Reclassification Study of TOI Catalog Sources as Eclipsing Binary Subtypes

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BRIEF

Background

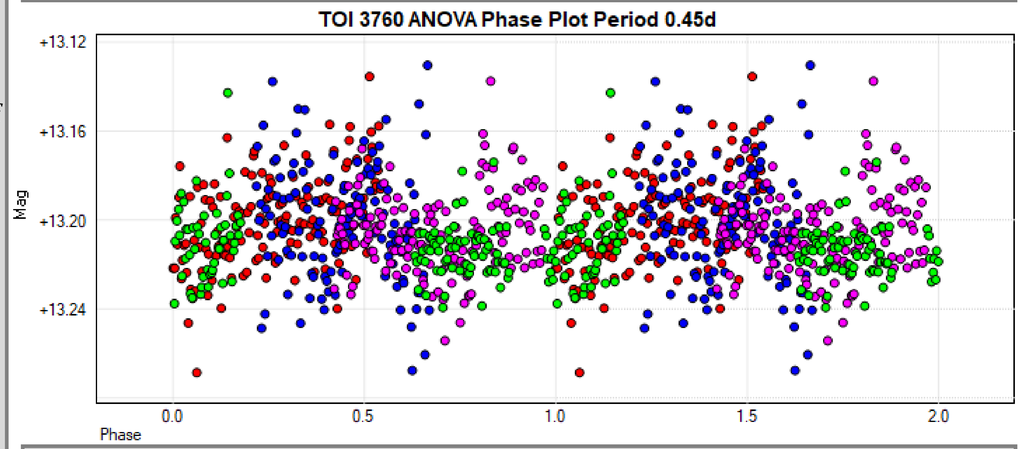
- The TESS Objects of Interest (TOI) Catalog contains data on more than 6,500 observations of periodic variable stars.
- The goal of the TESS project is to measure the changing fluxes of these stars and quantify their variability as evidence for transiting exoplanets.
- Not all sources TESS observes can be explained as transiting exoplanet systems.
- In a binary system, the secondary star will eclipse the primary star, resulting in a reduction of the observed flux from the system as a whole.
- Examination of flux measurements in light curves and phase plots enables the characterization of these sources as eclipsing binaries, exoplanets, or other variable sources.

Target Selection

- 10 TOI sources were initially selected for redundancy. 3 sources were discarded for too few observation opportunities and minimum observable elevation constraints on the telescope hardware.
- Two other targets were discarded due to a lack of data and poor seeing conditions (clouds, high airmass, priority scheduling)
- Targets were selected with two primary considerations:
  - Reports of a 'V-shaped' light curve, which are indicative of a rapid and non-total transit. These are often associated with eclipsing binaries.
  - Short (<2 day) orbital periods.
- Acceptable data was accumulated for 2 of these targets, TOI 3760 and TOI 2747, which are displayed at right.

Imaging Parameters

- 120-second integration times, Sloan-i' near-infrared filter (763 nm), 2x2 CCD pixel binning

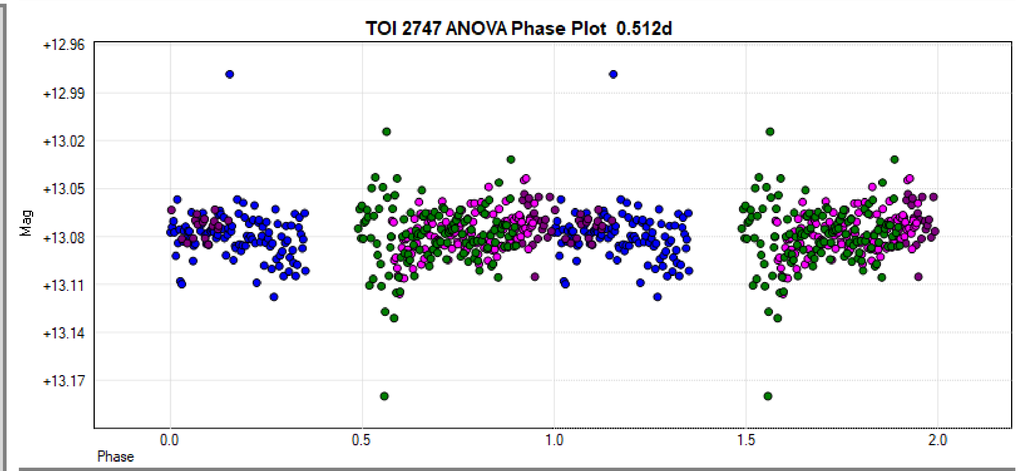


TESS Measurement

- Period: 0.53 days

BARON Measurement

- Period: 0.45 days ~15% discrepancy from TESS using ANOVA[1]



