

The GAPS programme at TNG

LXXIV. A reanalysis of the planetary systems TOI-1272 and TOI-1694 with HARPS-N and retraction of the planetary interpretation of TOI-1272 c

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ABSTRACT

Context. Hot Neptunes are close-in exoplanets that occupy a sparsely populated region of parameter space known as the hot Neptune desert. Their presence in this extreme environment is puzzling as it implies a complex history involving intense stellar radiation, atmospheric loss, and unique migration patterns that differ from more conventional Neptunes at larger orbital periods.

Aims. We are running an observational programme aimed at enlarging the number of close-in Neptune-sized planets, with well-measured physical and orbital parameters. It contributes to the compilation of a statistically significant sample that will aid in clarifying the formation and migration pathways characterising this class of exoplanets.

Methods. We used currently available TESS photometry, along with new (HARPS-N) and archival (HIRES) high-precision radial-velocity measurements, to review the main properties of the planetary systems TOI-1272 and TOI-1694 by means of joint-fit analyses. In the case of TOI-1272, this included Gaussian-process regressions for carefully modelling stellar activity.

Results. Our final estimates of the parameters of the two systems are consistent with previous measurements but have smaller uncertainties. We identified the radial-velocity variation of TOI-1272 found in the HIRES data as stellar activity, rather than planetary in nature and, therefore, we rejected the non-transiting planet TOI-1272 c. This opens up the possibility that TOI-1272 b’s eccentricity is the result of high-eccentricity migration. The larger store of data at our disposal also allowed us to point out that both TOI-1694 b and TOI-1694 c move on slightly eccentric orbits. The current orbital architecture of TOI-1694 suggests a history of migration driven by both disc and dynamical interactions.

Key words. methods: data analysis – techniques: photometric – techniques: radial velocities – stars: individual: TOI-1694 – stars: individual: TOI-1272

1. Introduction

Giant planets with sizes and masses between those of Neptune and Saturn bridge the gap between ice giants and gas giants, and they are often termed super-Neptunes, sub-Saturns, or more generically intermediate-mass giants (see, e.g. Bonomo et al. 2014; Bakos et al. 2015; Bayliss et al. 2015; Knudstrup et al. 2023; Castro-González et al. 2024b). These planets populate a wide-ranging region of the parameter space with no representation in the Solar System (Fig. 1), further proving that our immediate celestial neighbourhood is not the archetype of planetary systems in the Milky Way. In particular, exoplanets with radii between roughly 3 and 8.5 $R_{\oplus}$, masses between 10 and 100 $M_{\oplus}$, and orbital periods shorter than approximately three

days occupy a critical and still enigmatic regime in the exoplanet-parameter space. They reside within the so-called “hot Neptune desert,” which is a region of dramatically low occurrence, which was identified in the 2010s (e.g. Szabó & Kiss 2011) and still challenges the theoretical models of planet formation, migration, and atmospheric evolution. This deficit is particularly striking because although intermediate-sized planets are generally easier to detect at short periods, they remain extremely rare compared to smaller super-Earths or larger gas giants.

Despite early data from the *Kepler* mission indicating that this region was virtually uninhabited (Latham et al. 2011), recent discoveries from the TESS mission (Ricker et al. 2015) have identified several ‘desert dwellers’, revealing that the desert is not entirely empty. Rather, it likely comprises a complex landscape of rare and unique planets (Fig. B.1). The Neptune desert is currently attributed to a combination of atmospheric mass loss and

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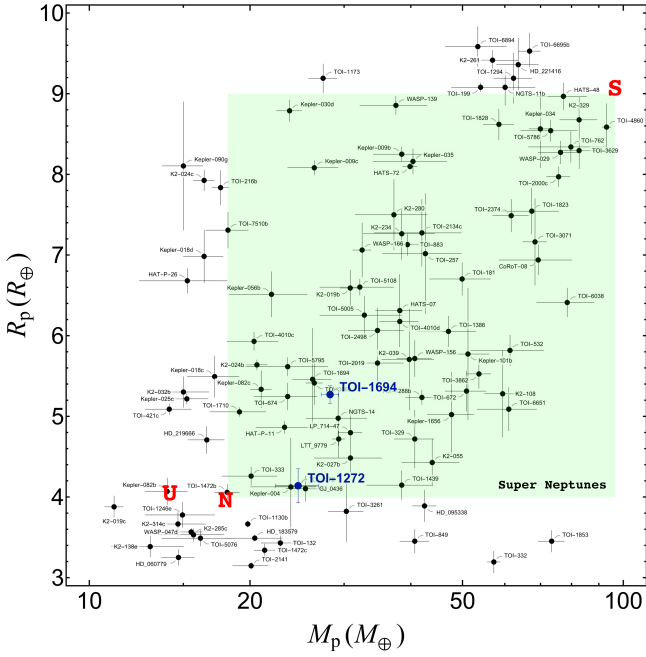


Fig. 1. Section of the R_p versus M_p linear-log diagram of known transiting exoplanets with a mass between 10 and $100 M_\oplus$ (measured with an accuracy to within 20%) and a radius between 3 and $10 R_\oplus$. Data taken from TEPcat. The positions of TOI-1274 b and TOI-1694 b are highlighted (this work). Exoplanets inside the green zone are giant planets with sizes and masses between those of Neptune and Saturn. The position of Uranus, Neptune, and Saturn are also marked with red capital letters.

dynamical migration. The lower edge of the desert is believed to have been shaped by photoevaporation caused by intense X-ray and extreme ultraviolet irradiation from the parent stars, which strips away the gaseous envelopes of low-to-intermediate-mass planets, leaving behind exposed rocky cores (Ionov et al. 2018; Owen & Lai 2018; Koskinen et al. 2022; Thorngren et al. 2023). In contrast, the upper boundary is likely sculpted by high-eccentricity migration and tidal disruption (Matsakos & Königl 2016; Owen & Lai 2018). A recent characterisation of desert dwellers revealed a remarkable diversity in density that challenges conventional formation theories. Despite having low core masses, some ultra-hot Neptunes have managed to retain extensive hydrogen-helium envelopes, resisting complete atmospheric escape (Jenkins et al. 2020; Nabbie et al. 2024). Conversely, other planets in the Neptune desert are exceptionally dense (reaching 10 g cm^{-3}), with core masses exceeding $30 M_\oplus$ (Armstrong et al. 2020; Osborn et al. 2023). Such massive, gas-poor planets are often interpreted as the exposed cores of giant planets (e.g. Hallatt & Millholland 2026), but extreme cases have required unconventional hypotheses, such as catastrophic formation scenarios (e.g. multiple planetary collisions; Naponiello et al. 2023), to explain their existence. As pointed out by Castro-González et al. (2024a), beyond this desert, planetary distribution transitions into the Neptunian ridge, a peak in occurrence at an orbital period (P_{orb}) between 3.2 days and 5.7 days, and the Neptunian savanna at longer orbital periods ($5.7 \text{ days} < P_{\text{orb}} < 100 \text{ days}$), each exhibiting distinct physical and orbital characteristics (Fig. B.1). The parent stars of Neptune-sized exoplanets in both the desert and the ridge are generally more metal-rich than those of the savanna (Dong et al. 2018; Vissapragada & Behrard 2025; Doyle et al. 2025). This is evident from Fig. 2 (bottom panel) and Fig. B.2 (top panel), in which we compared the cumulative distribution function

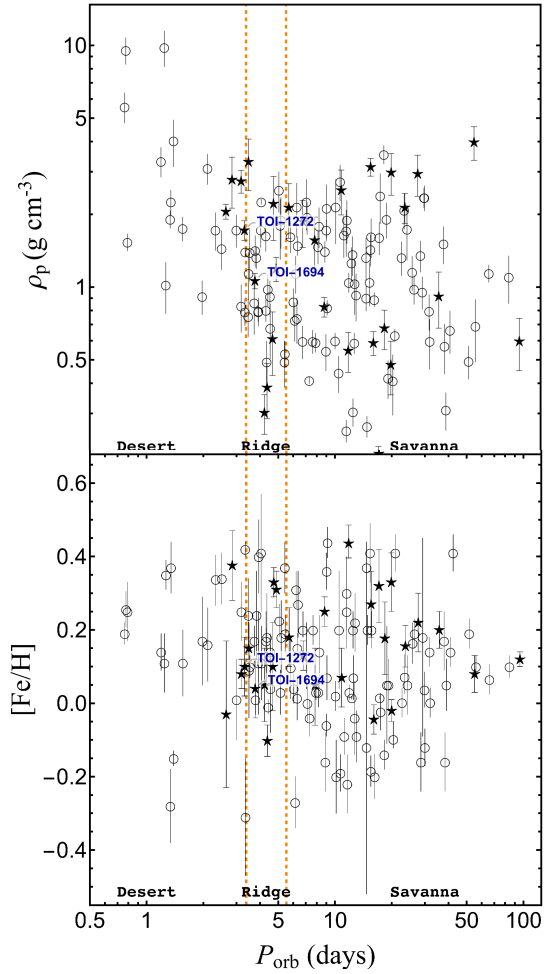


Fig. 2. *Top panel:* log-log diagram of the planetary density versus orbital period of known transiting exoplanets with ($3 R_\oplus < R_p < 7 R_\oplus$) and mean density measured with an accuracy to within 30%. *Bottom panel:* linear-log diagram of the parent-star metallicity versus planets' orbital period. Circles indicate planets with eccentricity $e \leq 0.1$, while five-pointed stars indicate those with $e > 0.1$. Data taken from TEPcat. Horizontal error bars have been suppressed for clarity. The positions of TOI-1274 b and TOI-1694 b are highlighted. The orange-dashed lines delimit the three regions recognised by Castro-González et al. (2024a).

(CDF) related to the host-star metallicities of the Neptune-desert sample with those of the ridge and savanna samples. Here, we considered all planets with a measured radius between 3 and $8.5 R_\oplus$ orbiting stars of known metallicity. The data were taken from the Transiting Extrasolar Planet Catalogue (TEPCat) (Southworth 2011). The null hypothesis that the Neptune-desert and Neptune-savanna datasets have the same distribution is rejected at the 5% level based on the Kolmogorov-Smirnov test ($p = 2.6 \times 10^{-4}$), whereas it is not rejected for the Neptune-desert and Neptune-ridge datasets ($p = 0.7$).

It is also evident that the Neptune desert is populated by planets that are denser than those of the ridge and savanna, as shown in Fig. 2 (top panel), with several extreme examples, as we already mentioned. In the bottom panel of Fig. B.2, we compared the CDF related to the planetary density of the Neptune-desert sample with those of the ridge and savanna samples (we only considered planets with a mean density measured with an accuracy of within 30%). Data were taken from TEPcat. Here, the null hypothesis that the Neptune-desert dataset has the same distribution as the ridge and savanna datasets is rejected at the 5%

level based on the Kolmogorov-Smirnov test ($p = 5.7 \times 10^{-4}$ and $p = 1.5 \times 10^{-3}$, respectively).

The evolutionary frameworks for planets in the Neptune desert, ridge, and savanna appear; therefore, to be distinguished by different migration histories, atmospheric loss mechanisms, and host star properties. Specific frameworks have been proposed as summarised by Vissapragada & Behmard (2025) and distinguishing between such formation pathways requires a large statistical sample and precise and accurate measurements of the physical parameters of the planetary systems populating these three regions. It is also essential to correctly know the orbital parameters (eccentricity and spin-orbit obliquity) as they provide critical insights into their dynamical history. In this context, we started an observational programme within the long-term Global Architecture of Planetary Systems (GAPS; e.g. Damasso et al. 2015; Esposito et al. 2017) project to confirm and characterise planets having intermediate masses and radii between super-Earths and sub-Saturns (Naponiello et al. 2022, 2023, 2025a, 2026). This was followed by the more focussed Hot Neptune Initiative (HONI) observational programme (Naponiello et al. 2025b; Manni et al. 2025). Both programmes are mainly based on data collected with the High Accuracy Radial velocity Planet Searcher for the Northern hemisphere (HARPS-N; Cosentino et al. 2012) spectrograph at the Telescopio Nazionale Galileo.

