



Ground-Based Observations of Two TESS Exoplanet Candidates

Ryan Chang, Sean Johnson, Jeslyn Liu, Madison Melendez, Andrea Juarez Nava, Milo Richard
Mentor: Audrey Omand



University of California, Berkeley — Undergraduate Lab at Berkeley, Physics & Astronomy Division

Abstract

Missions like Transiting Exoplanet Survey Satellite (TESS) have greatly accelerated exoplanet discovery, though candidates require ground-based follow-up to rule out false positives. To this end, we observed secondary transits of TOI-2758 and TOI-5451 at Leuschner Observatory. Using Python to plot their light curves, we find semi-distinct U-shaped dips consistent with exoplanets.

Background

Exoplanets—planets orbiting stars beyond our own—were first discovered in 1992, with the first transit detection following in 1999, where a planet passes in front of its star and blocks a measurable portion of its light. Despite the field's relative infancy, over 6,000 exoplanets have since been confirmed, and the rate of discovery continues to accelerate. Studying these worlds advances our understanding of planet formation and habitability, offering new insight into Earth's origins and the potential for life elsewhere in the universe.

Methodology

The first stage of our project involved identifying TESS objects with a high probability of being exoplanets. We analyzed relative flux curves, occultation number, radius, period, transit duration, signal-to-noise ratio (SNR), and transit depth (ppm), looking for a U-shaped flux curve, an occultation number below 5σ to rule out multiple-body systems, and a radius below 20 to favor planetary candidates.

The remaining parameters determined observability. The period indicated when the target could be observed, while transit duration gave how long it crossed its host star. We required an SNR above 50 and a transit depth between 10,000–20,000 ppm to ensure sufficient data quality with the Leuschner telescope.

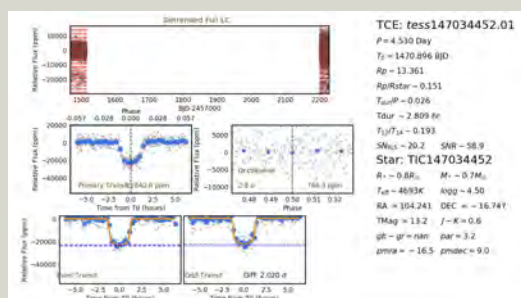


Figure 1. AQLP report for TOI-2758.

We identified two candidates, TOI-2758 and TOI-5451, for observation. Using the SIMBAD Astronomical Database [5], we found that TOI-2758 had two prior mentions in the literature, having been flagged as a planetary candidate by a convolutional neural network with independent human verification [4] and by the TESS Faint-star Search vetting pipeline [2].

Observations

With our primary candidate selected, we conducted three observation runs, capturing two partial transits and one observation of our backup candidate.

During these nights, we configured the Leuschner telescope to track the target star throughout the transit with 45-second exposures. To account for thermal noise, we took ten dark and bias frames each, and captured flat frames during the brief 15-minute twilight window to correct for dust or lens artifacts. Although the dome auto-adjusts to track the telescope, we logged any planes, insects, or equipment issues for later data processing.

Generating Light Curves

We inherited a mostly functional photometry code [3] from a ULAB group that conducted a similar project last year. Although it required modifications to improve efficiency and data management, it provided a strong foundation for an optimized pipeline [1]. The pipeline begins by loading raw transit images from a specified directory, followed by an initial check of pixel dimensions and frame count. The images are then calibrated using standard frames (darks and flats) to remove instrumental noise and thermal artifacts.



(a) Raw transit image of TOI-5451 taken on 4/7/2026. (b) Dark-subtracted image of TOI-5451 from 4/7/2026. (c) Fully calibrated image of TOI-5451 from 4/7/2026.

After calibration, the pipeline extracts the flux of the target star from each frame, using a reference star to correct for atmospheric effects. The flux is then normalized and binned to improve clarity. Finally, the pipeline generates a light curve overlaying raw data with the binned, smoothed data over time, enabling clear identification of any transit dip.

Conclusion

Although we were able to produce strong evidence that our candidate is an exoplanet, we cannot independently confirm its status. Confirmation typically requires coordinated observations from multiple telescopes; however, this dependency ensures that our contribution remains both valuable and necessary. By providing this foundational data, we have established a clear path for future work to build upon and eventually confirm the object as an exoplanet.

In terms of project improvements—we could gain more observation time by accelerating candidate selection, for example by automating it with a Python script to scrape necessary files from the database. Additionally, observations could begin as soon as a primary candidate is identified, rather than waiting to finalize the full candidate list.

Light Curves

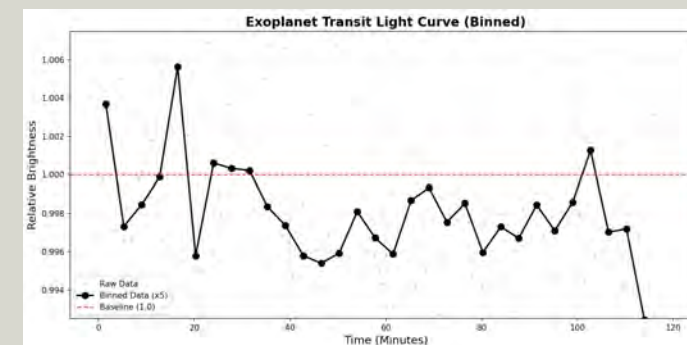


Figure 3. A light curve of TOI-2728, observed on March 9, 2026.

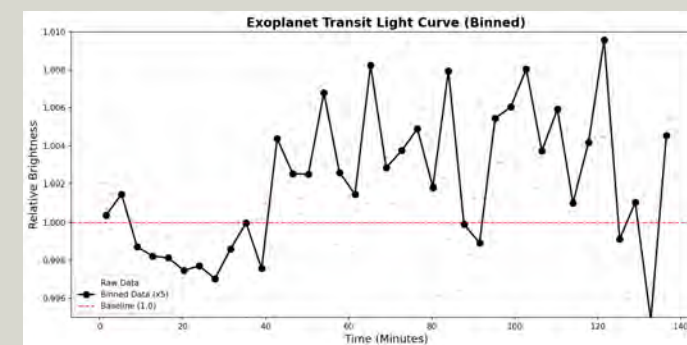


Figure 4. A light curve of TOI-5451, observed on April 7, 2026.

References

- [1] Sean Johnson. [LightCurve_SeanJohnson.ipynb](#), 2026. Jupyter Notebook.
- [2] M. et al. Kunimoto. The tess faint-star search: 1617 tois from the tess primary mission. *The Astrophysical Journal Supplement Series*, 259(2), 2022.
- [3] Andrew McHaty. [Light_curve_fixedforloops-Andrew.ipynb](#), 2025. Jupyter Notebook.
- [4] G. et al. Olmschenk. Identifying planetary transit candidates in tess full-frame image light curves via convolutional neural networks. *The Astrophysical Journal*, 161(6), 2021.
- [5] M. et al. Wenger. The simbad astronomical database. *Astronomy and Astrophysics Supplement Series*, 143(9), 2000.

Acknowledgments

We thank Professor Alan Chew for his mentorship, particularly his guidance in telescope management and troubleshooting, which was essential to our transit measurements. We also thank the Undergraduate Lab at Berkeley (ULAB), including Directors Andrew McHaty and Yaamini Jois, Curriculum Manager Brianna Peck, Python Lecturer Caitlin Begbie, and Faculty Sponsor Dan Kasen, for their support. Finally, we thank the UC Berkeley Department of Astronomy for access to the Leuschner Observatory, which made this research possible.