

First discovery of NIRPS: TOI-756c, an eccentric warm giant companion to the TESS Sub-Neptune



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NIRPS: Near Infra Red Planet Searcher

NIRPS is the new **infrared spectrograph** (in operation since April 2023) simultaneously operating with HARPS at the ESO 3.6-m telescope at the La Silla Observatory in Chile (Bouchy et al. 2017). It is the first instrument **fiber-fed from an AO system**. By operating in two observing modes with a resolution of 84'000 (High accuracy) or 72'000 (High efficiency), it achieves high RV precision (**1 m/s**) and high spectral fidelity. See poster 871 to learn more about the instrument!



Fig. 1 - NIRPS & the NIRPS consortium.

NIRPS @ Exoplanets 5

Talks: 986-Romain Allart ; 1234-Khaled Al Moulla.
Posters: 435-Alejandro Suarez-Mascareno ; 601-Yolanda Frensch ; 661-Yann Carteret ; 871-François Bouchy ; 967-Dany Mounzer ; 1275-Lucile Mignon

WP2 : Mass and density characterization of transiting exoplanets

Among the 725 nights of GTO over 5 years (~40% telescope time), the **follow-up of transiting planets** represent 225 nights inside the Work Package 2 of NIRPS. This WP is itself made up of several sub-programs designed to meet different scientific objectives:

- GIANTS** : Giant transiting exoplanets and BD orbiting M-dwarfs
- DEEP-SEARCH** : A deep search for additional planets
- MASS-RADIUS** : Mass-Radius diagram for mid-to-late M-dwarfs
- SUB-NEPTUNES** : Sub-Neptunes orbiting M dwarfs
- RADIUS-VALLEY** : Origin of the M-dwarf radius valley
- CMF** : Rocky planet iron core mass fractions
- TEMPERATE** : Temperate Super-Earths and Sub-Neptunes

TOI-756

TOI-756 is a faint M2V star ($V_{\text{mag}}=14.61$ | $J_{\text{mag}}=11.14$) discovered by Wroblewski & Torres 1991 : WT 351. It has a proper motion companion WT 352 at about 11 arcsec. These are its main parameters from the TICv8 catalog:

Teff [K]	R_* [R_{\odot}]	M_* [M_{\odot}]	L_* [L_{\odot}]	log(g)	[Fe/H]
3533 ± 157	0.51 ± 0.02	0.51 ± 0.02	0.04 ± 0.01	4.73 ± 0.01	-0.48 ± 0.08

TOI-756b : the Sub-Neptune discovered by TESS

TOI-756 was observed in 2-min cadence in Sectors 10, 11, 37 and 64 of the TESS survey (Ricker et al. 2015). These observations found a transiting planet to this star: TOI-756b, a 1.24-day **Sub-Neptune**. The transit event was confirmed by several ground-based telescope in multiple photometry bands: ExTrA and LCOCTIO making this target an excellent candidate for radial velocity follow-up. We confirm the detection and characterize this Sub-Neptune with NIRPS + HARPS. We analyse and fit the TESS PDCSAP LCs using *juliet* (Espinoza et al. 2019, see Fig. 2):

TOI-756c : first discovery of NIRPS

We began observing TOI-756 with NIRPS (and HARPS simultaneously) at the start of GTO in April 2023 as part of WP2's Sub-Neptunes sub-program. Soon after the start of the observations, a strong signal is detected and then confirmed by continuing to monitor: **a 150-day non-transiting eccentric external companion TOI-756c**. We use the *juliet* software package to model the RVs of the system: the Sub-Neptune, the outer companion but we also find a **long term drift**. Spectra are processed with APERO reduction pipeline (Cook et al. 2022) and the line-by-line (LBL) method (Artigau et al. 2022) to extract the RVs.

