



UNIVERSITÀ
DEGLI STUDI
FIRENZE



Osservatorio Polifunzionale Del Chianti

THE SYNERGY OF TRANSIT PHOTOMETRY AND ASTROMETRY IN EXOPLANETARY CHARACTERIZATION

THE ROLE OF THE OSSERVATORIO POLIFUNZIONALE DEL CHIANTI

Vincenzo Pettina, L. Baldi, M. Beretta, L. Betti, C. Calamai, G.G. Chiti, R. Ciantini, R. Conte, L. Fini, L. Fossi,
L. Graziani, M. Hofheinz, A. Liberti, M. Michelagnoli, V. Noce, E. Pace, I. Parenti, G. Pastacaldi, P. Oliva, R. Stanga -
Osservatorio Polifunzionale del Chianti, Università degli Studi di Firenze

Osservatorio Polifunzionale del Chianti (OPC)

OPC



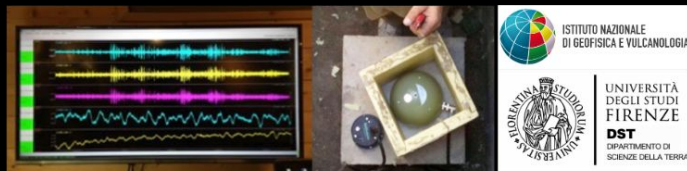
Coordinates

Lat.: 43°31'24" N

Lon.: 11°14'44" E Alt.: 455m



Geophysical Observatory



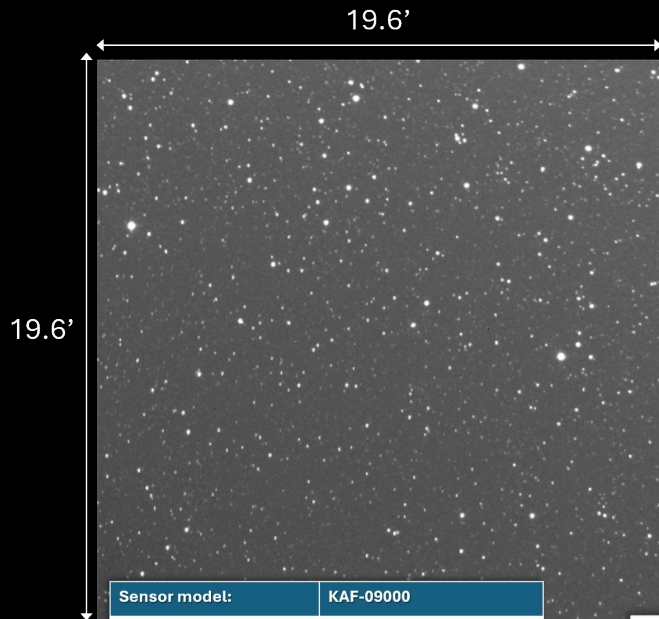
Environmental Observatory



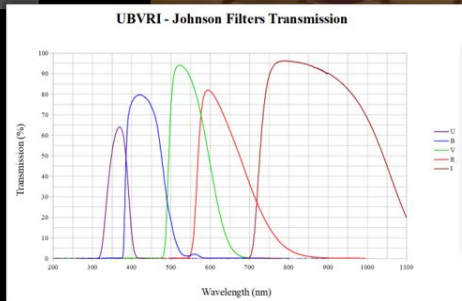
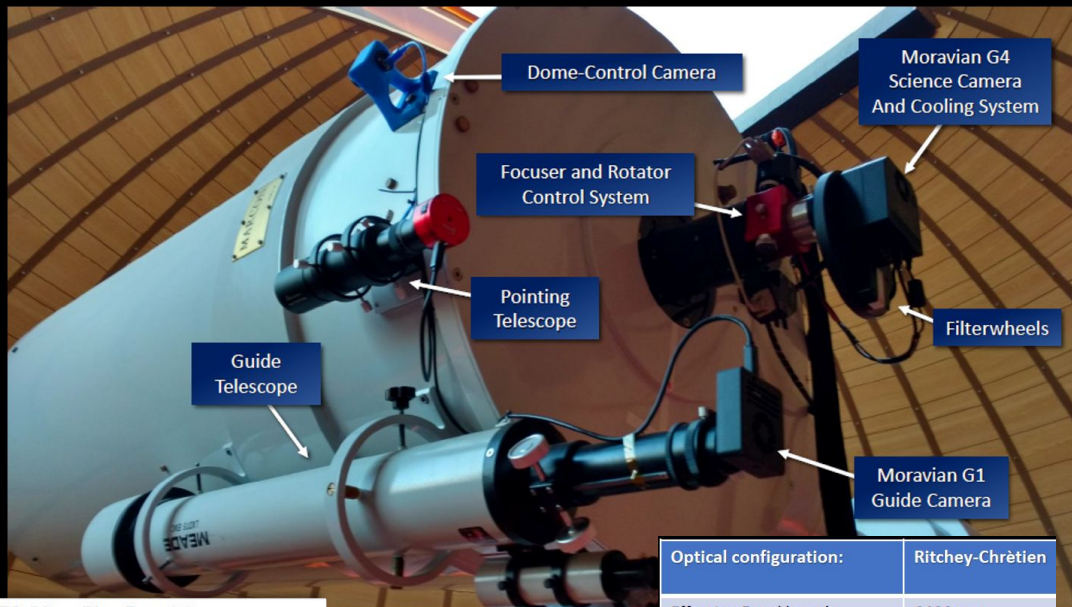
Meteorological Observatory



