Issue 47 – Feb 25th, 2025

ExoClock Newsletter

Dear ExoClock participants,

Hope you are all doing well!

We would like also to welcome the new members!

We send out a newsletter like this every month, while you can read the past newsletters, watch the past meetings, and have access to other educational material at:

www.exoclock.space/users/material

***We organise meetings dedicated to new ExoClock members**. These meetings are held just after our regular monthly meeting. The beginner's meeting is usually held on the Friday after our regular meeting or the week after. In these meetings, newcomers can ask questions of any level related to the operation of the website, observations of transits, data analysis etc. Note that these meetings are not recorded.*

*Finally, **we have a Slack channel** for more direct communication and if you want to join, follow this link:*

https://join.slack.com/t/exoclock/shared_invite/zt-1t5l875v6-x0s8s553kT8nbCvbyo7boA

In this newsletter, we discuss:

1. Announcements

1.1 Lecturers Without Borders and ExoClock partnership

We're excited to announce a new partnership between ExoClock and the Lecturers Without Borders (LeWiBo)! LeWiBo is an NGO with international presence and an extensive network of over 400 schools and more than 400 volunteer researchers. Through our collaboration, we aim to broaden outreach and enhance educational opportunities around Astronomy, by planning joint activities specifically designed for schools.

We would like to invite amateur astronomer volunteers to connect with schools and engage with students in either English or their native languages, to further enrich their educational journey.

If you have done an outreach activity related to ExoClock/ Ariel or you would like to organise something in your local area, please contact us. We would love to help organizing this effort!

1.2 ExoClock Unlocked

On the 13th of February, we successfully held the first seminar of the ExoClock Unlocked program. ExoClock Unlocked is a series of monthly training sessions including remote observations of exoplanet transits, analysis of the data, and contribution to the Ariel space mission. The program is designed for participants without access to observational equipment. We have received a large number of applications for this program, and we are excited to announce that 47 participants from around the globe have joined this initiative!

1.3 Ariel Data Challenge

The Ariel Data Challenge 2024 has concluded with impressive global participation, attracting 1,414 competitors from 75 countries. Over three months, the participants generated a remarkable 23,024 submissions, averaging more than 200 submissions per day. This year's challenge focused on overcoming various noise sources, such as "jitter noise" caused by spacecraft vibrations, which can complicate the analysis of spectroscopic data used to study exoplanet atmospheres.

Six teams distinguished, breaking new ground in data analysis and pushing the boundaries of what we can achieve in this field. This challenge underscores the Ariel mission's commitment to understanding exoplanet environments through international collaboration and cutting-edge research.

More at: https://arielmission.space/wp-content/uploads/2024/12/ADC24_Press-Release_1224.pdf

1.4 Ariel Stellar characterisation working group

Recently, the Ariel stellar characterization group launched the group's dedicated website.

https://sites.google.com/inaf.it/arielstellarcatalogue

Understanding the fundamental properties of host stars is crucial for optimizing the scientific outcomes of the Ariel mission. By accurately characterizing these stars—assessing their chemistry, activity levels, orbital properties, galactic origins, and age—we can refine the target list for observation when

Ariel launches in 2029. This comprehensive knowledge enables precise determinations of planetary characteristics such as radius and mass, and it aids in accurately identifying atmospheric features which are essential for studying planetary atmospheres and understanding the evolutionary dynamics of planetary systems.

1.5 Astronomy Convection in Sabadell

The 26th Astronomy Convention will be held from March 14th to 16th in Sabadell, Spain. The registration is available until March 10th and the convention will be conducted in Spanish. If you are interested in observational astronomy, whether in research or astrophotography, and speak Spanish, this is an event you won't want to miss!
https://astrosabadell.org/Convencio2025/inicio.html

1.6 ExoClock French communication group

Exoclock users from France have launched a dedicated Discord channel to discuss their experiences with exoplanet transit observations and the ExoClock project.

French-speaking participants interested in joining, can participate in the discussions on this platform. For access, please contact anael.wunsche@obs-bp.fr.