In this new paper of our series, we present new TESS photometric data and HARPS-N radial velocity (RV) measurements that allowed us to review the physical and orbital parameters of two known planetary systems, TOI-1272 and TOI-1694 (see Sect. 2), which are almost the same distance from us, 137 and 124 pc, respectively. The two parent stars have approximately the same effective temperature ($T_{\text{eff}} \sim 5000$ K) and are known to host two planets each, including a transiting Neptune-sized planet and a non-transiting planet. Both transiting exoplanets, TOI-1272 b and TOI-1694 b, have an eccentric orbit with a period of ~ 3.3 days, which places them in the ridge. The two non-transiting exoplanets, TOI-1272 c and TOI-1694 c have an orbital period of ~ 8.7 and ~ 389 days, respectively. The existence of the non-transiting planet, TOI-1272 c, is seriously questioned by our analysis.

The paper is organised as follows. In Sect. 2, we summarise the properties of the two planetary systems that are the subject of this study. In Sect. 3, we describe the TESS photometry that we used and present new times series of HARPS-N data. In Sect. 4, we provide a characterisation of the two parent stars, while that of all their planets is described in Sect. 5. Our analysis of the TOI-1272 system (Sect. 5.1) highlights how stellar activity has been previously misinterpreted as a planetary signal. Consequently, we show that the planet TOI-1272 c, claimed in the discovery paper, should be removed from the confirmed planet catalogues. Our conclusions are summarised in Sect. 6.

2. Target properties

In this section, we summarise the main properties reported in previous studies of the two planetary systems we study in this work.

2.1. TOI-1272

The discovery of the TOI-1272 planetary system was reported by MacDougall et al. (2022). It is composed of a main sequence dwarf star ($V = 11.76$ mag, $M_{\star} \sim 0.8 M_{\odot}$, $R_{\star} \sim 0.8 R_{\odot}$, $T_{\text{eff}} \sim 5000$ K) and an eccentric transiting hot super-Neptune, TOI-1272 b ($M_p \sim 25 M_{\oplus}$, $R_p \sim 4.1 R_{\oplus}$, $e \sim 0.3$), with an orbital

period of 3.316 days. The values of these parameters, which allowed the authors to confirm the existence of the planet, are based on the analysis of TESS photometry (sectors 15, 16, 22), 62 spectra obtained with the HIRES instrument (Vogt et al. 1994) at the Keck Observatory, and additional ground-based time-series photometry. Referring to *Gaia* Data Release 2 (DR2), MacDougall et al. (2022) noticed a neighbour star within $30''$ that dilutes the TOI-1272 light curve by less than 1%. A variability signal at 28.3 ± 0.6 days was noted in the TESS data, which was associated with stellar rotation. The analysis of HIRES RV measurements also enabled MacDougall et al. (2022) to identify a non-transiting outer companion, TOI-1272 c, on an 8.7 day orbit with a mass of $M_p \sin i = 26.7 \pm 3.1 M_{\oplus}$ and $e \lesssim 0.35$. However, their transit-timing-variation (TTV) analysis, whose search was extended over a photometric baseline of ~ 600 days, did not show any evidence that would favour TTVs.

The parameters of the TOI-1272 system were revised by MacDougall et al. (2023) in a study that included 85 TESS target stars from the TESS-Keck Survey sample (Chontos et al. 2022). TOI-1272 was also included in a subsequent uniform analysis of the TESS-Keck Survey data performed by Polanski et al. (2024), who found no evidence of likely false positives among their entire sample. Based on their updated analysis, they measured $M_p \sin i = 21.7 \pm 3.6 M_{\oplus}$ and $e \lesssim 0.12$ for TOI-1272 c. A comparison of the results of all these studies is reported in Tables 1 and A.1. We excluded the parameters related to TOI-1272 c from Table 1.

2.2. TOI-1694

The discovery of the TOI-1694 planetary system was announced by Van Zandt et al. (2023), who reported that the parent star is an early K dwarf ($V = 11.4$ mag, $M_{\star} \sim 0.8 M_{\odot}$, $R_{\star} \sim 0.8 R_{\odot}$, $T_{\text{eff}} \sim 5000$ K) hosting two planets; namely, TOI-1694 b and TOI-1694 c. They were confirmed thanks to TESS photometry (sectors 19 and 20) and 20 HIRES spectra. The inner planet in this system, TOI-1694 b, is a transiting hot super-Neptune ($M_p \sim 26 M_{\oplus}$, $R_p \sim 5.4 R_{\oplus}$) with an orbital period of 3.377 days; the outer planet, TOI-1694 c, is a non-transiting Jupiter analogue ($M_p \sin i \sim 1 M_{\text{Jup}}$) with an orbital period of ~ 390 days and low eccentricity ($e < 0.2$).

Mistry et al. (2023) presented an accurate study of the transit parameters of TOI-1694 b in a paper related to the validation of 11 TESS planet candidates by examining their light curves and computing false-positive probabilities using statistical validation tools. High-angular-resolution imaging, performed by using adaptive optics and speckle imaging techniques, did not detect any nearby sources. Ground-based photometry was also used by Mistry et al. (2023).

TOI-1694 was also included in the above-mentioned study by Polanski et al. (2024), who reported slightly different values of several parameters (Tables 2 and A.2). In particular, they mistakenly reported a value of the semi-major axis of the TOI-1694 c's orbit (0.10 ± 0.02 au), which is an order of magnitude lower than the correct value (see Fig. 6 from Van Zandt et al. 2023). This incorrect value, which was automatically included in the exoplanet archives, has had a negative impact on statistical studies of cold Jupiters, mainly in that this planet has remained out of the scope of investigations by means of *Gaia* astrometric data.

Finally, Handley et al. (2025) measured the Rossiter-McLaughlin effect by observing TOI-1694 during a transit of TOI-1694 b with the KPF spectrograph (Gibson et al. 2024). The sky-projected obliquity was constrained as $\lambda = 9^{\circ} + {}^{+22^{\circ}}_{-18^{\circ}}$, a value that suggests a nearly aligned orbit.

Table 1. Orbital and physical parameters for TOI-1272 b.

Parameter	This work	MacDougall et al. (2022)	MacDougall et al. (2023)	Polanski et al. (2024)
Transit parameters				
P_{orb} (d)	3.3159765 (15)	3.315990 (20)	3.3159790 (60)	3.315990 (18)
T_0 (BJD–2458000)	713.03098 (40)	713.0253 (60)	713.03150 (60)	713.02552 (36)
T_{14} (h)	$1.521^{+0.021}_{-0.019}$	...	$1.57^{+0.06}_{-0.05}$	...
R_p/R_*	$0.04881^{+0.00085}_{-0.00094}$	...	$0.0477^{+0.0025}_{-0.0017}$	...
b	$0.53^{+0.07}_{-0.12}$	$0.45^{+0.15}_{-0.21}$	...	...
i (deg)	$86.00^{+0.67}_{-0.39}$	...	...	...
a/R_*	11.03 ± 0.23	...	...	...
q_1 , TESS ^(a)	$0.17^{+0.18}_{-0.10}$	...	...	...
q_2 , TESS ^(a)	$0.35^{+0.37}_{-0.25}$	...	...	...
RV parameters				
K (m s ^{−1})	$12.5^{+0.68}_{-0.66}$	12.6 ± 1.1	...	13.5 ± 1.3
$\sqrt{e} \sin \omega$	0.495 ± 0.060	...	...	...
$\sqrt{e} \cos \omega$	-0.310 ± 0.060	...	...	...
e ^(b)	$0.345^{+0.046}_{-0.041}$	$0.338^{+0.056}_{-0.062}$	0.350 (55)	0.350 (55)
ω (deg)	122 ± 7	123.6 ± 11.5	...	141 ± 15
Instrumental parameters				
σ_{TESS} ^(c) (ppm)	$0.26^{+8.73}_{-0.25}$	...	...	...
$\sigma_{\text{HARPS-N}}$ ^(c) (m s ^{−1})	$1.74^{+1.17}_{-1.11}$	...	...	...
$\mu_{\text{HARPS-N}}$ ^(d) (m s ^{−1})	1901.5 ± 1.3	...	...	...
σ_{HIRES} (m s ^{−1})	$1.43^{+0.96}_{-0.93}$	...	...	...
μ_{HIRES} (m s ^{−1})	0.09 ± 1.23	...	...	...
Derived parameters				
M_p ($M_{\oplus}$)	24.1 ± 1.4	24.6 ± 2.3	...	$27.0^{+2.7}_{-2.5}$
R_p ($R_{\oplus}$)	4.26 ± 0.10	4.14 ± 0.21	$4.13^{+0.23}_{-0.15}$	...
ρ_p (g cm ^{−3})	$1.72^{+0.16}_{-0.15}$	1.9 ± 0.3	...	$2.09^{+0.44}_{-0.59}$
g_p (m s ^{−2})	$13.03^{+0.98}_{-0.94}$	...	...	...
a (au)	0.0410 (11)	0.0412 (08)	$0.0417^{+0.0002}_{-0.0003}$	0.0417 (07)
T_{eq} ^(e) (K)	1051^{+15}_{-14}	961 ± 32	...	...
TSM ^(f)	$54.8^{+4.7}_{-4.4}$	...	...	...

Notes. The median values of the best-fit parameters for TOI-1272 b, along with their upper and lower 68% credibility intervals as uncertainties. These values, both fitted and derived, were obtained from the posterior distributions of the corresponding models (this work). Values from literature are also reported for comparison. The numbers in brackets represent the uncertainties in the preceding digits. ^(a) $q_1 \equiv (u_1 + u_2)^2$ and $q_2 \equiv (u_1/2)(u_1 + u_2)^{-1}$, where u_1 and u_2 are the limb-darkening coefficients of the quadratic law (Kipping 2013). ^(b)The 95% confidence upper limit on the eccentricity determined when $\sqrt{e} \cos \omega$ and $\sqrt{e} \sin \omega$ are allowed to vary in the fit. ^(c) σ_{TESS} and $\sigma_{\text{HARPS-N}}$ are jitters added in quadrature to the errorbars of TESS and HARPS-N, respectively. ^(d)This is the systemic RV for HARPS-N. ^(e)This represents the equilibrium temperature assuming a Bond albedo of zero and an uniform redistribution of heat to the night side. ^(f)Transmission spectroscopy metric (TSM; Kempton et al. 2018).

3. Observations and data reduction

The current approved procedure for characterising transiting-exoplanet systems involves the joint modelling of transit photometric data and RV measurements. High-angular-resolution imaging is also part of the standard process to assess possible contamination by background stars (e.g. Lillo-Box et al. 2012; Evans et al. 2016). The datasets used in this study are described in the following.

3.1. TESS and ASAS-SN photometry of TOI-1272

TOI-1272 was observed by TESS while monitoring sectors 15, 16, and 22 (those used by MacDougall et al. 2022) as well

as, more recently, sectors 49 and 76. In particular, we adopted the Presearch Data Conditioning Simple Aperture Photometry (PDCSAP; Stumpe et al. 2012, 2014; Smith et al. 2012) short-cadence light curve (with exposure times of 120 s), provided by the TESS Science Processing Operations Center (SPOC) pipeline and retrieved via the Python package `lightcurve` (Lightcurve Collaboration 2018) from the Mikulski Archive for Space Telescopes Portal. No significant TTVs were reported for TOI-1272 b by Naponiello (2026) based on the same dataset.

We retrieved archival V-band photometry from the All-Sky Automated Survey for Supernovae (ASAS-SN; Kochanek et al. 2017), which provides a longer time baseline but at a lower cadence. For the ASAS-SN data, we removed a long-term trend by fitting a low-order polynomial and computed a generalised Lomb-Scargle (GLS; Zechmeister & Kürster 2009) periodogram. The main peak is found at $P = 24.3$ d, with a false alarm probability (FAP) slightly below 1%. Similarly, the GLS computed on the complete TESS dataset (all five sectors combined) shows a dominant peak at $P = 25.3$ d, consistent with the ASAS-SN result. We also applied the TESS Systematics-Insensitive Periodogram (TESS-SIP), following MacDougall et al. (2022), finding that the highest peak occurs at $P \sim 26$ d. When splitting the data into four segments (S15–16, S22, S49, and S76), the dominant periods are 25.5 d, 28.8 d, 23.6 d, and 17.6 d, respectively. The dispersion of these values and, in particular, the shorter period detected in the most recent sector suggest evolving active regions and a non-stationary starspot pattern.

