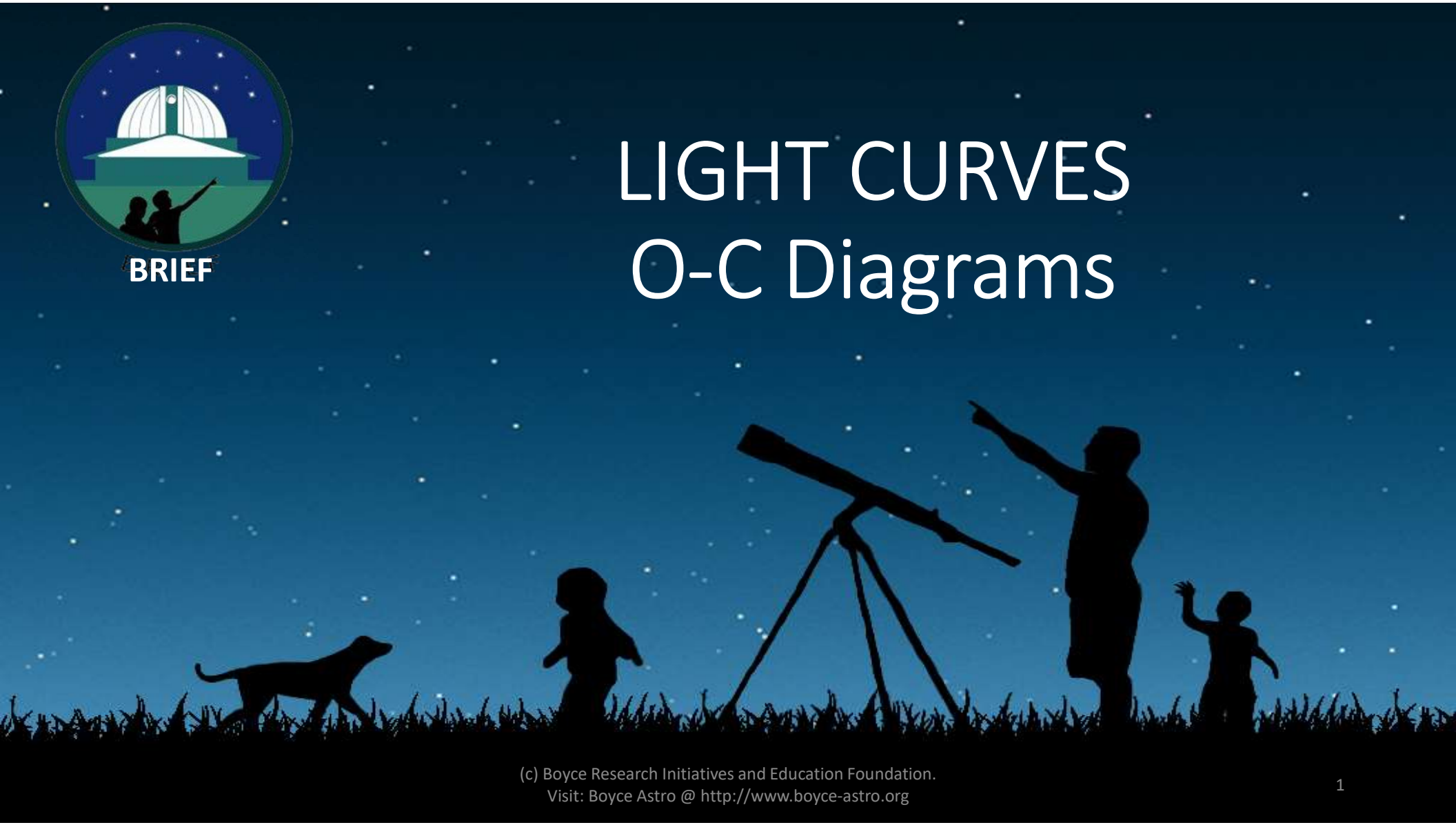
BRIEF

LIGHT CURVES
O-C Diagrams



Overview

The O–C (Observed – Computed) method is the classical method for studying period changes in variable stars, because it is sensitive to the *cumulative* effect of the period changes.

