Investigating Transiting Exoplanets in the ULTRASAT Fields

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Observing Transits in the UV

There are very few exoplanets that have been observed in the UV. This is due to limited space-based facilities (e.g. HST, Swift, CUTE[1]).

Therefore, we cannot build a large, unbiased sample.

What Can We Learn From the UV?

UV observations can constrain structure and processes of the upper atmosphere (such as escape).

Atmospheric escape is the best explanation for the observed radius gap in small exoplanets [see Fulton et al. (2017)[2]]

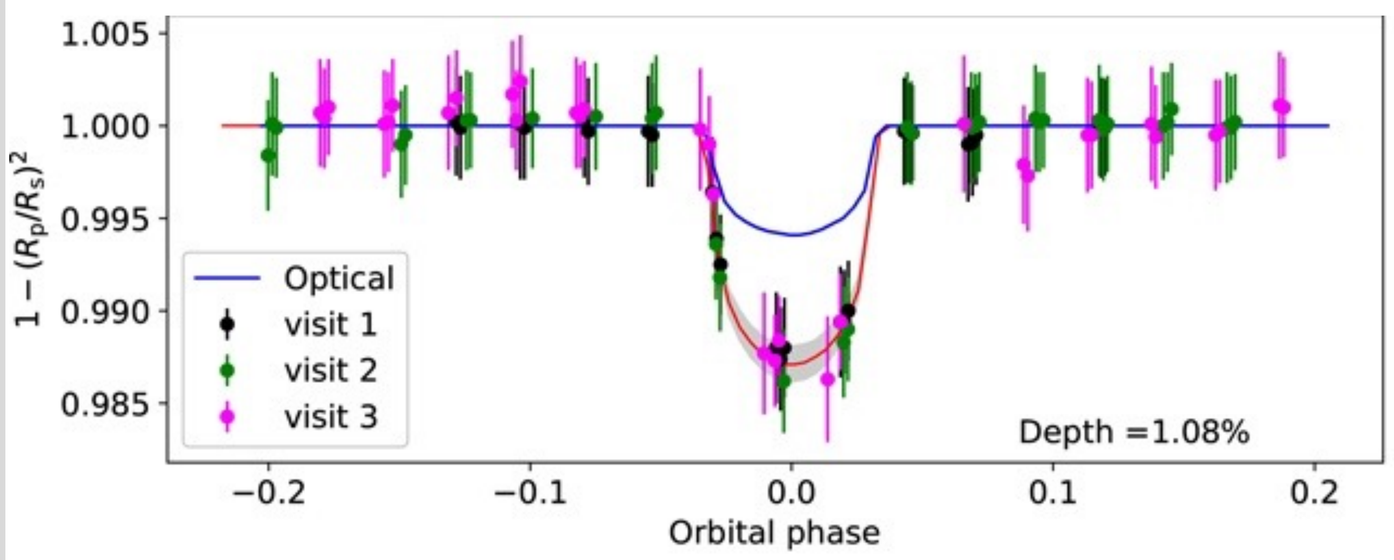


Figure 1: We sometimes observe deeper transits in the UV vs. the visible for the same exoplanet. NUV observation of WASP-189b using CUTE (colored points) compared to optical transit using observations from CHEOPS (in blue). Taken from Figure 2 of Sreejith et al. (2023)[3].

Some planets show UV absorption beyond the projected Roche Lobe (e.g. WASP-121 b[4]), indicating active escape.

A population of exoplanets observed in the UV and the visible would let us look at trends in atmospheric escape.