Astronomical Observatory

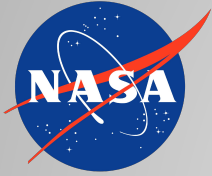


Sensor model:	KAF-09000
Imaging area:	36.7 mm x 36.7 mm
Resolution:	3056 x 3056
Pixel area:	12 μm x 12 μm
Field of View:	19.6 arcmin x 19.6 arcmin
Pixel Scale	0.38676 arcsec/pix
Measured read noise:	7 e^-
Measured gain:	1.5 e^-/ADU
Dark current (per sec):	0.6 e^-/pixel at 0°C

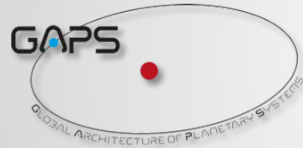


Optical configuration:	Ritchey-Chrétien
Effective Focal length	6400 mm
Primary diameter (D1)	800 mm
Focal ratio:	f/8
Primary Focal Length (F1)	2402 mm
Dist. Primary-Focal Plane (E)	500 mm
Field Diameter	70 mm

ExoPlanetary Transits



- Confirming transit events and identifying false positives (NASA's TESS Follow-up Observing Program – TFOP);



- Simultaneous observations with the Telescopio Nazionale Galileo (TNG) team, combining OPC photometric data with HARPS-N spectroscopic measurements (INAF's Global Architecture of Planetary Systems – GAPS program);



- Refining ephemeris of known exoplanets (ESA's Ariel ExoClock project).

HAT-P-23b Observation and data reduction

Photometric data

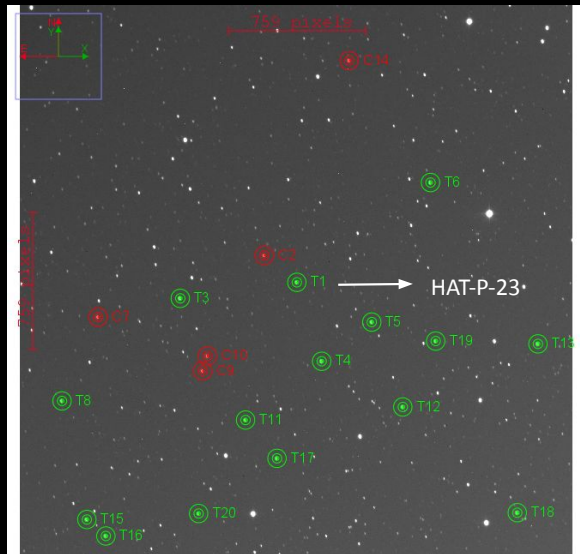


Table 1: SUMMARY OF PHOTOMETRIC OBSERVATIONS

Observatory	Date(s)	Number of Images	Cadence (s)	Filter
HAT-P-23b				
OPC	2026-08-04	85	120	R
OPC	2026-08-10	65	120	R
OPC	2026-09-01	96	120	R

Astrometric data



Gaia Data Release 3 (Gaia DR3)

