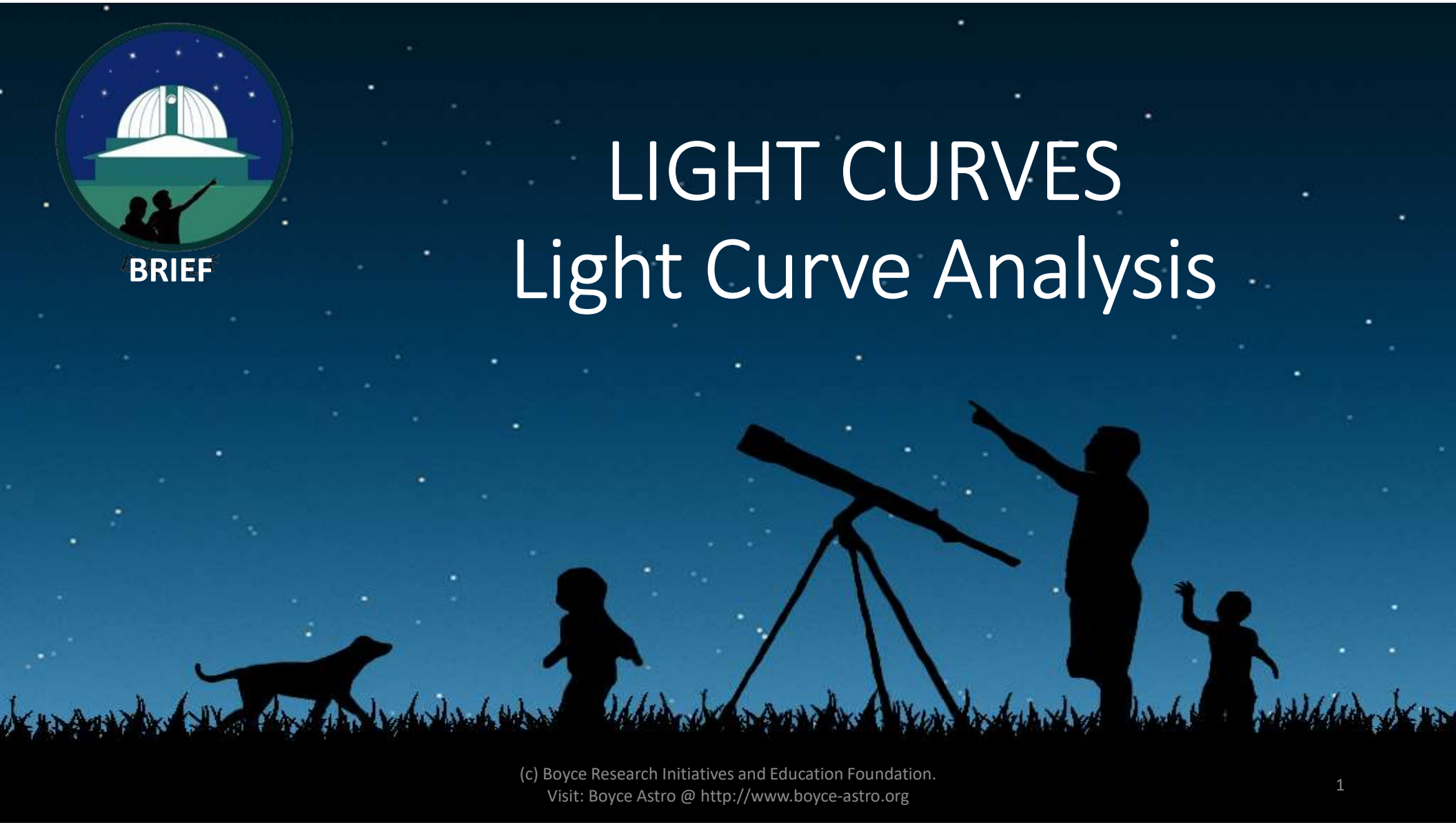
BRIEF

LIGHT CURVES
Light Curve Analysis



Overview

Light curves are at the heart of Photometry. These are essentially a collection of magnitude observations over a period of time.

