Confirmation of the Exoplanet KELT-18b transit time

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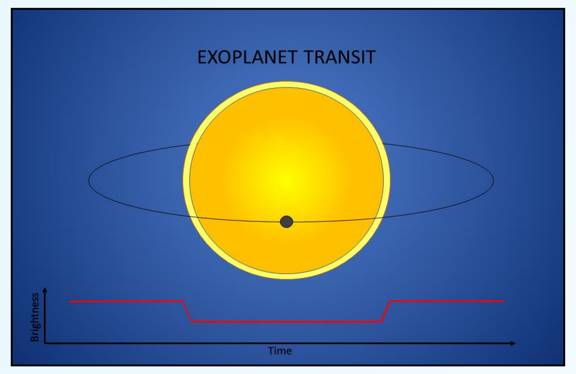
Introduction

Exoplanets are being followed by the ExoClock Project to follow the transit timings of exoplanet transits (fig. 1). The main objective of the project is to keep the ephemeris up to date so during the upcoming Ariel space mission the satellite will be able to study exoplanets during the crucial time of transit. In order to do this efficiently, the mission must have updated ephemeris and this is where the ExoClock Project comes in.



Amateur and professional astronomers contribute observations to the Exoclock Project by monitoring the host stars during transit times, so the ephemerides of exoplanets can be updated accordingly.

Participants in this project routinely receive updates, and notifications for observations where exoplanet timings can be improved upon as the current data is considered as inaccurate. The follow-up of transit events by ground based observatories provide a good means to update the exoplanet orbital timings.

One such event, illustrated here is that of HAT-18b where the circumstances of one such event had severe limitations due to partial coverage due to twilight and the observation site at the time of observation had less than optimal weather conditions. Contrary to the initial pessimistic expectations, preliminary analysis of the data obtained revealed that the data contained useful scientific data.

The Exoplanet

Discovered in 2017(McLeod, 2017), the host star where this exoplanet resides, is at a distance of 1080 light years away and was designated as TYC 3865-1173 or GAIA 1612165353793791488, located at RA 14:26:05.75 DECL. +59:26:39.28, on the border of the constellation of Ursa Majoris (UMa) as shown in figure 2.. This star is a 10.16 magnitude star in the V bandpass with a surface temperature of 6670K that makes it a F4V spectral type star. This implies that the host star is a giant star that is somewhat slightly hotter than the sun by around 900K but is larger than our nearest star, the sun as it has a radius of 1.908 that of the sun.

KELT-18b (fig. 3) is classed as torrid Jupiter exoplanet that has mass of 1.18 times as that of Jupiter with a very close orbital path of just 0.0455 AU away from the host star. Due to its proximity to its star, this exoplanet revolves every 2.87 days around its star.

