TOI-2257 b: A highly eccentric long-period sub-Neptune around an M3 star

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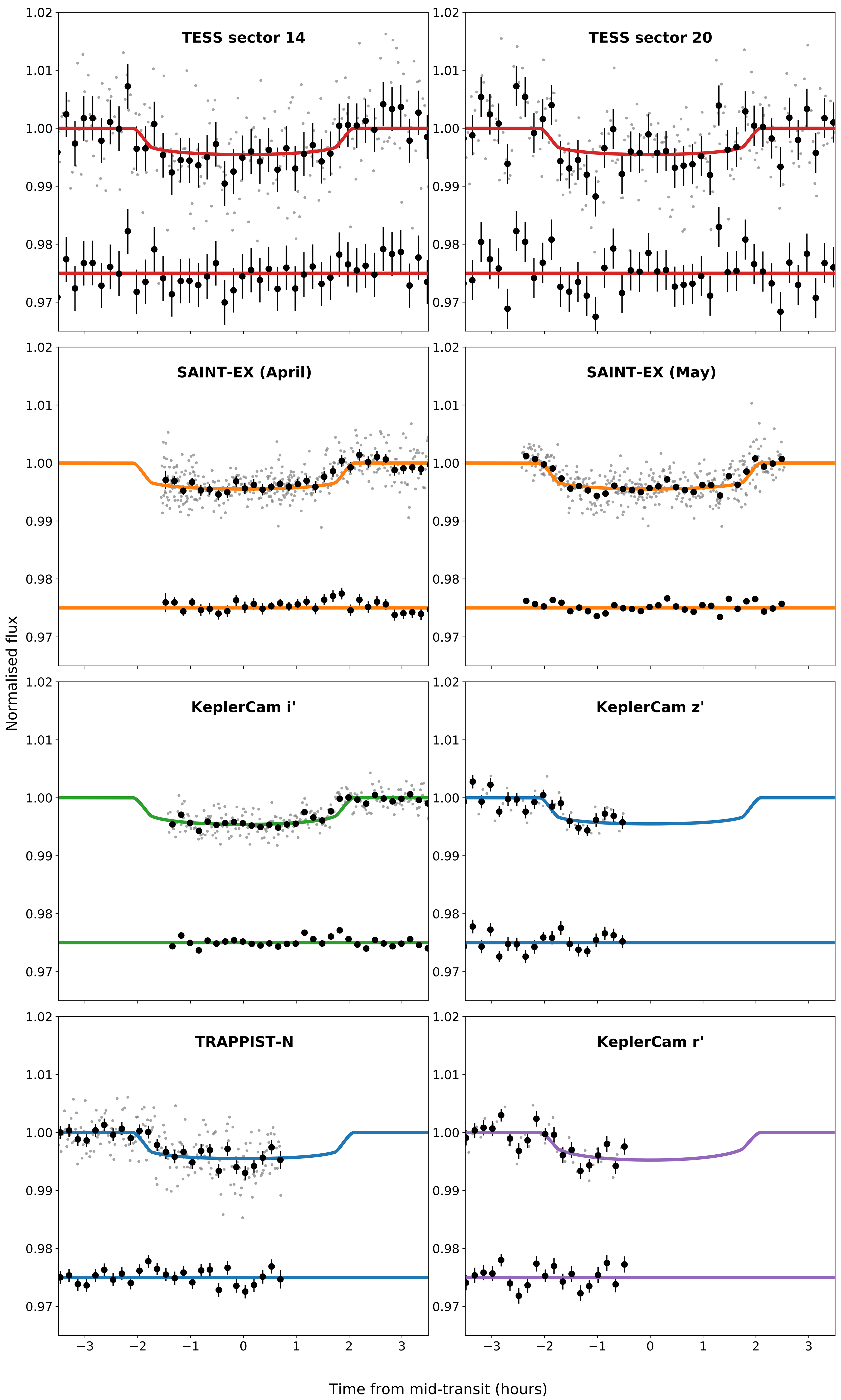

Figure 1: Model of the best-fit transit parameters along with the photometric lightcurves used for characterization. Black points show data binned in 10-minute intervals. Residuals are shown below the lightcurve with an arbitrary offset.

Here we highlight the discovery of TOI-2257 b (submitted Sep 2021), a long-period (35d) sub-Neptune (2.19 R_{Earth}) planet orbiting an M3 star ($M_* \approx 0.33\ M_{sun}$, $R_* \approx 0.31\ R_{Sun}$).

TOI-2257 b was initially identified in TESS data with a period of 175 days, but due to the gaps in the TESS observations, a series of shorter harmonic periods could not be excluded. Further ground-based follow-up from a number of facilities including the 1-m SAINT-EX observatory in San Pedro Martir, Mexico, confirmed the transit with the period reported above.

