Modeling Exoplanet Transits using Bayesian Analysis: A Comprehensive Approach

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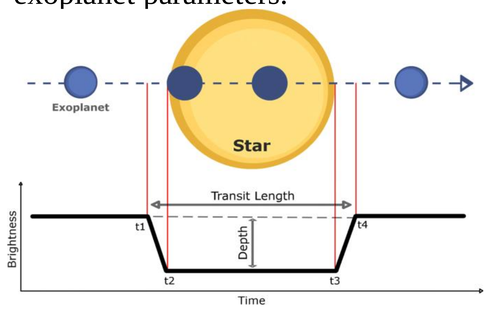
PROJECT OVERVIEW

We present a Bayesian analysis of the transit of TOI-3362b, using probabilistic modeling to constrain its orbital and physical properties. Employing PyMC and exoplanet tools, we fit a transit model to high-precision light curve data, yielding robust estimates of the planet's size, density, and orbital dynamics. This work demonstrates the efficacy of Bayesian methods in exoplanetary science, highlighting their ability to quantify uncertainties.

INTRODUCTION

- **Transit Photometry & Exoplanet Discovery:** Observing the dimming of stars to identify exoplanets, a critical method for understanding planetary systems.

- **Bayesian Modeling:** Combines prior knowledge and observed data, using priors and likelihoods to estimate and refine exoplanet parameters.



$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

METHODS AND CONTROLS

- **Data Search & Model Setup:** Use TESS data to identify transit events and define a Bayesian model with priors in PyMC.

- **Parameter Estimation & Analysis:** Apply MCMC for parameter estimation and analyze trace plots for model reliability.

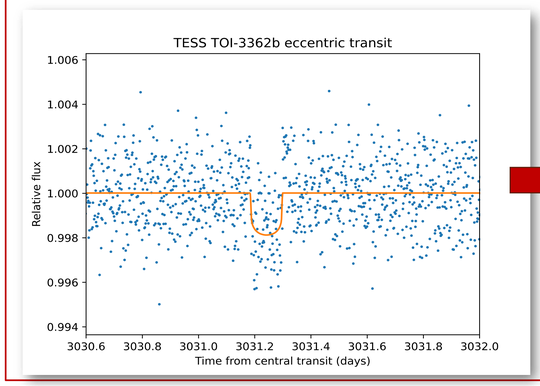


Figure 1. ***Modeling the transit*** The goal is to successfully model the transit, so that the PyMC model can easily infer the properties of the planet.

RESULTS

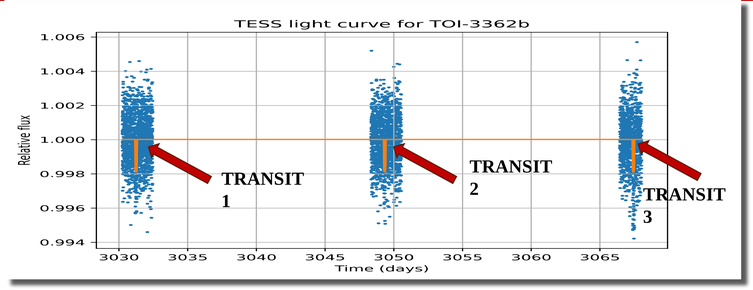


Figure 2. ***Light curve of TOI-3362b*** After searching the TESS database and flattening the light curve, the result is the transit of TOI-3362b.