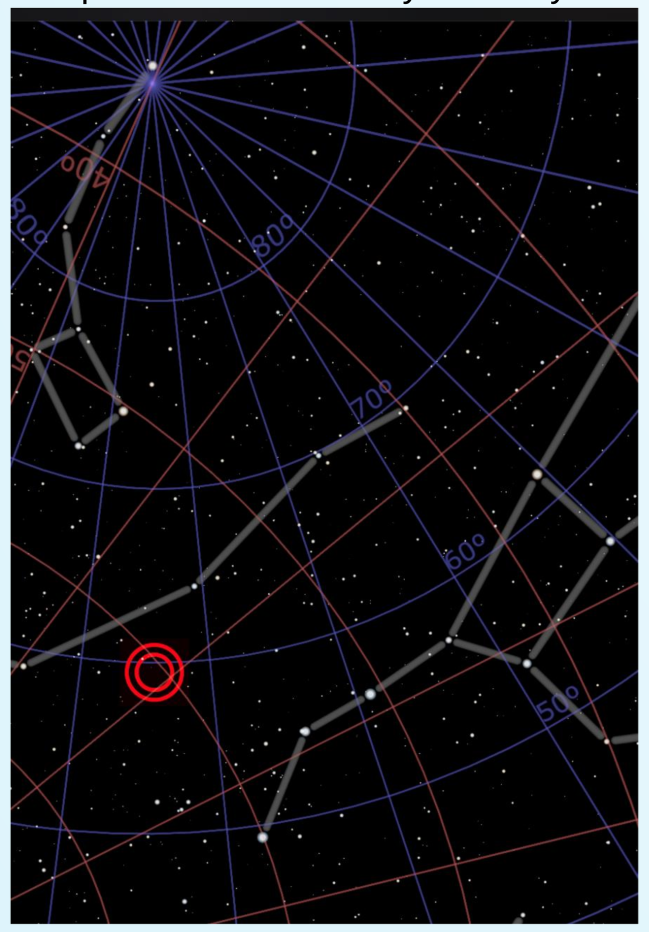


Fig 2: The location of KELT-18b in the constellation of UMa makes it an optimal target for sites in the northern hemisphere as it is visible for a good number of months . Image source: Romanyuk (2016).

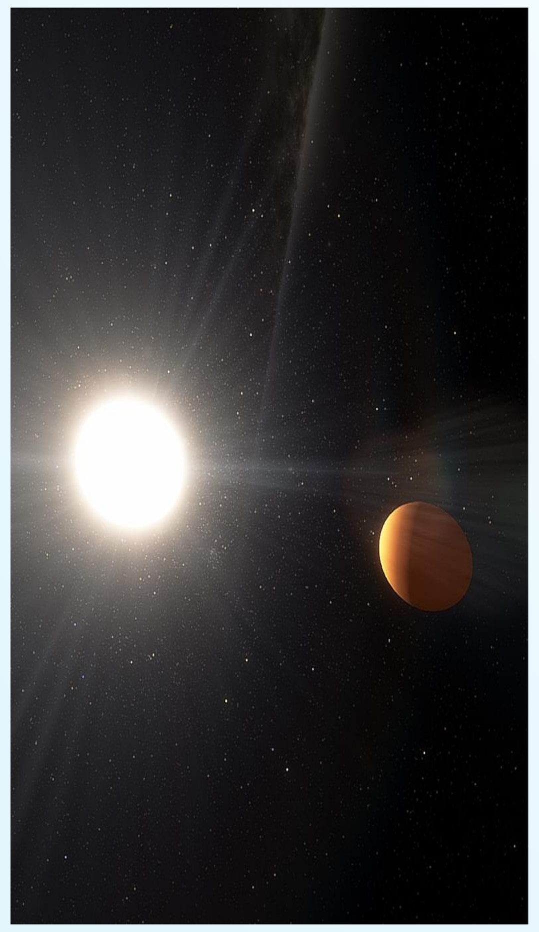


Fig 3: SpaceEngine simulation of exoplanet KELT-18b. Image source: Romanyuk (2016).

The Transit Prediction

Exoplanet KELT-18b was predicted by ExoClock to be in transit on 2021 July 07, starting from 20:45 to 01:24 UT. As observations obtained by other observers indicated that the timing of this exoplanet is off by the order of several tens of minutes, an Alert was highlighted within the observation schedule.

In order to obtain good data, observers are required to observe the star an hour before the transit beings so in case that the timing is off, there would be enough time to cover it. However in the case of the 7 July transit, such pre transit time was not available due to the time of twilight. Hence, it was known beforehand that some of the transit light curve would not be covered.