Interestingly, several of the detected periods are close to integer multiples of 8.7 d, since $2 \times 8.7 = 17.4$ (≈ 17.6 d) and $3 \times 8.7 = 26.1$ (≈ 25.5 d). The peaks at 17–18 d and 25–26 d are therefore consistent with a scenario in which the 8.7 d signal, the period of the supposed planet TOI-1272 c, is related to stellar activity and its harmonics. Overall, the photometry supports a stellar rotation period of $P_{\text{rot}} = 25\text{--}26$ d, with variability in the recovered peak likely driven by the temporal evolution of magnetic activity. However, it is not possible to establish a more accurate constraint on P_{rot} based solely on all available photometry (TESS and ASAS-SN). We also retrieved an archival light curve of roughly 5000 points collected by the SuperWASP survey (Butters et al. 2010) over ~ 120 nights. The Lomb-Scargle periodogram for this dataset does not show any clear periodicity.

3.2. TESS photometry of TOI-1694

TOI-1694 was observed by TESS while scanning sectors 19, 20 (those analysed by Van Zandt et al. 2023), and the most recent sector 73 (included in Handley et al. 2025). For the data in the first two sectors, we adopted the short-cadence 120 s PDCSAP light curve provided by the TESS SPOC pipeline; whereas for the data from sector 73, we used the same light curve that was obtained by Handley et al. (2025) after a detrending and removal of systematics (see their Fig. 1) since TOI-1694 was only partially captured on the outermost pixel of the TESS imaging area. This light curve was kindly provided to us by that team of authors. No significant TTVs were reported for TOI-1694 b by Naponiello (2026) using the same dataset. Furthermore, our analysis, carried out on the basis of a GLS, did not indicate any significant signals related to stellar activity.

3.3. HARPS-N spectra

We acquired times-series spectroscopic data of TOI-1272 and TOI-1694 with HARPS-N, which is a high-resolution ($R = 115\,000$), visible-light ($383\text{ nm} \leq \lambda \leq 690\text{ nm}$), fibre-fed echelle spectrograph mounted on the 3.58-m Italian

Table 2. Orbital and physical parameters for TOI-1694 b and TOI-1694 c.

Parameter	TOI-1694 b						TOI-1694 c		
	This work	Van Zandt et al. (2023)	Mistry et al. (2023)	MacDougall et al. (2023)	Polanski et al. (2024)	Handley et al. (2025)	This work	Van Zandt et al. (2023)	Polanski et al. (2024)
Transit parameters									
P_{orb} (d)	3.7701389 (17)	3.7701379 (33)	3.770179 (60)	3.770137 (89)	3.770107 (85)	3.77015 (10)	$386.25^{+2.08}_{-2.13}$	389.2 ± 3.9	393.1 ± 4.7
T_0 (BJD-2458000)	843.65726 (40)	...	817.26620 (70)	817.26640 (60)	817.26629 (61)	817.26640 (40)	$1174.84^{+2.97}_{-2.81}$	...	170.5 ± 4.3
T_{14} (h)	2.178 ± 0.043	...	...	...	$2.869626^{+0.035}_{-0.032}$	...	...	...	...
R_p/R_*	$0.05947^{+0.00080}_{-0.00082}$	...	$0.0610^{+0.0017}_{-0.0013}$	$0.0609^{+0.0014}_{-0.0010}$	$0.0609^{+0.0013}_{-0.0010}$	$0.061^{+0.02}_{-0.01}$	...	...	...
b	$0.17^{+0.12}_{-0.11}$	...	$0.33^{+0.17}_{-0.20}$	...	$0.26^{+0.20}_{-0.18}$	$0.35^{+0.17}_{-0.19}$	...	...	...
i (deg)	$89.25^{+0.49}_{-0.51}$	...	$88.17^{+1.15}_{-1.19}$	...	...	$87.61^{+1.07}_{-0.99}$	...	...	...
a/R_*	$11.79^{+0.28}_{-0.30}$	...	$10.21^{+0.47}_{-0.79}$	...	...	$10.11^{+0.52}_{-0.86}$	$258.09^{+6.11}_{-6.54}$	...	...
q_1 , TESS ^(a)	$0.26^{+0.11}_{-0.06}$	...	...	...	...	$0.38^{+0.15}_{-0.11}$	...	...	...
q_2 , TESS ^(a)	$0.80^{+0.14}_{-0.21}$	...	...	...	...	$0.57^{+0.20}_{-0.19}$	...	...	...
RV parameters									
K (m s ⁻¹)	$13.26^{+0.45}_{-0.46}$	12.06 ± 0.96	11.81	...	14.3 ± 1.1	...	$31.71^{+0.75}_{-0.74}$	33.4 ± 1.6	28.84 ± 0.98
$\sqrt{e} \sin \omega$	$-0.325^{+0.045}_{-0.040}$	...	...	...	...	...	$-0.315^{+0.047}_{-0.039}$	...	...
$\sqrt{e} \cos \omega$	$-0.125^{+0.036}_{-0.037}$	...	...	...	...	...	$-0.099^{+0.051}_{-0.049}$	...	...
e ^(b)	$0.122^{+0.025}_{-0.024}$	0	...	...	0	0	0.111 ± 0.025	0.18 ± 0.05	0
ω (deg)	$-110.95^{+6.60}_{-7.73}$	...	...	...	90	...	$-107.40^{+8.92}_{-9.66}$	...	90
Instrumental parameters									
σ_{TESS} (ppm)	$0.52^{+6.21}_{-0.49}$	...	...	...	...	...	...	...	...
$\sigma_{\text{HARPS-N}}$ (m s ⁻¹)	$1.53^{+0.60}_{-0.65}$	...	...	...	...	...	...	...	...
$\mu_{\text{HARPS-N}}$ (m s ⁻¹)	$-22\,545.73^{+0.60}_{-0.61}$	...	...	...	...	...	...	...	...
σ_{HIRES} (m s ⁻¹)	$1.77^{+0.89}_{-0.86}$	...	...	...	...	...	...	...	...
μ_{HIRES} (m s ⁻¹)	$-1.07^{+0.73}_{-0.71}$	...	...	...	...	...	...	...	...
Derived parameters									
M_p ($M_{\oplus}$)	$28.24^{+1.05}_{-1.06}$	26.1 ± 2.2	25.5 ± 11.9	...	$31.3^{+2.7}_{-2.5}$	...	...	...	...
$M_p \sin i$ (M_{Jup})	...	...	...	...	...	...	$0.996^{+0.027}_{-0.026}$	1.05 ± 0.05	0.935 ± 0.050
R_p ($R_{\oplus}$)	5.27 ± 0.11	5.44 ± 0.18	$5.46^{+0.47}_{-0.79}$	$5.34^{+0.15}_{-0.12}$	...	...	...	...	...
ρ_p (g cm ⁻³)	$1.062^{+0.080}_{-0.076}$	0.89 ± 0.12	0.87	$1.13^{+0.21}_{-0.26}$	...	...	...	...	...
g_p (m s ⁻²)	$9.97^{+0.57}_{-0.55}$	...	...	...	...	...	...	...	...
a (au)	0.0445 ± 0.0013	...	...	$0.045^{+0.0004}_{-0.0004}$	0.0450 ± 0.0008	...	$0.974^{+0.028}_{-0.029}$	...	0.10 ± 0.02
$T_{\text{eq}}^{(c)}$ (K)	1037^{+17}_{-16}	...	1136.57	...	...	...	222 ± 4	...	...
TSM ^(d)	$95.45^{+6.42}_{-5.77}$	...	125.91	...	...	...	...	...	...

Notes. Notes are the same as Table 1. μ_{HIRES} represents the offset between HARPS-N and HIRES RV measurements. The numbers in brackets represent the uncertainties in the preceding digits.

Telescopio Nazionale Galileo (TNG), located at the Observatorio del Roque de los Muchachos in the island of La Palma, Spain. Due to its long-term stability and simultaneous wavelength calibration, HARPS-N can achieve RV measurements with an accuracy of $\sim 1 \text{ m s}^{-1}$ (Cosentino et al. 2012).

HARPS-N high-resolution spectra were obtained within the GAPS-Neptune project (Naponiello et al. 2022). Data collection began when the two targets were still considered exoplanet-system candidates. In total, we collected 94 spectra for TOI-1272 between 17 May 2020 and 13 August 2023, and 89 spectra for TOI-1694 between 3 October 2020 and 7 November 2022. These two datasets are available at the CDS. RVs and activity indices were determined from HARPS-N spectra, which were reduced using version 3.2.0 of the HARPS-N Data Reduction Software (DRS; Dumusque et al. 2021). The activity indices were extracted manually after reduction, using a script that is not officially part of the DRS but that we adapted to make it compatible with the HARPS-N reduced data.

3.4. High-angular-resolution imaging

We observed TOI-1694 with the AstraLux lucky-imaging camera (Hormuth et al. 2008) mounted at the 2.2 m telescope at the Observatorio de Calar Alto on February 26, 2020, at an airmass of 1.16 and using a z filter, obtaining 42 868 frames with a 10 ms exposure time per frame. The instrument pipeline reduced the

data and selected the best 10% of the frames to finally stack them in a composite image with an effective exposure time of 43 s. No companions were found in this image. We determined the sensitivity limits following the procedure explained by Lillo-Box et al. (2012, 2014) and used them to compute the blended source confidence. This parameter measures the probability that the target has a companion not detected by our high-resolution image that could potentially mimic the depth of the transit signal. In this case, this probability is as low as 0.12% (see also Lillo-Box et al. 2024 for further details).

Unpublished adaptive optic and speckle images of TOI-1272 were obtained with the NIRC2@KECK II (Wizinowich et al. 2000) and the 'Alopeke@GEMINI North (Scott et al. 2021), respectively, and are available in the ExoFOP archive. We did not use them.

4. Host-star characterisation

To estimate the photospheric parameters of the host stars, we produced co-added spectra from the available HARPS-N data (see Sect. 3.3). The signal-to-noise ratio (S/N) of the co-added spectra reached typical values of ~ 150 – 200 at $\lambda \sim 6000 \text{ \AA}$.

4.1. Atmospheric parameters and iron abundance

We derived the spectroscopic atmospheric parameters, i.e. the effective temperature (T_{eff}), the surface gravity ($\log g$), the

microturbulence velocity (ξ), and iron abundance ($[\text{Fe}/\text{H}]$), by measuring the equivalent widths (EWs) of iron lines. The EWs were measured using the ARESv2 code (Sousa et al. 2015) taking into account the line list by Biazzo et al. (2022).

The analysis was performed using the 2019 versions of the MOOG radiative transfer code (Snedden 1973), adopting the Castelli & Kurucz (2003) grid of model atmospheres with new opacities (ODFNEW). We followed the standard methodology described by Biazzo et al. (2022): (i) T_{eff} was derived by imposing the independence of the iron abundance on the line excitation potentials (excitation equilibrium); (ii) $\log g$ was determined via the ionisation equilibrium between Fe I and Fe II lines; (iii) ξ was obtained by minimising the trend between the reduced EW (EW/λ) of Fe I lines and the corresponding iron abundance. The final values of the stellar parameters are listed in Tables A.1 and A.2 for TOI-1272 and TOI-1694, respectively.

4.2. Projected rotational velocity

Once the atmospheric parameters were fixed, we derived the projected rotational velocity, $v \sin i$, for both stars using the spectral-synthesis method and the synth driver of MOOG. We targeted specific spectral regions around 540, 620 and 670 nm. Following Brewer et al. (2016), we assumed a macroturbulence velocity $v_{\text{macro}} = 1.8 \text{ km s}^{-1}$ for both targets and found $v \sin i = 1.8 \pm 0.9 \text{ km s}^{-1}$ and $1.2 \pm 0.8 \text{ km s}^{-1}$ for TOI-1272 and TOI-1694, respectively.

4.3. Stellar parameters

To determine the mass, radius, and age of both host stars, we used the EXOFASTv2 tool (Eastman 2017; Eastman et al. 2019; see also Naponiello et al. 2025a for more details), which allows simultaneous modelling of the stellar spectral energy distribution (SED) and the MIST evolutionary tracks (e.g. Paxton et al. 2015) in a differential evolution Markov chain Monte Carlo Bayesian framework. We used the APASS Johnson B and V , Sloan g' , r' , and i' magnitudes, the 2MASS near-infrared J , H , and K_s magnitudes, and the WISE $W1$, $W2$, and $W3$ infrared magnitudes to model the SED of both stars (Tables A.1 and A.2). Moreover, we imposed Gaussian priors on the *Gaia* DR3 parallax as well as on the T_{eff} and $[\text{Fe}/\text{H}]$ derived in Sect. 4.1. The stellar SED and its best fit are shown for both stars in Fig. B.3. The stellar masses, radii, ages, and their 1σ uncertainties were derived from the medians and 15.86–84.14% percentiles of the posteriors, respectively. These values are given in Tables A.1 and A.2 for TOI-1272 and TOI-1694, respectively.