Based on the long transit duration, the transit is best fit with an eccentric model (e≈0.5). It has been recently highlighted that single-planet systems tend to have dynamically hotter orbits with higher eccentricities than those in multi-planet systems (Xie et al, 2016; Van Eylen et al 2019; Masuda et al, 2020). One possible explanation for this is the influence of a long-period giant planet, such as was found with the GJ 1148 system (Haghighipour et al 2010; Trifonov et al 2018). Future radial velocity measurements will help test this interpretation.

TOI-2257 b shares many similarities with the well studied K2-18 b system. Using Hubble data, this system was shown to contain significant amounts of water vapor in its atmosphere (Tsiaras et al, 2019; Benneke et al, 2019). As TOI-2257 b is expected to have a very similar TSM as that of K2-18 b, future studies of the transmission spectra would provide a useful addition to the cool sub-Neptune population.

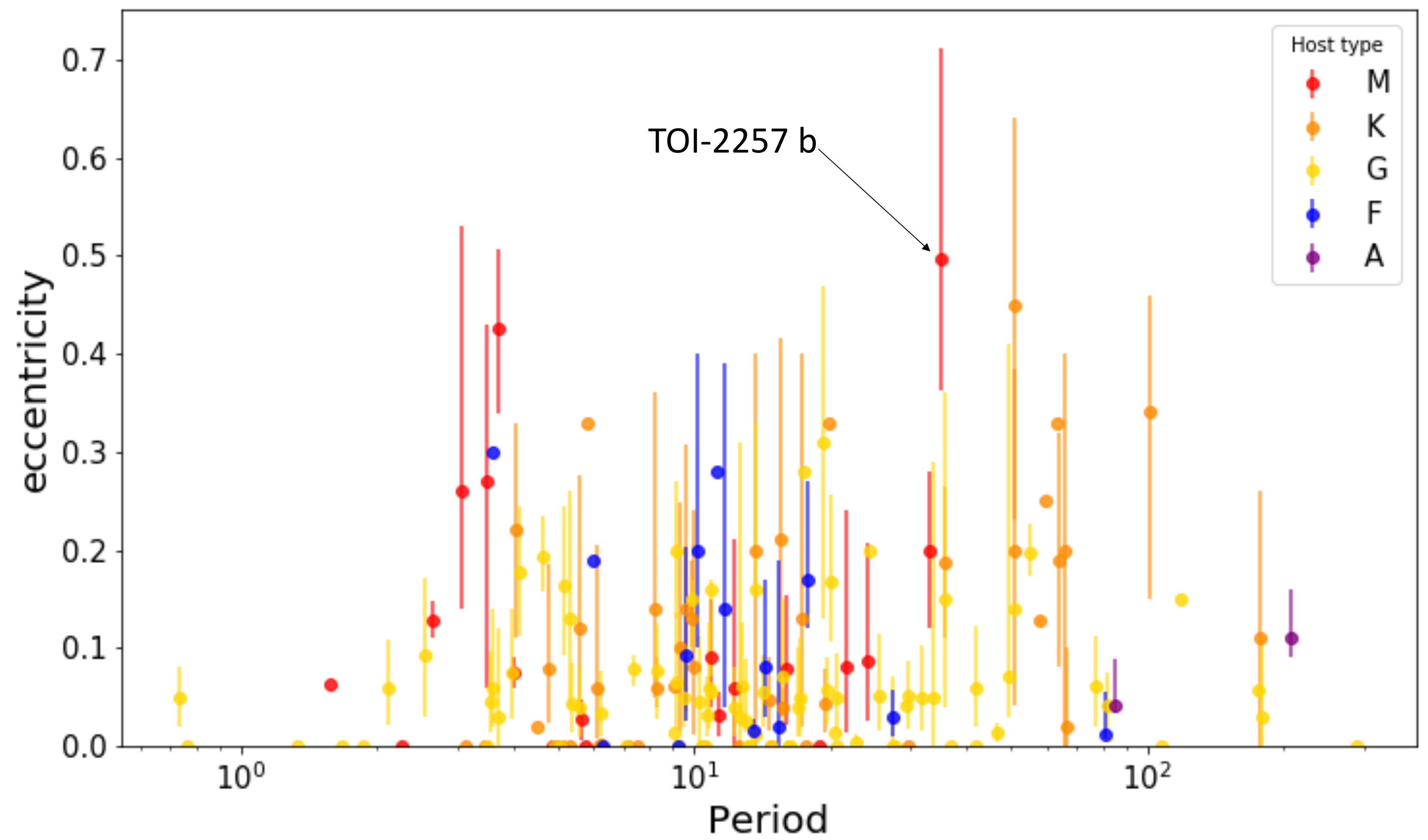

Figure 2: Periods and eccentricities for known sub-Neptunes ($1.8<R_p<4\ R_{Earth}$). TOI-2257 is potentially the most eccentric of these systems known to date. Future RV follow-up will be used to verify the eccentricity, as well as search for the possibility of an outer perturbing planet in the system.