ULTRASAT Mission Overview

See Schvartzvald et al. (2024)[5]

- Ultraviolet Transient Astronomy Satellite
- Mission led by Israel Space Agency & Weizmann Institute (in partnership with NASA), set for launch in late 2027
- Wide-field survey looking for transient and variable UV sources
- Continuous, long baseline observations
  - 300-second cadence for 21 hours per day
  - Large field of view (300 times larger than GALEX)
- 3 fields near the ecliptic poles overlap with many TESS sectors
  - Will be sensitive to stars that are faint in TESS

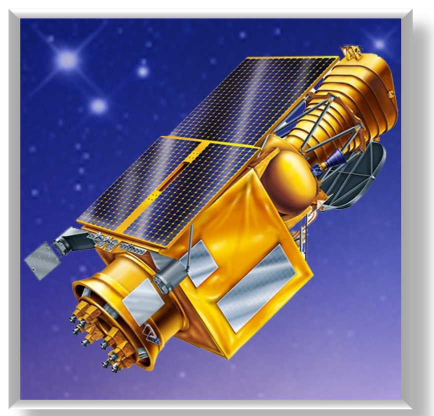


Image Credit: NASA

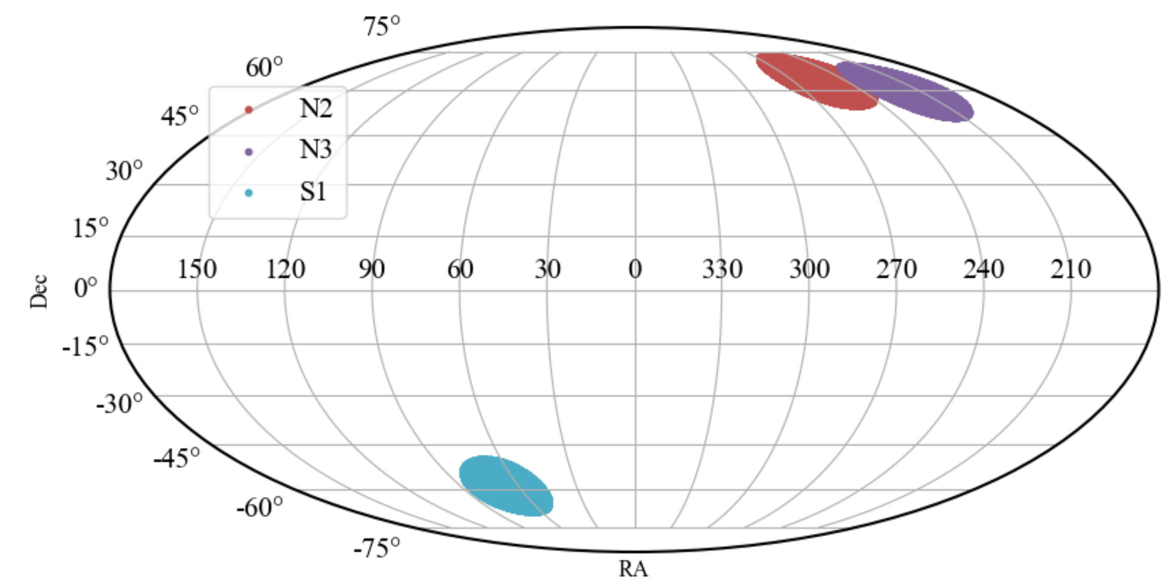


Figure 2: ULTRASAT Fields

Project Motivation

For effective demographic studies, we want ~hundreds of planets. However, there are less than 50 confirmed planets in the ULTRASAT fields.

Most faint stars in the TESS field have not been systematically searched for planets (computationally expensive). ULTRASAT fields are relatively small, and therefore feasible to search fainter stars.

Project Goal:
Develop a well-vetted list of transiting planet candidates in the ULTRASAT fields that are likely observable with ULTRASAT.

How We Search for New Planets

1. Make a target list of stars brighter than 16th magnitude (~650,000).
2. Use TESSphomo[7] to make light curves for each star from TESS Full-Frame Image (FFI) data. These are better than SPOC for faint stars.
3. Search the new light curves for transits to identify new planet candidates, and systematically vet new candidates.
4. Calculate expected ULTRASAT SNR for planet candidates. This is very uncertain due to significant uncertainties in the estimated stellar brightness in the ULTRASAT bandpass.