2. Submitting data to ExoClock

2.1 Tips and guidelines for your submissions

We'd like to remind you of some key guidelines and tips for submitting data to ExoClock. Before submitting an observation, please make sure to:

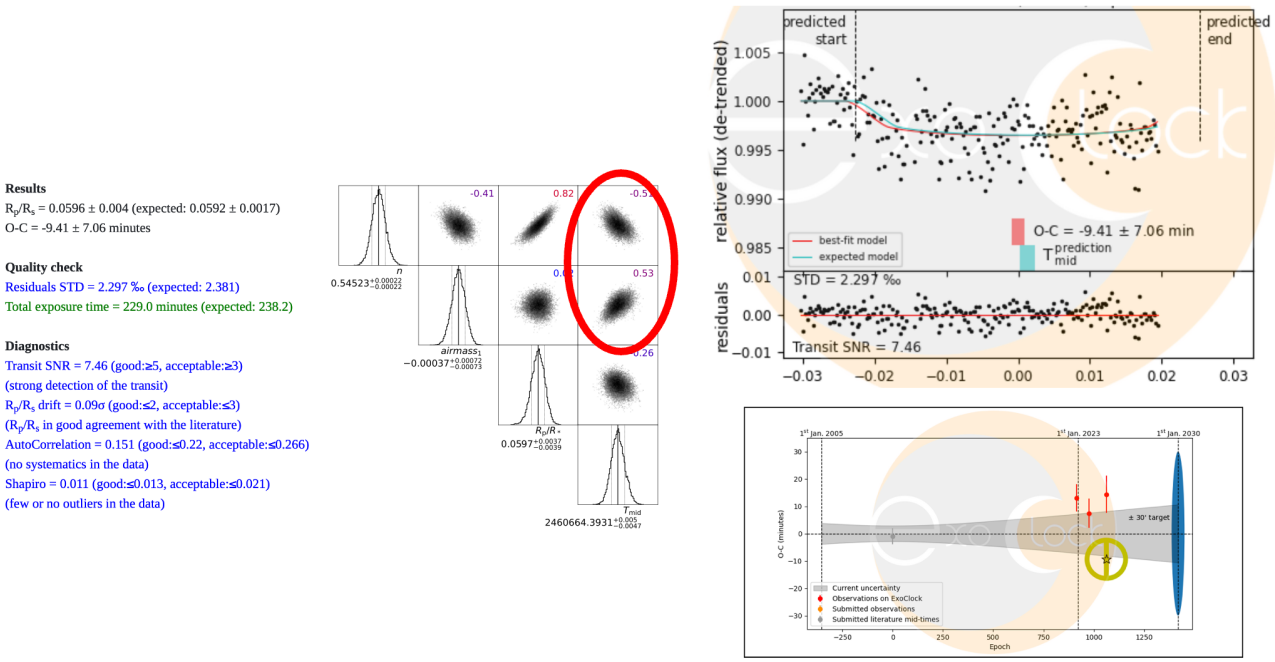
- DO self-assess your light curve before you submit it. Is the transit clear? Does the fitting look reliable?
- DO provide information in the "Comments" box such as observing conditions, any technical issues or meridian flip. In particular, please give the reason for any gaps in the light curve and if data points have been removed manually. This information helps the reviewers to make a proper assessment.
- DO try to submit full transit observations with adequate out-of-transit data. Good quality partial transit observations can sometimes be accepted if there are few other observations AND more than 50% of the transit is covered.
- DON'T submit an observation that has no (or almost no) out-of-transit data; the results won't be reliable, and it won't be accepted.

- DON'T submit an observation that has red warning diagnostics for Rp/Rs (or Autocorrelation sometimes) - these will almost always be returned for re-analysis. Follow the feedback advice to try different photometry options.