Parameter	Value	Unit
Gaia DR3 Source ID	1808938730710633984	-
Parallax	2.736 ± 0.011	mas
FLAME Radius (radius.flame)	1.1920	$R_{\odot}$
16% Lower Limit (radius.flame_lower)	1.1678	$R_{\odot}$
84% Upper Limit (radius.flame_upper)	1.2166	$R_{\odot}$
Symmetric Uncertainty ($\pm\sigma$)	± 0.0244	$R_{\odot}$

FLAME module (*Final Luminosity, Age and Mass Estimator*)

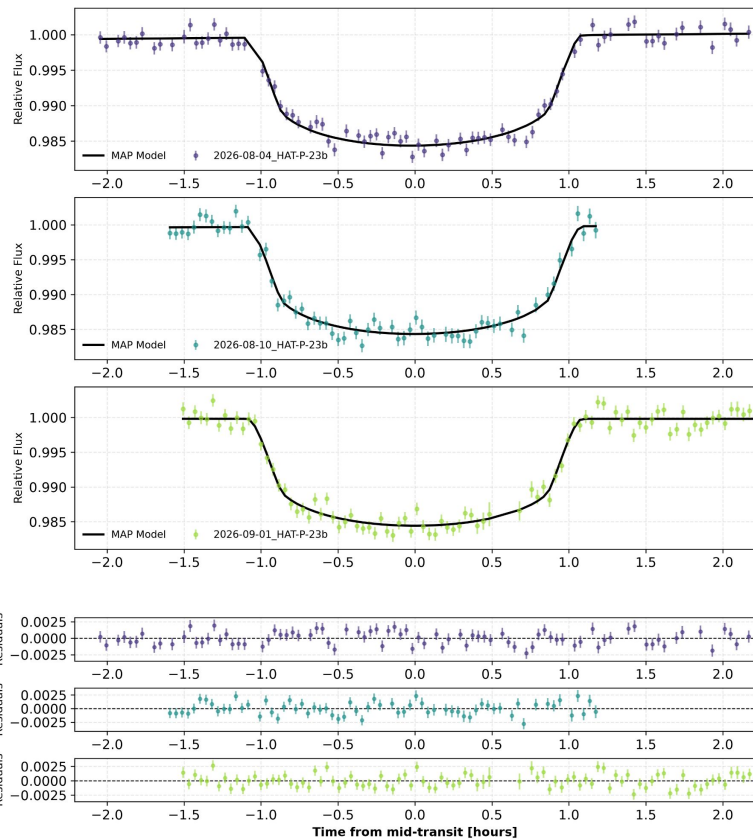
AstroImageJ V-6.0.11

- Data reduction (CCD bias, flat-field and dark current).
- multi-aperture photometry on HAT-P-23 (relative flux and associated photometric uncertainties).

HAT-P-23b Data Analysis - This work



HAT-P-23b — MAP Fit: Data, Model and Residuals



exoplanet is a toolkit for probabilistic modeling of time series data in astronomy with a focus on observations of [exoplanets](#), using [PyMC](#). *exoplanet* extends *PyMC*'s language to support many of the custom functions and distributions required when fitting *exoplanet* datasets.

By Dan Foreman-Mackey

<https://docs.exoplanet.codes/en/latest>



Relative flux curves extracted using **AstroImageJ** and passed into the **exoplanet** pipeline.

Model constrained using literature priors on key parameters:

- Orbital Period (P) & Mid-transit Time (t_0)
- Limb Darkening Coefficients (u_1, u_2)
- Radius Ratio (R_p/R_*) & Impact Parameter (b)

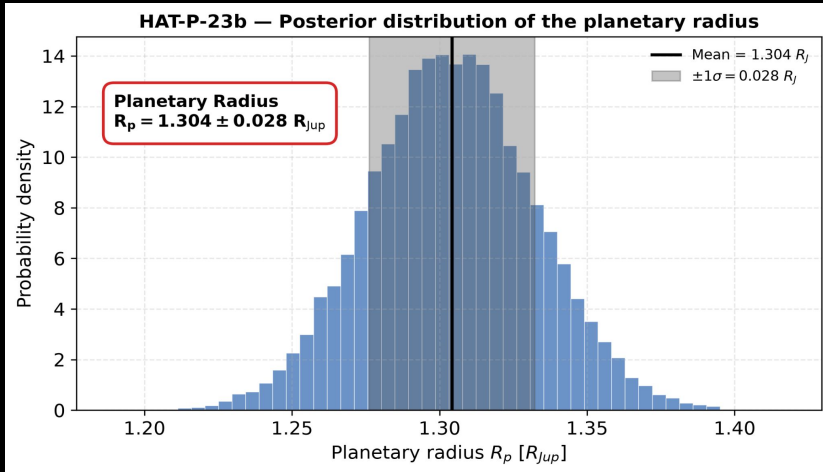
Initial transit fit to derive Maximum A Posteriori (MAP) parameters, serving as the starting point for MCMC sampling.

