Long-Period Transiting Exoplanets in the Roman Galactic Bulge Time Domain Survey

UMBC

GRANTEE

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Key result: Roman will discover ~ 100,000 transiting exoplanets, of which ~ 9,000 will be detected with ambiguous orbital periods.

1. Introduction

The Nancy Grace Roman Space Telescope (Roman) is scheduled to launch on 30 August 2026. Its Galactic Bulge Time Domain Survey (GBTDS) will observe six fields (covering a total area of 1.7 deg^2) for six high-cadence observing seasons, each spanning ~ 70.5 days. It will deliver high-precision photometry for more than 100 million stars at a 12-minute cadence.

Simulations have predicted that the Roman GBTDS will discover ~ 100,000 transiting planets [Wilson et al. 2023]. Any planet with an orbital period P ≳ 70 days, and some planets with P ~ 35 – 70 days, will transit at most once per observing season. We investigate the observational signatures and physical properties of these detections.

2. Methods

We used the catalog of simulated planets from Wilson et al. 2023 to identify planets detected as single transit events in the first observing season. With each additional observing season, new single transits are discovered and existing single transits may exhibit additional transits. These additional transits can either uniquely resolve the orbital period or leave multiple viable period aliases. For each detection with two or more non-consecutive observed transits, we computed the set of allowed period aliases (**Figure 1**). Using these results, we determined the total number of systems with ambiguous and resolved orbital periods at the end of each observing season (**Figure 2**).

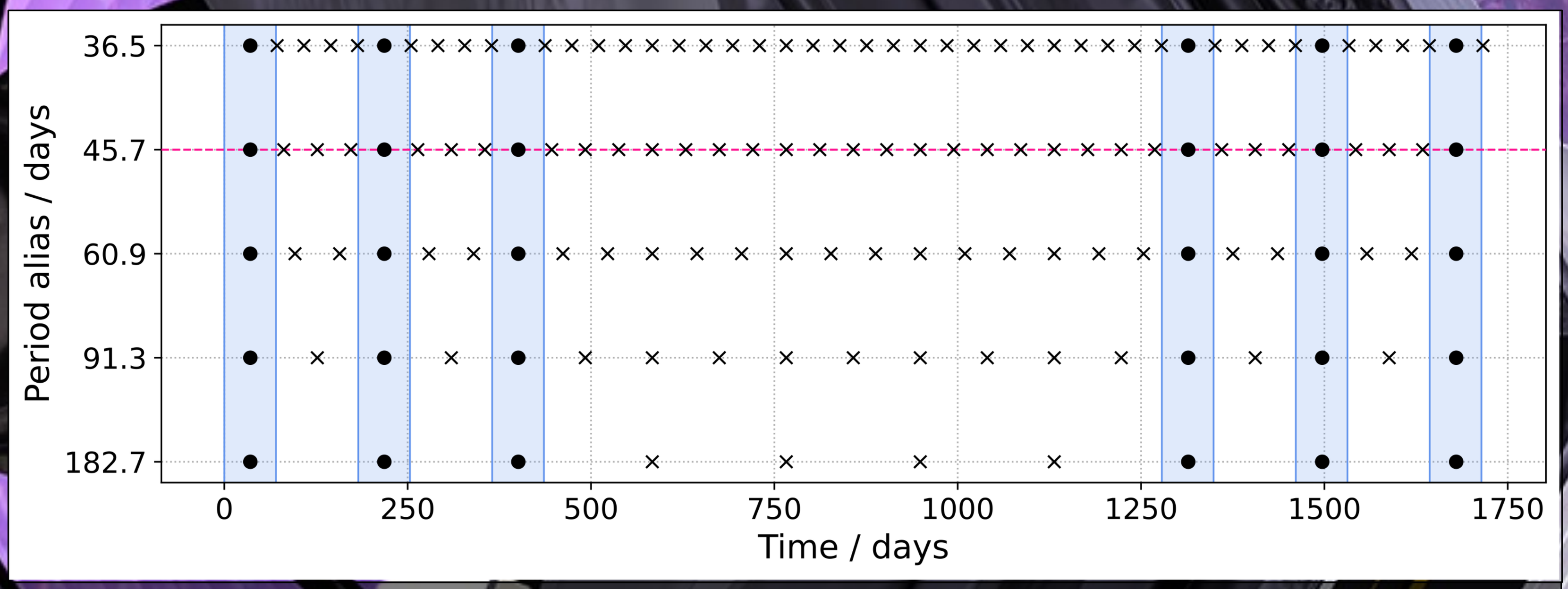

Figure 1: Period aliases for a simulated planet detected in the GBTDS. The blue shaded regions correspond to the six observing seasons, each value on the y-axis represents a possible period alias, the circles are transits that were observed, the crosses represent unobserved transits for each alias, and the dashed pink line is the true simulated orbital period.