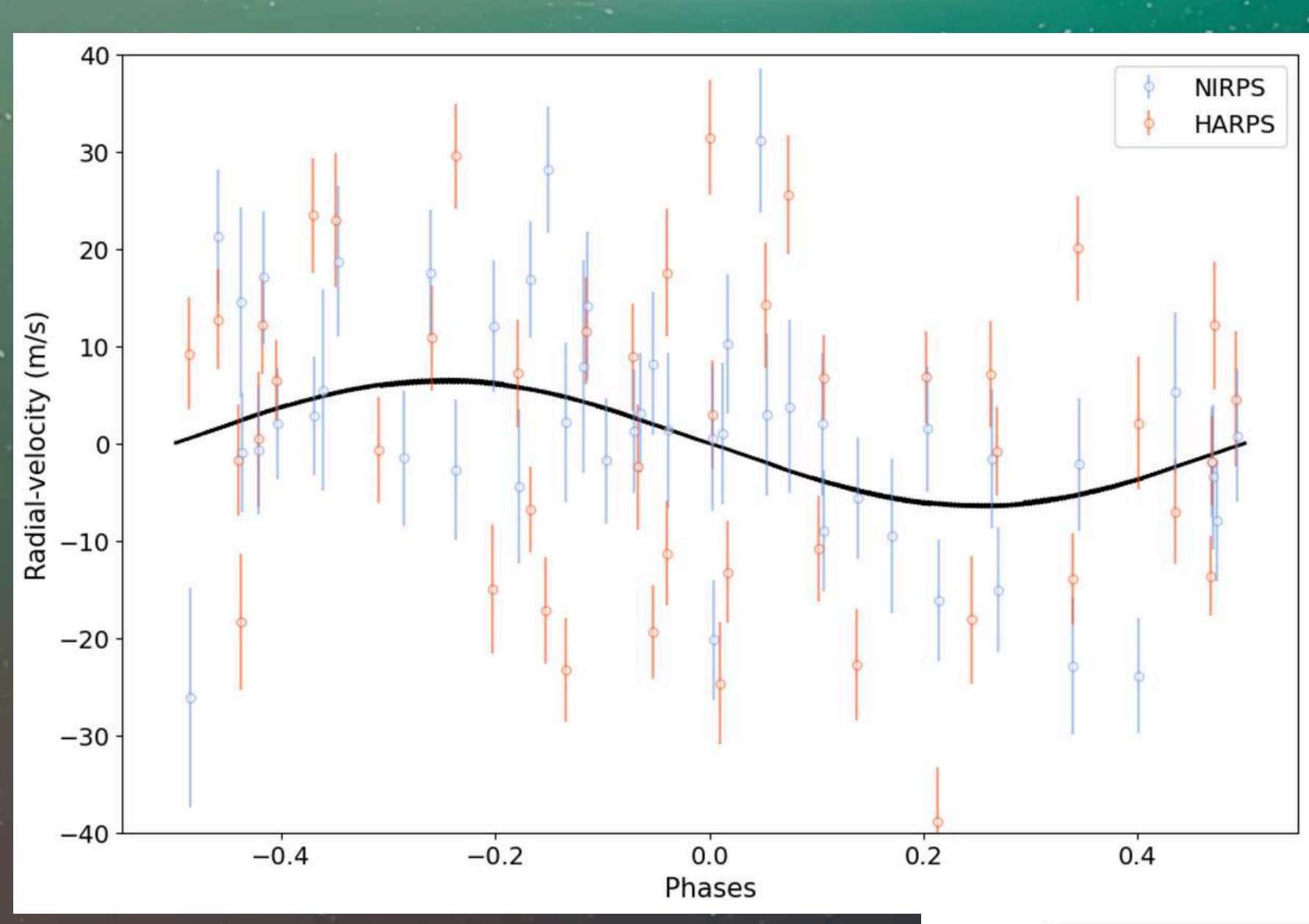