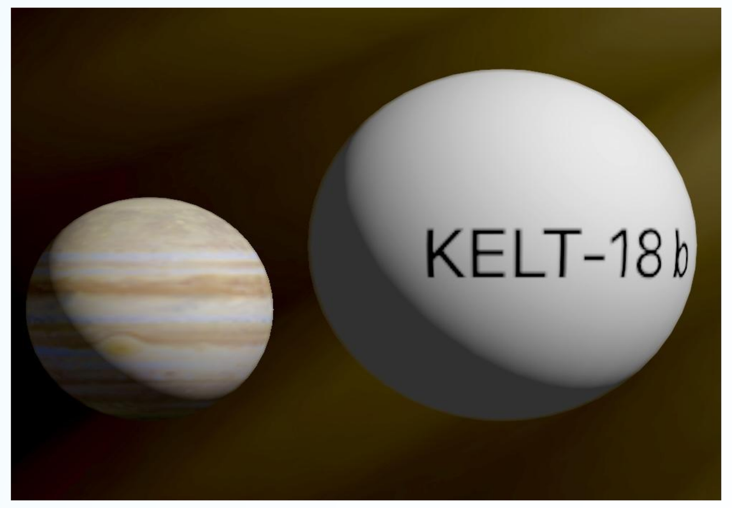


Figure 4 showing the estimated size of Kelt-18b and that of the planet Jupiter. (source: Rein 2021)

The illustration on Figure 4 is reproduced from the app by Rein (2021), whose database is being cited through Rein (2012). The illustration shows the estimated size of Kelt-18b with that of the largest planet of the solar system–Jupiter.

Methodology

All of our data was acquired through a 0.25-m Schmidt Cassegrain Telescope (SCT) coupled with a Moravian G2-1600 scientific-grade CCD camera operating at a set temperature of -15º C. All images were calibrated through dark subtraction and flat fielding.

The research-level program HOPS (Holomon Astronomical Station) by Tsiaras (2019), was utilized for image analysis and image processing. All flux measurements were acquired through the differential aperture photometry technique as employed by the same program. A photometric V-filter was used to attenuate atmospheric effects caused by changing airmass and varying atmospheric conditions.