HAT-P-23b Data Analysis - This work



MCMC Sampling & Convergence

- Efficient parameter space exploration;
- Extracted posteriors & uncertainties for key transit parameters;
- Optimal chain convergence verified across all parameters;



Final Physical Parameters of HAT-P-23b

Parameter	Value	Unit
P	1.212850 ± 0.000010	days
t_0	$2461257.51350 \pm 0.00021$	BJD
R_p/R_*	0.1124 ± 0.0007	—
b	0.054 ± 0.038	—
u_1	0.44 ± 0.09	—
u_2	0.20 ± 0.15	—
e (fixed)	0	—
δ	1.263 ± 0.017	%
Δm	13.80 ± 0.18	mmag
a/R_*	4.14 ± 0.12	—
i	89.25 ± 0.53	deg
T_{14}	2.49 ± 0.07	hours
R_* (Gaia DR3)	1.192 ± 0.024	$R_\odot$
R_p	1.303 ± 0.028	R_{Jup}

Physical planet radius: posterior R_p/R_* samples combined with Gaia DR3 stellar radius, via Monte Carlo error propagation.

Final Results

HAT-P-23b — Comparison with Literature			
Work / Source	R_p/R_*	$R_* [R_\odot]$	$R_p [R_{\text{Jup}}]$
Bakos et al. (2011)	0.1169 ± 0.0012	$1.20 \pm 0.07^\dagger$	1.368 ± 0.090
Ciceri et al. (2015)	0.1162 ± 0.0008	$1.089 \pm 0.027 \pm 0.006^\dagger$	$1.224 \pm 0.036 \pm 0.007$
OPC (2026)	0.1124 ± 0.0007	$1.192 \pm 0.024^*$	1.304 ± 0.028
[†] R_* derived from theoretical stellar evolution models (isochrones).			
[*] R_* empirically derived from Gaia DR3 astrometric measurements.			

- Values are consistent within 1σ with Bakos et al. and Ciceri et al.
- Previous works: R_* derived from theoretical stellar evolution models (no Gaia DR3 available at the time).
- This work: less model-dependent R_* determination using Gaia DR3 astrometry.
- Proves feasibility for small-class telescopes.
- Plan to refine the methodology and apply it to future observational campaigns.

Thanks for your attention!



We look forward to seeing
you at our observatory....

SOLO STELLE NEL CIELO

Convegno nazionale sull'inquinamento luminoso

7-9 ottobre 2026

Osservatorio Polifunzionale del Chianti
Barberino Tavarnelle (Firenze)

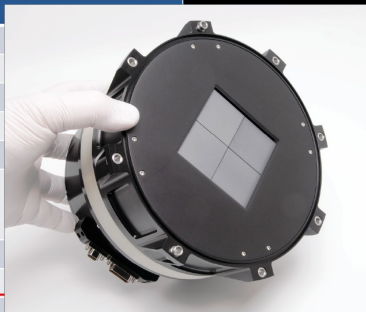
10° Chianti Topics

Convegno nazionale sull'inquinamento luminoso

Osservatorio Polifunzionale del Chianti
Barberino Tavarnelle, Firenze
7-9 ottobre 2026 | <https://chiantitopics.it>
Illuminare meglio. Proteggere la notte. Ritrovare il cielo.