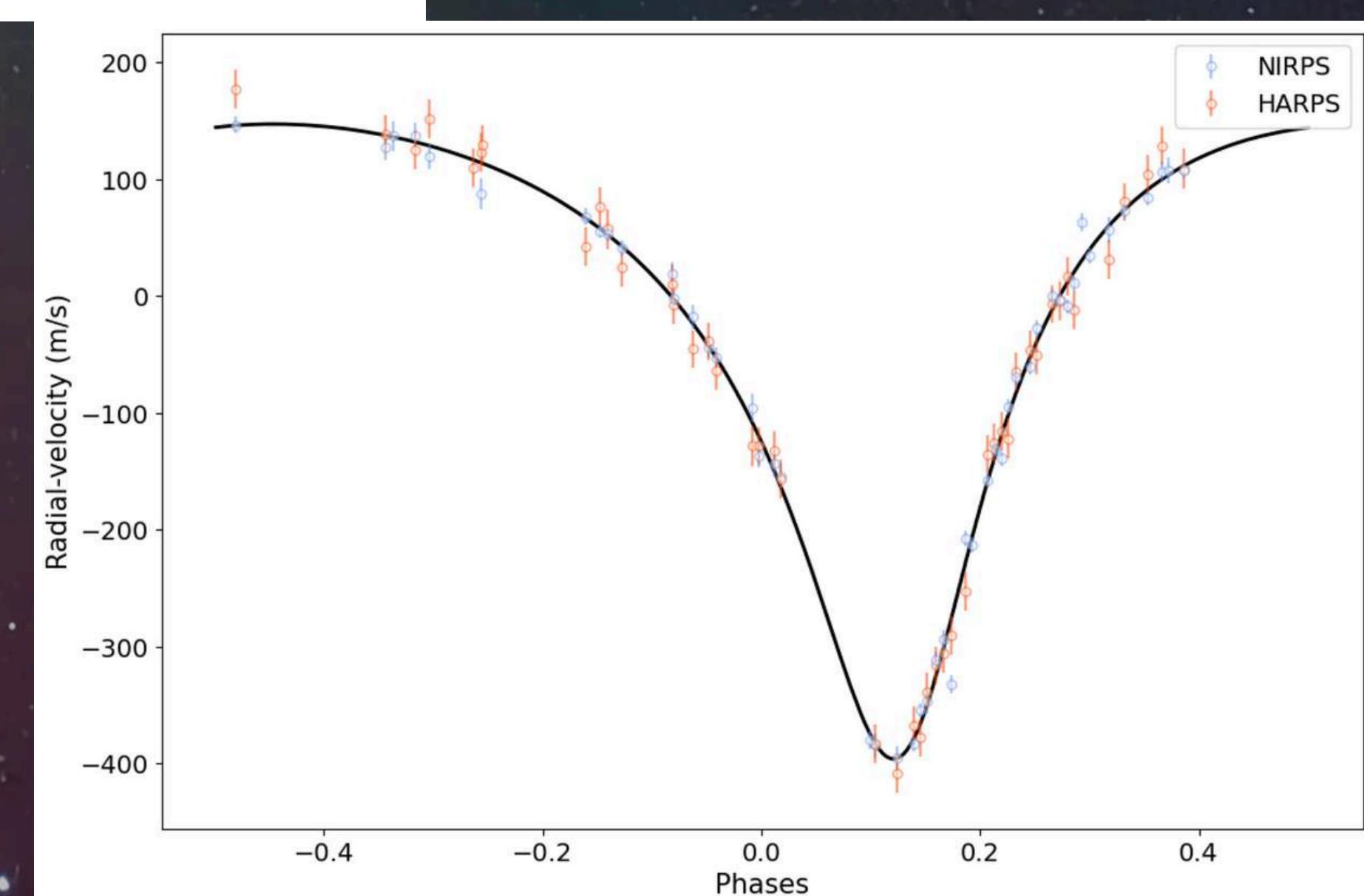