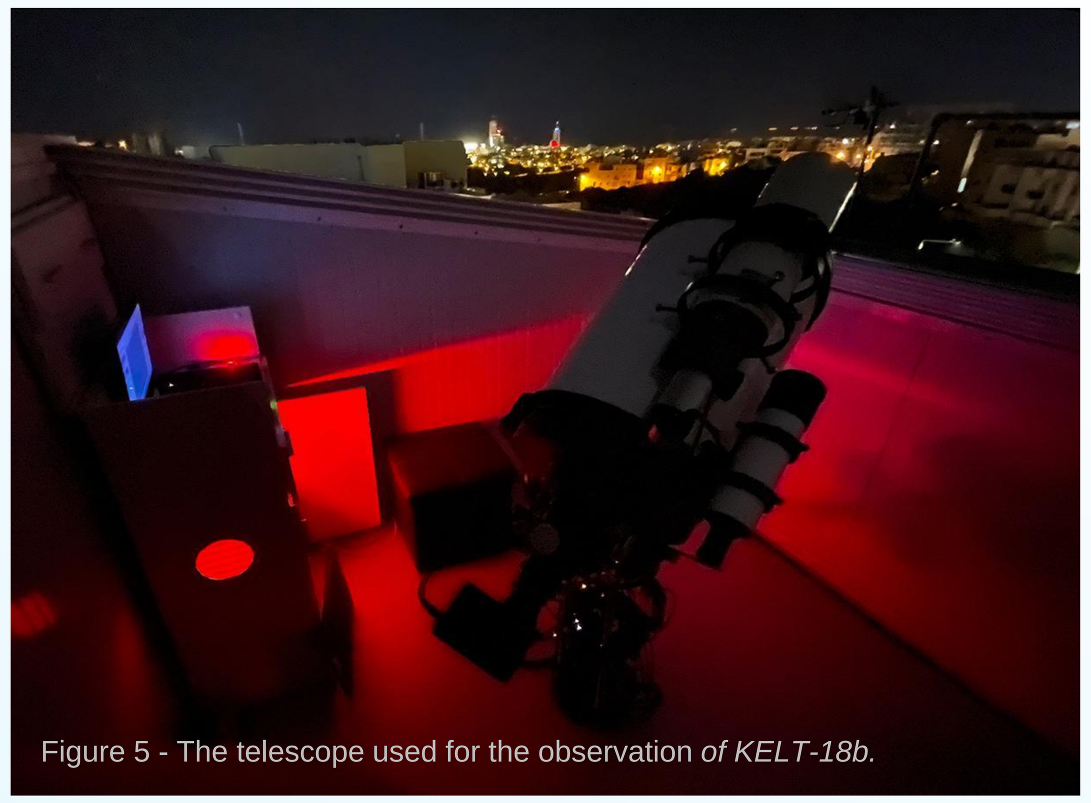


Figure 5 - The telescope used for the observation *of KELT-18b.*

The observation session for KELT-18b was conducted on the night of 7 July 2021 and the observation run commenced at 19:43 UT and was concluded by 00:22 UT. The moon did not interfere with the session, however the transparency was very low due to atmospheric dust. The seeing was around 3.0" ± 0.5". A photometric V-filter was used to attenuate atmospheric effects. By the end of the observation session, 132 images, each with 120-sec. exposure were acquired. All data was gathered through the telescope shown in Figure 5 that comprises a 0.25-m Schmidt Cassegrain Telescope coupled with a G2-1600 CCD camera.

Results

Figure 6 shows the transit Observed minus Calculated time (O-C). The data shows that the observations obtained by other observers are in line with the results that shows that the timing of mid-transit predicted time is off by around 40 min. The data acquired by the author on the night of July 7th shows that the timing of the predicted time is happening 41.3 minutes earlier than predicted. In comparison with the data obtained from other observatories, the blue dot below in figure 5 represents our results as obtained through this observation run.

Figure 6 – O-C data by ExoClock Observers (source: ExoClock, 2021)