Specs	Value
FOV(for each lense system)	24° x 24°
Combined FOV	24° x 96° = 2300 sq. degrees
Entrance Pupil Diameter	10.5 cm
Focal ratio (f/#)	f/1.4
CCD Wavelength Range	600-1000 nm
CCD Dimensions	2048 x 2048 imaging array 2048 x 2048 frame-store region 15 μm square pixels
CCD Separation	2mm
Full well capacity	200 000 electrons
Pixel Scale	21 arcsec/pix ~ 54x OPC
Enquared Energy	50% within 15 μm x 15 μm (1 pixel = 21 arcsec x 21 arcsec) 90% within 60 μm x 60 μm (4 x 4 pixels = 1.4 arcmin x 1.4 arcmin)
CCD Operational Temp.	-75°C
Read Noise (f = 625 kHz)	< 10 e ⁻



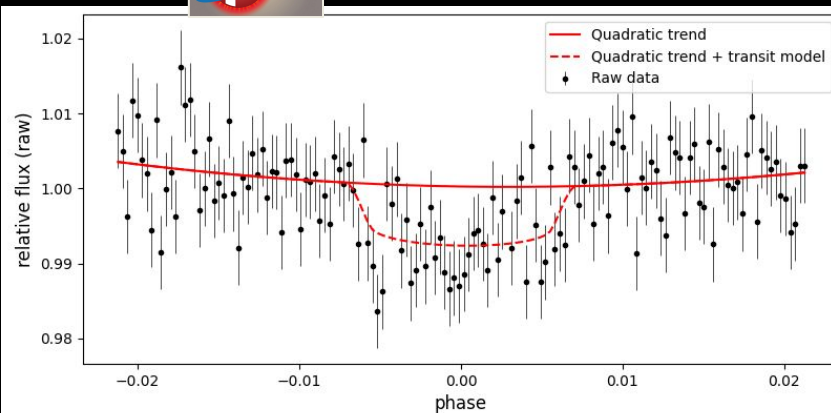
TESS Follow-up

2022-01-06

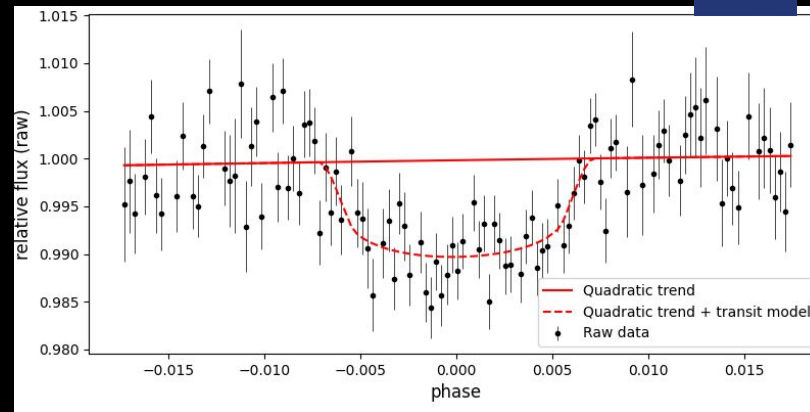


TOI-3785b

2025-10-11

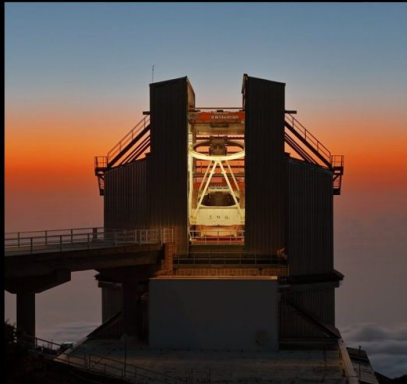
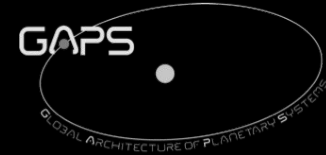


S/N = 5.61



S/N = 12.7

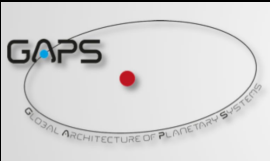
GAPS



GAPS is a long-term program for the comprehensive characterization of the architectural properties of planetary systems as a function of the hosts' characteristics (mass, metallicity, environment).

The goal of the project is to take advantage of the unique capabilities of the instrumentation at the TNG to study the origin of the diversity of planetary systems, shaped by variable degrees of orbital evolution, exploring uncharted territories in the realm of planet formation and evolution with emphasis on the innermost regions.

The GAPS collaboration was set up at the end of 2011 in response to a solicitation formulated by the INAF Science Directorate to optimise the science return to the community of the HARPS-N @TNG open time. Several observing programs were carried out since then, also in combination with the NIR spectrograph GIANO-B@TNG (GIARPS configuration), that GAPS members contributed to design, test, and optimize.



