

Investigation of planetary transits in TESS photometric light curves

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Abstract. In exoplanetary astronomy, eclipses of celestial bodies play a fundamental role in the detection and study of planets outside the Solar System. The observation of so-called planetary transits — the passage of a planet in front of its host star — allows us to discover new systems and derive their physical properties. Thus, in this work, we use data obtained by the *Transiting Exoplanet Survey Satellite (TESS)* to search for possible exoplanet candidates, using computational techniques applied to the planetary transit method.

Resumo. Na astronomia exoplanetária, os eclipses de corpos celestes desempenham um papel fundamental na detecção e estudo de planetas fora do Sistema Solar. A observação dos chamados de trânsitos planetários — a passagem de um planeta em frente de uma estrela hospedeira — permite descobrir novos sistemas e derivar suas propriedades físicas. Assim, neste trabalho, utilizamos dados obtidos pelo *Transiting Exoplanet Survey Satellite (TESS)* em busca de possíveis candidatos a exoplanetas, utilizando técnicas computacionais aplicadas ao método de trânsito planetário.

Keywords. Planets and satellites: detection – Techniques: photometric

1. Introduction

Through photometric observations of stars, we can express their brightness intensity variations over time in the so-called light curves. Thus, we identify planetary transits as periodic decreases in the star's observed flux. These phenomena are fundamental to exoplanetary astronomy, offering a powerful means of detecting and characterizing planets beyond the Solar System. In addition to identifying new exoplanetary systems, the transit method enables the extraction of key physical parameters such as the orbital period and planetary radius.

In fact, the decrease in flux due to the planet eclipsing the star represents less than 1% of the observed flux (Winn 2010). Nevertheless, according to the NASA Exoplanet Archive (Christiansen et al., 2025), over 4 000 exoplanets have been discovered using this technique, accounting for the majority of confirmed exoplanets, while more than 8 000 additional candidates await confirmation. This result is largely due to the development of purpose-built missions, such as the *Transiting Exoplanet Survey Satellite (TESS)* (Ricker et al. 2014), a NASA mission led by MIT and operational since 2018, which has expanded the search to a broader area of the sky and remains active to this day.

In this study, we analyze light curve data obtained from *TESS* to investigate a potential exoplanet candidate using computational and statistical methods. Through automated pipelines to process, detect and validate transit signals, we examined the transit features and assessed their consistency with a planetary origin.

2. Methodology

Seeking to investigate possible transiting planet candidates, we applied the methodology described in the following steps:

1. To first identify potential host stars within the large amount of data from *TESS*, a neural network pipeline designed to detect planetary transit signatures in stellar light curves is implemented, using the same methodology as presented in Olmschenk et al. (2021);

2. High-probability cases are then examined using consolidated softwares for the vetting process, such as the Discovery and Vetting of Exoplanets (DAVE) (Kostov et al. 2019) and the Lightcurve Analysis Tool for Transiting Exoplanet (LATTE) (Eisner et al. 2020). In this stage, parameters including transit shape and depth, centroid variations, and even-odd transit depth differences were evaluated. Possible false-positives such as eclipsing binaries, systematic errors and potential contamination in the light curves are also taken into account;
3. Refining the analysis of a new candidate and seeking to derive its physical properties, we explore the parameter space using the Markov Chain Monte Carlo (MCMC) method. For this purpose, we employed the `exoplanet` toolkit (Foreman-Mackey, D. et al., 2021), applying a Keplerian orbital model to impose physical constraints on the fitted parameters.

3. Results

As a result of the application of this methodology, we identified a new exoplanet candidate in the *TESS* data. The target's light curve show decreases in brightness consistent with planetary transits. Fig. 1 shows the complete light curve from Sector 38, obtained from Full Frame Images (FFI) and processed with the Science Processing Operations Center pipeline (SPOC) (Jenkins et al. 2016).

Its vetting through DAVE and LATTE suggests that an eclipsing binary scenario is unlikely, and that its signals show typical transit characteristics, including the expected transit depth, shape, and duration consistent with a planetary origin.