Fig. 4 - Phase-folded signal of TOI-756c of NIRPS and HARPS data with the RV model

Fig. 3 - Phase-folded signal of TOI-756b of NIRPS and HARPS data with the RV model



P_b [days]	$1.23925 \pm 1e-6$
i_b [°]	86.1 ± 0.6
R_b [R_{\oplus}]	2.68 ± 0.11
M_b [M_{\oplus}]	7.26 ± 3.39
P_c [days]	149.9 ± 0.2
$M_c \sin(i_c)$	4.01 ± 0.12
e_c	0.47 ± 0.01
Drift [m/s/d]	0.37

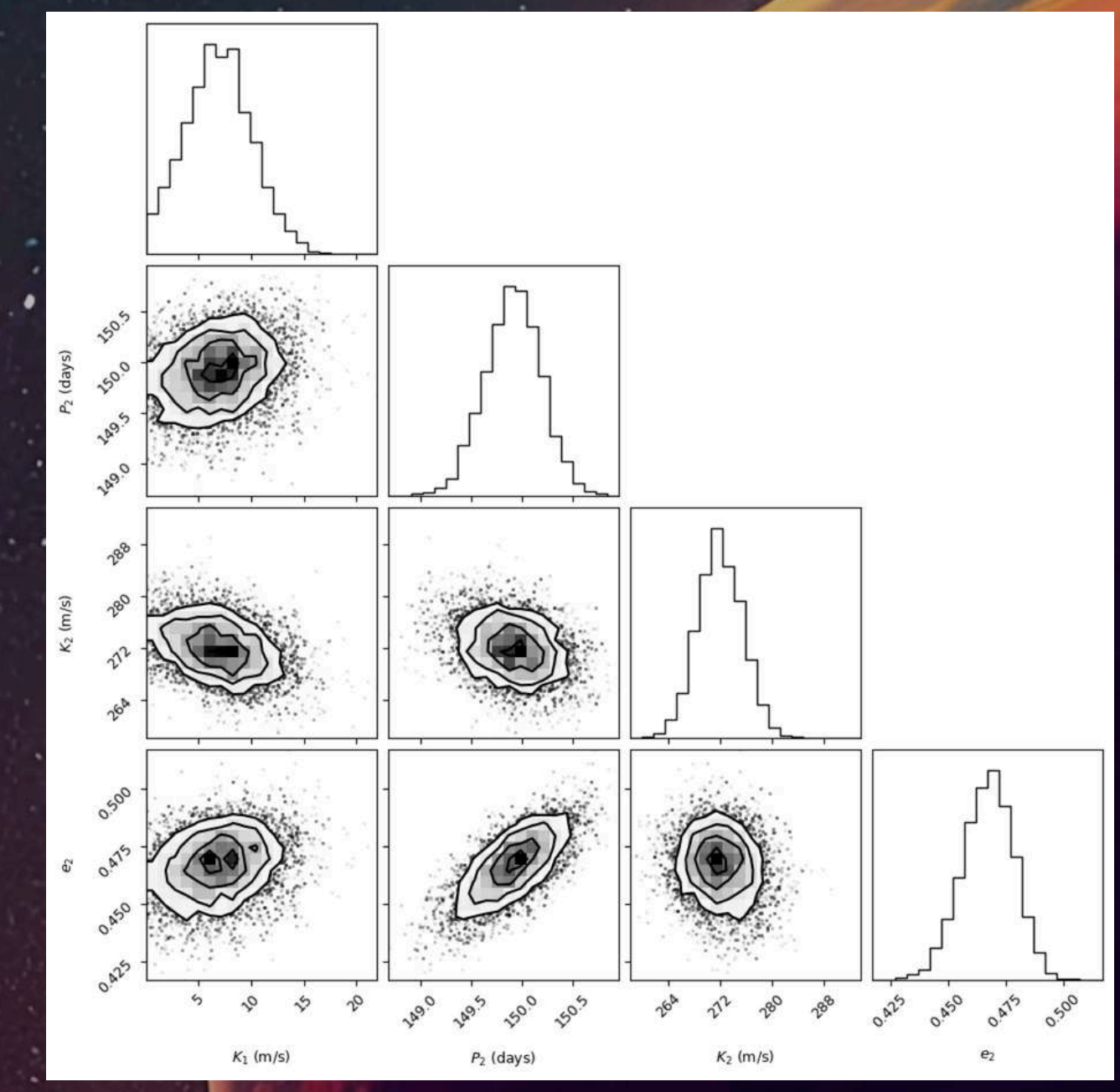


Fig. 5 - Corner plot of the RVs fit.