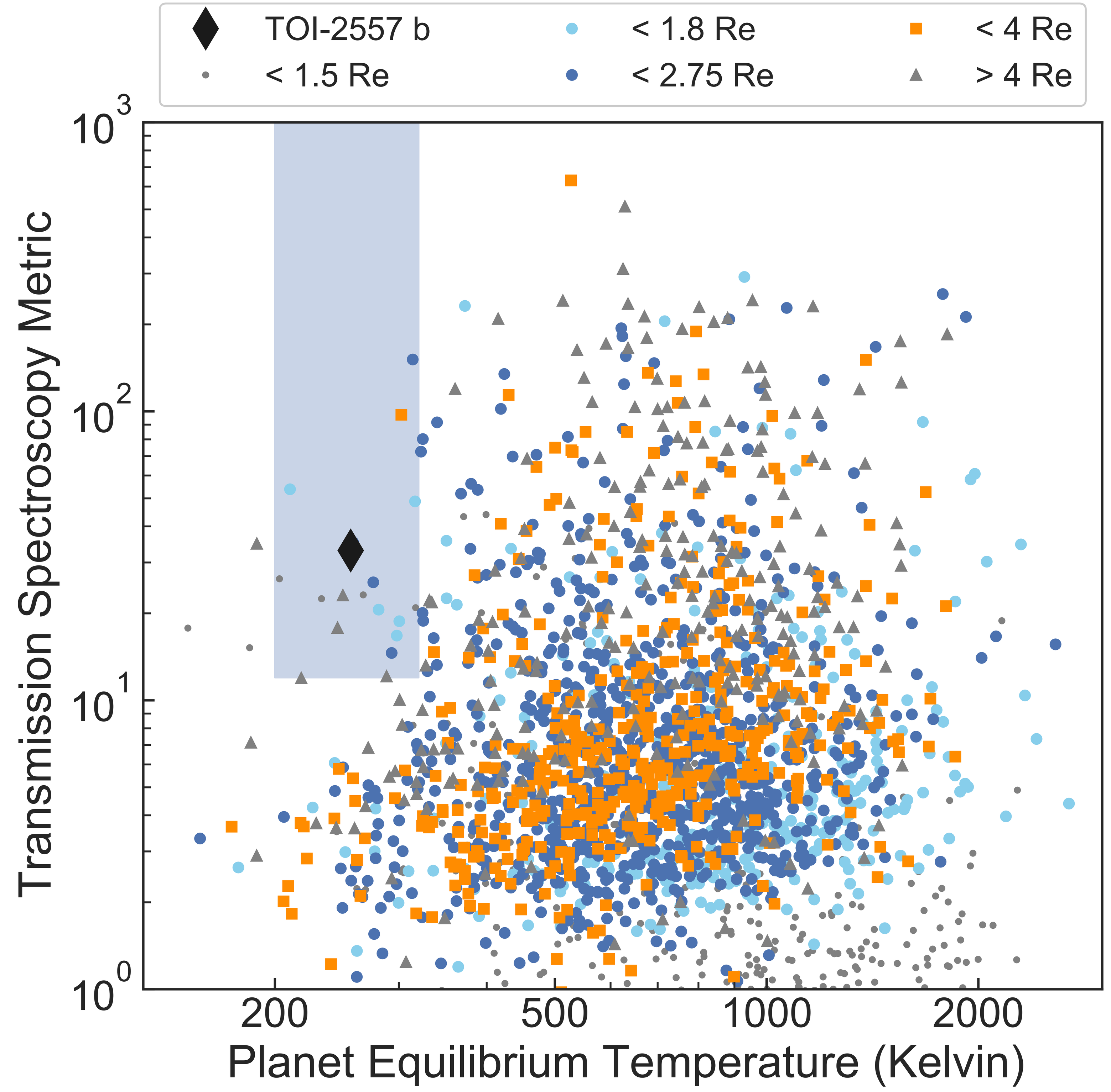

Figure 3: Equilibrium temperature vs TSM for the known population of exoplanets. The blue shaded region highlights the parameter space in which the temperature could support life in the clouds (Seager et al, 2021) and for which the TSM is estimated to be supportive of further atmospheric characterization by JWST. Data retrieved from the Exoplanet Archive on 2021-07-30. Figure adapted from Seager et al, 2021.

CONCLUSIONS

One of the primary goals of the PLATO mission is the discovery of exoplanets in the habitable zone. TOI-2257 b is one of the few current examples of such planets. While the temperature extremes in the highly elliptical orbit may be detrimental to life in the clouds, it is still one of the most promising temperate worlds for follow-up spectroscopy and atmospheric characterization.

REFERENCES

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