Analysis of High-Resolution Images of Exoplanet Host Stars from Keck Observatory

Madelyn Latiolais B.S. ; Carl Ziegler, Ph.D
Department of Physics, Engineering, and Astronomy, Stephen F. Austin State University

Background

In our solar system, there are eight planets. However, planets can and do exist around other stars. These planets are called extrasolar or exoplanets, which typically require a natural phenomena called a transit to occur in order to detect their presence. A transit occurs when the exoplanet passes between the Earth and the exoplanets' host star; thus, the observed brightness of the star decreases. As the host star is orbited by the exoplanet, there is a periodic decrease and increase in the brightness of the star as observed from Earth. A visual representation is shown below in Figure 1.

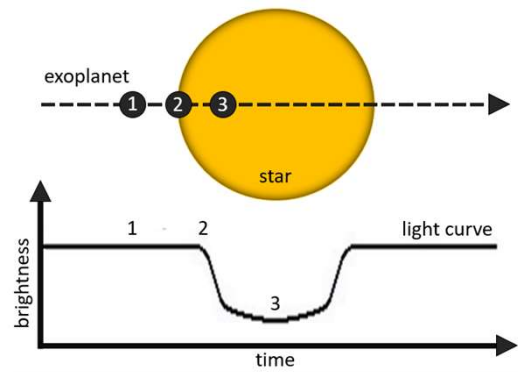

Figure 1: Illustration of Transiting Exoplanet with Light Curve

Context

The Kepler Space Telescope was launched by The National Aeronautics and Space Administration (NASA) in 2009 to search the cosmos for evidence of exoplanets. The telescope detected periodic changes in observable brightness to determine the potential existence of exoplanets around more than 500,000 stars. However, the telescope did not possess the resolution to detect sub-arcsecond companion stars. When a transit is detected in a system with multiple stellar bodies, certain scenarios are potentially present. Regardless of which star the exoplanet is orbiting, the light from the other stellar body dilutes the detected transit signal. If this specific system were considered to contain only one stellar body, the calculated radius of the exoplanet may be underestimated due to the additional light from the unaccounted star. Furthermore, in some systems, the transit signal may not be from an orbiting planet, but from an astrophysical false positive, such as a blended eclipsing binary, in which one star occults the other, moving between the Earth and the other stellar body in the system.