4.4. Age estimate for TOI-1272 via gyrochronology

We also inferred the age of TOI-1272 thanks to the thanks to the gyrochronology method. Taking into account Fig. 4 of Gruner et al. (2023) and a *Gaia* colour index $G_{\text{BP}} - G_{\text{RP}} = 1.11 \text{ mag}$ and assuming a rotation period of ~ 26 – 28 d , we estimated an age of about 4 Gyr for TOI-1272 with an uncertainty of at least 25–30%, compatible with that of the previous section.

The chromospheric index, $\log R'_{\text{HK}} \sim -4.705$, as found by MacDougall et al. (2022), points to an age of 2–3 Gyr according to the relations of Lorenzo-Oliveira et al. (2018) and Carvalho-Silva et al. (2025). Nevertheless, such an age estimate can be affected by a modulation of the chromospheric index associated with a stellar activity cycle. Considering that the cycle amplitude can be similar to that of the Sun ($\Delta \log R'_{\text{HK}} \sim 0.25$) or greater, TOI-1272 could have a mean chromospheric index lower

than that reported by MacDougall et al. (2022) and, therefore, compatible with an age of $\sim 4 \text{ Gyr}$.

5. Analysis and results

In this section, we report our revision of the TOI-1272 and TOI-1694 planetary systems. Specifically, we redetermined the physical and orbital parameters of these two systems based on all available TESS photometry and HARPS-N RV measurements, described in Sect. 3, and the HIRES data, which were taken from Polanski et al. (2024). We noted that Van Zandt et al. (2025) published a TOI-1272 RV dataset with the same values as those of Polanski et al. (2024), with the difference that the first 21 spectra were left out and 5 additional, more recent spectra were added. Therefore, we used the dataset from Polanski et al. (2024) as it contains a larger number of measurements.

5.1. TOI-1272

Our analysis of the TOI-1272 system is more detailed and in-depth compared with that of TOI-1694. This is because, while for TOI-1694 the results of our analysis agree with those of the literature (see Sect. 5.2), in the case of TOI-1272 our analysis shows that the planet TOI-1272 c is a false positive, contrary to what was identified in the discovery paper.

5.1.1. No significant signal at 8.7 days in the HARPS-N data

Our review of the properties of this system began with the analysis of the new data collected with the HARPS-N spectrograph. In Fig. B.4, we show the time series of HARPS-N RVs and those of HIRES (Polanski et al. 2024). It is noteworthy that the two data sets were collected in approximately the same time period. We calculated the GLS periodogram using a Keplerian to model the HARPS-N time series, with the eccentricity sampled from a grid with a step size of 0.1. We found a significant peak at the orbital frequency of the transiting planet (first row of Fig. 3), with a least-square best-fit eccentricity of 0.4, close to the value measured by MacDougall et al. (2022).

In the next step, we performed a more sophisticated analysis by jointly modelling HARPS-N RVs and TESS transits with a single Keplerian signal within a Bayesian framework, using the juliet package (Espinoza et al. 2019) and sampling the posterior distribution with the nested sampler dynesty (Speagle 2020). The GLS periodogram of the RV residuals is shown in the second row from the top of Fig. 3. The main peak occurs at the period of 46.3 days with a FAP of 9.3%, which was estimated via a bootstrap simulation from 10 000 mock time series, noting that there is no significant peak at the orbital period of the second planet reported by MacDougall et al. (2022), namely, at $P = 8.69 \text{ days}$. We noticed that this period is likely compatible with being the second harmonic of the stellar rotation period as measured from the TESS light curve (see Sect. 3.1).

5.1.2. Analysis of the activity indices

The next step of our analysis was the characterisation of stellar activity by modelling the time series of the activity diagnostics extracted from the HARPS-N spectra, namely the full width at half maximum (FWHM) and the bisector span (BIS), measured from the CCF, and the activity indices calculated from the H- α and Ca II H&K lines, the latter known as the $\log R'_{\text{HK}}$ index. Their time series and GLS periodograms are shown in Fig. 3. The main peaks are located at 8.69 d (BIS), 25.3 d (FWHM),

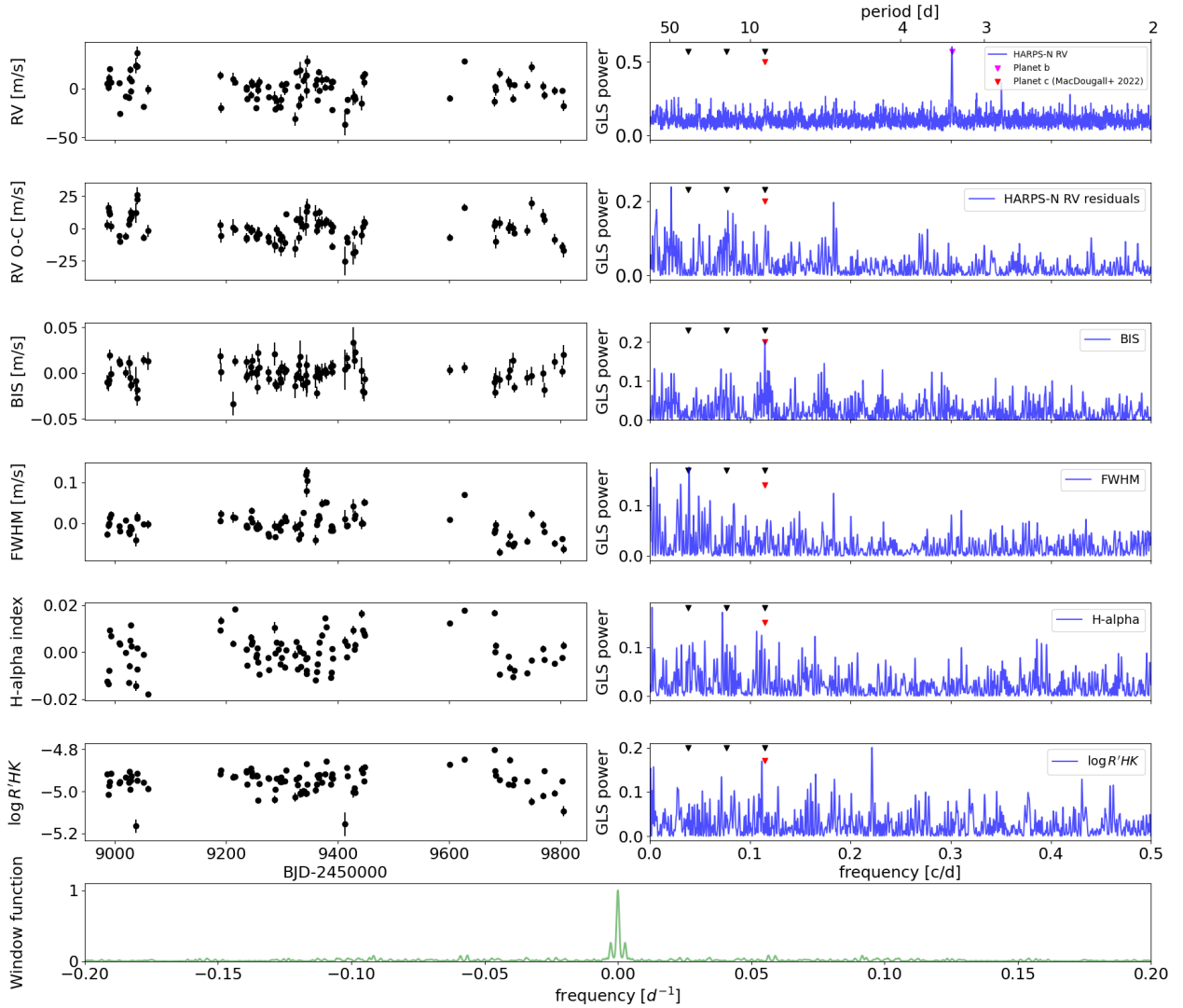


Fig. 3. *Left panels:* time series of the RVs and spectroscopic activity indicators derived from the HARPS-N spectra of TOI-1272, with the average values subtracted. The residual RVs, after subtracting the signal of the transiting planet b obtained with a Monte Carlo analysis, are shown in the second panel from the top. *Right panels:* corresponding GLS periodograms. The GLS of the original RVs is obtained by fitting the data with a Keplerian. The magenta and red triangles refer to the orbital periods of the transiting planet TOI-1272 b and the non-transiting planet TOI-1272 c, which was identified by [MacDougall et al. \(2022\)](#), respectively. Black triangles identify the stellar rotation period and its first and second harmonic. *Bottom panel:* plot of the window function related to the HARPS-N observations.

389.9 d (H- α), and 4.5 d ($\log R'_{\text{HK}}$), though none of them are statistically significant (bootstrap FAP 16%, 10%, 26% and 23%, respectively). However, the peak value for the BIS is found at the same period as the signal attributed to TOI-1272 c and there is a weak-to-moderate anti-correlation between the BIS and the RV residual data ($\rho_{\text{Pearson}} = -0.35$).

The main peak of the FWHM periodogram is compatible with the stellar rotation period. These signals could have a quasi-periodic modulation; however, the GLS fits the data with a simple sinusoid. Thus, we modelled the four indices with a Gaussian Process (GP) regression using the quasi-periodic kernel, and a slightly different parametrisation than described above. In this case, a generic element of the quasi-periodic covariance matrix is defined as

$$k_{\text{QP}}(t, t') = h^2 \cdot e^{-\frac{(t-t')^2}{2\lambda^2} - \frac{\sin^2\left(\frac{\pi(t-t')}{\theta}\right)}{2w^2}} + \left(\sigma^2(t) + \sigma_{\text{jit}}^2\right) \cdot \delta_{t,t'} . \quad (1)$$

Here, t and t' represent two different epochs of observations, σ is the uncertainty on the measurements (RVs or activity indices),

and $\delta_{t,t'}$ is the Kronecker delta. Any source of uncorrelated noise (either instrumental and astrophysical) can be modelled by adding a constant jitter term, σ_{jit} , in quadrature to σ . The GP hyper-parameters are:

- h , which denotes the scale amplitude of the correlated signal;
- θ , which represents the periodic time scale of the correlated signal and corresponds to the stellar rotation period;
- w , which describes the ‘weight’ of the rotation period harmonic content within a complete stellar rotation (i.e. a low value of w indicates that periodic variations contain a significant contribution from the harmonics of the rotation period);
- λ , which represents the decay timescale of the correlations. It is related to the temporal evolution of the magnetically active regions responsible for the correlated signal.

We explored the full (hyper-)parameter space using the publicly available Monte Carlo nested sampler and the Bayesian inference tool `MultiNest v3.10` (e.g. [Feroz et al. 2019](#)), through the `pyMultiNest` wrapper ([Buchner et al. 2014](#)). To perform

Table 3. Results of a GP regression analysis of spectroscopic activity indicators derived from HARPS-N spectra.

Parameter	Activity diagnostic ^a			
	BIS	FWHM	H α	log R'_{HK}
h	$3.0^{+3.3}_{-2.1}$ [m s ⁻¹]	$34.2^{+5.2}_{-4.4}$ [m s ⁻¹]	$0.0080^{+0.0019}_{-0.0014}$	$0.029^{+0.013}_{-0.017}$
w	$0.47^{+0.37}_{-0.32}$	$0.55^{+0.16}_{-0.11}$	$0.40^{+0.15}_{-0.11}$	$0.41^{+0.42}_{-0.28}$
λ [d]	523^{+321}_{-392}	$22.5^{+4.6}_{-5.2}$	67^{+25}_{-20}	206^{+508}_{-138}
θ [d]	$17.2^{+10.4}_{-9.3}$	$27.2^{+2.1}_{-1.2}$	24.2 ± 0.4	$23.5^{+3.9}_{-14.5}$
$\Delta \ln \mathcal{Z}^b$	-2.9	+35.8	+3.7	-2.2

Notes. The hyper-parameters are those defined in Eq. (1). The Prior distributions are the following. h (BIS and FWHM): $\mathcal{U}(0,200)$ m s⁻¹; h (H- α): $\mathcal{U}(0,0.5)$; h (log R'_{HK}): $\mathcal{U}(0,0.5)$ dex; w (all activity diagnostics): $\mathcal{U}(0,1)$; λ (all activity diagnostics): $\mathcal{U}(0,1000)$ d; θ (all activity diagnostics): $\mathcal{U}(0,35)$ d. ^(a)The best-fit values are given as the median and 16th–84th percentiles of the posterior distributions. ^(b)Difference between the Bayesian evidences of the models with and without GP regression, the latter being by a constant and representing the null hypothesis model.

