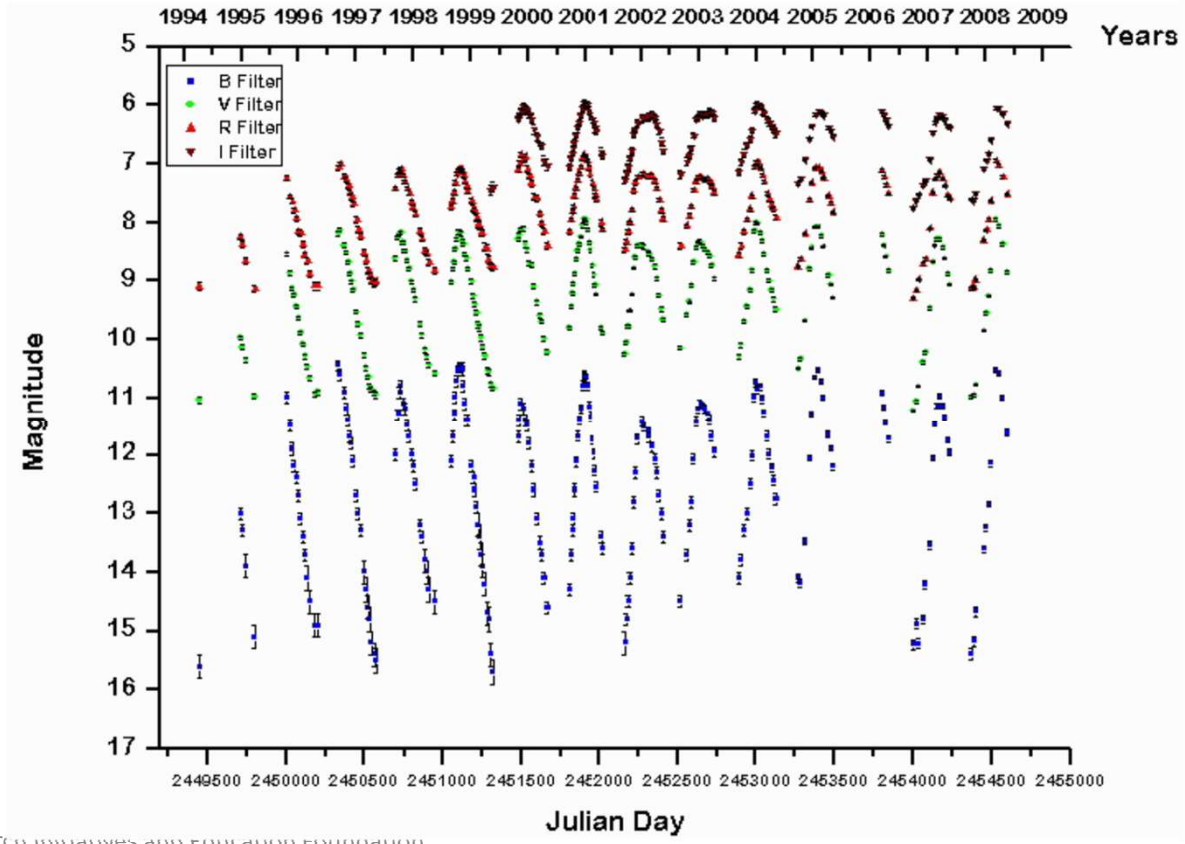




Overview of a Light Curve

Light Variability with bandpass of light





Overview of a Light Curve

CY Aqr

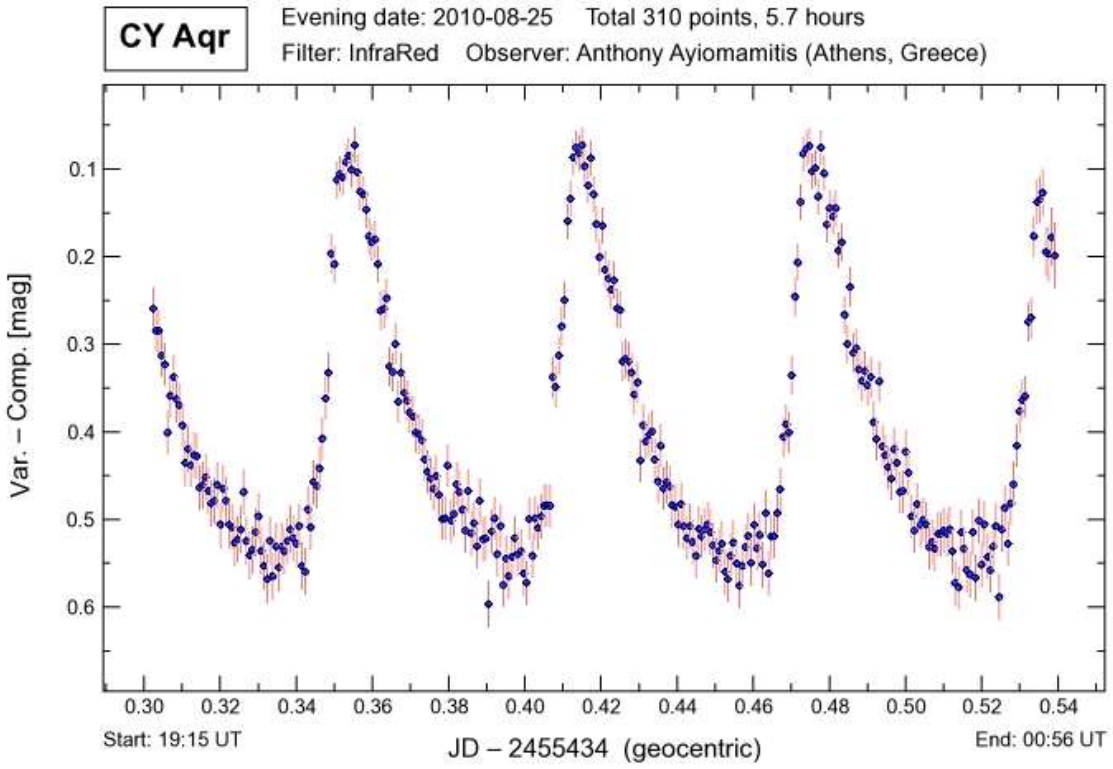
Constellation: Aquarius

Variability Type: Pulsating Sub –Dwarfs common in globular clusters

Spectral Type: A2-A8

Magnitude Range: 10.42 – 11.14

Period: 0.06 days (~87.9 mins)