O-C diagrams compare the observed time of maximum brightness O with the calculated time C, assuming a known constant period P.

A perfectly periodic system repeats exactly the same behavior, over and over again. Other variables are not as reliable with each cycle a little different from every other cycle.

Not only are their periods not perfectly periodic, but these stars also sometimes “switch” from one period to another (a process known as mode switching). Their amplitudes change dramatically: they may suddenly increase their variability, or they may stop varying altogether (but when they do, they usually start up again soon after).

Many variables are not perfectly periodic despite repeating cycles over and over again. Each cycle is a little different.

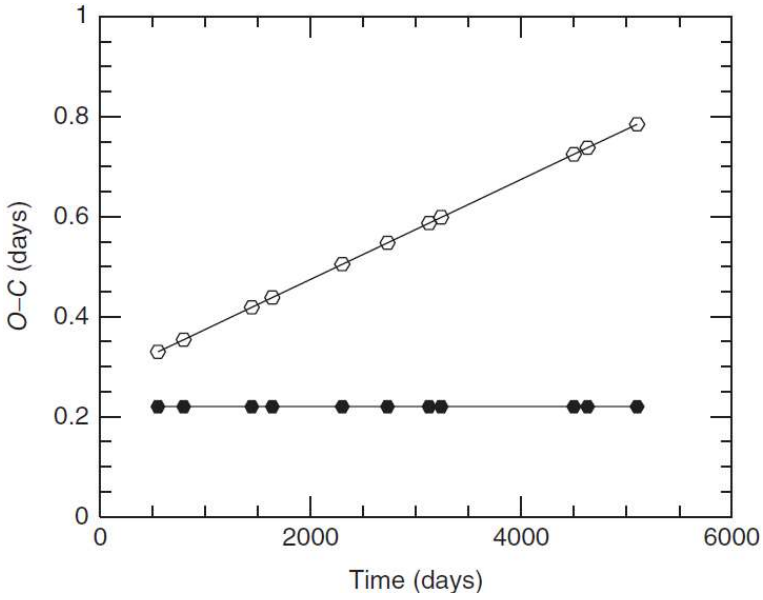
O–C Diagram

The O–C Diagram ("O minus C") is based on the following idea: if a star is perfectly periodic, then every period is exactly the same.

Thus, you can predict cycles in advance. This allows a comparison of predictions with future observations.

If it's periodic, it has a maximum at time t_o (the epoch), and the period is P. The next maximum will occur at $t_o + P$, $t_o + 2P$, then $t_o + 3P$, etc.

Therefore, you can compute the times of all maxima, past, present, and future.



What is an O-C Diagram

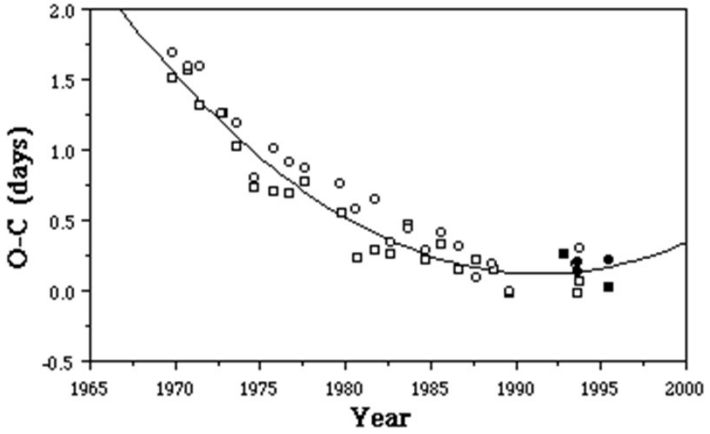
The *O−C* (*observed* minus *computed*) diagram is used to refine periods or to determine period changes in a light curve.