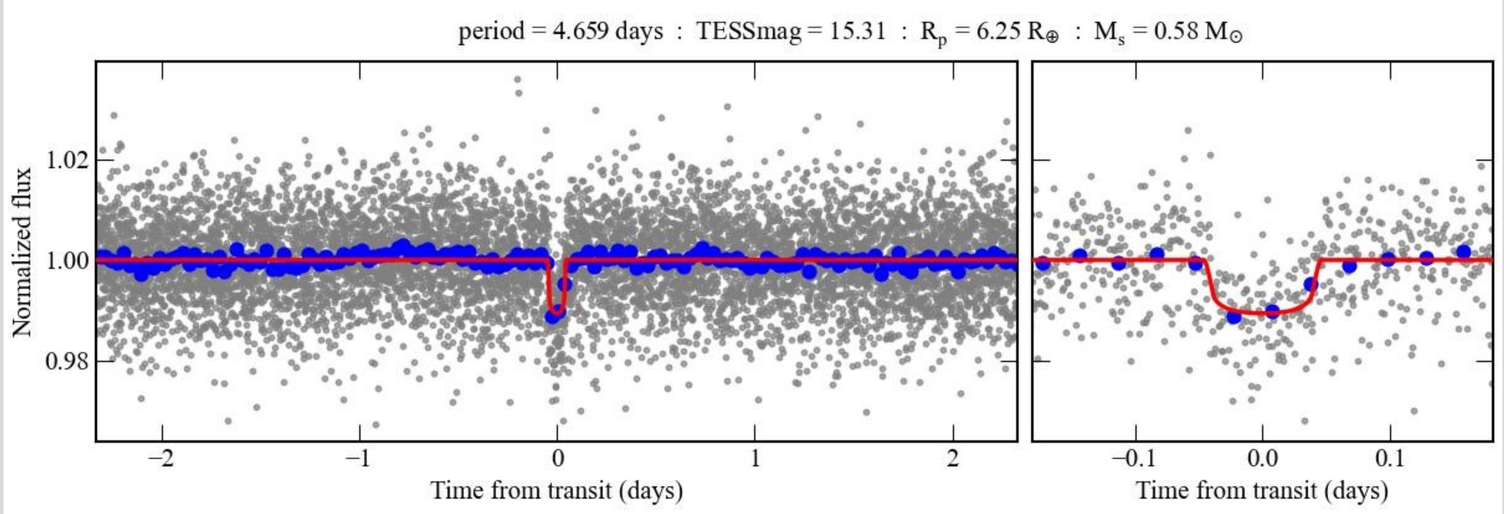
