Improved Methods for Ground-Based Follow-Up of Young Stars and Planets from the ZEIT Survey

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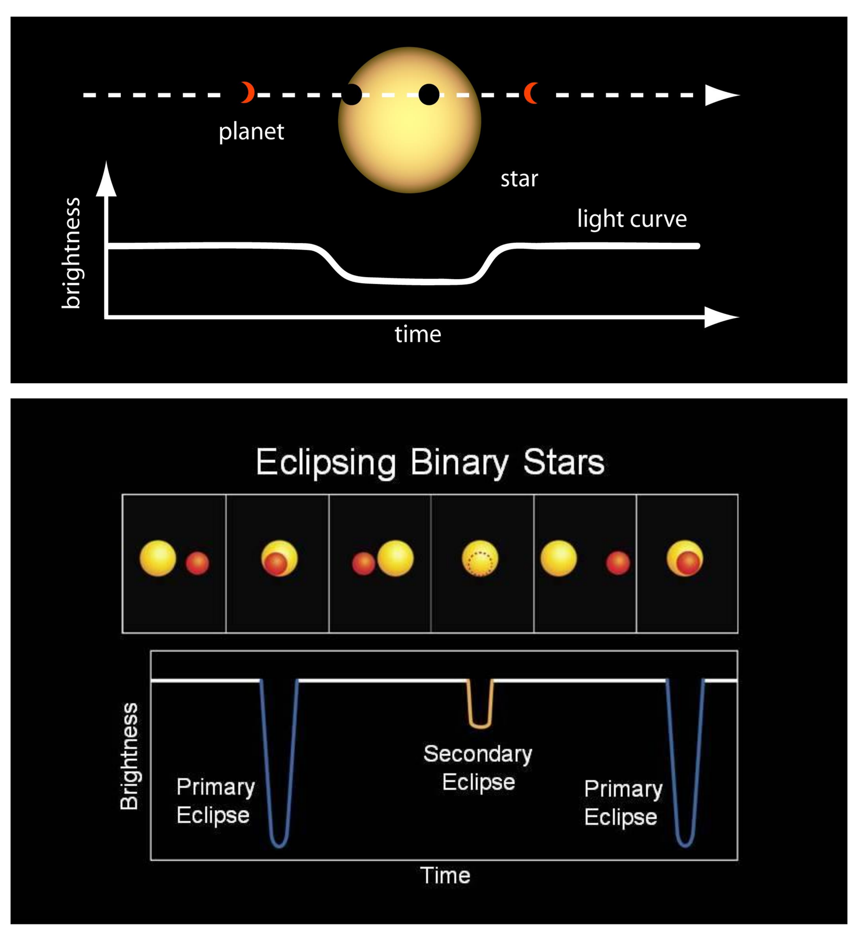
How Transits Work

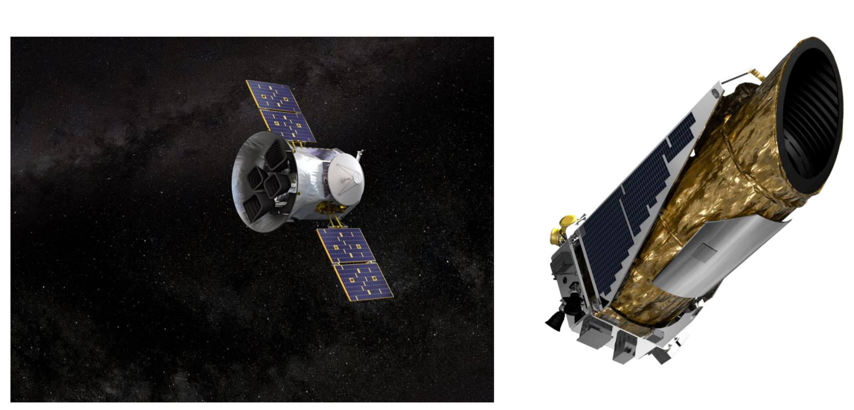
When a planet (or a separate, smaller star) passes in front of a star, the amount of light received from the star appears to decrease by a regular amount and for a specific regularly occurring amount of time. From these observations, you can determine several things about the relation between the host star and the orbiting object, and how long it takes for the object to complete an orbit. As eclipsing binary stars both emit light, this phenomenon occurs two distinct times in an orbit.