From our MCMC modeling, we derive an exoplanet radius of 1.428 ± 0.158 Jupiter radii with an orbital period of 2.79656 ± 0.00013 days. Fig. 2 represents the result of the MCMC fit to the observed transit profile and, as can be seen, the output suggests a good fit, indicating a high reliability of the parameters inferred from the light curve.

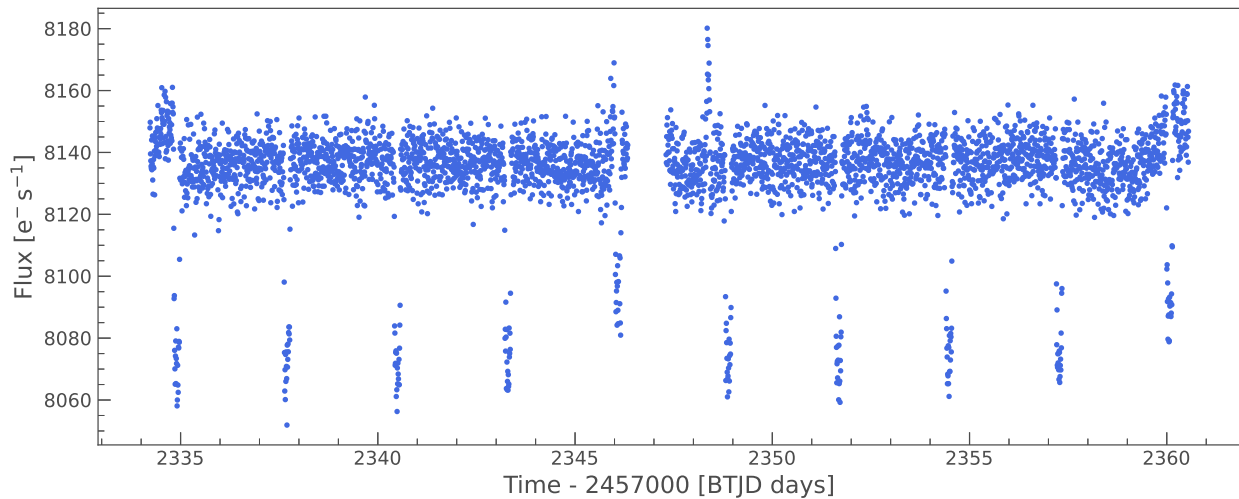


FIGURE 1. Light curve of the target star, with flux measured in electrons per second as a function of Barycentric TESS Julian Date (BTJD).

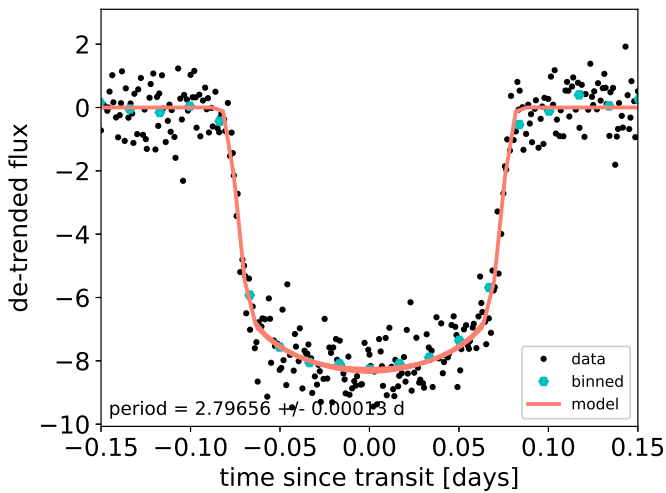


FIGURE 2. Phase-folded light curve showing the best-fit MCMC model (pink) and binned data points (blue hexagons).

4. Conclusion

This analysis culminated with the report of a promising new exoplanet candidate and present a preliminary characterization based on transit depth, duration, and periodicity. This result is currently submitted for publication (Bittencourt et al.). The candidate is also a suitable target for follow-up radial-velocity observations, which would allow both refinement of the derived planetary parameters and confirmation of its planetary nature.

This finding contributes to the expanding catalog of TESS-discovered exoplanets and highlights the continued importance of refining data analysis techniques to improve detection efficiency and reliability.

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