3. Results

At the end of the survey, ~ 9,000 planets have ambiguous orbital periods with at most one transit per season.

- ★ ~ 45% are single transits with unknown orbital periods.
- ★ ~ 55% have 2 – 6 observed transits, with up to 9 period aliases and a median minimum period alias of 106 days.
- ★ They have transit depths greater than ~ 0.6 ppt and transit durations between ~ 2 hours and 2.4 days.
- ★ They have true orbital periods spanning ~ 45 – 5,000 days and radii larger than ~ 4 R_{Earth} (**Figure 3**).
- ★ They orbit host stars fainter than R = 13.7 mag, with an average value of R = 19.4 mag.

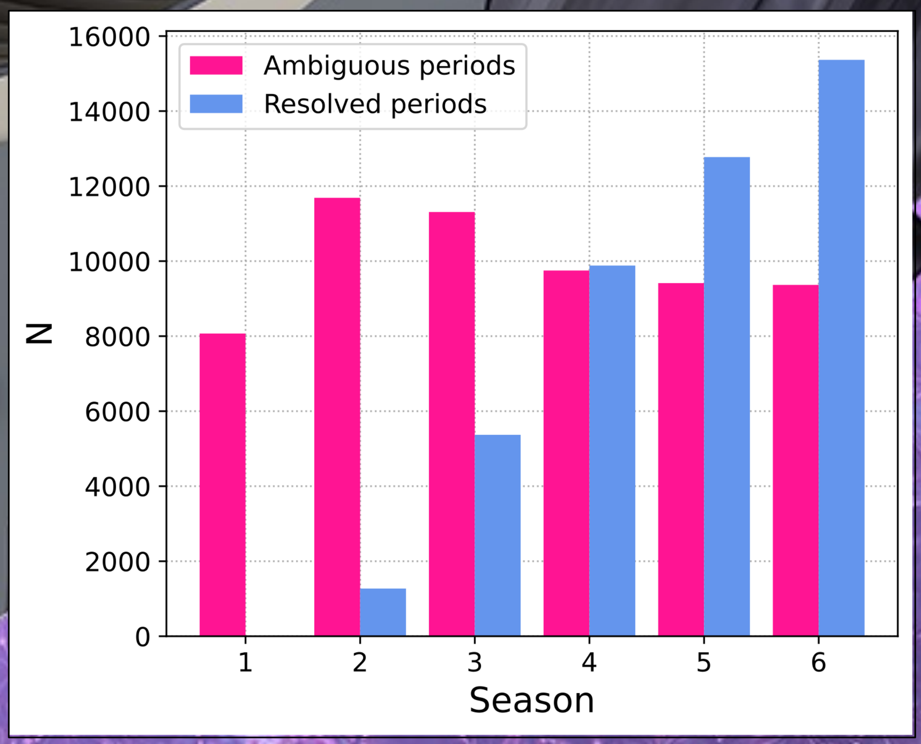

Figure 2: Number of planets with ambiguous and resolved orbital periods at the end of each observing season. Ambiguous (pink) are those that have an ambiguous orbital period and resolved (blue) are those which were discovered with an ambiguous period but have been resolved.