R Sct

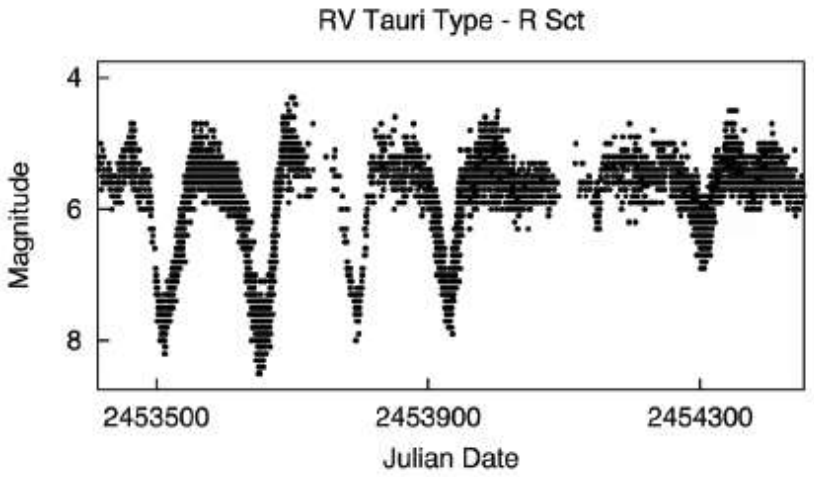
Constellation: Scutum

Variability Type: RV Tauri (Luminosity changes with surface pulsations

Spectral Type: G-K

Magnitude Range: 4.2 – 8.6

Period: 146.5 days



RV Tauri stars – These are yellow supergiants, near the end of their life, having a characteristic light variation with alternating deep and shallow minima.

