An ultra-close non-transiting hot Neptune around a *Kepler* solar-type star ?

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1. Close-in non-transiting planets in photometry

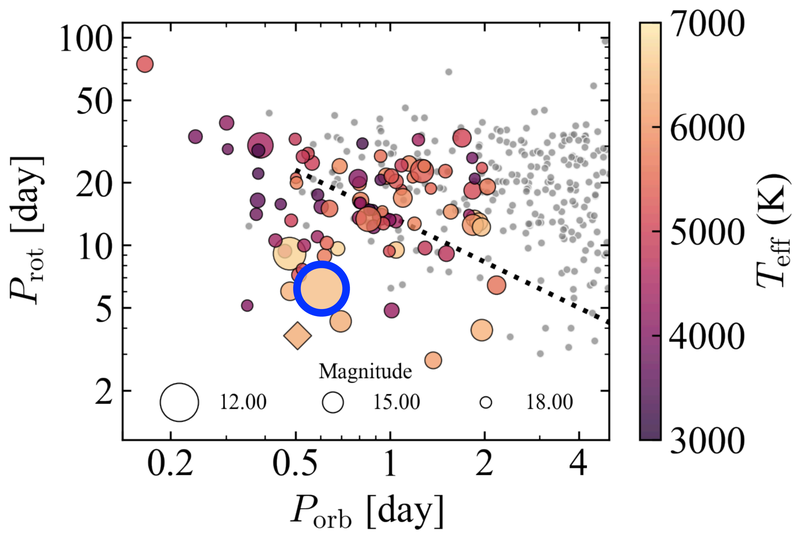


Figure 1: *Location of the 88 candidate non-transiting planets (dots filled in colours) identified by Gourvès et al. 2025 [2] in the Kepler data. The grey dots correspond to the Kepler close-in transiting planets hosted by stars with known surface rotation period (see e.g. [4]). The location of KIC9139163 is highlighted with the blue circle. Figure from Gourvès et al. 2025 [2].*

- **Close-in non transiting planets can be detected in photometry** thanks to their phase curve [1].
- Gourvès et al. (2025) [2] characterised **88 non-transiting candidate planets** in the *Kepler* data (see **Figure 1**).
- Radial velocity (RV) follow-up with HARPS-N and detailed phase curve analysis (Breton, Dyrek et al. 2026 [3]) revealed that the brightest star in the sample, **KIC9139163, may host an ultra-close hot Neptune**.

$$P_{\rm orb} = 0.60474 \text{ day}$$

2. KIC 9139163, a hot solar-type pulsator

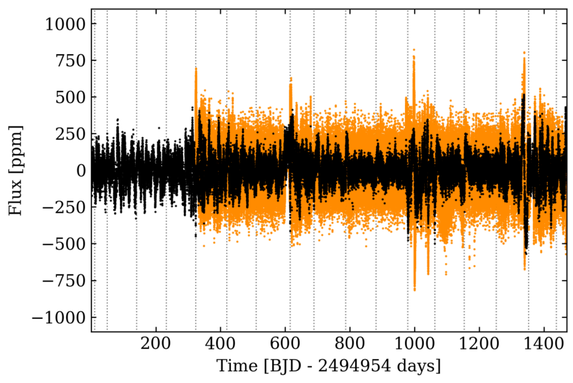
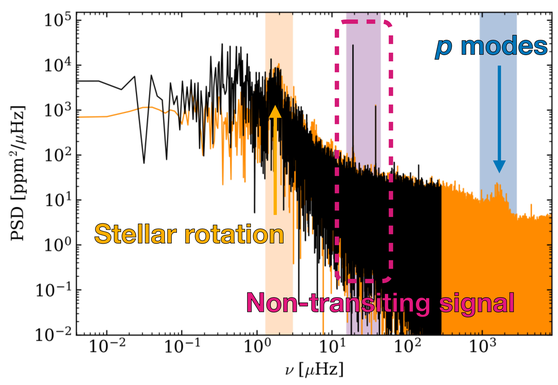


Figure 2: *Light curve (top) and power spectral density (PSD, bottom) for the long (black) and short (orange) Kepler data of KIC9139163. The frequency range with the p-mode oscillation, the stellar surface rotation signature, and the non-transiting candidate planet contribution are highlighted in blue, orange, and purple, respectively. Figure from Breton, Dyrek et al. (2026) [3].*



$$M_\star = 1.39 \text{ M}_\odot$$
$$R_\star = 1.56 \text{ R}_\odot$$
$$T_{\rm eff} = 6358 \text{ K}$$
$$P_{\rm rot} = 6.3 \text{ day}$$