GP regression within the MultiNest framework, we used the publicly available python module *george* v0.2.1 (Ambikasaran et al. 2015). The results are summarised in Table 3, which includes the values $\Delta \ln \mathcal{Z}$ that represent the difference between the Bayesian evidence of a model with and without the GP term.

We found that the FWHM is the activity indicator that shows a very significant quasi-periodic behaviour, with a well constrained stellar rotation period ($\theta = 27.2^{+2.1}_{-1.2}$ d), and a short evolutionary time-scale ($\lambda = 22.5^{+4.6}_{-5.2}$ d). The H- α index shows moderate quasi-periodic behaviour ($\theta = 24.2 \pm 0.4$ d; $\lambda = 67^{+25}_{-20}$ d). The BIS and log R'_{HK} do not show significant quasi-periodic variability, but their posteriors for θ are characterised by overdensity peaks related to the stellar rotation period or its harmonics. In particular, for log R'_{HK} , the posterior is bimodal (see Fig. B.5), with peaks in agreement with the stellar rotation period (~ 27 d) and its second harmonic (~ 9 d), which is very close to the orbital period of the putative planet c. These results show that the spectroscopic time series are affected by signals due to stellar activity and that the signal found in the HIRES RVs, which was attributed to a second planet, is actually due to activity.

5.1.3. Rejection of planet TOI-1272 c

Motivated by the findings discussed above, we performed a new joint RV+transit photometry modelling as before, but this time including a GP quasi-periodic kernel applied to the RVs. We find that the model with the GP regression is statistically strongly favoured ($\Delta \ln \mathcal{Z} = +13.7$), and the posterior of the hyper-parameter θ shows a peak around 8–9 days, corresponding to a short time-scale signal with amplitude and periodicity compatible with that of the claimed planet c. Concerning the HARPS-N data, our conclusion is that the RV time series is affected by correlated noise due to activity, that would explain the result of MacDougall et al. (2022) for their second signal in terms of activity instead of a second planet.

To verify this hypothesis, we analysed the Mount Wilson S-index and the RV time series calculated from the HIRES spectra (taken from Polanski et al. 2024) within a GP framework as that we previously used in the case of HARPS-N RVs. We stress that this kind of analysis is lacking in MacDougall et al. (2022). For the S-index, we find that the GP model with a quasi-periodic

kernel is largely favoured over the null hypothesis model represented by a constant offset ($\Delta \ln \mathcal{Z} = +40$), revealing the presence of a periodic modulation with a short timescale ($\theta = 29.0^{+2.1}_{-1.5}$ d; $\lambda = 43 \pm 12$ d) linked to the rotation period of the host star. For the RVs, we modelled the time series adopting three models: (i) only a Keplerian for the transiting planet; (ii) a Keplerian for the transiting planet and a GP quasi-periodic term; (iii) a Keplerian for the transiting planet and a sinusoid to model the signal of a possible second planetary. We found that model (ii) is strongly favoured over the other two models ($\Delta \ln \mathcal{Z} > 10$) and shows that the RVs are affected by a correlated signal with quasi-periodic properties ($\theta = 26.1 \pm 0.2$ d; $\lambda = 64.6^{+25.9}_{-19.3}$ d) and amplitude of ~ 9 m s⁻¹. We note that the signal with period ~ 8.7 d attributed to a second planet (MacDougall et al. 2022) coincides with the second harmonic of θ . The uncorrelated jitter is ~ 2 m s⁻¹, significantly lower than that found for the other two models (~ 8 m s⁻¹). The results for the HIRES-RV modelling (second scenario) are summarised in Table A.3.

Our conclusion is that the second signal found by MacDougall et al. (2022) in the HIRES RVs is real, but the interpretation is incorrect. This signal is better explained as due to quasi-periodic stellar activity, as was similarly found for the HARPS-N RVs, instead of invoking the existence of a second planet.

Simulations do show that a first- and second-harmonic signal, in addition to the star's rotation period, can be produced by starspots (see, e.g., Boisse et al. 2011). Moreover, there are stars that exhibit first- and second-harmonic signals, in addition to the rotation period, in their observed RV series (see, e.g., Suárez Mascareño et al. 2017; Desidera et al. 2023; Sozzetti et al. 2024).

The amplitude of the TESS light curve of TOI-1272 for the sectors 15 and 16 is $\sim 2\%$. It can be used to estimate the amplitude of the RV jitter induced by stellar activity by applying the results by Hojjatpanah et al. (2020). They show that an RV rms of ≥ 10 m s⁻¹ is generally observed for such an amplitude of light modulation. The top-right panel of Fig. 4 of Luhn et al. (2020) also indicates that a S_{HK} index equal to 0.331 (MacDougall et al. 2022) gives an RV rms of about 7–10 m s⁻¹. This conclusion is supported by the simulations by Desort et al. (2007) for a K-type star with $v \sin i = 1.1$ km s⁻¹ and a starspot filling factor of $f_t \sim 1.2\%$ as derived from the TESS light curve and a starspot with an effective temperature of ~ 3600 K, as they adopted in their Eq. (5). The simulations by Desort et al. (2007) neglect the effect of the blueshift quenching on the RV variations, but it is remarkably smaller than in the solar case for a K2-type star such as TOI-1272 (Meunier et al. 2017). Therefore, it is not expected to significantly modify our conclusion. The amplitude of the line bisector inverse slope variations, as obtained from Eq. (6) of Desort et al. (2007), is significantly smaller than in the third panel of Fig. 3; however, a peak-to-peak amplitude of ~ 6.5 m s⁻¹ is obtained when $v \sin i = 2.1$ km s⁻¹ is adopted, which is still compatible with the uncertainty of our measurement of the rotational spectral line broadening.

5.1.4. Apodised sine periodogram

To further investigate the nature of the $P = 8.7$ d signal, we analysed the HARPS-N and HIRES datasets using the apodised-sine-periodogram formalism introduced by Gregory (2016) and developed by Hara et al. (2022). This approach is designed to test whether a periodic signal is coherent over the entire time span of the observations, as expected for a Keplerian modulation, or is confined to a limited temporal window, as typically observed for activity-driven variability. In practice, the model consists of

a sinusoid multiplied by a temporal window function, $\mu(t) = w(\tau, t_0) [A \cos(\omega t) + B \sin(\omega t)]$, where $w(\tau, t_0)$ is an apodisation function centred at t_0 with a characteristic timescale, τ . By varying τ over a grid of values that span several times the value of T_{obs} down to shorter timescales, we can assess whether the signal is compatible with a constant-amplitude sinusoid ($\tau \gg T_{\text{obs}}$) or rather favours a localised wavelet-like behaviour ($\tau \ll T_{\text{obs}}$). For each pair (ω, τ) , the improvement with respect to the base model is quantified through the $\Delta\chi^2$ statistic, maximising over t_0 .

The apodised-sine-periodogram analysis of the RV residuals, after subtracting the signal of planet TOI-1272 b, shows that the 8.7 d signal is prominent only in the first portion of the dataset (see Fig. B.6) and rapidly decreases in power when larger apodisation timescales are enforced. The best-fitting solutions correspond to low values of τ , indicating that the signal is temporally localised, rather than coherent over the full observing baseline. In contrast, solutions with $\tau \gtrsim T_{\text{obs}}$, corresponding to a strictly periodic and phase-coherent signal as expected for a planetary companion, are not preferred by the data. This behaviour further suggests that the 8.7-day modulation is not consistent with a stable Keplerian origin but is, instead, more likely associated with stellar activity evolving on relatively short timescales. If we remove the 8.7-day signal, which we associate with the second harmonic of the rotation period of the parent star, a series of high-power peaks appear in the apodised periodogram around 13 days (i.e. the first harmonic).

5.1.5. Final parameters of the TOI-1272 system

To derive final results for the TOI-1272 system, we performed a joint RV+transit photometry modelling with *juliet*, including a GP regression, using the RVs from both HARPS-N and HARPS-N and the complete TESS timeseries. This time, we employed the QP kernel as implemented in the *celerite* package (Foreman-Mackey et al. 2017), namely,

$$k_{\text{QP}}(t, t') = \frac{B}{2 + C} e^{-\frac{|t-t'|}{L}} \left[\cos\left(\frac{2\pi(t-t')}{P_{\text{rot}}}\right) + (1 + C) \right] + \left(\sigma_{\text{RV}}^2(t) + \sigma_{\text{jit}}^2 \right) \cdot \delta_{t,t'}, \quad (2)$$

where B , C , and L are the amplitude, the constant scaling term, and the characteristic time-scale of the QP kernel, with P_{rot} being its characteristic period. The resulting parameters of the star and planet b are listed in Tables A.1 and 1. Our estimations are all within the error bars of the literature determinations, but slightly more accurate. HARPS-N and HIRES RVs are shown in the top panel of Fig. 4 (phase-folded), together with the preferred global model (top panel) and its residual (bottom panel). The TESS light curve of TOI-1272, folded with the planet's orbital period, is shown in the bottom panel of Fig. 4 together with the best-fit transit model resulting from the global fit.

5.2. TOI-1694

Unlike TOI-1272, both previously announced planetary signals for TOI-1694 (Van Zandt et al. 2023; Polanski et al. 2024) are aptly retrieved within our HARPS-N dataset. Since no activity signal can be appreciated either in photometry or spectroscopy data, we performed a joint transit+RV fit of both HARPS-N and HIRES RVs to retrieve updated planet parameters, using the same approach described in Sect. 5.1.5, but without the use of any GP; see Figs. 5, 6 and Table 2. We found that most of the parameters align well with those in the literature, although

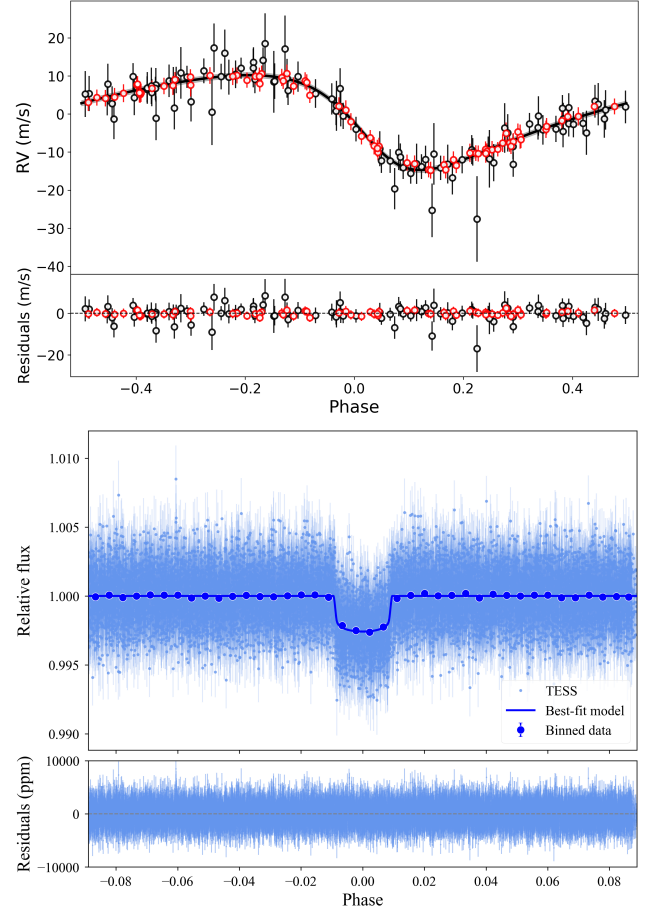


Fig. 4. *Top panel:* HARPS-N (HIRES) RV measurements of TOI-1272 in black (red) phase-folded to the period of planet b, together with our best-fit model. RV residuals from the best fit are also shown in parts per million. *Bottom panel:* phase-folded unbinned TESS light curve for TOI-1272 (light-blue points). The solid blue line shows the model fit to the light curve. The residuals are also shown. The blue filled circles show the light curves binned in phase. In both the panels, the error bars include both the data uncertainty and the jitter derived from the analysis.

with a higher degree of accuracy (e.g. $M_b = 28.2 \pm 1.1 M_{\oplus}$ vs $31.3^{+2.7}_{-2.5} M_{\oplus}$ or $P_{\text{orb},c} = 386.2 \pm 2.1$ d vs. 393.1 ± 4.7 d from Polanski et al. 2024). The correct value of the semi-major axis of TOI-1694 c is reported here for the first time. Moreover, we find that the free eccentricity model for the hot Neptune TOI-1694 b is statistically favoured over the circular one, resulting in a small but significant eccentricity $e_b = 0.122^{+0.025}_{-0.024}$. We note that the HIRES sampling for planet b was rather poor (Fig. 5), so this result largely stems from the larger and more complete HARPS-N dataset.