Omi Cet

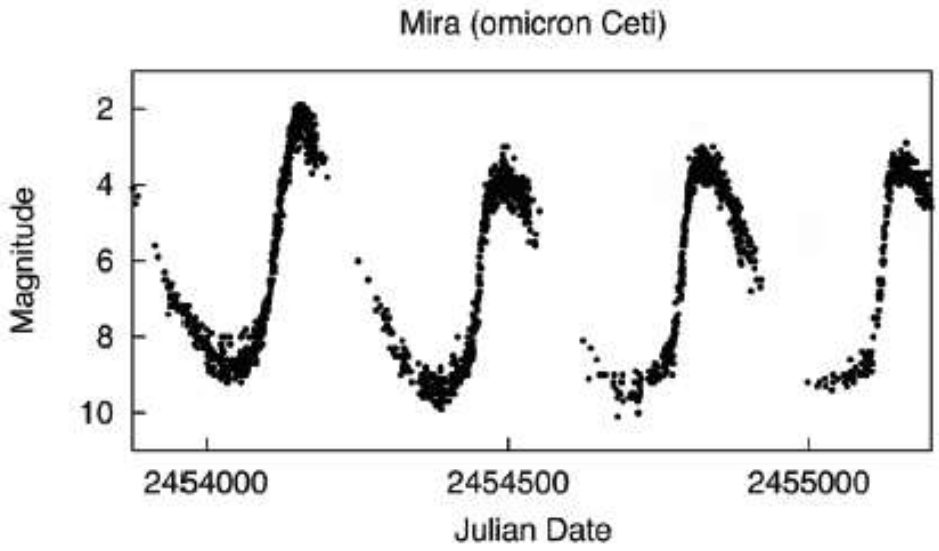
Constellation: Cetus

Variability Type: Mira

Spectral Type: M5 – M9

Magnitude Range: 2 – 10.1

Period: 331.96 days



Long Period Variables– Long Period Variables
Pulsating red giants or supergiants with periods ranging from 30-1000 days. Usually of spectral type M, R, C or N.

Mira – These periodic red giant variables vary with periods ranging from 80 to 1000 days and visual light variations of more than 2.5 magnitudes.

Z UMa

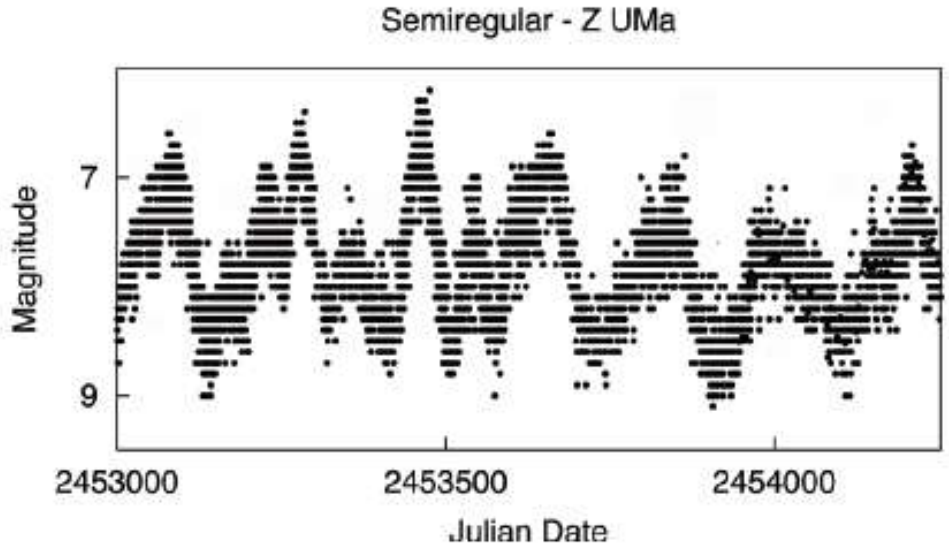
Constellation: Ursa Major

Variability Type: Semiregular

Spectral Type: M5 III

Magnitude Range: 6.2 – 9.4

Period: 195.5 days



Semiregular – These are giants and supergiants showing appreciable periodicity accompanied by intervals of semiregular or irregular light variation.

Periods range from 30 to 1000 days, generally with amplitude variations of less than 2.5 magnitudes.