2.2 Why the out of transit data is important?

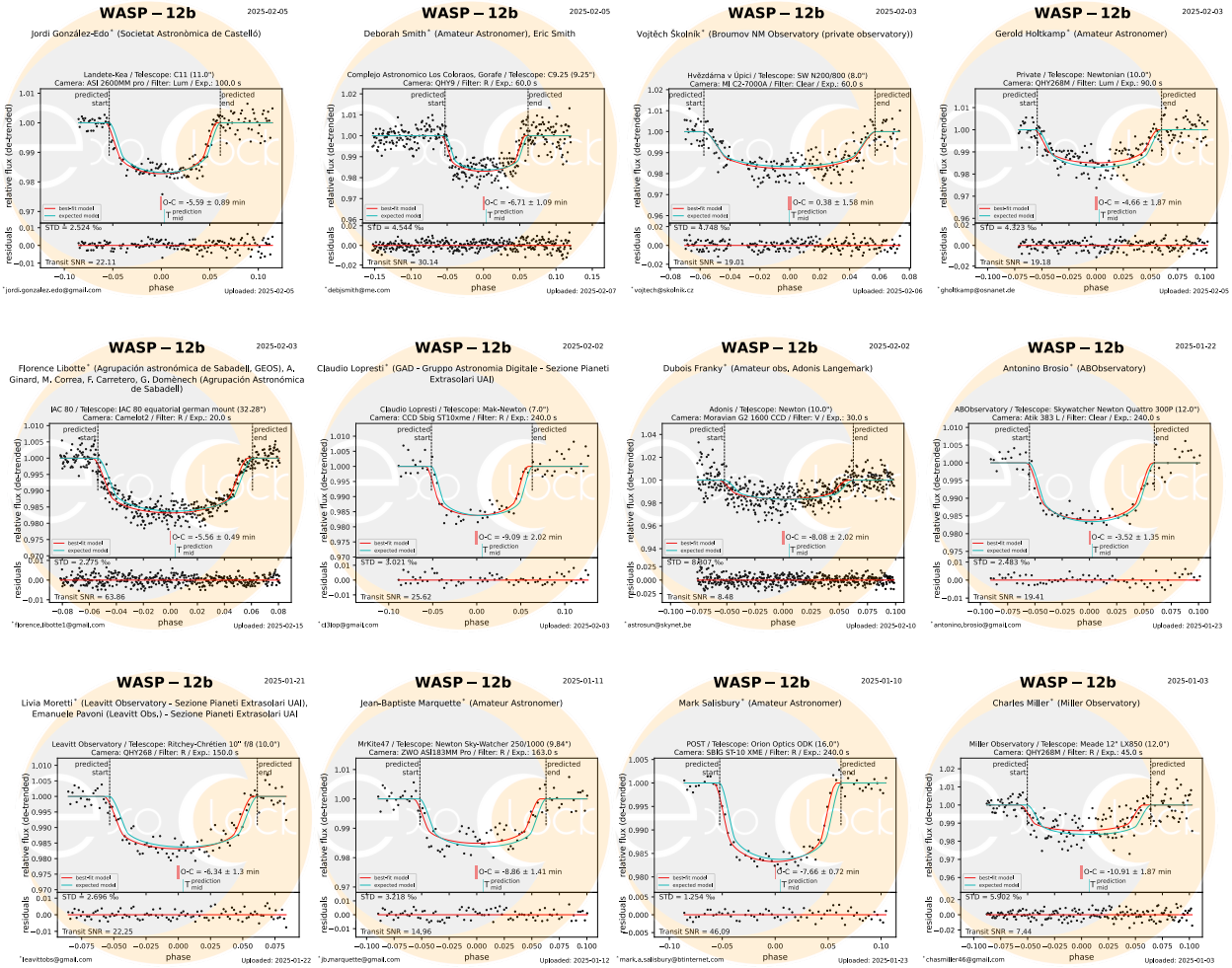
In exoplanet transit observations, capturing the entire transit along with sufficient out-of-transit (O.O.T.) data is crucial for establishing a reliable baseline flux level. This baseline is essential for accurately measuring the transit depth and ensuring effective de-trending of the light curve. This is because we are trying to measure the difference between the out-of-transit flux of the star and the in-transit flux of the stars. Without adequate O.O.T. data we are missing half of the information needed, and it becomes challenging to distinguish between genuine transits and noise, compromising the reliability of the results. We strongly recommend observing at least one hour of data before and after the predicted times for transit ingress and egress. Insufficient O.O.T. data cannot be compensated by re-processing, and unfortunately, observations with limited coverage may not be usable. Thus, while in exceptional cases partial transits are considered, ensuring comprehensive O.O.T. coverage remains vital for accurate transit analysis.