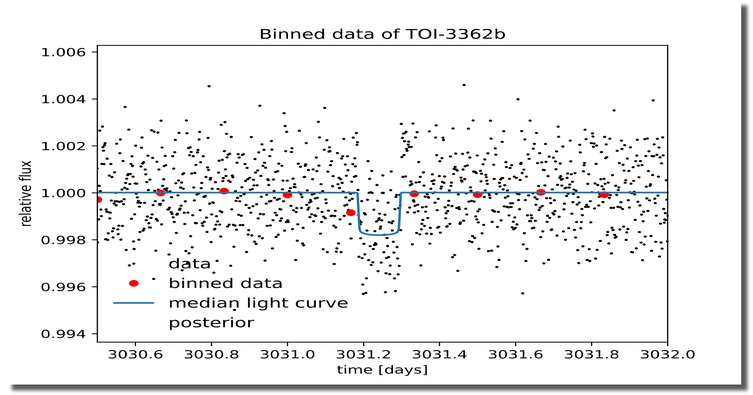


Figure 3. ***Binned Data:*** Displays TOI-3362b's transit light curve with binned data points, overlaid by the Bayesian model's posterior distribution to show fit, precision, and uncertainties.

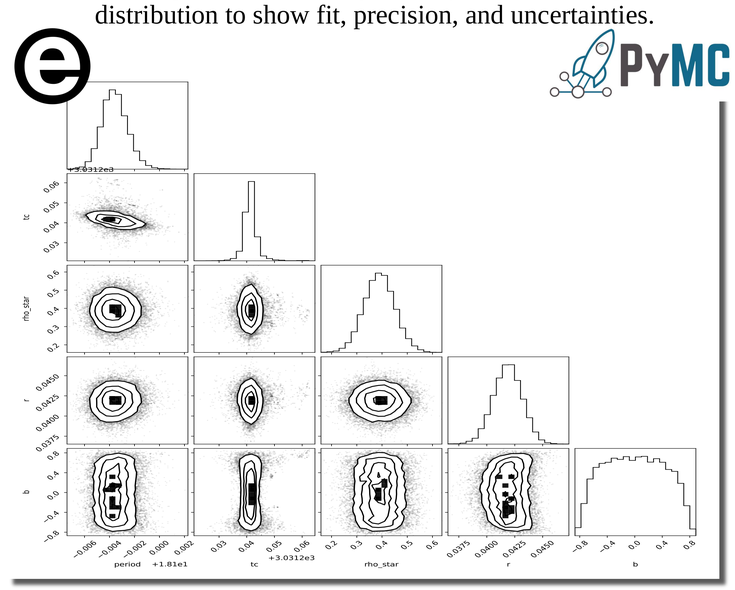
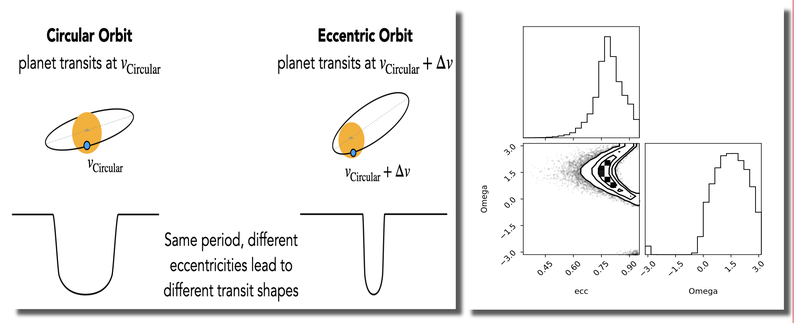


Figure 4. ***Corner plot*** The graph illustrates the posterior distributions of planet properties that have been modeled in PyMC and Exoplanet for TOI-3362b.

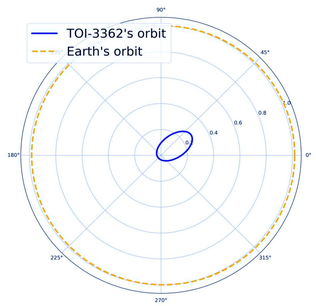
RESULTS (ECCENTRICITY)

- **Orbital Eccentricity in PyMC Model:** We applied a unit disk transformation to estimate orbital eccentricity, ensuring valid parameter sampling and enhancing our understanding of planetary system dynamics, formation history, and habitability potential.



CONCLUSION

- **TOI-3362b Characteristics:** With extreme eccentricity (0.815) and a short 18.1-day period, TOI-3362b is a key post-hot Jupiter candidate, offering insights into tidal migration and planet formation.



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