TIC 150070085.01



INAF – TIME ALLOCATION COMMITTEE

Application for observing time

Period AOT50 (October 2024 – March 2025)

Category: C

Submit using: www.tng.iac.es/submit.html

1. Title

ORME. Probing the orbital obliquity of a planet transiting a member of the 96 Myr old Theia214 association

2. Abstract

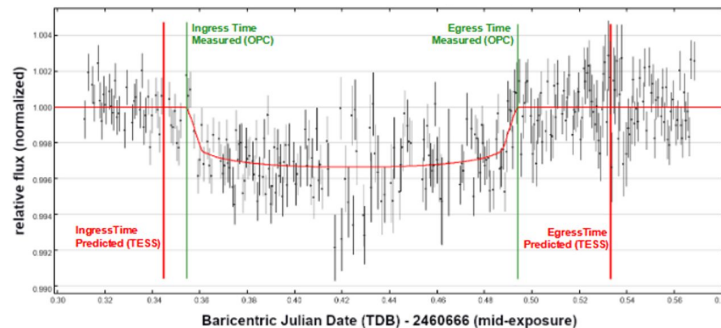
The measurement of the exoplanet sky-projected obliquity, which refers to the angle between the orbital axis of a planet and the host star spin axis, provides crucial insights into how planets form and migrate. The obliquity can be detected with in-transit radial velocities through the Rossiter-McLaughlin effect. Observations of young transiting planets, which have not yet experienced significant tidal alterations, offer a unique opportunity to study their original obliquity configuration.

TIC150070085.01 is an high-confidence vetted planet in a stellar association, allowing a precise estimate of stellar parameters such as age, metallicity, mass and radius, through statistical approaches. The system's young age (96 Myr) makes it particularly promising for measuring system obliquity, allowing us to extend the sample of only 5 (!) stars with ages ≤ 100 Myr that have obliquity measurements. An aligned orbit would become an important clue about obliquity excitation for hot Neptune planets in close orbits ($2-6 R_{\oplus}$, $P \lesssim 10$ d).

should be significantly lower than its typical level of variability. Finally, simultaneous photometric monitoring will be performed with Italian telescopes (e.g. Asiago, Isnello, Chianti), further contributing to the modelling of stellar activity. The total requested time at TNG is 5.8 hours.

TIC 150070085.01

Oss. Pol. del Chianti - R_C Filter (2024.12.21)



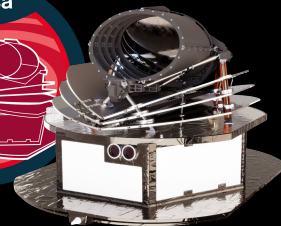
	Ingress Time	Egress Time	Transit Duration (min)
TESS _(Predicted)	0.3447	0.5330	t14(TESS) = (170 ± 30)
GAPS _(Predicted)	0.372325	0.513925	t14(GAPS) = (204 ± 7)
OPC _(Measured)	0.354513	0.493885	t14(OPC) = (199 ± 8)

This proposal is an example of collaboration in simultaneous monitoring with TNG - RVs measurements and photometric monitoring of other Italian telescopes (eg. OPC+Asiago+Isnello) showing an important results about the duration of the event respect to TESS measurements.

- Obliquity Measurements in young planetary systems is crucial to understand planetary formation and migration
- TIC 150070085.01 is a good candidate for extend sample of known obliquity in young stellar system (< 100 Myr)



ExoClock Project

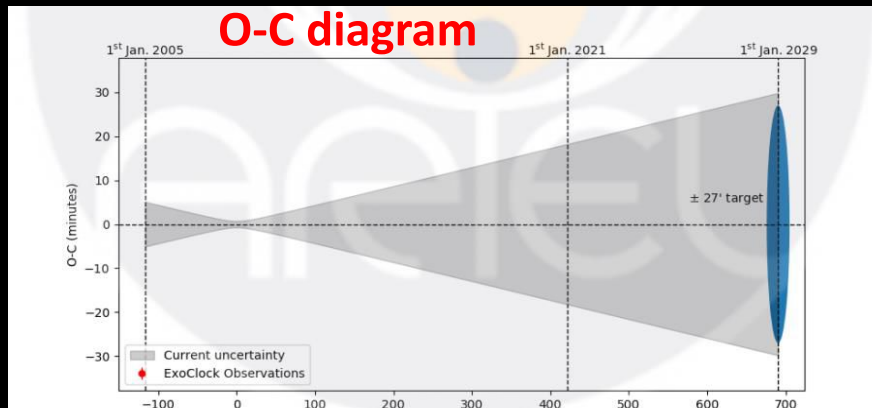
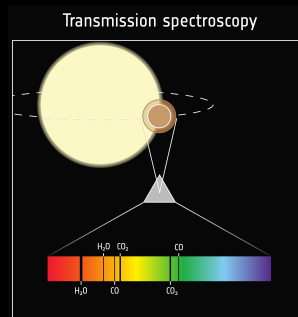