From the de-trending point of view, the O.O.T. data points are more important than the in-transit data points. In absence of sufficient O.O.T. data the final mid-time is correlated with the de-trending parameters leading to biased O-C values, even if all the diagnostics are good. See the example below, where the corelations are marked in the red circle. In case you are interested to see the corelation plot, you can run the fitting inn HOPS locally and find the corelation plot in the folder with the final fitting results.



3. Highlighted observation of the month

We would like to thank you all for the observations you contributed during the previous months! We have selected **WASP-12b**, a unique target among hot Jupiters as the first case where orbital decay was detected. This decay is accompanied by potential apsidal precession, indicating a slightly eccentric orbit. Such rapid changes are indicative of evolutionary transformations within its system, making WASP-12b a key subject for studying dynamic planetary processes. Current data predicts that WASP-12b may be engulfed by its host star in a few million years, adding importance to our observations.



Congratulations and thank you for your efforts!

4. "Exoplanet CV of KELT-9b"

These CV articles aim to enrich your background knowledge on the Ariel candidates. The articles feature one exoplanet each month and are written by our literature team. This month we are featuring **KELT-9b**. The article is attached in the next page. Enjoy!

Clear Skies,
the ExoClock team

"CV" of KELT-9b

by Alex Capildeo (The Open University, UK) ExoClock Literature Team Member

Meet KELT-9b, the hottest exoplanet we've discovered as of 2022

KELT-9b is remarkable amongst the exoplanet population due to the fact that it is the hottest exoplanet discovered as of 2022 (Jones et al. 2022), with a dayside atmosphere temperature of over 4500K and an equilibrium temperature of over 4000K (Gaudi et al. 2017). This is as hot as some K-type stars. As such, KELT-9b belongs to a new class of exoplanets known as ultra-hot Jupiters (UHJs).

Unlike the slightly cooler hot Jupiters, KELT-9b showcases temperatures that challenge our understanding of planetary atmospheres. Check out Figure 1 to see how it compares to other hot Jupiters.

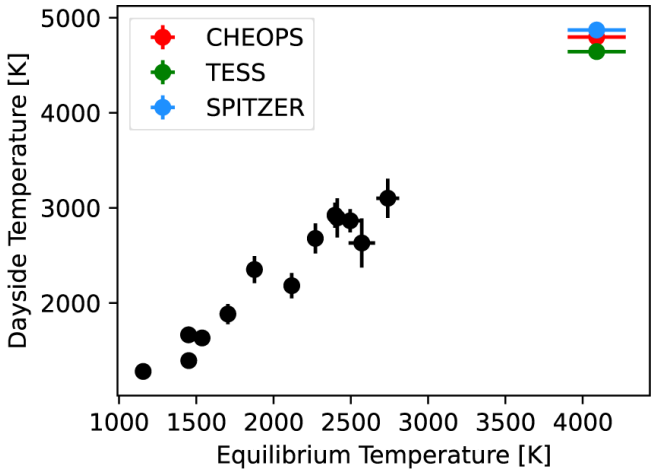


Figure 1: A selection of hot Jupiters' dayside temperatures plotted against their equilibrium temperatures in black from Keating et al. (2019). The coloured points represent KELT-9b's, with temperatures derived from various space telescope observations by Jones et al. (2022).

Ultra Hot Jupiters like KELT-9b are so close to their host stars that their intense heat breaks apart molecular hydrogen. When these molecules recombine on the cooler side of the planet, it increases even more heat across the atmosphere (Bell & Cowan 2018). Remarkably, the extreme temperatures of KELT-9b's atmosphere are also high enough to sustain atomic forms of iron and titanium, making its environment one of the most extreme known in the galaxy (Hoeijmakers et al. 2018).

