

TKS XI: Characterising 4 sub-Neptunes orbiting K dwarf TOI 1246

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	c	d	b	e
Star	1246.02	1246.03	1246.01	1246.04
P	4.31d	5.90d	18.66d	37.92d
R _p	2.47 ±0.10R _⊕	2.37 ±0.10R _⊕	3.42 ±0.10R _⊕	3.61 ±0.10R _⊕
M _p	7.6 ±1.5M _⊕	7.8 ±1.7M _⊕	5.9 ±2.7 M _⊕	14.6 ±3.4M _⊕

TESS observed this moderately bright K dwarf (V=11.6, K=9.9) for 12 sectors, and found four transiting planets. We collected 90 RV observations with Keck/HIRES and TNG/HARPS-N, many of which were contemporaneous with TESS photometry. We refit the photometry to refine planet radii, measure masses for all four planets, and find a surprising range of masses and densities (0.81-3.22 g/cm³).

This system is **brighter than 93% of systems with four confirmed planets**, and is a particularly interesting testing ground for mass loss and formation hypotheses due to the high planet multiplicity and varied planet masses. The four planets have distinct masses and densities and thus likely have a range of atmospheric properties. This system showcases several different outcomes of sub-Neptune formation around a common host star, which allows us to compare planets within the system more directly than planets orbiting different stars. There is a wealth of data on this interesting system, and TESS will observe it for 10 more sectors in Cycle 4 which will further enrich our understanding of this system.

Stability Analysis

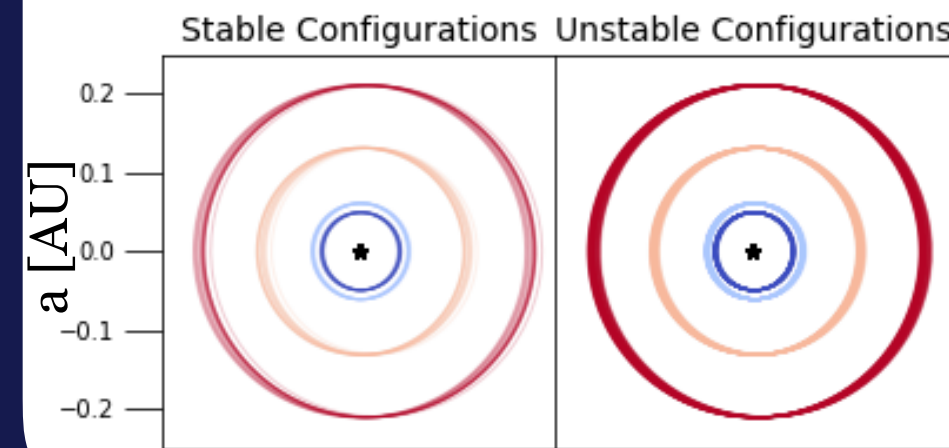
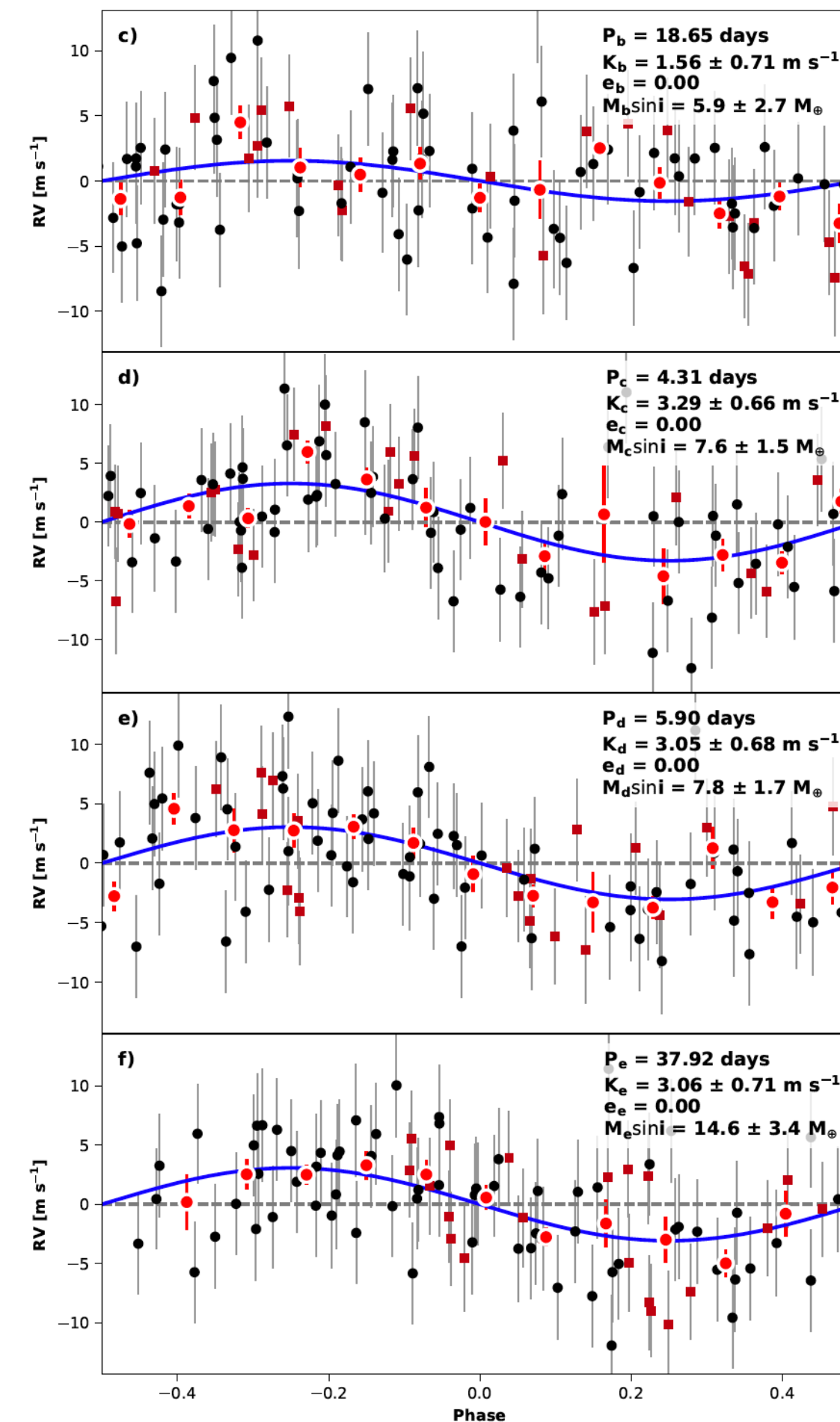