5.3. Dynamical evolution

The non-existence of the external planet, TOI-1272 c, allows us to explain the presence of TOI-1272 b in the Neptune desert as a result of planet-planet scattering followed by high-eccentricity migration. Specifically, in Sect. 6.3 of MacDougall et al. (2022), it is shown that the estimated age of TOI-1272 is compatible with its planet b having initially acquired an eccentricity of ~ 0.8 followed by tidal dissipation inside the planet itself to reach the present value 0.3, assuming a constant planetary modified tidal quality factor $Q' \sim 10^5$, similar to those of Neptune and Uranus (Ogilvie 2014).

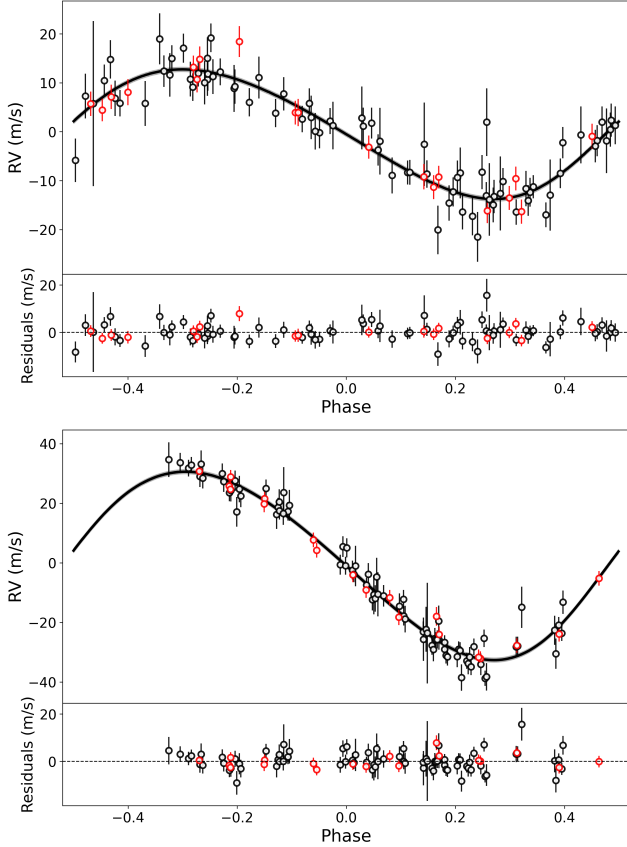


Fig. 5. Phase-folded RV measurements to the period of planet TOI-1694 b (*top panel*) and TOI-1694 c (*middle panel*), together with their residuals superimposed on the model. The black and red circles represent HARPS-N and HIRES data sets, respectively. The error bars include both the data uncertainty and the jitter derived from the analysis.

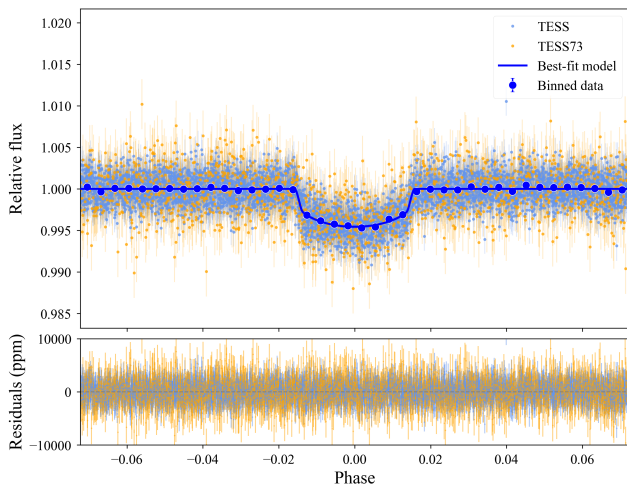


Fig. 6. Same as the bottom panel of Fig. 4, but for TOI-1694. The light-blue points refer to sectors 19 and 20, while green points refer to sector 73 (see Sect. 3.2).

The architecture of TOI-1694, instead, resembles that of WASP-107 (Piaulet et al. 2021), as illustrated in Fig. 7. Both planets likely formed further out, beyond the snow line, and migrated inward, while the protoplanetary disc was still present, through a gas-driven disc migration. TOI-1694 c likely underwent type II migration; as a massive body, it cleared a gap in

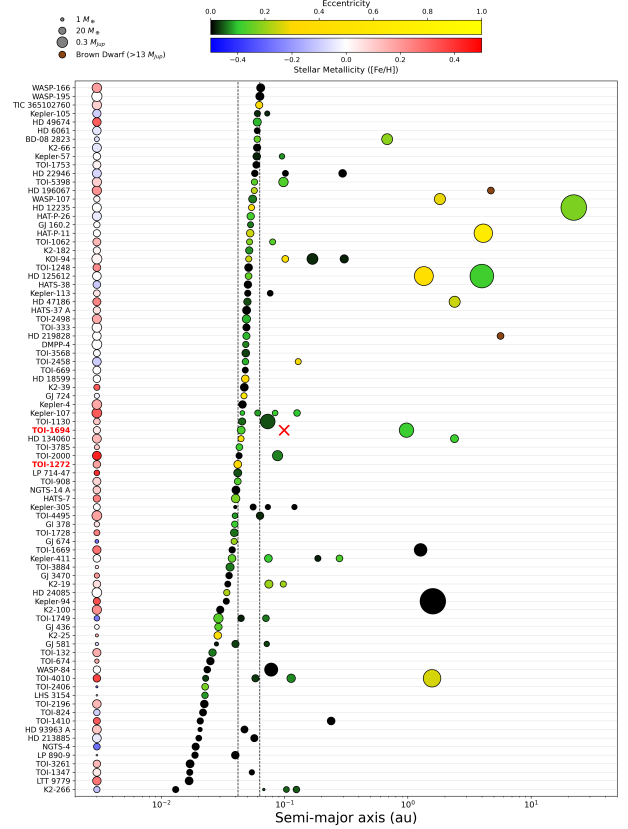


Fig. 7. Comparison of exoplanetary systems' architectures that have at least one Neptunian planet (defined as having a mass between 10 and 40 $M_{\oplus}$) with $P_{\text{orb}} \lesssim 5.7$ d, therefore inside the ridge (delimited by the two dashed lines) and the desert. TOI-1272 and TOI-1694 are highlighted. Host stars' metallicity and size are illustrated by color and circle size, respectively. Planets' orbital eccentricity and mass are illustrated by color and circle size, respectively. Note that the TOI-1272 system hosts only one planet now. The red cross marks the wrong position of TOI-1694 c reported in the exoplanet archives up to now (June 2026).

the gas disc and moved inward as the disc material evolved viscously. Its current position suggests that it stopped migrating before the gas fully dissipated. Instead, being less massive, TOI-1694 b likely migrated via type I migration, which is much faster (see, e.g., Ward 1997; Kley 2000; Masset & Snellgrove 2001), and would have been pushed toward the inner edge of the disc, near the magnetospheric cavity of the star (Kuchner & Lecar 2002). Planet-planet scattering could have affected planet TOI-1694 c, if another giant planet was initially present in the system. In that case, the orbit of planet c could have been remarkably inclined to the initial plane of the disc, while the other massive planet could have been expelled from the system (e.g. Dawson & Johnson 2018).

However, the present non-zero eccentricities of planets TOI-1694 b and c suggest that the system did not settle into a quiet circular configuration. The outer Jupiter-mass planet could have gravitationally perturbed the inner Neptune. If we again assume that $Q' \sim 10^5$, the tidal decay timescale for the present eccentricity of TOI-1694 b is ~ 325 Myr (Jackson et al. 2008), remarkably shorter than the estimated age of the system. This indicates that the eccentricity of planet b must be continuously excited. If the orbits of planets b and c were initially inclined, this could have triggered cycles of Kozai-Lidov (KL) oscillations that exchanged inclination for high eccentricity in the inner planet (Wu & Murray 2003; Fabrycky & Tremaine 2007). Given the

relatively low eccentricity of the orbit of the outer planet c, we can apply Eq. (27) of [Naoz \(2016\)](#) to estimate the timescale of the KL oscillations and find a maximum period of $\sim 1.2 \times 10^4$ yr that corresponds to the minimum relative inclination of $\sim 40^\circ$ between the orbits of planet b and planet c to produce such oscillations. The precession of the line of the apsides of the inner planet is dominated by General Relativity effects and its period is of $\sim 1.8 \times 10^4$ yr ([Mardling & Lin 2002](#)), comparable with but still longer than the period of Kozai oscillations, making it possible for the KL mechanism to account for the observed eccentricity of the inner planet. In other words, the system of TOI-1694 could be a rare planetary system caught in the final phase of the dynamical evolution produced by the KL mechanism. In the past, when the semi-major axis of TOI-1694 b was larger, the KL mechanism was capable of driving the eccentricity of the planet to very high values, so its periastron would come extremely close to the star. Tidal friction would then drain orbital energy, shrinking the semi-major axis to the current value and gradually circularising the orbit. It remained slightly eccentric because the KL mechanism continued to operate with an efficiency that was gradually reduced as the period of the KL oscillations approached the period of the apsidal precession of the orbit of the planet. In the future, once the KL mechanism and tidal dissipation have brought planet b still closer to the host star, the period of general relativity precession will become shorter than that of the KL oscillations, thereby preventing the KL mechanism from operating further ([Naoz 2016](#)) and leaving planet b on its final orbit.

The possibility that the eccentricity of planet b is excited by the perturbations induced by planet c on a coplanar or low inclination ($\lesssim 40^\circ$) orbit can be investigated by applying the model by [Mardling \(2007\)](#). It gives an equilibrium eccentricity smaller than 10^{-3} , that is too small to account for the observed eccentricity of planet b. Therefore, the interpretation based on the KL mechanism seems more likely.

Alternatively, if the TOI-1694 system originally contained a third planet that was subsequently ejected, the resulting planet-planet scattering followed by tidal dissipation could have affected also the less massive Neptune and brought it into the inner system, leaving the Jupiter-mass planet on its current slightly eccentric orbit ([Rasio & Ford 1996](#); [Chatterjee et al. 2008](#); [Dawson & Johnson 2018](#)). In this scenario, the present eccentricity of TOI-1694 b would be a relic of that formation mechanism, implying that its modified tidal quality factor is $Q' \gtrsim 10^6$ to avoid a significant damping of the primordial eccentricity along the lifetime of the system.

6. Conclusions

Within the GAPS-Neptune and HONEI programmes, we used high-resolution spectrographs to observe a sample of TESS transiting-planet candidates, mostly hosting hot and warm Neptune-sized planets. This class of exoplanets exhibits significant diversity in physical properties, even extreme ones, indicating heterogeneous internal structures and atmospheric compositions. Our aim is to confirm the planetary nature of many of these candidates and accurately characterise their main orbital and physical properties. In this way, we can enlarge the sample of well-studied Neptune-sized exoplanets. Thus, it becomes possible to deduce more robust information about their plausible formation and migration mechanisms. In this work, we present new HARPS-NRV measurements of two already known planetary systems, TOI-1272 ([MacDougall et al. 2022](#)) and TOI-1694 ([Van Zandt et al. 2023](#)), along with a comprehensive analysis of

their properties. We started collecting spectra of these two targets with HARPS-N when they were still considered candidates, but other teams preceded us and published their results concerning these two planetary systems before we finished our analyses. However, neither of these two systems has been fully characterised by previous studies. Several parameters were previously derived or have been incorrectly reported such as the semi-major axis of TOI-1694 c. Moreover, a stellar activity signal from TOI-1272 was mistaken for a non-transiting planet.