For different types of object (ex. Supernova, Asteroids, Exoplanets, RR Lyrae, etc) the light curve will have different features. As such, the analysis will be different for each.

Time-series analysis is the application of mathematical and statistical tests to any set of time-varying data in an attempt to: 1) quantify the variation itself, and 2) use that variation to learn something about the behavior of the system.

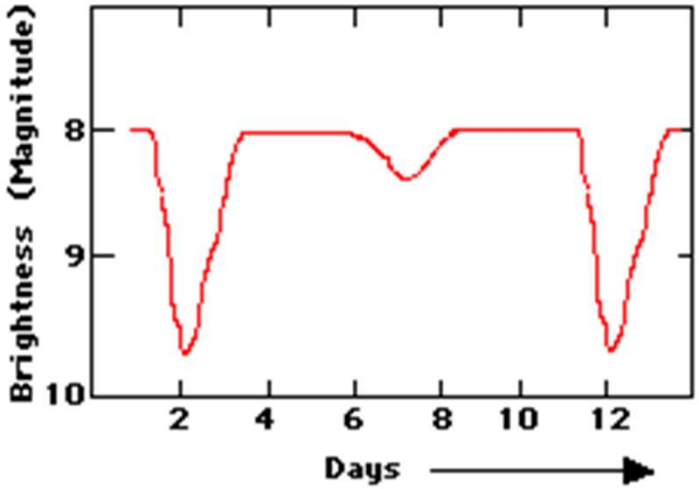
Ultimately, the goals of time-series analysis are to gain some physical understanding of the system under observation: what makes the system time variable, what makes this system similar to or different than other systems with similar variability, and so on. The other goal is to perhaps be able to predict future behavior; if not an exact prediction, then at least some quantification of the limits of the system.

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.