KELT-9b orbits its host star every 1.48 days, positioned only 0.035 AU away—much closer than Mercury is to our Sun. With a mass of 2.88 Jupiters, it contrasts sharply with our own Jupiter, which orbits the Sun at a much larger distance of 5 AU. The star KELT-9 is hotter and larger than our Sun, with a temperature of about 10,170K—nearly twice as hot as our Sun—and a mass 2.5 times greater, making it significantly more intense and radiant than our Sun (Gaudi et al. 2017).

KELT-9b's extreme environment creates unique challenges for astronomers. Despite its nightside still being a scorching 2500K, it's much cooler than the dayside (Mansfield et al. 2020). This significant temperature difference generates powerful winds that move from the hotter dayside to the cooler nightside, influencing how heat moves through the planet's atmosphere. These dynamics adjust how KELT-9b absorbs and emits heat, essentially turning it into a planetary thermostat that varies its own temperatures (Jones et al. 2022). Understanding these wind patterns is crucial as they impact its

observational properties, from the planet's brightness changes to the timing of its transits across its star, shaping how we see and study this distant world (Pai Asnodkar et al. 2022).

Continuously observing exoplanets like KELT-9b is vital, as each transit observation will eventually help into unlocking secrets of this spectacularly extreme environments, revealing how they function and evolve.

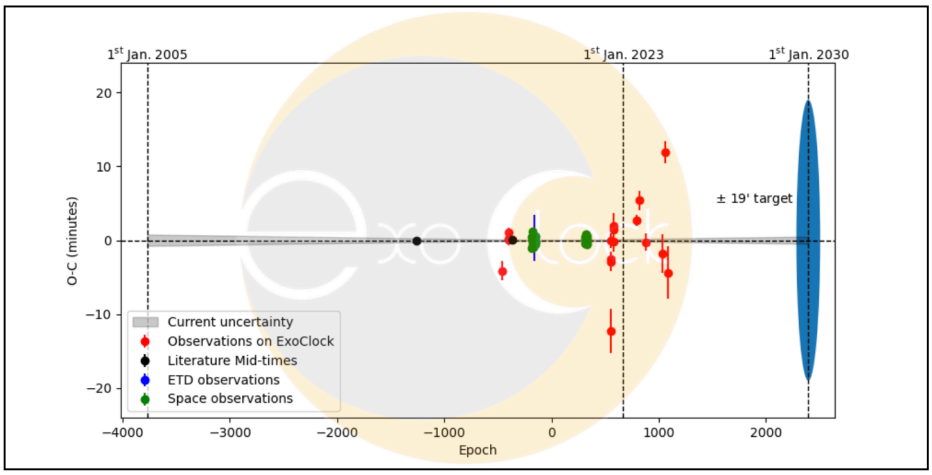


Figure 2: Observations of the KELT-9b transit events in the ExoClock database.

KELT-9b has a total of 60 observations in the ExoClock database while 18 of them are recorded by ExoClock members as in Figure 2. Observing its transit requires a minimum aperture of 5 inches, making this ultra-hot Jupiter an accessible and interesting target for backyard astronomers. It is important to note that, while the ExoClock database contains 60 observations, only 3 of them are recent. Before the ARIEL launch in 2029, certainly more observations can help to confirm and perhaps even refine the ephemeris further.

References:

[1] Jones et al. 2022 (https://ui.adsabs.harvard.edu/abs/2022A%26A...666A.118J/abstract)
[2] Gaudi et al. 2017 (https://ui.adsabs.harvard.edu/abs/2017Natur.546..514G/abstract)
[3] Keating et al. 2019 (https://ui.adsabs.harvard.edu/abs/2019NatAs...3.1092K/abstract)
[4] Bell & Cowan 2018 (https://ui.adsabs.harvard.edu/abs/2018ApJ...857L..20B/abstract)
[5] Hoeikmakers et al. 2018 (https://ui.adsabs.harvard.edu/abs/2018Natur.560..453H/abstract)