Light curves of a transiting exoplanet (top), and eclipsing binary stars (bottom)

Space-based Telescopes (*Kepler/K2* and *TESS*)

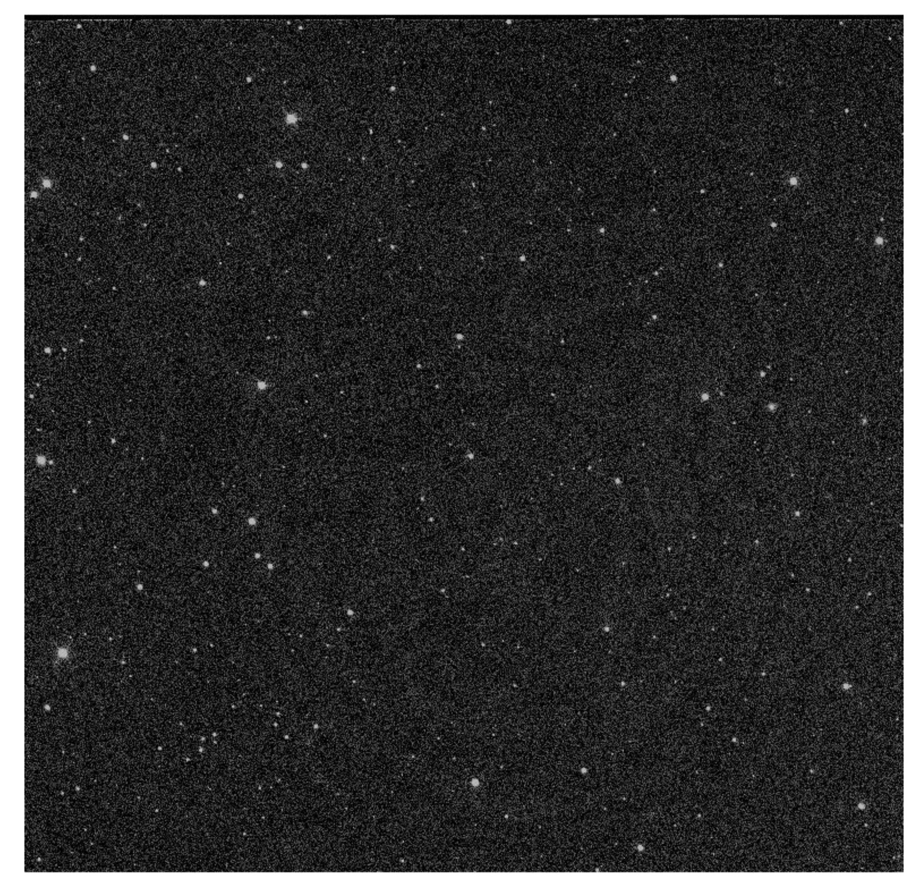
In space, there is no atmosphere to distort light before it enters a telescope. NASA's *Kepler, K2,* and *TESS* missions have focused on detecting as many exoplanets as accurately as possible from space. As the time available for any target is severely limited, ground-based telescopes are crucial for further investigation of these targets.



TESS (left), and *Kepler* (right)

Atmospheric Interference

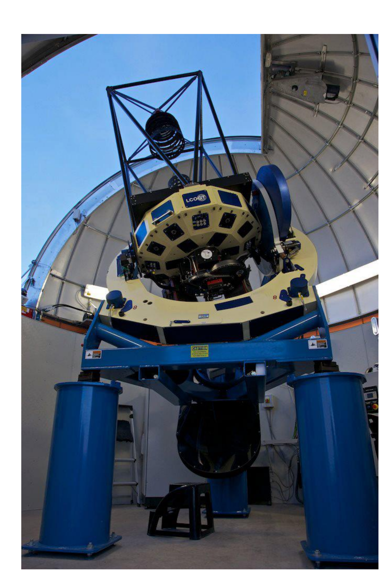
Light that passes through any gas is subject to scattering, where some light changes direction from where it was emitted and can't be detected by a telescope. Unfortunately, some wavelengths of light are more prone to scattering than others, so certain measures must be taken to ensure that these effects are mitigated.



An example LCO image. Notice that the stars appear as discs on this image.

Las Cumbres Observatory (LCO)

The Las Cumbres Observatory is a global network of optical telescopes, which can be used to collect data on stars, galaxies, and other distant sources of light. Since telescopes can only work at night and have a limited section of the sky they can see, a global network allows for data to be collected at almost any time.



LCO Las Cumbres Observatory

Some of LCO's facilities. The left facility is in Texas and the right facility is in Australia.

Methods

Photometry: Using apertures of varying size and location on the sets of images, the amount of light received from each source is fitted to an external catalog and used to find the magnitude of the target star in the image.