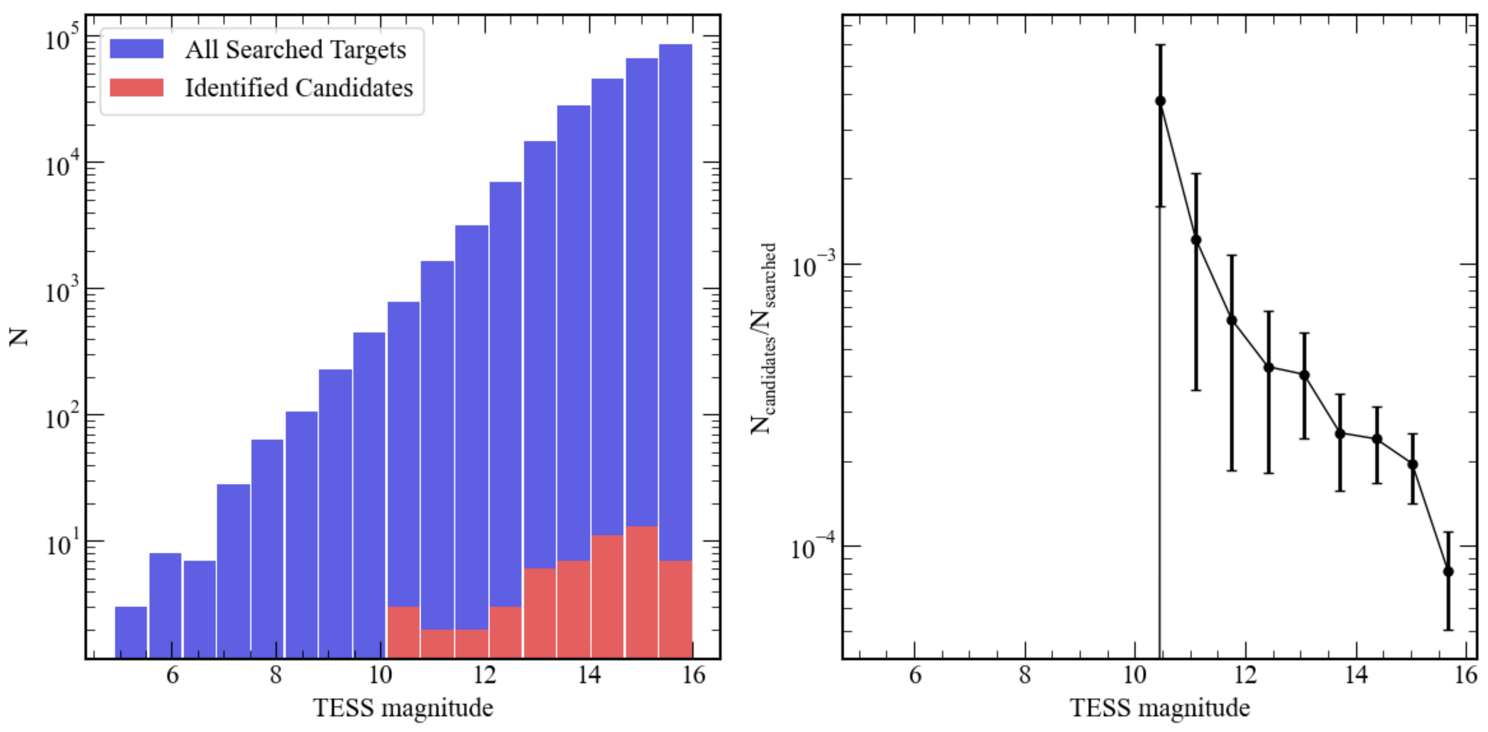


