

TOI-544b: a new small planet inside the radius valley

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Main Takeaways:

- Precise mass measurements are key to understanding small planet compositions and the formation of the radius valley
- TOI-544 b and c have some of the **most precisely characterised** planet masses (uncertainties of 15% and 9%)
- TOI-544b has a density which suggests a mostly **water-dominated composition**
- TOI-544b sits **inside the radius valley** – making it a key contribution to understanding the radius valley
- TOI-544b has a high predicted ESM – meaning it is **ideal for future atmospheric characterisation**

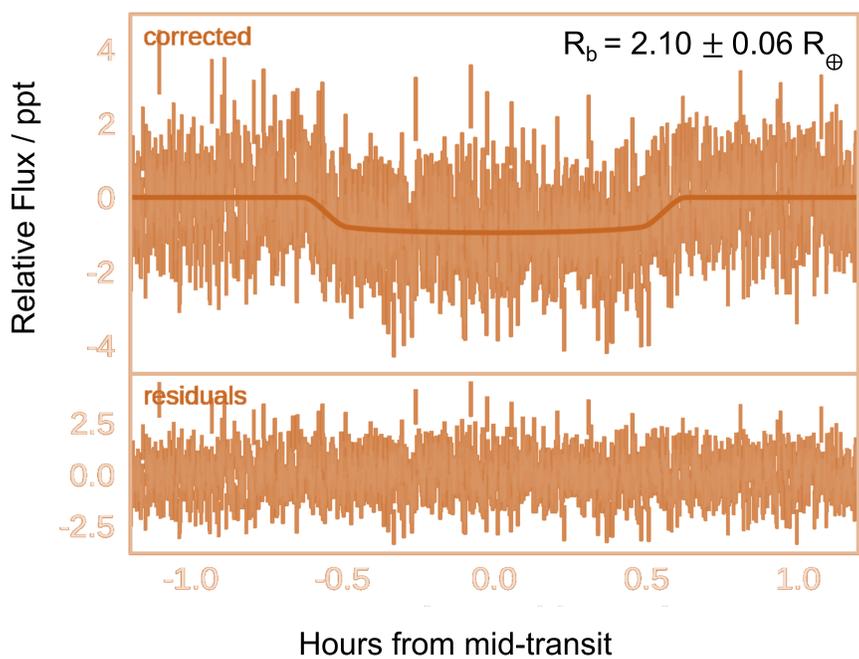


Figure 1: Phase-folded TESS observations of TOI-544b, with best-fit model overlaid

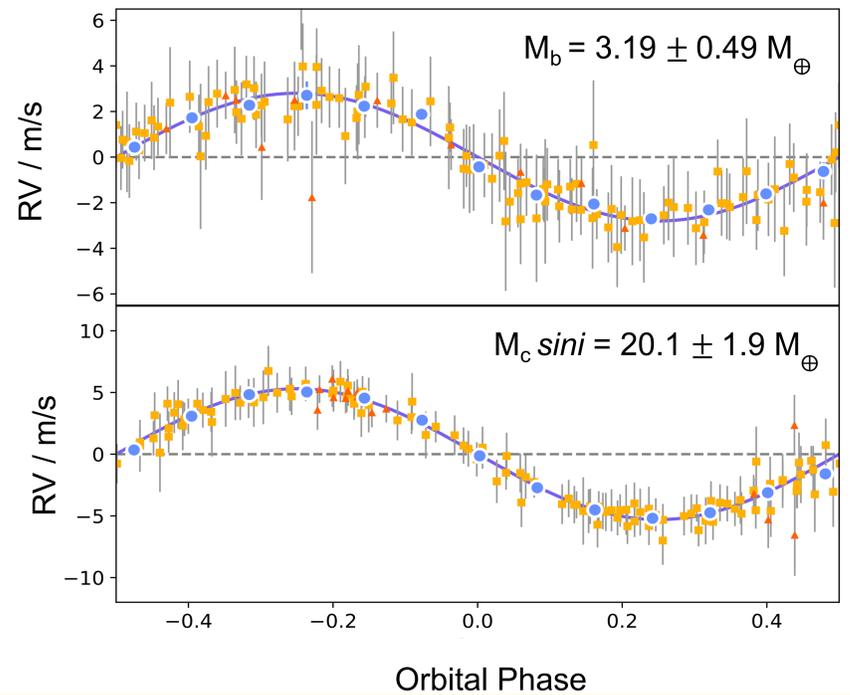


Figure 2: Phase-folded RV data for TOI-544b (top panel) and c (bottom panel), best fit model (minus GP fit) overlaid with binned data points

Observations:

- TIC 50618703 was observed with TESS in sectors 6 and 32, and promoted to TOI-544
- KESPRINT performed high-resolution RV follow-up with HARPS to confirm and characterise TOI-544b, 108 HARPS spectra were taken between December 2020 and March 2022

Modelling:

- We performed RV modelling using a GP with a quasi-periodic kernel trained on the activity indicators [1] [2]
- TOI-544b has a high emission spectroscopy metric (ESM) for such a low-mass planet, putting it in the top 5 planets within the parameter space for atmospheric characterisation