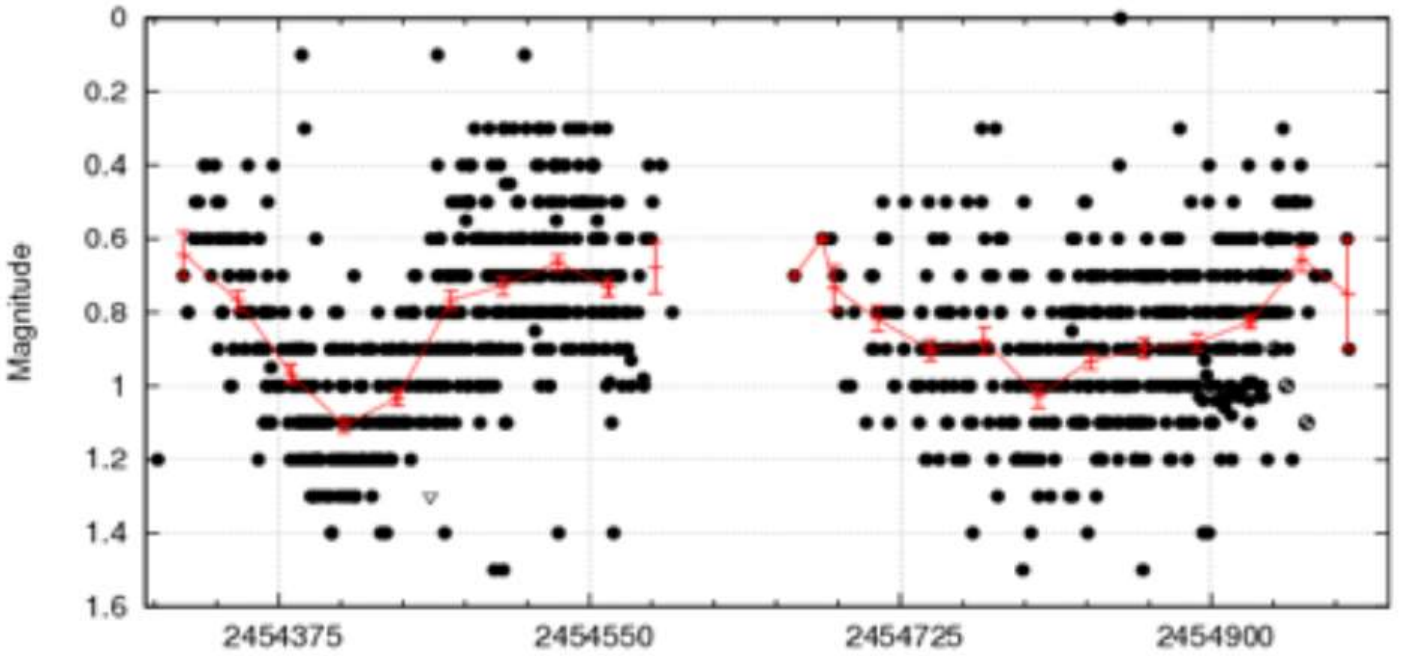


What is Light Curve Analysis

A scatter of magnitude measurements 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 is Light Curve Analysis

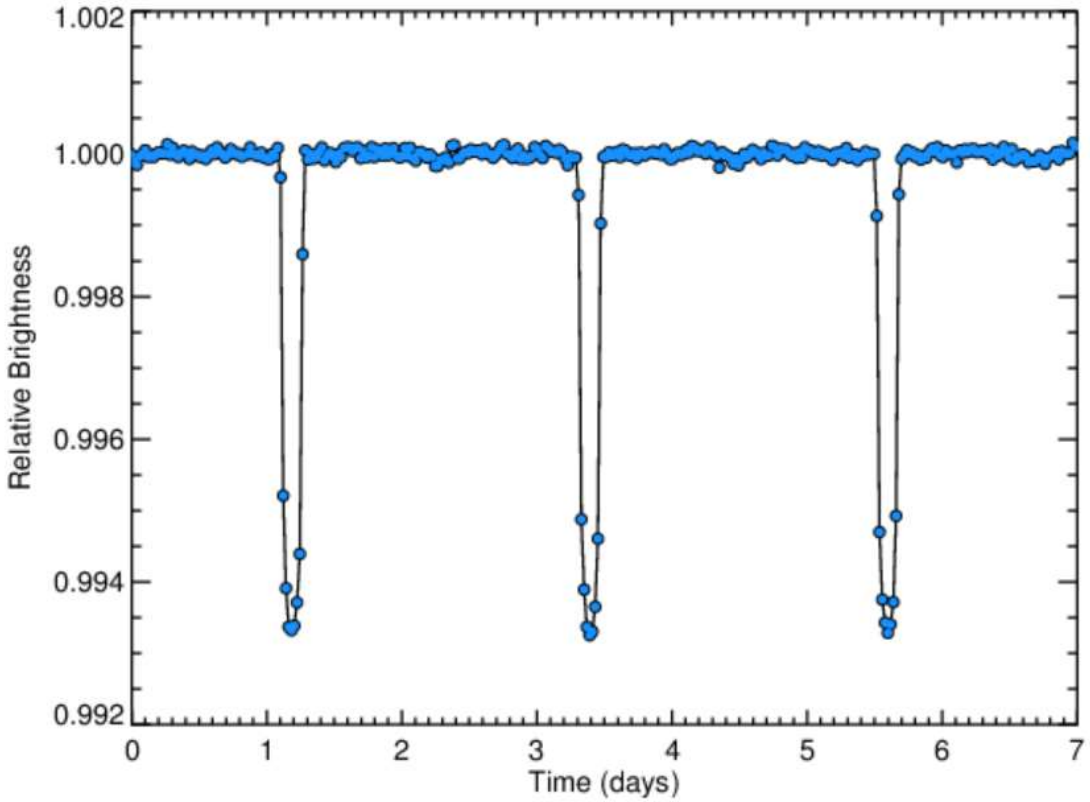
This is an example of an Exoplanet Transit.