- Host star characterised thanks to **asteroseimology** and **spectroscopy**

3. Radial velocity with HARPS-N

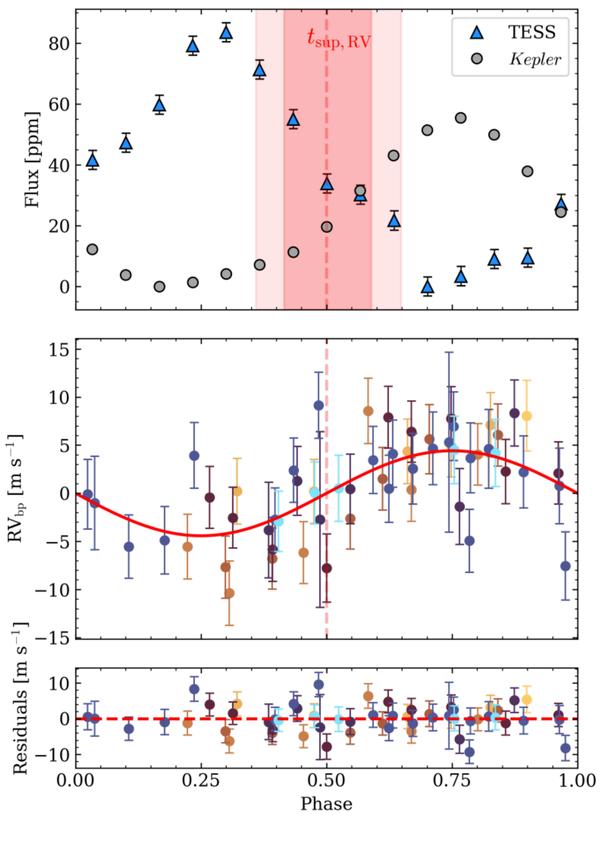
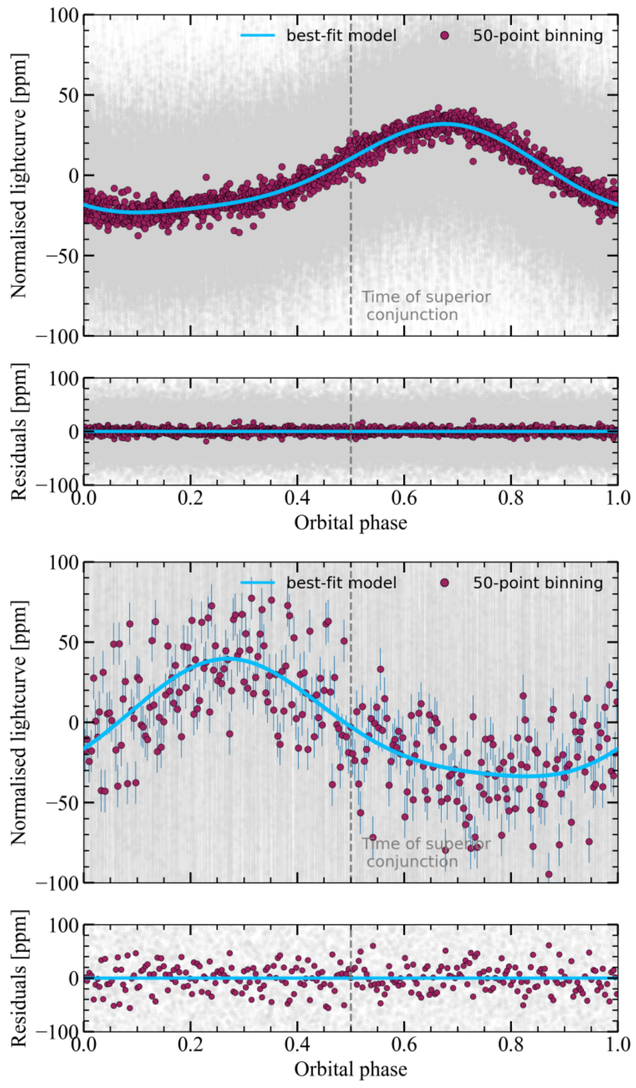


Figure 3: *Top: binned phase curve of the 0.6 day signal in Kepler and TESS, respectively. Middle: RV obtained with HARPS-N, together with the best-fit Keplerian model. Bottom: Residuals of the RV fit. The time of superior conjunction inferred from the RV is indicated as the vertical dashed red line. Figure from Breton, Dyrek et al. (2026) [3].*

- Observation campaign with HARPS-N from March to August 2022.
- **59 spectra** acquired on short exposures (<5 min).
- Analysis following the method of [5,6]: **statistically significant detection** (see **Figure 3**).
- Characterisation of time of superior conjunction.

$$K = 4.42 \pm 0.84 \text{ m s}^{-1} \qquad M_p \sin i = 7.28 \pm 1.38 \text{ M}_\oplus$$

4. Phase curve analysis of *Kepler* and TESS data



- Phase curve evolution between Kepler (2009 to 2013) and TESS (2018 to 2025) observations (see **Figure 3, 4**): **evidence for atmospheric variability** ?
- Phase curve are analysed with a **1D model of emission/reflection** accounting for the offsets introduced by **clouds** and **heat redistribution**.
- Evidence for a cloud longitudinal offset.
- Best fitting models have **moderate-to-high geometrical albedos** (>0.5) and **low-to-moderate heat redistribution**.