B Per

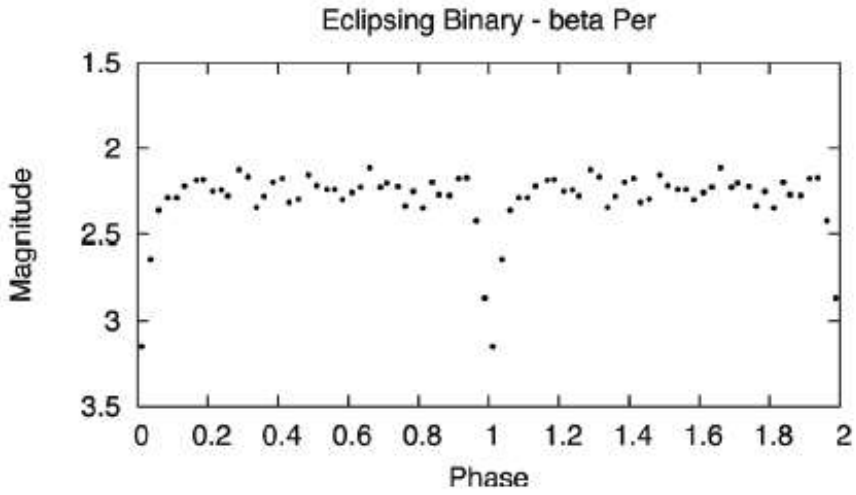
Constellation: Perseus

Variability Type: Eclipsing Binary

Spectral Type: A2 V

Magnitude Range: 4.57 – 4.75

Period: 1.52 days



ECLIPSING BINARY STARS

These are binary systems of stars with an orbital plane lying near the line-of-sight of the observer. The components periodically eclipse one another, causing a decrease in the apparent brightness of the system as seen by the observer. The period of the eclipse, which coincides with the orbital period of the system, can range from minutes to years.

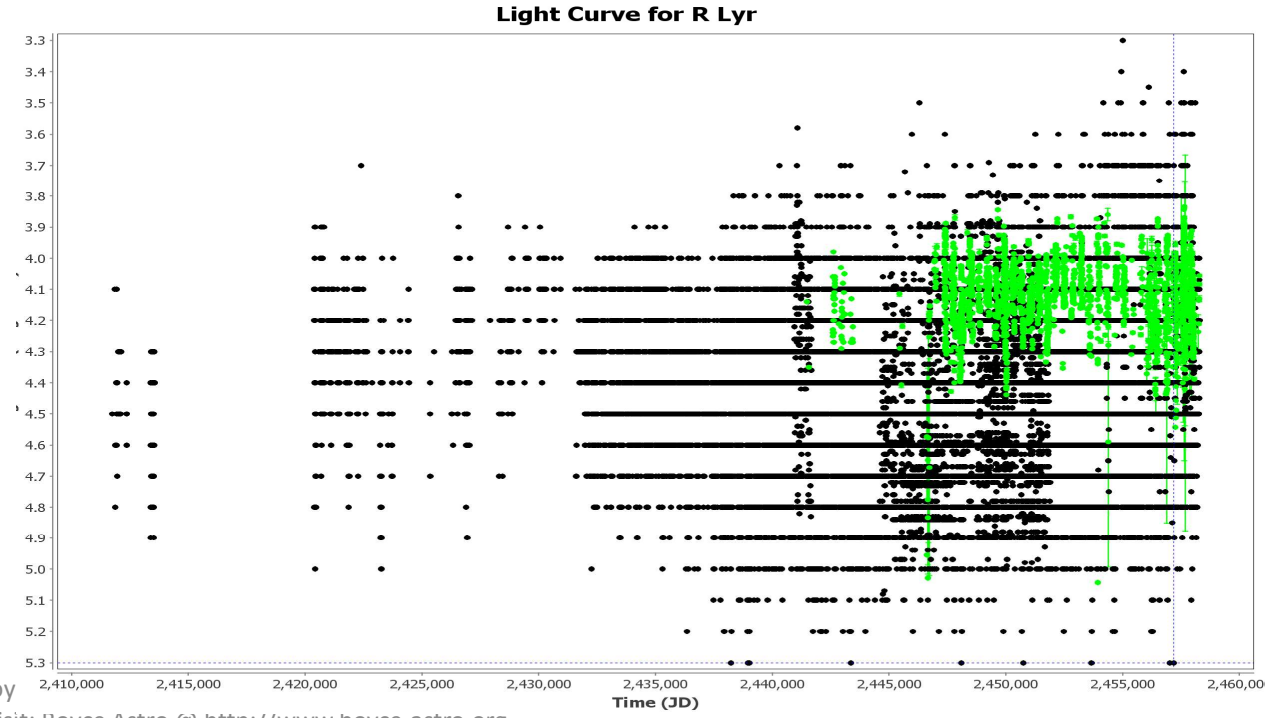
Light Curve Overview

Summary

In the realm of Variable Stars, light curves reveal will tell us what type of variable we are studying. OR, if a new discovery is made, it reveals what type of Variable you have discovered.

However, there may be times when a light curve alone is not enough. will be discernable just by looking at the curve. For example: when there are tons of data, and vast amounts of time, there can develop a tremendous amount of data from which a light curve is difficult to discern.

In such cases, as seen here, software can be used to help discern a period pattern, and confine data, even when collected over a period of time.



Questions?