How connects the mid-times of different transit events in the past and in the future.

$$T = T_0 + N \times P$$

where:

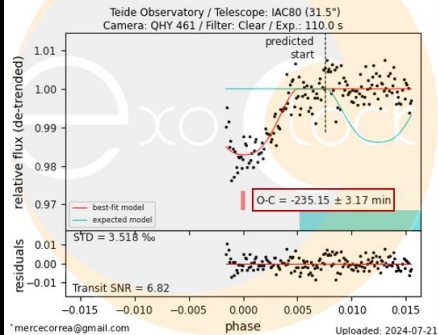
- T_0 is the zero-epoch transit mid-time
- P is the period – the difference in time between two transit mid-times
- T is the transit mid-time, refers to the mid-time a transit
- N is the transit epoch, the number of periods that have elapsed since the reference transit



CoRoT – 10b

2024-07-18

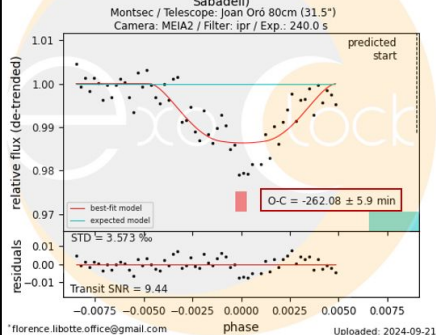
Mercedes Correa* (Agrupació Astronòmica de Sabadell), F. Libotte (AAS); A. Ginard (AAS); T. Poyato (AAS); F. Carretero (AAS); G. Domènech (AAS)



CoRoT – 10b

2024-09-09

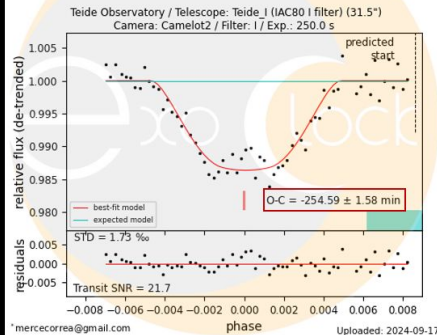
Florence Libotte* (Agrupación astronómica de Sabadell, GEOS), Gemma Domènech, Kike Herrero (Montsec Observatory), Mercedes Correa, Antelm Ginard, Trinidad Poyato (Agrupación astronómica de Sabadell)



CoRoT – 10b

2024-09-09

Mercedes Correa* (Agrupació Astronòmica de Sabadell), R. Clavero (IAC), D. Perez (IAC); A. Ginard, F. Libotte, T. Poyato, X. Bros, F. Carretero (A. A. Sabadell); G. Domènech (OdM)



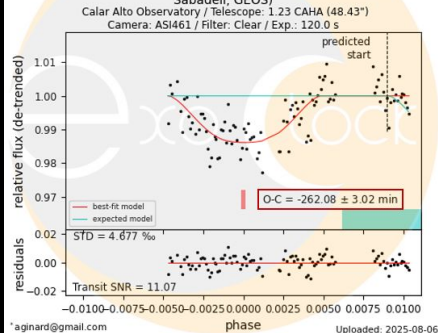
CoRoT-10b



CoRoT – 10b

2025-08-06

Antelm Ginard* (Sabadell Astronomical Society & AstroMallorca), Ana Guijarro (CAHA), Mercè Correa (AA Sabadell), Gemma Domènech (OdM), Joan Miquel González (UB, AA Sabadell), Florence Libotte (AA Sabadell, GEOS)



CoRoT – 10b

2025-08-06

Lorenzo Betti* (University of Florence - Osservatorio Polifunzionale del Chianti), E. Pace, R. Stanga, L. Fossi, M. Michelagnoli, C. Calamai, I. Parenti, A. Liberti, V. Noce, L. Fini, R. Ciantini (University of Florence - Osservatorio Polifunzionale del Chianti)