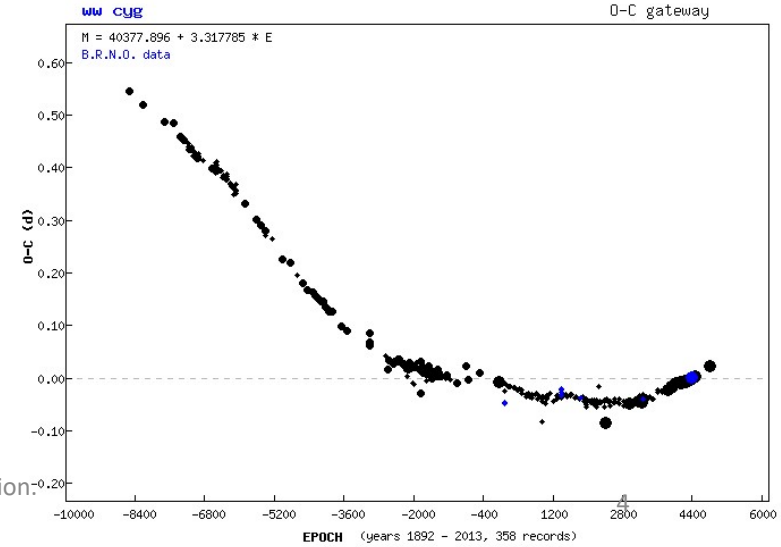
This assumes there is already an ephemeris. An ephemeris uses an adopted period, *P*, to calculate future times of maximum light, *C*, for a pulsating star. We also see this in Double Star research.

Given this you can create a series of observed times of maximum light.

Now, assume that the next observation, the ephemeris for the next maximum, is wrong. This is where the O-C Diagram is handy.

You can create an *O − C* diagram by plotting the difference between the observed and calculated times of maximum light as a function of time.





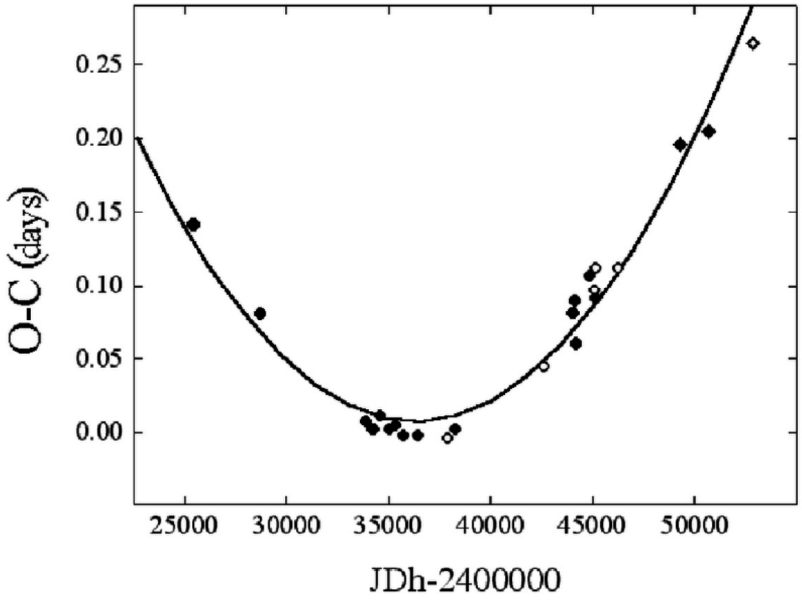
Measurements

The horizontal axis of the O-C diagram most often represent time, usually expressed in days.

The typical unit of time measurement is the Julian Date (JD) of the observation. It can also be cycles or phase.

The vertical axis is the "O-C" part which gives the diagram its name and its interpretive power. For each observed event one takes the observed time of the event (that's the "O" part) and subtracts the time predicted from the existing data or model of the star.

The difference, Observed minus Calculated or "O - C", is plotted on the vertical axis of the graph. The pattern that shows up in the O - C diagram can tell if your predictions (or model) are valid.