TESS Measurement

- Period: 0.52 days

BARON Measurement

- Period: 0.512 days ~1.5% discrepancy from TESS using ANOVA[1]

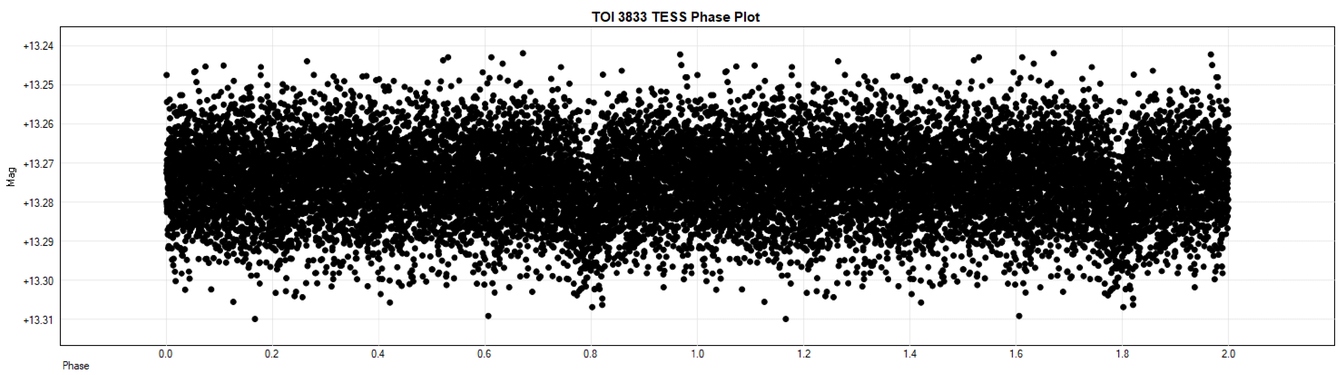
Procedure

- Five TOI sources were selected for closer observation using combined observing time from the 17" Boyce-Astro Research Observatory telescopes (BARO and BARON).
- Flux measurements were gathered throughout the month of November 2023.
- Two comparison stars with comparable magnitude to the target were selected for each source as non-variable standards.
- Images with clear distortion or errors were identified and removed using the AstroImageJ (AIJ) software.
- The Mira Pro x64 software was used to perform dark, flat, and bias calibration on every image in each sequence.
- Phase plots are generated and analyzed using Peranso software with the ANOVA[1] prediction method for period estimation.

What are the types of eclipsing binaries?

- W Ursae Majoris-type
  - Each component shares a stellar atmosphere, known as a common envelope.
  - Orbital periods are far shorter than other subtypes.
  - Light curve shows continuous and consistent eclipsing.
- Beta Lyrae-type
  - The components do not share a common envelope.
  - Each star has an ellipsoidal shape due to tidal interactions.
- Algol-type
  - Co-orbiting stars are more distant from one another.
  - Light curve shows definitive eclipsing and non-eclipsing period.

Boyce-Astro Research Observatory—North (BARON)



Conclusions

- More observation time is needed to make definitive conclusions.
- Despite less than ideal data, the ANOVA[1] phase plot fitting method predicts similar periodicity to TESS measurements.
- TOI 2747 data is far too insufficient for distinguishing between eclipsing binary subtypes.
- The TOI 3760 phase plot appears to share similarities with the expected appearance of a W Ursae Majoris-type variable[2], but more observational data is required to support this conjecture.
- Longer measurement periods during non-transit times would assist in building the case for classification as an eclipsing binary.

References

[1] Schwarzenberg-Czerny, A., ApJ, 460, L107-110, 1996 [2] Polakis, T., J. Am. Assoc. Var. Star Obs. (JAAVSO) 2019, 47, 117.