In our study, we joined our new RV measurements and those already published. It is worth emphasising that the new HARPS-N data cover the same time span as the data collected with HIRES for both TOI-1272 and TOI-1694. Finally, in our investigation, we considered new TESS photometric data for these two objects that were not available at the time of their discovery papers. Our main results are as follows.

We fully characterised the two stars, finding that both are K2 V stars (Sect. 4). Our estimations of their physical parameters are all within the error bars of previous determinations but are slightly more accurate. Their ages are not very-well constrained but indicate that the two stars are older than 2 Gyr. This conclusion is also supported by the low $v \sin i_*$ ($< 2 \text{ km s}^{-1}$) that we measured for both stars.

In the case of TOI-1272, our analysis of the HARPS-N data did not reveal any planetary signal other than that related to TOI-1272 b, but revealed that the GLS periodogram of the BIS peaks exactly at the period of the planet c claimed by [MacDougall et al. \(2022\)](#) and [Polanski et al. \(2024\)](#). We also reanalysed the HIRES data and found that the ~ 8.7 d signal coincides with the second harmonic of the stellar rotation period (see Sect. 5.1). Our conclusion is that this signal should be considered due to stellar activity, the planetary interpretation should be discarded and the planet TOI-1272 c should be rejected.

Although our estimated physical and orbital parameters for TOI-1272 b, TOI-1694 b and c are mostly consistent with previous determinations, they offer an enhanced level of precision. This is essentially due to the fact that our analysis is based on two and five times more RV measurements for TOI-1272 and TOI-1694 systems, respectively, as well as on photometric data from two and one more TESS sectors for TOI-1272 and TOI-1694 systems, respectively.

The increased number of RV measurements have allowed us to appreciate that the orbit of TOI-1694 b is slightly eccentric ($e = 0.122^{+0.025}_{-0.024}$). We also improved the measurements of the orbital period and eccentricity of TOI-1694 c ($P_{\text{orb}} = 386 \pm 2$ d; $e = 0.111 \pm 0.025$).

Data availability

The RV measurements of TOI-1272 and TOI-1694, which were obtained with HARPS-N, and the corresponding activity indices are available at the CDS via <https://cdsarc.cds.unistra.fr/viz-bin/cat/J/A+A/712/A147>.

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Appendix A: Additional tables

Tables A.1 and A.2 contain the stellar parameters that we estimated. Values from the literature are also reported for a quick comparison among the various studies. Table A.3 contains priors and best-fitting values for the GP regression analysis of the HIRES-RV dataset.

Table A.1. Stellar parameters of TOI-1272.

Parameter	Unit	This work	Source	MacDougall et al. (2022)	MacDougall et al. (2023)
Cross-identifications					
TOI	...	1272	TOI catalog	...	...
TIC	...	417948359	Tycho-2	...	...
2MASS ..	...	J13164717+4951399	2MASS	...	...
<i>Gaia</i> ...	...	1556242405699527424	<i>Gaia</i> DR3	...	...
Astrometric properties					
α (J2015.5)	h:m:s	13:16:47.09	<i>Gaia</i> DR2	...	...
δ (J2015.5)	°:′:″	+49:51:39.8	<i>Gaia</i> DR2	...	...
π	mas	7.26 ± 0.01	<i>Gaia</i> DR3	7.24 ± 0.021	...
$\mu_\alpha \cos \delta$..	mas yr ⁻¹	-63.24 ± 0.01	<i>Gaia</i> DR3	...	...
μ_δ	mas yr ⁻¹	4.75 ± 0.01	<i>Gaia</i> DR3	...	...
Photometric properties					
<i>B</i>	mag	12.846 ± 0.024	APASS Johnson ^(a)	...	...
<i>G</i> _{BP}	mag	12.0694 ± 0.0008	<i>Gaia</i> DR3	...	...
<i>V</i>	mag	11.878 ± 0.011	APASS Johnson ^(a)	...	...
<i>g</i> ′	mag	12.320 ± 0.030	APASS Sloan ^(a)	...	...
<i>r</i> ′	mag	11.566 ± 0.006	APASS Sloan ^(a)	...	...
<i>G</i>	mag	11.5948 ± 0.0003	<i>Gaia</i> DR3	...	...
<i>i</i> ′	mag	11.311 ± 0.025	APASS Sloan ^(a)	...	...
<i>T</i>	mag	11.0244 ± 0.0061	<i>Gaia</i> DR3	...	...
<i>G</i> _{RP}	mag	10.9633 ± 0.0005	<i>Gaia</i> DR3	...	...
<i>J</i>	mag	10.218 ± 0.019	2MASS ^(b)	...	...
<i>H</i>	mag	9.793 ± 0.029	2MASS ^(b)	...	...
<i>K</i> _s	mag	9.701 ± 0.020	2MASS ^(b)	...	...
<i>W</i> 1 (3.4 μm)	mag	9.632 ± 0.023	AllWISE ^(c)	...	...
<i>W</i> 2 (4.6 μm)	mag	9.698 ± 0.020	AllWISE ^(c)	...	...
<i>W</i> 3 (12 μm)	mag	9.613 ± 0.041	AllWISE ^(c)	...	...
Spectroscopic properties					
Spectral type		K2 V – K3 V ^(d)	This work	...	...
<i>T</i> _{eff} ^(e) ...	K	4985 ± 40	This work	4985 ± 121	5065^{+52}_{-50}
<i>v</i> sin <i>i</i> _★ ..	km s ⁻¹	1.2 ± 0.9	This work	...	...
<i>v</i> _{micro} ...	km s ⁻¹	0.51 ± 0.32	This work	...	...
[Fe/H] ..	dex	0.10 ± 0.08	This work	0.17 ± 0.06	$0.18^{+0.05}_{-0.06}$
Derived parameters					
<i>L</i> _★	<i>L</i> _☉	$0.3424^{+0.048}_{-0.047}$	This work	...	...
<i>M</i> _★	<i>M</i> _☉	$0.828^{+0.037}_{-0.032}$	This work	0.851 ± 0.049	$0.88^{+0.01}_{-0.02}$
<i>R</i> _★	<i>R</i> _☉	$0.800^{+0.011}_{-0.013}$	This work	0.788 ± 0.033	$0.79^{+0.01}_{-0.01}$
log <i>g</i> _★ ...	cgs	4.551 ± 0.022	This work	4.55 ± 0.10	...
$\rho_\star$	g cm ⁻³	$2.29^{+0.15}_{-0.13}$	This work	2.453 ± 0.343	$2.46^{+0.08}_{-0.09}$
log <i>R</i> _{HK} ^(f) .	dex	-4.9315 ± 0.0007	This work	-4.705	...
Age	Gyr	$7.0^{+4.5}_{-4.3}$	This work	$3.65^{+4.17}_{-0.98}$	$1.1^{+1.6}_{-0.8}$
<i>A</i> _V	mag	< 0.022	This work	...	...
<i>d</i>	pc	$137.73^{+0.21}_{-0.20}$	This work	...	...

Notes. ^(a)Values taken from the AAVSO Photometric All Sky Survey (APASS) project (Henden et al. 2016). ^(b)Values taken from the Two Micron All Sky Survey (2MASS) project (Skrutskie et al. 2006). ^(c)Values taken from the Wide-field Infrared Survey Explorer (WISE) mission (Cutri et al. 2021). ^(d)The spectral type was obtained from Pecaut & Mamajek (2013) (Table 5, Version 2022.04.16). ^(e)The effective temperature was obtained using the EXOFASTv2 tool (Sect. 4.3) considering both the colour index and the effective temperature. ^(f)This is the weighted mean from the values reported in the Table available at the CDS.

Our RV measurements of TOI-1272 and TOI-1694, which were obtained with HARPS-N, and the corresponding activity indices are available at the CDS in two tables. These two tables contain the following information. Column 1 lists BJD_{TDB} ; column 2 lists the exposure time; column 3 lists the RVs; column 4 lists the S/N; columns 5, 6, and 7 list the full width at half maximum, contrast, and bisector span of the cross-correlation function, respectively; columns 7 and 8 list the $H\alpha$ and $\log R'HK$ indices, respectively.

Table A.2. Stellar parameters of TOI-1694.

Parameter	Unit	This work	Source	Van Zandt et al. (2023)	Mistry et al. (2023)	MacDougall et al. (2023)
Cross-identifications						
TOI	...	1694	TOI catalog	...	...	...
TIC	...	396740648	TIC	...	...	...
TYC ...	...	4108-01434-1	Tycho-2	...	...	...
2MASS ..	...	J06305955+6621384	2MASS	...	...	...
<i>Gaia</i> ...	...	1104269596843209472	<i>Gaia</i> DR3	...	...	...
Astrometric properties						
α (J2015.5)	h:m:s	06:30:59.69	<i>Gaia</i> DR2	...	...	...
δ (J2015.5)	°:':"	+66:21:38.1	<i>Gaia</i> DR2	...	...	...
π	mas	8.04 ± 0.03	<i>Gaia</i> DR3	...	...	7.99
$\mu_\alpha \cos \delta$..	mas yr ⁻¹	46.35 ± 0.02	<i>Gaia</i> DR3	...	...	...
μ_δ	mas yr ⁻¹	-20.25 ± 0.02	<i>Gaia</i> DR3	...	...	...
Photometric properties						
<i>B</i>	mag	12.477 ± 0.081	APASS Johnson ^(a)	...	...	...
<i>G</i> _{BP}	mag	11.7737 ± 0.0006	<i>Gaia</i> DR3	...	...	...
<i>V</i>	mag	11.520 ± 0.046	APASS Johnson ^(a)	...	...	...
<i>g'</i>	mag	12.044 ± 0.088	APASS Sloan ^(a)	...	...	...
<i>r'</i>	mag	11.229 ± 0.067	APASS Sloan ^(a)	...	...	...
<i>G</i>	mag	11.3084 ± 0.0003	<i>Gaia</i> DR3	...	...	...
<i>i'</i>	mag	10.980 ± 0.065	APASS Sloan ^(a)	...	...	...
<i>T</i>	mag	10.7424 ± 0.0061	TESS	...	...	...
<i>G</i> _{RP}	mag	10.6847 ± 0.0003	<i>Gaia</i> DR3	...	...	...
<i>J</i>	mag	9.957 ± 0.029	2MASS ^(b)	...	...	...
<i>H</i>	mag	9.473 ± 0.030	2MASS ^(b)	...	...	...
<i>K</i> _s	mag	9.425 ± 0.020	2MASS ^(b)	...	...	...
<i>W</i> ₁ (3.4 μm)	mag	9.364 ± 0.023	AllWISE ^(c)	...	...	...
<i>W</i> ₂ (4.6 μm)	mag	9.431 ± 0.020	AllWISE ^(c)	...	...	...
<i>W</i> ₃ (12 μm)	mag	9.363 ± 0.041	AllWISE ^(c)	...	...	...
Spectroscopic properties						
Spectral type		K2 V – K3 V ^(d)	This work	...	...	...
T_{eff} ^(e) ...	K	5005 ± 65	This work	5066 ± 100	5135 ± 50	5058^{+60}_{-55}
$v \sin i_\star$..	km s ⁻¹	1.2 ± 0.8	This work	1.2 ± 1.0	...	...
v_{micro} ...	km s ⁻¹	0.41 ± 0.31	This work	...	...	...
[Fe/H] ..	dex	$+0.04 \pm 0.08$	This work	0.12 ± 0.06	$+0.06 \pm 0.08$	$+0.13^{+0.05}_{-0.06}$
Derived parameters						
$L_\star$	$L_\odot$	$0.381^{+0.022}_{-0.017}$	This work	...	...	...
$M_\star$	$M_\odot$	$0.828^{+0.039}_{-0.032}$	This work	0.84 ± 0.03	0.85 ± 0.11	$0.85^{+0.02}_{-0.02}$
$R_\star$	$R_\odot$	$0.812^{+0.023}_{-0.022}$	This work	...	0.818 ± 0.048	$0.80^{+0.01}_{-0.01}$
$\log g_\star$...	cgs	$4.536^{+0.028}_{-0.026}$	This work	4.53 ± 0.10	4.66 ± 0.10	...
$\rho_\star$	g cm ⁻³	$2.18^{+0.20}_{-0.18}$	This work	...	...	$2.3^{+0.14}_{-0.15}$
$\log R'_{\text{HK}}$ ^(f) .	dex	-4.8664 ± 0.0016	This work	<-4.7	...	...
Age	Gyr	$7.8^{+4.1}_{-4.6}$	This work	...	...	$4.3^{+3.5}_{-2.6}$
A_V	mag	< 0.065	This work	...	...	...
<i>d</i>	pc	$124.36^{+0.42}_{-0.43}$	This work	...	...	...