Note the X and Y-axis commonality to other light curves.

The primary star is consistent in its Flux until the planet transits in front of the solar disk.

In the case of exoplanets, the entire span of the graph is within 1% of the total brightness of the star.

This emphasizes how searching for transiting planets requires highly precise brightness measurements.



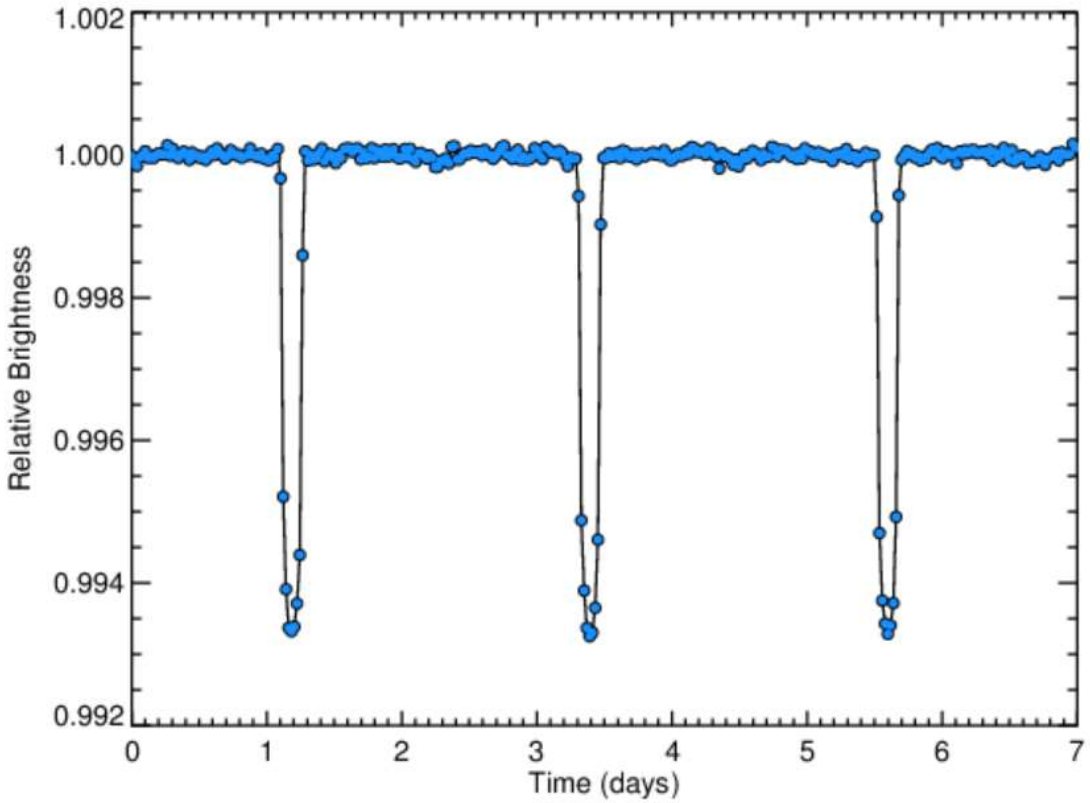
SOURCE: Harvard

What is Light Curve Analysis

In the case of an Exoplanet Transit, the size of the dip reveals the size of the planet orbit the parent star through the following formula:

$$R_p = R_\star \sqrt{\text{Depth}}$$

The length of time between the dips shows the orbital period of the Exoplanet.

