Discovery of TOI-700 d: The First Earth-Sized Habitable-Zone Planet Found by TESS

Hilal Can Ekiz[a]

[a]*Maltepe University, , Istanbul, , , Turkey*

Abstract

TESS (Transiting Exoplanet Survey Satellite) revealed a compact three-planet system around the nearby M-dwarf TOI-700. The outer planet, TOI-700 d, is approximately Earth-sized and receives ∼86% of Earth's insolation, placing it within the conservative habitable zone. In this short note, I summarize the validation of the system, basic derived properties, and the implications for future atmospheric characterization, based on Gilbert et al. (2020).

Keywords: Exoplanets, TESS, TOI-700, Habitable zone, M-dwarfs, Transit photometry

Quantity	Symbol	Value
Distance	d	~ 31.1 pc
Planet radius	R_p	$1.19 \pm 0.11\,R_\oplus$
Orbital period	P	~ 37.43 d
Insolation	S	$\sim 0.86\,S_\oplus$
Stellar type		M-dwarf (quiet)

Table 1: Adopted TOI-700 d properties summarized from Gilbert et al. (2020).

1. Introduction

The TESS mission has surveyed nearly the entire sky for transiting exoplanets around bright nearby stars. In early 2020, a multi-planet system around the M-dwarf TOI-700 (distance ∼31.1 pc) was validated, including TOI-700 d—the mission's first Earth-sized planet in the habitable zone (Gilbert et al., 2020). This makes TOI-700 d a benchmark for habitability studies around cool stars.

2. Validation and Methods

The planetary nature of TOI-700 d was established through: (i) multi-sector TESS photometry and vetting to exclude eclipsing binary scenarios; (ii) ground-based follow-up to rule out nearby contaminants; and (iii) space-based confirmation photometry. Transit modeling yielded precise ephemerides and radii for the three planets. The host star exhibits relatively low activity, which benefits long-term atmospheric retention.

3. Results

Table 1 lists key parameters compiled from Gilbert et al. (2020). TOI-700 d is $1.19 \pm 0.11\,R_\oplus$ with an orbital period of ∼37.43 days. The incident flux is $\sim 0.86\,S_\oplus$, placing it within the conservative habitable zone for plausible albedos.

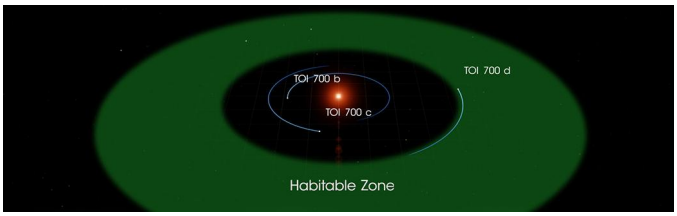

Figure 1: Schematic layout of the TOI-700 system (illustrative). Replace this placeholder with any diagram of the system; highlighting planet d in the habitable zone is recommended.

4. Illustrative Equation

A simple zero-order estimate of planetary equilibrium temperature ($T_{\rm eq}$) is

$$T_{\rm eq} = T_\star \left(\frac{R_\star}{2a}\right)^{1/2} (1 - A)^{1/4}, \tag{1}$$

where $T_\star$ and $R_\star$ are the stellar effective temperature and radius, a is the semi-major axis, and A is the Bond albedo. For TOI-700 d, insolation near $0.86\,S_\oplus$ implies an Earth-like $T_{\rm eq}$ for comparable albedo.

5. Figure

6. Discussion and Conclusions

TOI-700 d is a key target for comparative planetology: it is small, temperate, and orbits a relatively quiet M-dwarf. Transmission or emission spectroscopy with JWST may be challenging due to weak spectral features, yet feasible with multiple transits and careful systematics control. As an early TESS milestone, TOI-700 d motivates continued searches for temperate terrestrial planets around nearby cool stars.

Acknowledgements

I thank the Intro2Astro course staff for guidance and discussion.

References

Gilbert, E. A., et al. 2020, *The First Habitable Zone Earth-sized Planet from TESS. I: Validation of the TOI-700 System*, arXiv:2001.00952.