Fig 1. Stable (left) and Unstable (right) orbit configurations for the four planets in the TOI 1246 system. We drew 10,000 samples from planet radius, mass, inclination and eccentricity, and stellar mass and radius distributions, and evaluated system stability over 10⁹ orbits using the SPOCK package (github.com/dtamayo/spock). Very low or zero eccentricities are preferred for this compact multiplanet system.

Radial Velocity Analysis



Photometric Analysis

Fig 2. Folded light curves for TOI 1246, restricted to the zero-eccentricity case. The inner two planets are tightly packed and similar in size (2.47 & 2.37 R_⊕), while the outer two planets lie just exterior to the 2:1 period resonance, and are also similar in size (3.42 & 3.61 R_⊕).

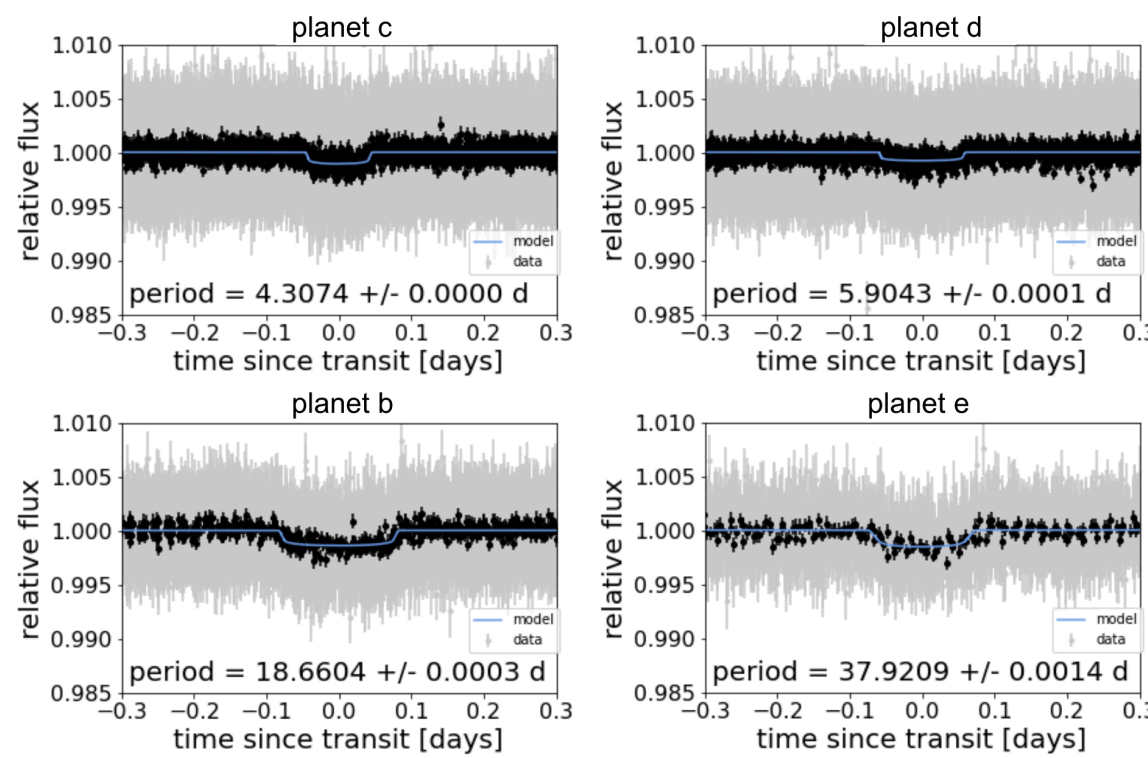


Fig. 3 Phase-folded RV data from Keck/HIRES (black), TNG/HARPS-N (red squares) and binned (red), and zero-eccentricity models (blue).