Notes. Notes are the same as Table A.1.

Table A.3. Priors and best-fitting values for the GP regression analysis of the HIRES RV dataset.

Parameter	Prior	Best-fit value ^(a)
Stellar activity GP term		
θ [d]	$\mathcal{U}(0, 35)$	26.05 ± 0.20
λ [d]	$\mathcal{U}(0, 1000)$	$66.65^{+25.37}_{-20.02}$
h [m s ⁻¹]	$\mathcal{U}(0, 50)$	$9.17^{+1.68}_{-1.26}$
w	$\mathcal{U}(0, 1)$	0.26 ± 0.04
Planetary parameters		
K_b [m s ⁻¹]	$\mathcal{U}(0, 20)$	$11.80^{+0.72}_{-0.69}$
P_b [d] ^(b)	$\mathcal{N}(3.3159765, 0.0000015)$	$3.3159765 (15)$
$T_{b, \text{conj}}$ [BJD-2 450 000] ^(b)	$\mathcal{N}(8713.03098, 0.00040)$	$8713.03097 (39)$
$\sqrt{e_b} \cos \omega_{\star, b}$ ^(c)	$\mathcal{U}(-1, 1)$	$-0.347^{+0.073}_{-0.065}$
$\sqrt{e_b} \sin \omega_{\star, b}$ ^(c)	$\mathcal{U}(-1, 1)$	$0.384^{+0.077}_{-0.089}$
Derived planetary parameters		
e_b	...	0.27 ± 0.05
ω_b [deg]	...	$131.78^{+10.89}_{-10.31}$
Instrument-related parameters		
σ_{jit} [m s ⁻¹]	$\mathcal{U}(0, 20)$	$1.84^{+0.79}_{-0.86}$
offset γ [m s ⁻¹]	$\mathcal{U}(-100, 100)$	$0.83^{+2.33}_{-2.34}$

Notes. ^(a)Percentiles (16th, 50th, and 84th) of the posterior distributions. ^(b)The numbers in brackets represent the uncertainties in the preceding digits. ^(c)We adopted the parametrisation $\sqrt{e_b} \cos \omega_{\star, b}$ and $\sqrt{e_b} \sin \omega_{\star, b}$ instead of using e_b and $\omega_{\star, b}$ as free parameters.

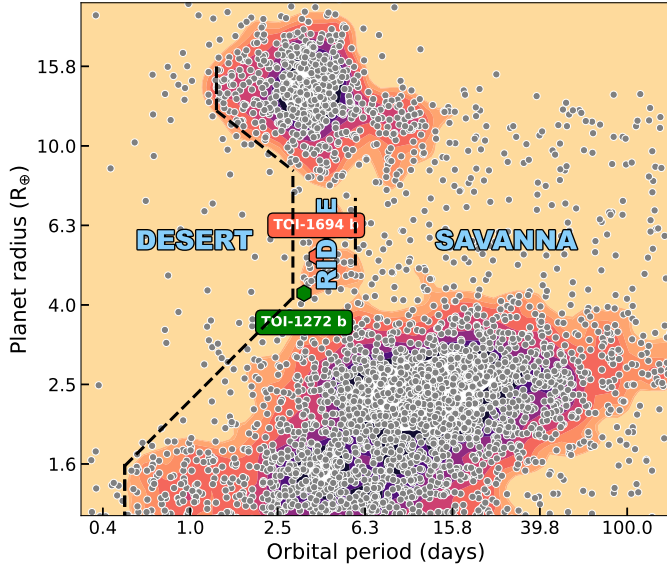


Fig. B.1. Radius-period diagram of close-in exoplanets with mass and radius measured to an accuracy of at least 5σ . The data were obtained from the NASA Exoplanet Archive on March 10, 2026. Error bars were suppressed for clarity. The positions of TOI-1272 b and TOI-1694 b (this work) are highlighted, together with the population-based boundaries of the Neptunian desert, ridge, and savanna, as derived by [Castro-González et al. \(2024a\)](#). This plot was generated with `nep-des` (github.com/castro-gzljz/nep-des).

Appendix B: Additional plots

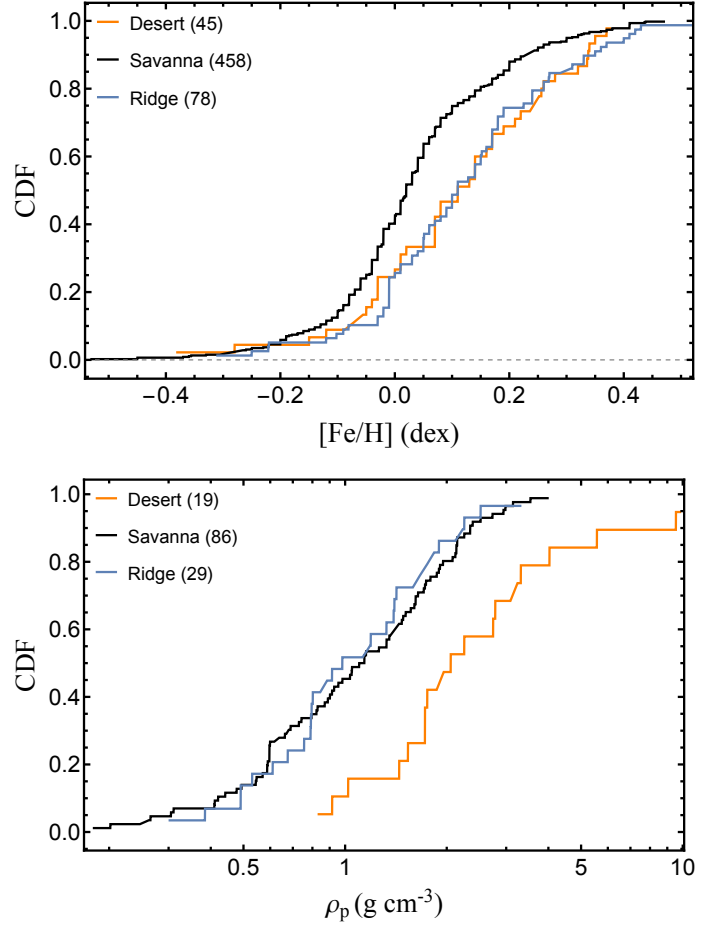


Fig. B.2. *Top panel:* Comparison of host-star metallicity CDFs for different Neptune-sized-planet ($3 R_{\oplus} < R_p < 8.5 R_{\oplus}$) samples belonging to the desert (orange), ridge (blue) and savanna (black), whose boundaries are specified in the text. We considered only planets orbiting stars of known metallicity. *Bottom panel:* comparison of planetary-density CDFs for the same Neptune-sized-planet samples as in the left-hand panel. We only considered planets with a mean density measured with an accuracy to within 30%. Data taken from TEPcat.

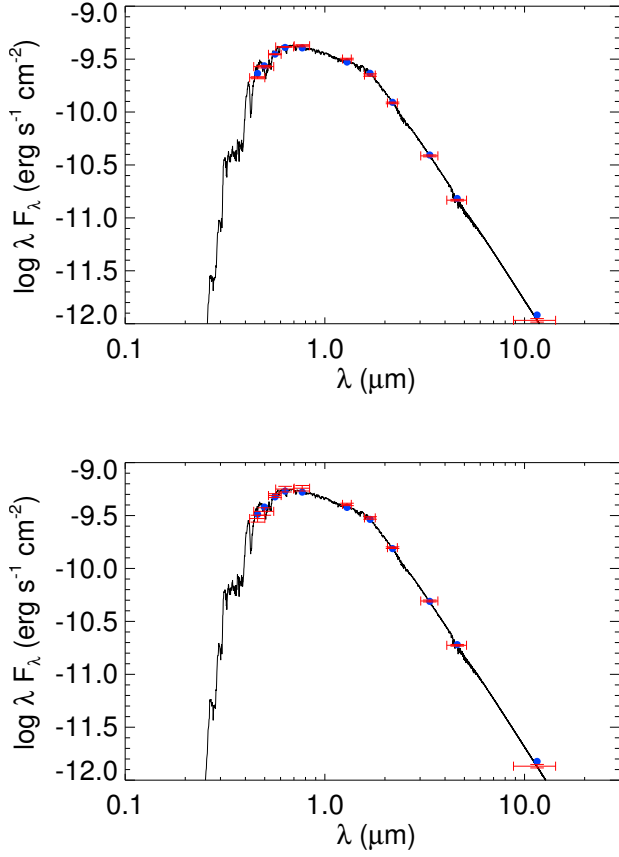


Fig. B.3. SED of the host stars TOI-1272 (top panel) and TOI-1694 (bottom panel). The broadband measurements from the APASS Johnson and Sloan, 2MASS, and WISE magnitudes are displayed in red, and the corresponding theoretical values with blue circles. The solid black lines in both plots show the non-averaged best-fit models. The strong similarity of the SEDs is due to the almost identical stellar spectral types.

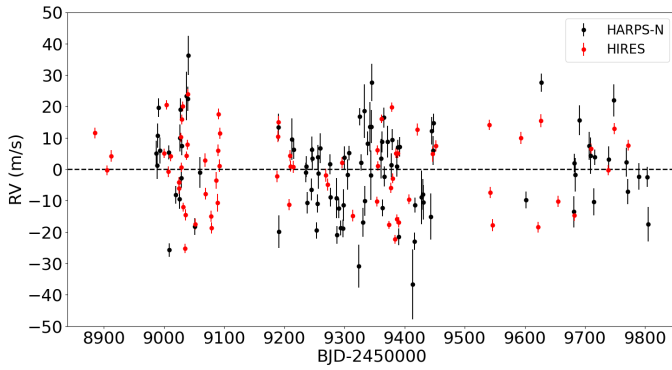


Fig. B.4. TOI-1272 time series of the RVs extracted from HIRES (Polanski et al. 2024) and HARPS-N (this work) spectra.

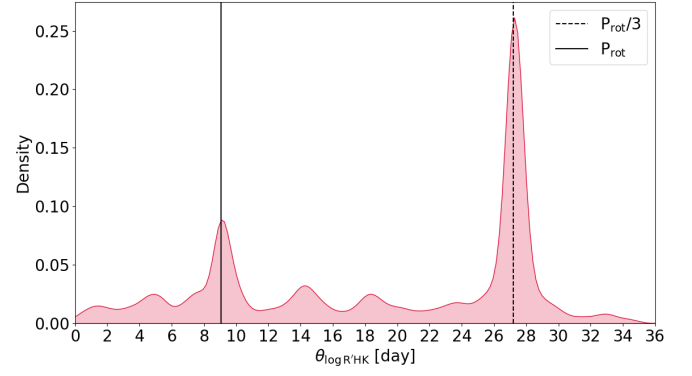


Fig. B.5. Posterior distribution of the θ hyper-parameter (stellar P_{rot}) obtained from a GP quasi-periodic regression of the $\log R'_{\text{HK}}$ time series measured from HARPS-N spectra. The rotation period and its second harmonic are indicated by a dashed and a solid vertical line, respectively.

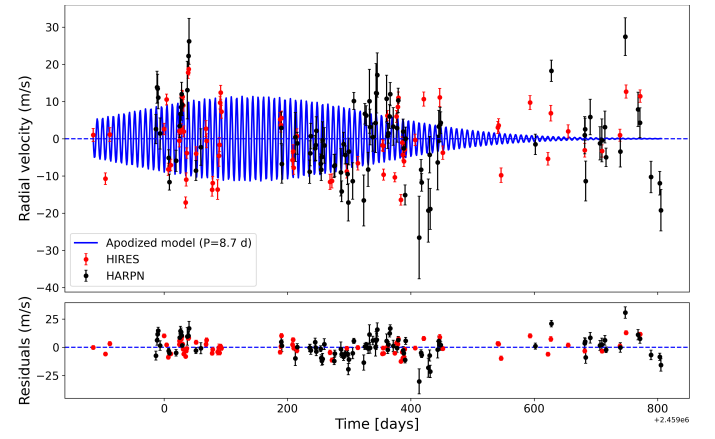


Fig. B.6. Residual RVs after subtracting the signal of TOI-1272 b over-plotted with the apodized sine model identified at the period $P = 8.7$ d (in blue).