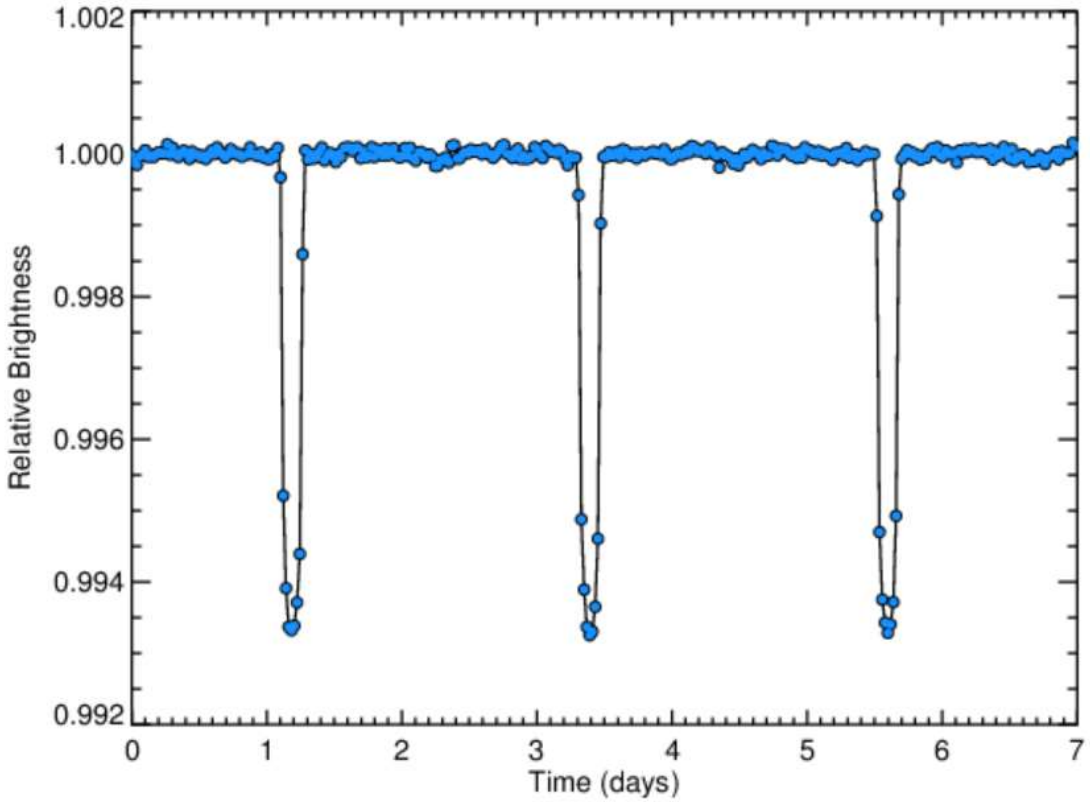


SOURCE: Harvard

What is Light Curve Analysis

The duration of the transit is the time it takes for the planet to cross over the face of the star.

This relays how close to the center of the star the planet transits, the size of the star (or more precisely, how dense the star is), and the eccentricity of the planet's orbit, or how close to a circle the planet's orbit is.