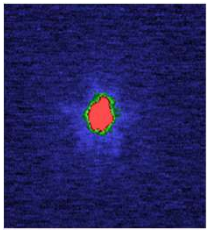

Figure 2: KOI 5084

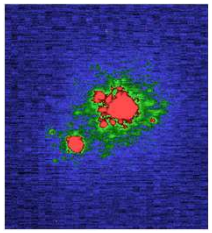

Figure 3: KOI 4923

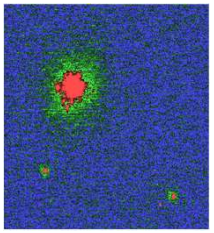

Figure 4: KOI 3460

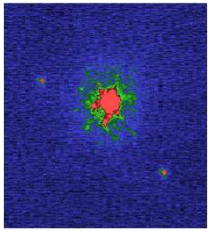

Figure 5: KOI 1855

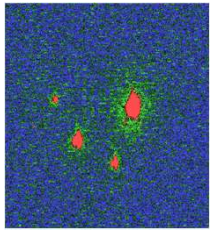

Figure 6: KOI 799

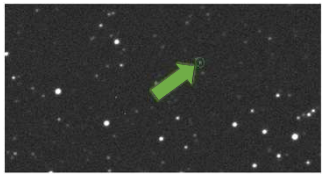

Figure 7: KOI 5084

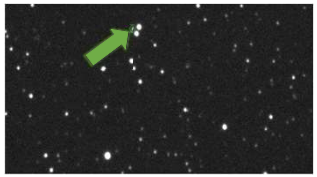

Figure 8: KOI 4923

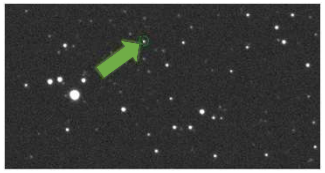

Figure 9: KOI 3460

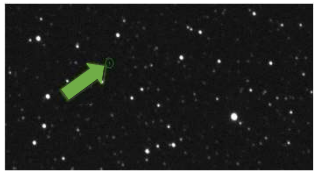

Figure 10: KOI 1855

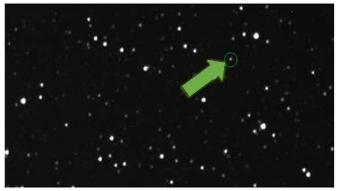

Figure 11: KOI 799

Procedure

A Kepler Object of Interest (KOI) is a star system observed by the Kepler space telescope that hosts a suspected one or multiple transiting exoplanets. ROBO-AO, utilizing a 2-m class telescope, captured the first high-resolution images of KOI targets, in which evidence of possible companion stars were detected in numerous KOI systems. In 2017, further high-resolution images were captured of these KOI objects by the Keck2 telescope, a 10-m class telescope, at the W.M. Keck Observatory in Hawaii, USA. Analysis of the KOI images taken at Keck Observatory led to a better estimate of the number of solar bodies in a specific KOI system and an updated estimation of the radii of the suspected exoplanet(s). The original dataset of images taken by the Keck2 telescope contained over eighty stellar systems. Five systems were prioritized for further investigation due to their high multiplicity and/or previously confirmed exoplanets.

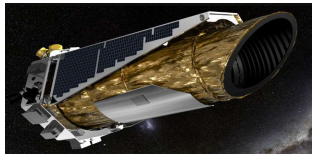

Figure 12: The Kepler Space Telescope

Figure 13: W.M. Keck Observatory

Conclusion

The images taken by the Keck2 telescope of the five selected KOI systems are shown in Figure 2 through Figure 6. The images of the selected KOI systems displayed in Figure 7 through Figure 11 were taken by various telescopes using the Skynet Robotic Telescope Network. As shown, the companion stars in a stellar system are generally not resolvable with seeing-limited imaging. Thus, the images taken by Keck2 introduce new data about each selected KOI system.

- KOI 799: quaternary system with exoplanet declared a false positive.
- KOI 1855: trinary system with exoplanet declared a false positive.
- KOI 3460: trinary system with exoplanet candidate.
- KOI 4923: binary system with exoplanet candidate.
- KOI 5084: single-star system with confirmed exoplanet Kepler-1625b.

The estimations of the exoplanet radii, as well as the orbital periods of the exoplanet, are shown in Table 1.

KOI Object	Best Radius Estimate (R⊕)	Updated Radius Estimate (R⊕)	Orbital Period (days)
799	6.07	7.23326	1.6266
1855	3.26	3.30366	58.4299
3460	1.19	1.231674	62.5964
4923	1.4	1.538850	38.1687
5084	11.831	11.831	287.3774

Table 1: Estimates of Exoplanet Radii and Orbital Periods

Contact

Madelyn Elaine Latiolais
Stephen F. Austin State University – Department of Physics, Engineering, and Astronomy
1936 North St. Nacogdoches, Texas 75962
latiolaime@jacks.sfasu.edu

Acknowledgement

This work was supported by Summer Undergraduate Research Experience (SURE) through the College of Sciences and Mathematics at Stephen F. Austin State University.

References

1. Ziegler et al. (2018), AJ 155 161
2. https://exoplanetarchive.ipac.caltech.edu/ (NASA Exoplanet Archive)
3. https://gea.esac.esa.int/archive/ (European Space Agency GAIA Archive)
4. https://skynet.unc.edu/ (Skynet Robotic Telescope Network)
5. https://aladin.u-strasbg.fr/AladinLite/ (AladinLite)