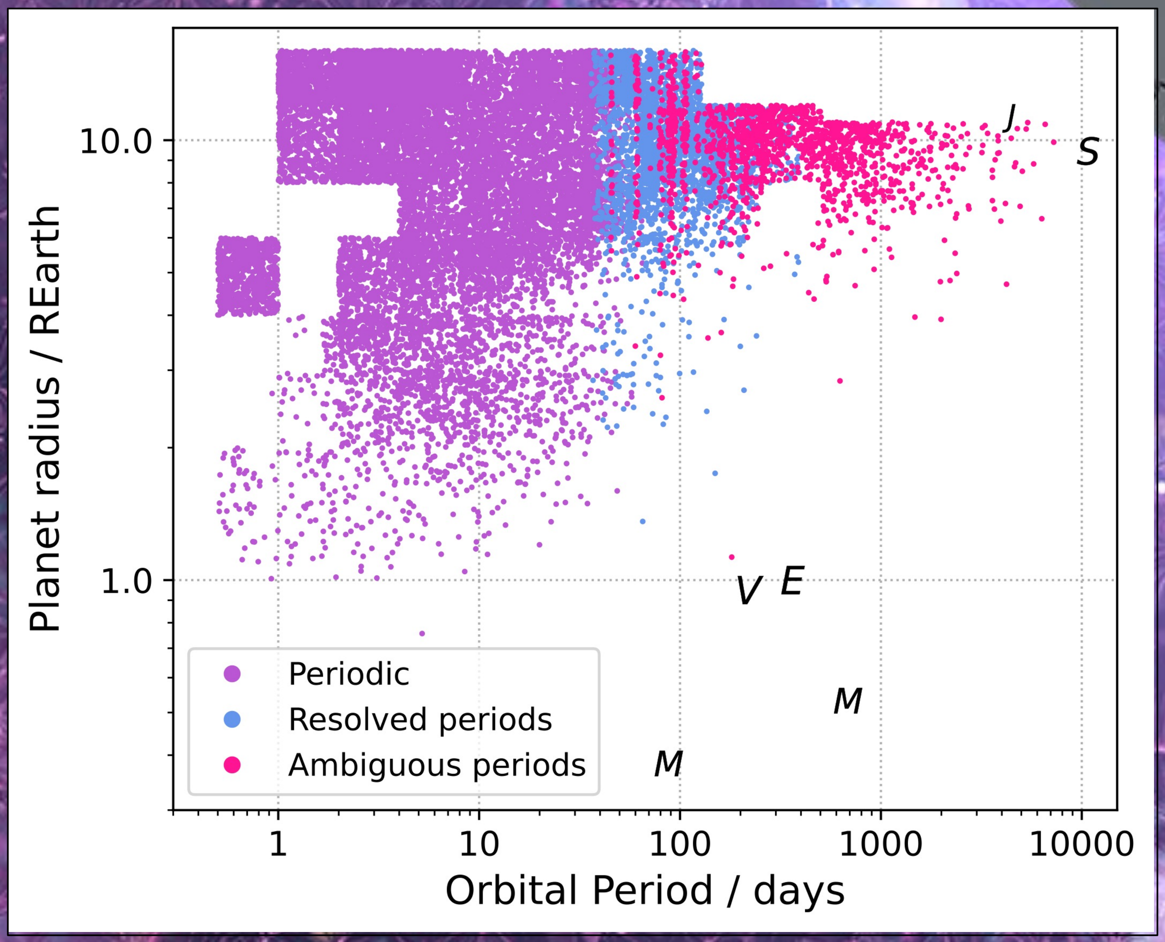

Figure 3: Period-radius diagram of expected discoveries from a single field of the GBTDS. Periodic (purple) are those which were discovered with an unambiguous period, resolved and ambiguous are the same as in Figure 2.

4. Comparison with TESS

The Transiting Exoplanet Survey Satellite (TESS) has discovered a large population of planets with ambiguous periods [e.g. Tuson 2023, Hawthorn et al. 2024]. These detections typically have two observed transits separated by about two years, with ~ 30 period aliases in the range 20 days to 2 years. The expected discoveries from Roman have fewer period aliases that tend to span a narrower range. However, they orbit significantly fainter host stars and only a few of the brightest systems will be amenable to follow-up observations to confirm their orbital periods, as has been done for many TESS discoveries [e.g. Tuson et al. 2023, Ulmer-Moll et al. 2023].

5. Conclusion

Roman will be a powerful facility for the discovery of long-period transiting exoplanets, yielding thousands of planets with orbital periods greater than 1 year and dozens of Jupiter analogs. Most of these detections will have ambiguous orbital periods, but they will be critical for demographic studies. This is especially true because they overlap in parameter space with Roman's expected microlensing discoveries, enabling a direct comparison of demographic predictions from both methods.

References

Hawthorn et al. 2024, MNRAS, 528, 1841
Tuson 2023, PhD thesis
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Ulmer-Moll et al. 2023, A&A, 674, A43
Wilson et al. 2023, ApJS, 269, 5

Acknowledgments

The material is based upon work supported by NASA under award number 80GSFC24M0006.

Background image: NASA GSFC SVS