$$R_p = 2.43 \pm 0.14 \text{ R}_\oplus$$

Figure 4: *First row: 0.6 day phase curve of the Kepler light curve (grey dots, binned phase curve in purple) and best-fit model (blue line). Second row: Residuals after subtraction of the phase curve model. Third row: 0.6 day phase curve of the TESS light curve (grey dots, binned phase curve in purple) and best-fit model (blue line). Fourth row: Residuals after subtraction of the phase curve model. Figure from Breton, Dyrek et al. (2026) [3].*

4. Conclusion and perspectives

- The candidate planet is located above the **lower edge of the Neptune desert** (see **Figure 5**) and represent an extremely interesting candidate for future follow-ups.
- **Very few planets in this parameter range** with photometric phase curves in the optical wavelengths.
- *Two birds with one stone*: **new HARPS-N and GIANO-B observations** to confirm the planetary companion through the characterisation of the atmospheric composition (DDT time request to observe the system was just accepted: **full night of observation on June 21**).
- The role of infrared spectroscopy: **a valuable target for future JWST observations** ?
- PLATO mission [7] soon to be launched: towards an **extended sample of close-in non-transiting planets** around bright stars ?

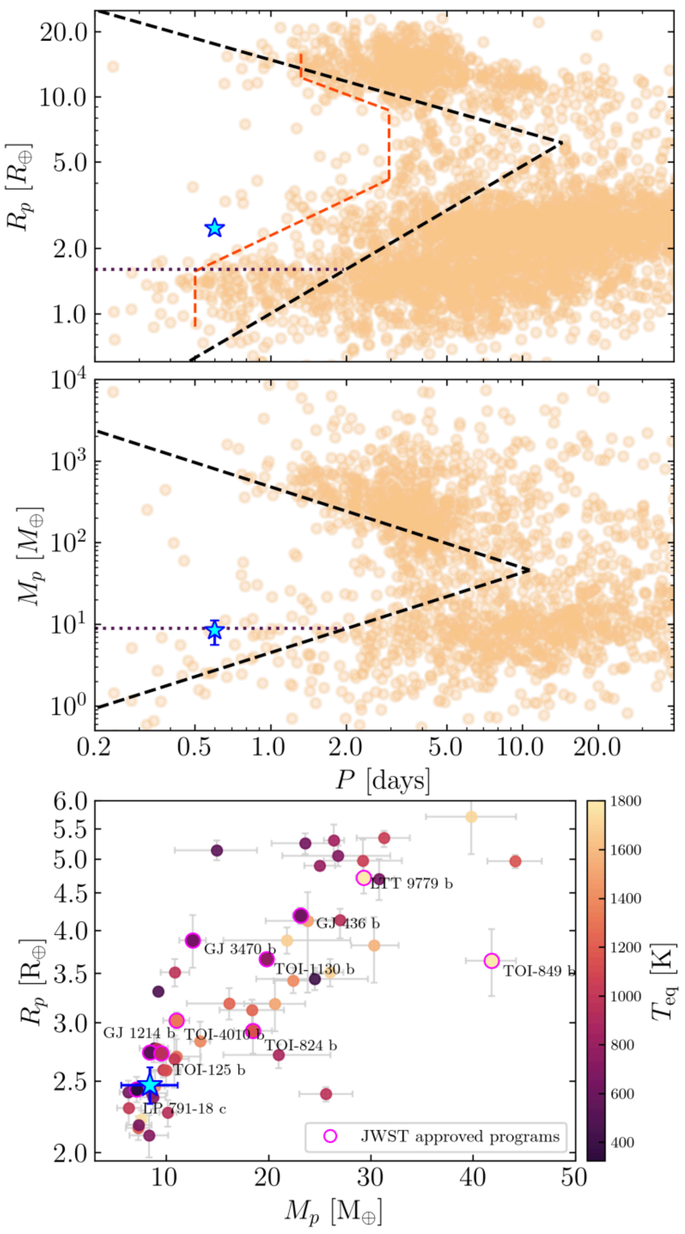


Figure 5: *Location of the KIC9139163 system (blue star) in the radius-period, mass-period and radius-mass diagrams, respectively. Other known systems are represented as orange dots in the top panels, systems observed by JWST are represented in the bottom panel. Figure from Breton, Dyrek et al. (2026) [3].*

References

[1] Shporer, A. PASP 129.977 (2017).
[2] Gourvès, C., Breton, S. N., et al. A&A 699, A226 (2025).
[3] Breton, S. N., Dyrek, A., et al. arXiv e-prints, arXiv:2605.28755 (2026).
[4] García, R. A., Gourvès, C., et al. A&A 679, L12 (2023).
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[7] Rauer, H., Aerts, C., et al. Experimental Astronomy 59.3, 26 (2025)

Link to the papers
Gourvès et al. (2025): https://doi.org/10.1051/0004-6361/202553791
Breton, Dyrek et al. (2026): https://doi.org/10.48550/arXiv.2605.28755