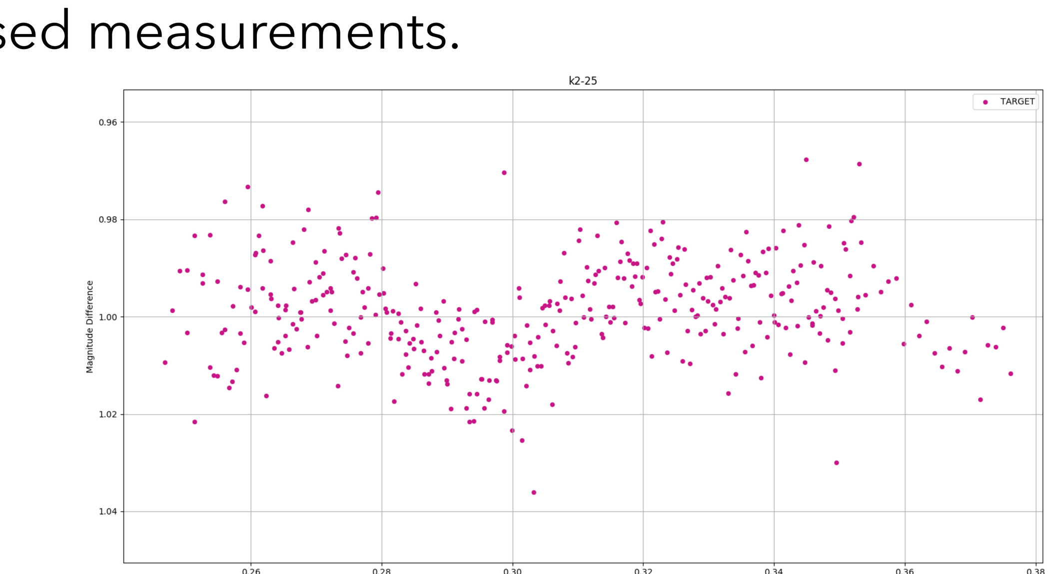
$$m = -2.5\log_{10}(f+b) + z_p - a_{BV} * (B-V)$$

The magnitude equation. Using the flux (f), and background (b), a zero point (z_p) matches the catalog, and a color term (a_{BV}) matches for color trends (B-V)

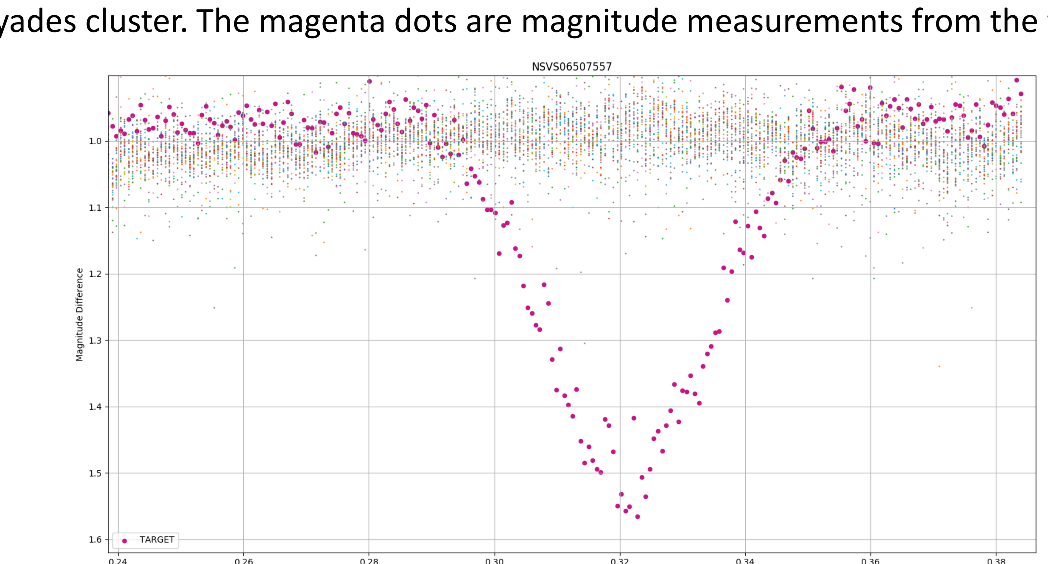
Light Curves: The data from the target, extracted from the image and corrected based on the background, is plotted against time to show the "event" present in it.

Results

Using our photometry pipeline, we were able to construct light curves that agree with prior space-based measurements.



A light curve for the transiting exoplanet K2-25b, a Neptune-sized planet in the Hyades cluster. The magenta dots are magnitude measurements from the target.



A light curve for NSVS06507557, an eclipsing binary system. The magenta dots are magnitude measurements from the target, and smaller dots are background stars.

References

Thao, P.C., Mann, A. W., Johnson, M. C., et al., 2020, AJ, 159, 32.
Mann, A. W., Gaidos, E., Mace, G. N., et al., 2016, ApJ, 818, 46.