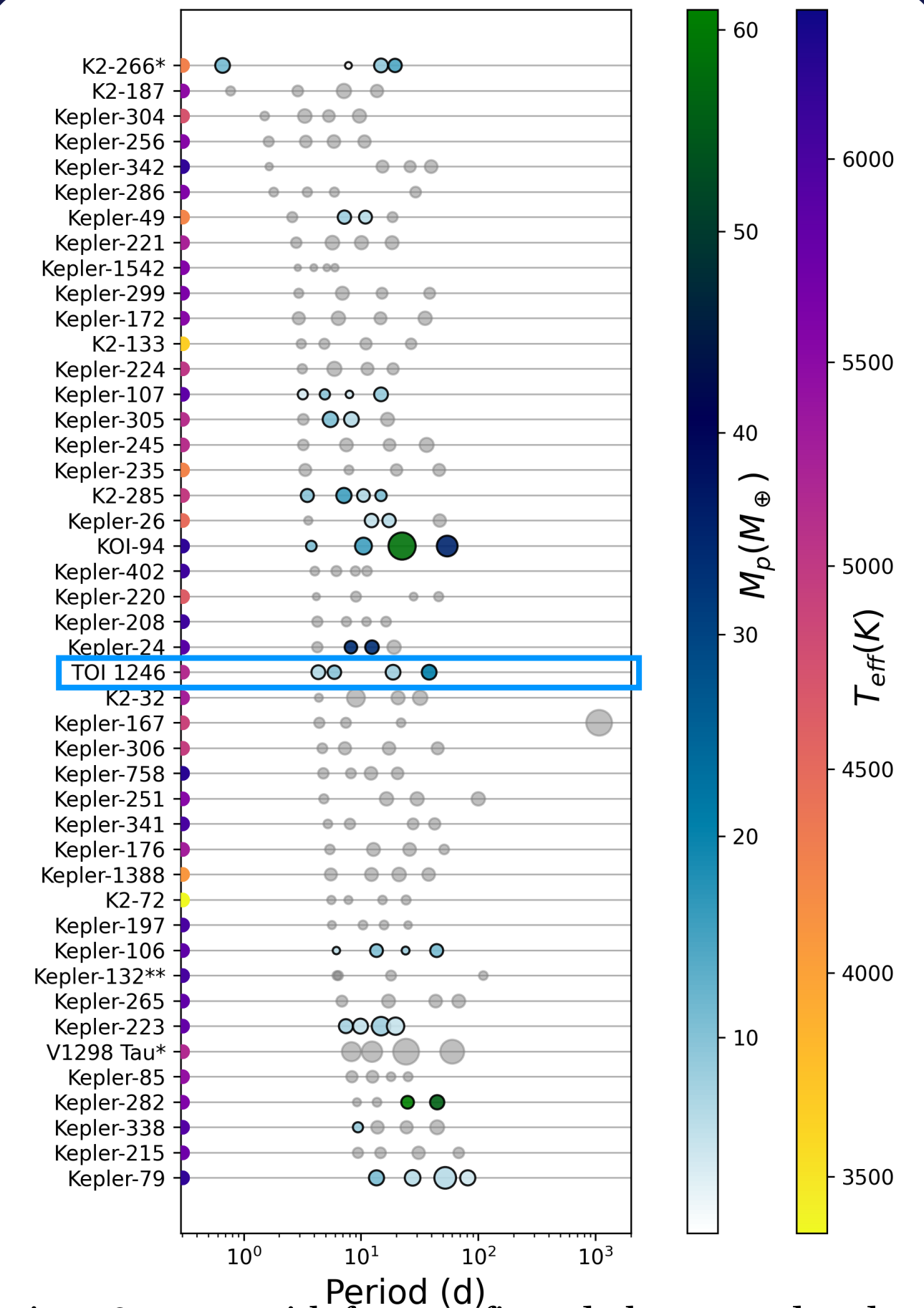


Fig 4. Systems with four confirmed planets, ordered by innermost planet period, with dot size scaled by planet radii, and dot colour scaled by planet mass. **TOI 1246 is one of only 8 systems with both measured masses and radii for all four planets.** It also has an unique architecture within this group of systems, with two tightly packed inner planets and an outermost planet that is significantly more massive than the inner three planets.