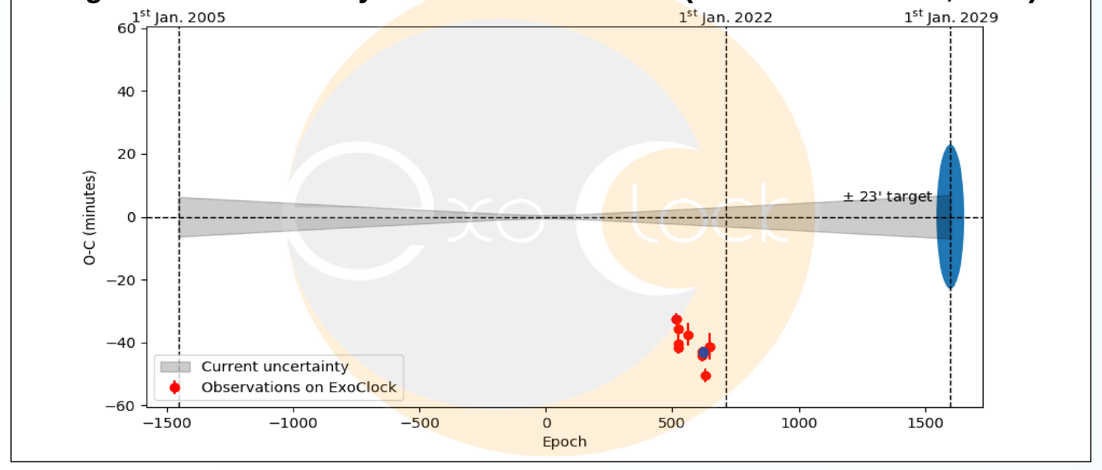
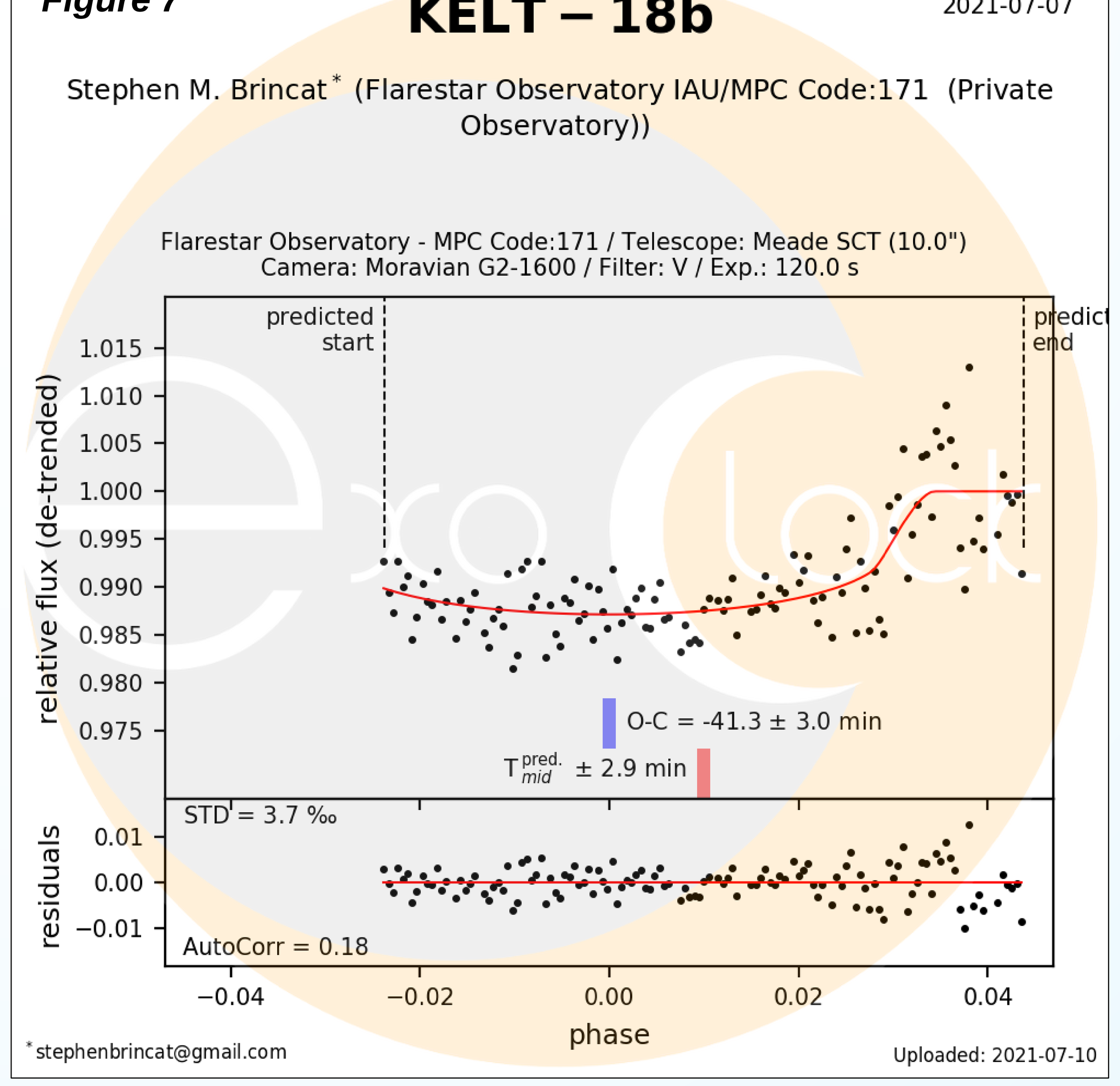


Figure 7 shows the transit (eclipse) data of KELT-18b as obtained from Flarestar observatory where it shows light intensity attenuation as the exoplanet transited the disk of the host star. The black dots are the light intensity measurements as obtained from each individual image. The light curve (graph) is asymmetrical due to the fact that twilight prevented the observer from monitoring the event earlier. The transit light curve shown here was detrended to compensate for atmospheric extinction (scattering). The derived result displays the time of mid-transit that happened 41.3 ± 3.0 minutes before the predicted time as derived at the time of discovery.