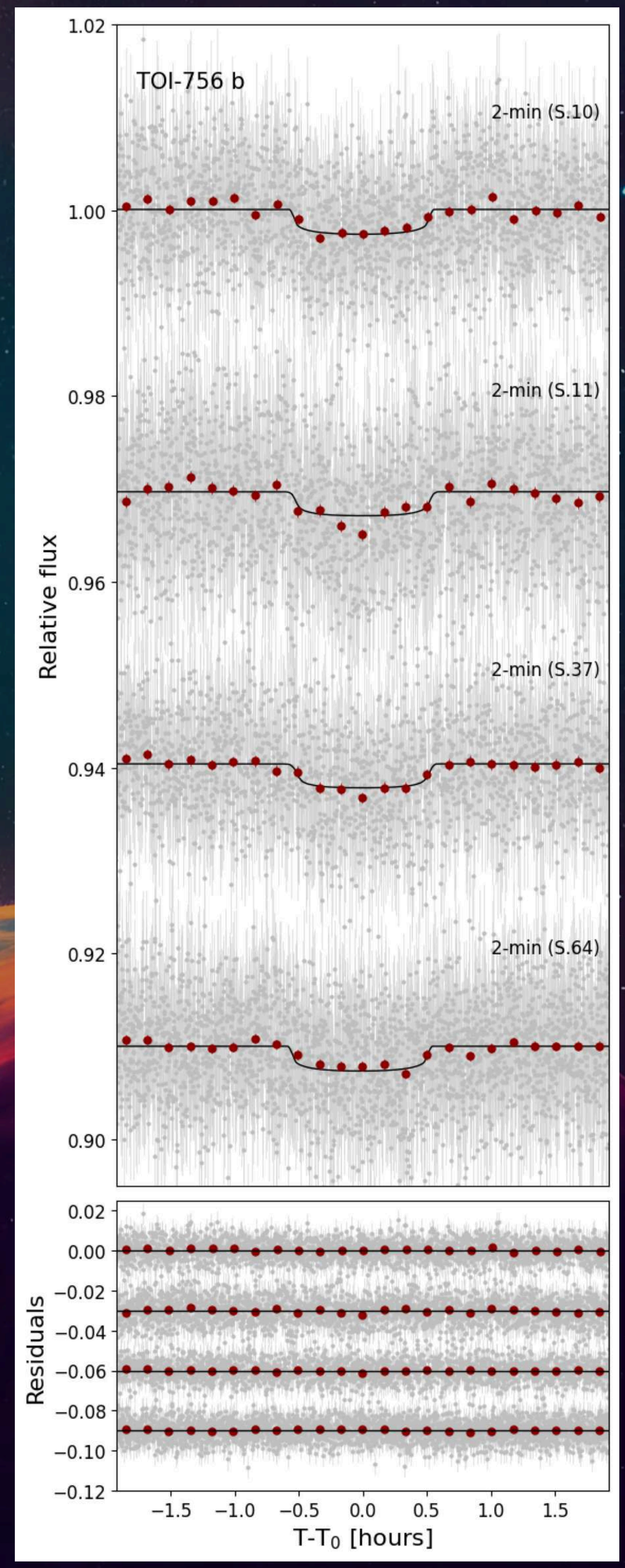


Fig. 2 - TESS fit with *juliet* for TOI-756b.

References:
 Bouchy et al. 2017, The Messenger, 169
 Wroblewski & Torres 1991
 Ricker et al. 2015, JATIS, 1
 Espinoza et al. 2019, MNRAS, 490, 2
 Cook et al. 2022, ASP, 134, 1041
 Artigau et al. 2022, AJ, 164, 3