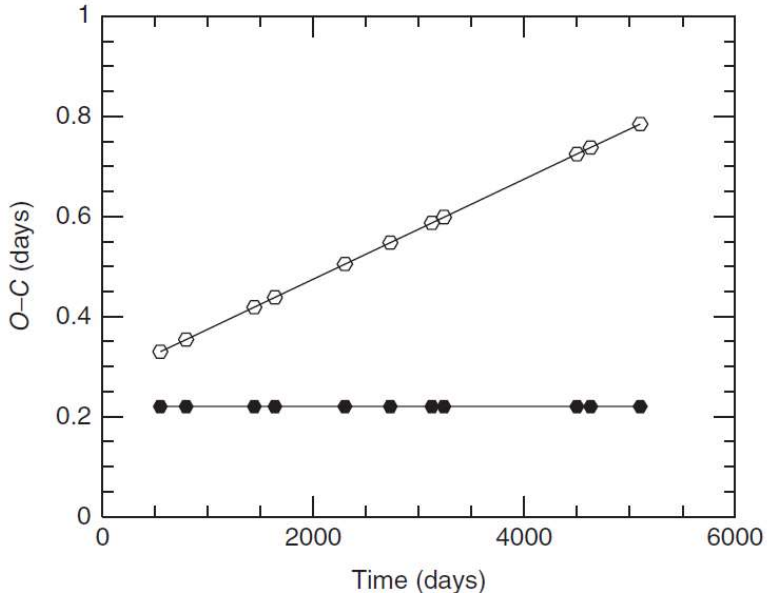
O-C Diagram Example

If the *O* − *C* diagram is a straight horizontal line: predicted meets actual.

If the O-C Diagram is a straight line but slopes up or down, then the expected period is too short or too long, respectively.

The amount of the slope can be used to correct the adopted period to obtain a more accurate value.

If the period of the star changes significantly during the time of observation, then the *O* − *C* diagram will not be well represented by a single straight line.



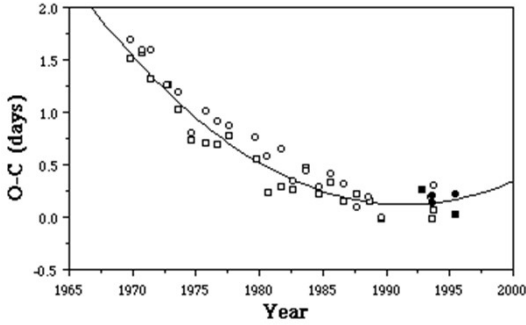
O-C Diagram Example

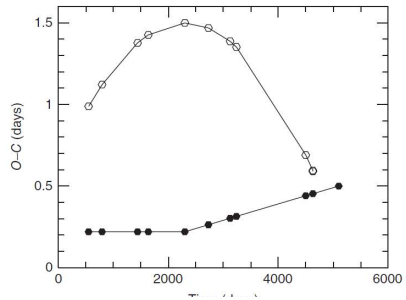
Interpreting real *O* − *C* diagrams can be complicated.

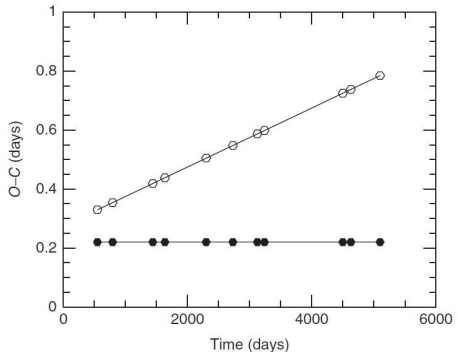
Observational uncertainties, gaps in the observational record, multiple periods, and real but random jumps in the phase of a light curve are all among the circumstances that can complicate the interpretation of an *O* − *C* diagram.

The line with a sudden change in slope (*filled symbols*) corresponds to the case where the period abruptly changes, whereas the line resembling a parabola (*open symbols*) corresponds to a period that changes linearly with time.

When (O–C) is plotted against time, it produces a straight line if the period is constant, a parabola opening upward if the period is increasing linearly, a parabola opening downward if the period is decreasing linearly, and a broken straight line if the period changes abruptly.







Summary

The O–C (Observed – Computed) method is the classical method for studying period changes in variable stars, because it is sensitive to the *cumulative* effect of the period changes.

In an ideal situation, variable star periods repeat exactly the same behavior, over and over again.

However, this is often not the case and many variables have cycles a little different from other cycle.

The O-C Diagram helps us refine astrophysical behavior and theories.

Questions?