Figure 3 (above): Phase folded light curve centered on the transit for a new candidate identified in this work. The blue points are binned data points, and the red curve is the best-fit transit model.

Figure 4 (below): We are sensitive to planets around faint stars, with a possible cutoff >15th magnitude. The left panel shows histograms of identified candidates (in red) and all targets searched (in blue). The right panel shows the number of candidates in each bin divided by the total number of targets searched in that bin.



Preliminary Results

The transit search and vetting is ongoing (~39% complete).

We've identified 42 new planet candidates (Fig. 3) and a possible cutoff in sensitivity (Fig. 4).

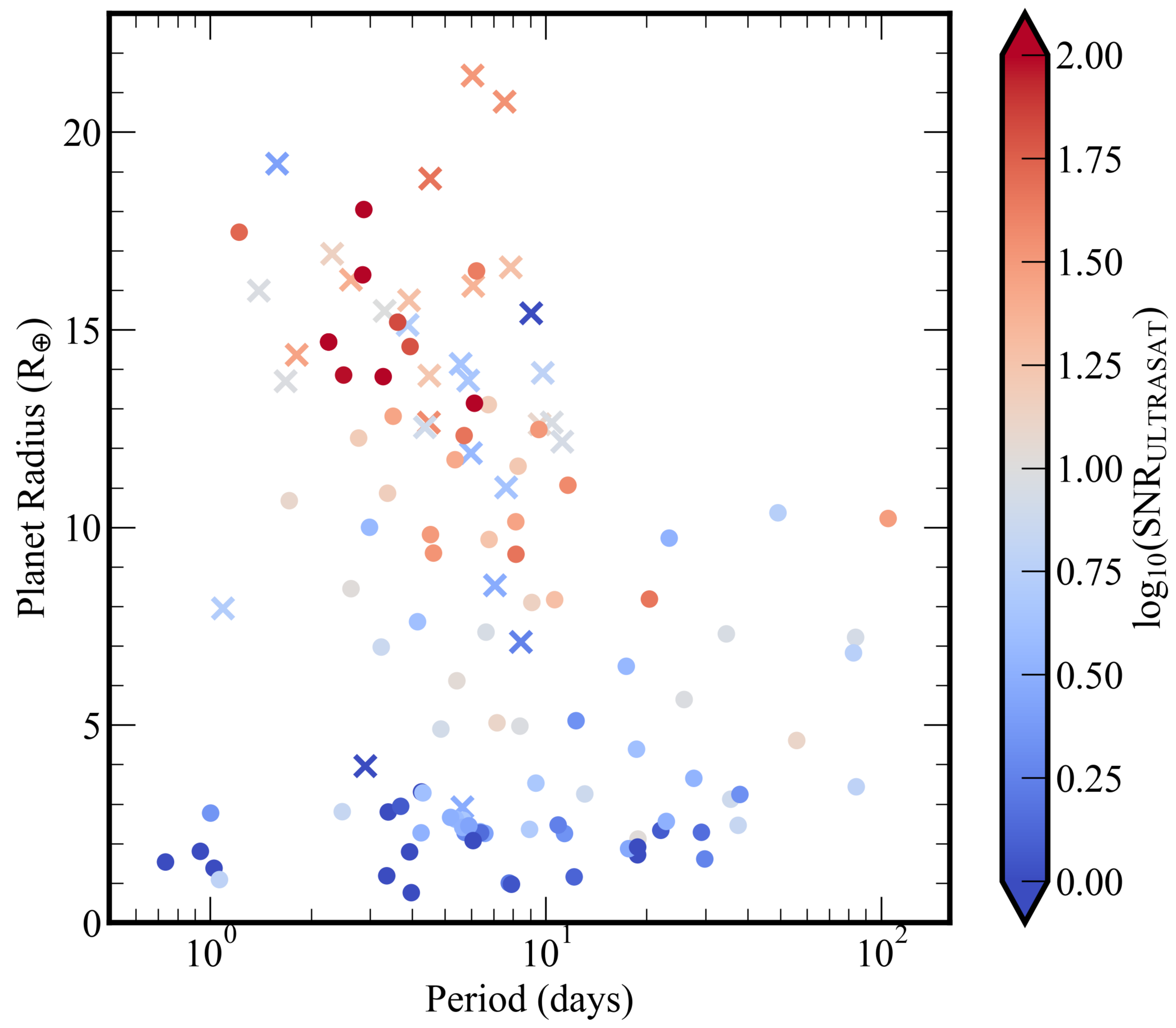


Figure 5: We've identified many new planet candidates in the ULTRASAT fields. Circles indicate previously known planet candidates listed on the TOI list and crosses indicate new planet candidates from this search. The data points are colored by expected ULTRASAT SNR, with red indicating likely detectable and blue indicating likely not detectable.

Many candidates in the ULTRASAT fields (44 new + existing) will be observable with ULTRASAT. This number is likely even higher due to the uncertainties in $SNR_{ULTRASAT}$.

Discussion

ULTRASAT will provide an unprecedented opportunity to investigate exoplanet transits in the UV. It will provide larger and less biased sample to investigate trends between visible and UV transit depths.

The expanded catalog from this work would ~ double the number of planets with visible + UV transit observations.

References

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