National Aeronautics and Space Administration

FY25 Strategic University Research Partnership (SURP)

Saving High Precision Transit Observations

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Primary Topic Area subcategory: Exoplanet Science and Discovery

Background & Motivation

This collaborative research initiative brings together an international network of amateur astronomers and professional scientists from various institutions, featuring undergraduates from Co-I Simon's online exoplanet research class at Arizona State University (ASU), to conduct high-precision photometric observations on selected exoplanetary targets.

Our collaboration leverages the Exoplanet Watch program's network of ground-based telescopes to provide critical transit timing and duration analyses for exoplanets and planet candidates discovered by TESS and of interest to missions like Pandora, JWST, and Ariel. We have also expanded to include competitively awarded radial velocity (RV) programs aimed at characterizing and confirming compelling, multi-planet systems from TESS.

By combining expertise across disciplines, including planetology, astrophysics, and stellar activity studies, this project aims to refine the orbital parameters of exoplanets, detect additional planets within known planetary systems, and contribute valuable insights into the dynamics of multi-planetary systems.

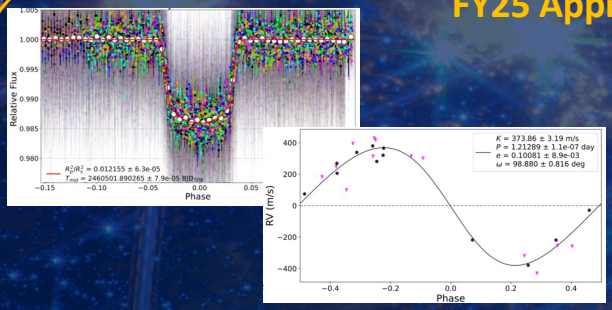
Project Objectives

This year our team has focused on two systems for deep characterization :

- HAT-P-23 : A Hot Jupiter with a previously large mid-eclipse uncertainty, complicating the scheduling of eclipse / emission spectroscopy observations. Using repositories of ground and space-based telescopes' optical transits, eclipses, and radial velocity measurements, we were able to decrease the timing uncertainty on the planet's mid-eclipse time from 52 minutes down to 2 minutes.
- TOI-1873 : A G5V star hosting three transiting planets that have been statistically validated but lack mass measurements. The two inner planets have well defined periods (P = 7 and 24 days) while the third has five potential periods spanning 128 - 900 days as it has only been seen in three, non-sequential TESS sectors. Our NEID RVs provide mass estimates for the inner planets and lay the groundwork for confirming the outer planet.

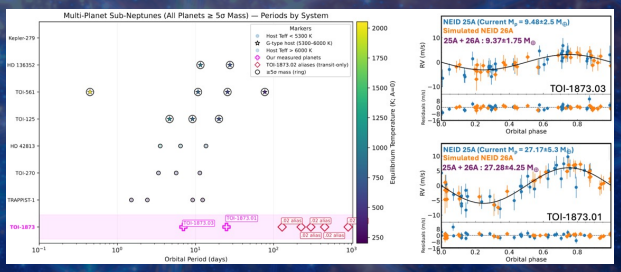
In addition, we have provided photometric monitoring using competitively awarded time on the Kuiper 61" for a variety of planet hosting stars that are likely to be observed with NASA's PANDORA mission to improve knowledge of their rotational periods and modulation patterns.

FY25 Approach & Results



Right: Combined transit fit incorporating 58 citizen scientists' optical transit observations from Exoplanet Watch and ExoClock and three sectors of data from TESS. The full system fit also includes two Spitzer eclipse observations, one in each of the 3.6 and 4.2μm bands. Right: Radial velocity fit incorporating 25 archival RV data points from the SOPHIE and HIRES spectrographs.

This updated analysis of the hot Jupiter Hat-P-23 b decreases the uncertainty of the planets secondary eclipse events from 52 minutes down to only 2 minutes, which would save 2+ hours of schedule padding when the star is targeted by space-based missions such as JWST, PANDORA, or Ariel.



Left: Orbital periods of multi-planet systems containing 3+ sub-Neptunes with ≥5σ masses. Unlike most multi-planet sub-Neptune systems that follow the "peas-in-a-pod" trend of evenly spaced, similar-sized planets, TOI-1873 shows a striking separation in orbital period: two inner planets at 7 and 25 days, and a third candidate with possible aliases between 128–900 days. This unusual architecture makes TOI-1873 an important laboratory for testing planet formation and migration scenarios within a single system.
Right: our phase-folded folded NEID RV from 2025 A (blue) and simulated 2026 A (orange) for the two inner TOI-1873 planet candidates. The black curves trace the best-fit Keplerian from the joint RV + stellar activity + transit model. The existing 25A data cannot provide robust, 5-σ masses for both inner planets but the additional 26A data will deliver the mass precision required to understand the planets' bulk compositions and ready them for atmospheric follow up efforts.

Future Efforts

- Complete manuscript updating the orbital solution of HAT-P-23 b and submit to PASP
- Continue confirmation/characterization efforts for the inner TOI-1873 planets and potentially the outer planet (pending results of 2026A NEID time request) and develop a JWST Cycle 5 proposal to obtain transmission spectra of one or both inner planets.
- Use recently acquired nights on the Kuiper 61" telescope run by the Arizona Consortium of Telescopes to update the transit ephemerides of Pandora targets in the 2025B/2026A semesters.
- Increase ephemeris refinement efforts from single targets (e.g. HAT-P-23 b) to a larger-scale effort refining the orbital parameters for likely Pandora and Ariel targets.

Benefits to JPL/NASA

- The coordinated Exoplanet Watch transit follow up and photometric monitoring efforts organized here support the upcoming PANDORA and Ariel missions by increasing community knowledge of the host stars' variability (which can impact accurate atmospheric retrievals) and the planet's exact orbital parameters (allowing for more efficient scheduling)
- Publication of the updated HAT-P-23 b orbital fit establishes our archival search and analysis methodology as an efficient way to scrape existing but neglected knowledge of planetary systems, which can be leveraged for future XRP or Citizen Science seed funding calls.
- Confirmation of the TOI-1873 planets positions our team to apply for follow-up atmospheric characterization of the system with JWST

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