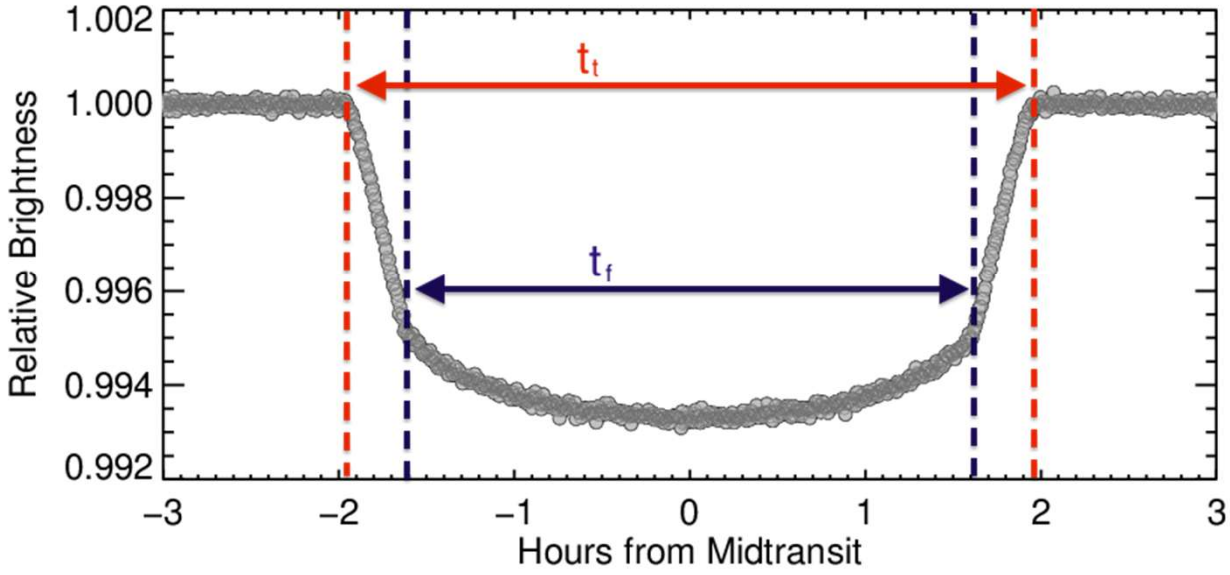


SOURCE: Harvard

What is Light Curve Analysis

Zooming into Exoplanet Light Curves reveals that the full transit is not instantaneous.

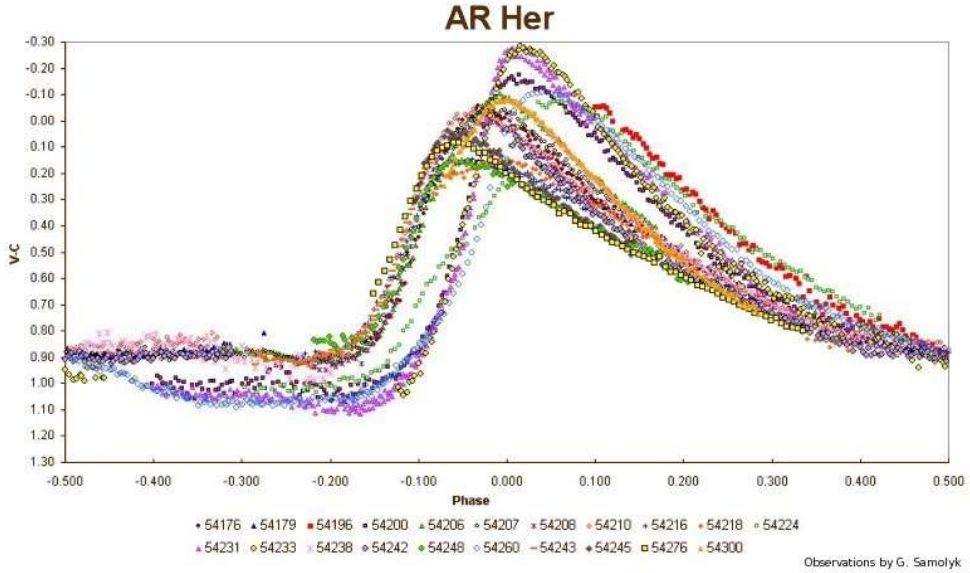
In the image to the right, there are two time measurements: the "total duration" t_t, from the beginning of the decrease in brightness to the end of the rise, and the "full duration", t_f, the amount of time the planet is fully over the surface of the star.



Summary

Here we have seen simple light curves, complex data sets and exoplanet light curves. Outside of the X and Y-axis orientations, each light curve is unique and displays characteristics of that type of variable star.

As a final example of how even the same type of variable star can vary, the RR Lyrae class of stars can display the Blazhko effect.



Questions?