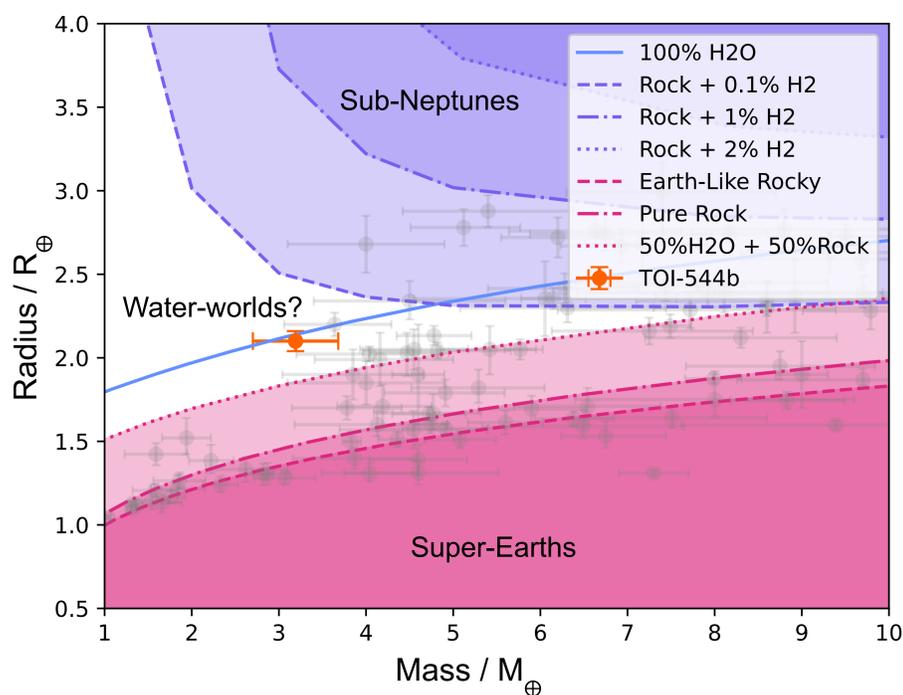


Figure 3: Mass – radius diagram showing all small planets, with TOI-544b highlighted. Composition tracks are shown with lines and shading indicates the populations of sub-Neptunes and super-Earths [3]

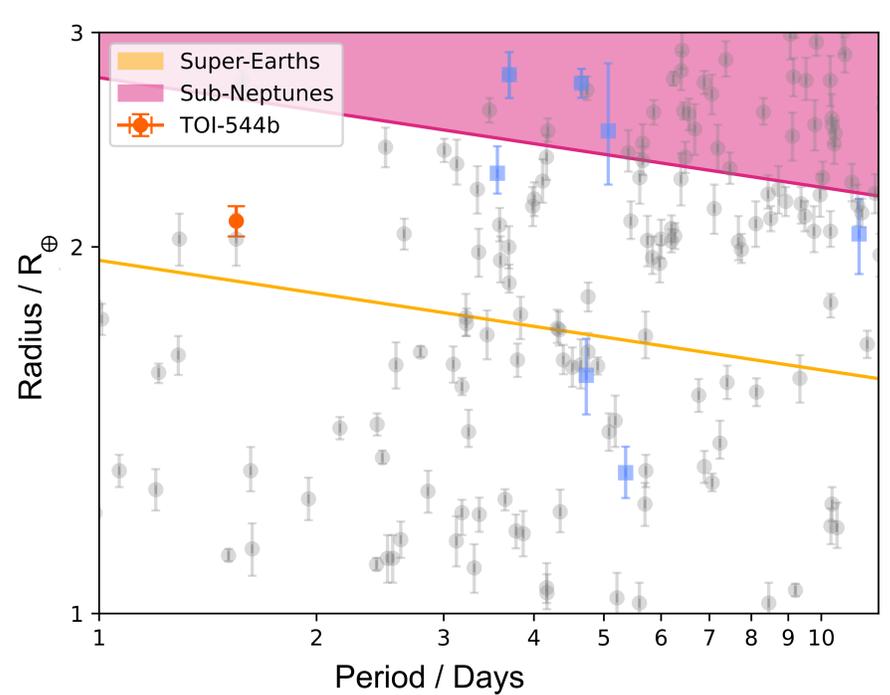


Figure 4: Radius valley expected location for FGK stars as a function of orbital period, with TOI-544b highlighted. Planets with radius uncertainty < 5% shown in grey circles, planets with mass uncertainties < 20% shown in blue squares. Data from NASA Exoplanet Archive [4]

Composition:

- The density of TOI-544b does not fit into either a super-Earth composition (rock, silicates and iron core) or a sub-Neptune (rocky-core surrounded by a Hydrogen atmosphere)
- Could TOI-544b be a planet with a high proportion of water – a ‘water-world’?

Radius Valley:

- TOI-544b is located within the radius valley - where no/very few planets are expected to be found
- TOI-544b is one of only 3 planets thought to be inside the radius valley which have precise mass measurements
- Could TOI-544b be undergoing atmospheric loss?

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References:

1. Fulton, B. J. et al. 2018 PASP 130 (986) 044504
2. Foreman-Mackey, D. et al. 2017, AJ 154 220
3. Zeng, L. et al. 2019. PNAS 116 (20) 9723-9728
4. Van Eylen, V. et al. 2018 MNRAS 479 (4) 4786-4795