Figure 7



The lower panel of Figure 7 shows the residuals of the comparison stars that indicate that the recorded dimming of the parent star was not due to a measurement scatter or atmospheric artifacts.

Exoplanet: KELT-18b
Host Star Mag: 10.16 mv
Constellation: Ursa Major
Filter: V ; Exposure: 120 s
O-C: -41.3 ± 2.9 min
Telescope: 0.25-m SCT + Moravian CCD
Observatory: Flarestar Observatory IAU/MPC code:171
Observation Site: San Gwann, Malta.

Figure 8

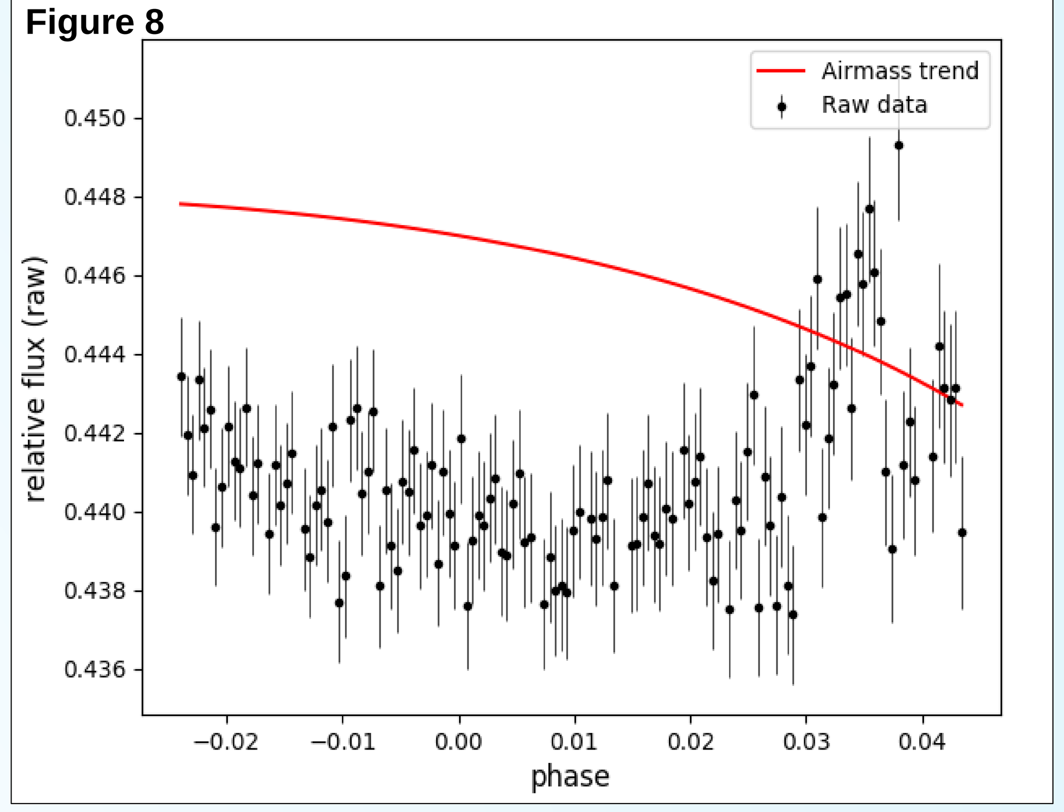


Figure 8 above shows the brightness measurements obtained during the observation when compared with the airmass trend. Flux is the measure of the recorded intensity of light as recorded by the instruments at the observatory.

Conclusion

Our results are consistent with those published by other observers and in due course, an update by Exoclock would be conducted to update the ephemeris of KELT-18b. The results presented here have been accepted and published by the ExoClock database (Kokori et al., 2020). This observation run shows that partial light curves could still have scientific value despite limited coverage due to external factors such as twilight. Such work has the potential to have scientific value that can be utilized by the professional community. Hence such undertaking can be an important factor that might free up monitoring time on large professional telescopes.

References / Sources

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