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A long period ($P = 61.8\text{-d}$) M5V dwarf eclipsing a Sun-like star from TESS and NGTS

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ABSTRACT

The Transiting Exoplanet Survey Satellite (TESS) has produced a large number of single transit event candidates which are being monitored by the Next Generation Transit Survey (NGTS). We observed a second epoch for the TIC-231005575 system ($T_{\text{mag}} = 12.06$, $T_{\text{eff}} = 5500 \pm 85 K$) with NGTS and a third epoch with Las Cumbres Observatory’s (LCO) telescope in South Africa to constrain the orbital period ($P = 61.777 \text{ d}$). Subsequent radial velocity measurements with CORALIE revealed the transiting object has a mass of $M_2 = 0.128 \pm 0.003 M_\odot$, indicating the system is a G-M binary. The radius of the secondary is $R_2 = 0.154 \pm 0.008 R_\odot$ and is consistent with MESA models of stellar evolution to better than 1-$\sigma$.

Key words: binaries: eclipsing

1 INTRODUCTION

The Transiting Exoplanet Survey Satellite (TESS, Ricker et al. 2015) is well into its primary mission having finished its observations of the southern ecliptic and moved onto the north. However, there are still many discoveries to be found in the first hemisphere of data of which the TESS Object of Interest (TOI) catalogue just scrapes the surface. The TOI catalogue is heavily biased towards short period systems that exhibit many transits within their remit of TESS data. However, TESS data provides an excellent hunting ground for single transit systems (Cooke et al. 2018; Villanueva et al. 2019; Cooke et al. 2019). TESS single transit systems have, by necessity, periods of greater than $\sim 15$ days. Recovering such signals based on a single transit is difficult, though the results are scientifically very interesting. Around M-stars, planets at these periods may be in the temperate zone and longer period eclipsing binaries are of
interest as they are less likely to be under the influence of strong tidal interactions. Recently it has been shown that recovery of TESS single transits is possible and practical for specialised facilities (Gill et al. 2020; Lendl et al. 2019). This is allowing us to begin probing more of these longer period planets and stellar binaries using facilities such as the Next Generation Transit Survey (NGTS, Wheatley et al. 2018).

Continuing to probe systems with larger orbital periods will enable us to learn about the different types of planets, brown dwarfs, and stellar binaries as well as to examine the transition regions between them. Kepler was successful in finding planets within their stars temperate zones; the region around a star whereby liquid water could remain stable if an appropriate planetary atmosphere is present (Shapley 1953). The observing strategy of TESS is such that planetary systems identified from a single sector will have orbital periods below 15 days and only reside within the temperate zone if the host is a late M-dwarf. Planets in the temperate zone of more massive stars will have wider orbital separations and longer times between potential eclipses; such systems may transit only once during TESS observations. The mon transit Working Group has been established within the Next Generation Transit Survey (NGTS; Wheatley et al. 2018) to recover the orbital period and physical properties of single transit candidates discovered by TESS. The strategy of the working group is to use NGTS to monitor TESS single-transit candidates with radii below < 1.5 \( R_{\text{up}} \) and recover subsequent epochs in which to determine the physical properties of the transiting system. The transiting companion of some single-transit candidates with radii below < 1.5 \( R_{\text{up}} \) are revealed to be stellar in nature owing to the similarity in size of Jovian-like planets and red-dwarfs. This paper lays out our recovery and characterisation of a TESS single-transit candidate, TIC-231005575, that is revealed to be an M-dwarf eclipsing a G-type host.

### Table 1. Photometric colours of TIC-231005575.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaia Source ID</td>
<td>491247299133826560</td>
</tr>
<tr>
<td>RA</td>
<td>01°40'01.35''</td>
</tr>
<tr>
<td>Dec</td>
<td>-54°31'=21.98''</td>
</tr>
<tr>
<td>G</td>
<td>12.855639</td>
</tr>
<tr>
<td>BP</td>
<td>12.855639</td>
</tr>
<tr>
<td>RP</td>
<td>14.713296</td>
</tr>
<tr>
<td>pmRA (mas yr(^{-1}))</td>
<td>52.658 ± 0.038</td>
</tr>
<tr>
<td>pmDec (mas yr(^{-1}))</td>
<td>20.588 ± 0.039</td>
</tr>
<tr>
<td>Parallax (mas)</td>
<td>2.7886 ± 0.0267</td>
</tr>
</tbody>
</table>

| TESS [T]       | 12.061 ± 0.010 |
| APASS [B]      | 13.289 ± 0.010 |
| APASS [V]      | 12.625 ± 0.030 |
| APASS [g']     | 12.903 ± 0.038 |
| APASS [r']     | 12.442 ± 0.036 |
| APASS [i']     | 12.228 ± 0.037 |
| 2MASS [J]      | 11.293 ± 0.040 |
| 2MASS [H]      | 10.981 ± 0.040 |
| 2MASS [K\(_s\)] | 11.037 ± 0.040 |

Figure 1. Difference imaging TESS light curve for TIC-231005575 (black). The inset axis shows the transit event highlighted in green, showing the best-fitting global model (red) and box used to detect the single-transit event (blue-dashed).

### 2 SINGLE-TRANSIT EVENT DETECTION

We conducted a systematic search for single-transit events in lightcurves produced from TESS full-frame images (Jenkins et al. 2016) as described by Gill et al. (2020). The G-type Solar analogue TIC-231005575 was observed with Camera 3 during sectors 2 and 3 (2018 Aug 22 - 2018 Oct 18). We identified a transit event from TIC-231005575 in our search of the TESS Sector 3 data, at JD 2458397.77783. The single transit event has a depth of 22 mmag and a duration of 7 hours. Excluding the transit feature, the light curve of TIC-231005575 shows a RMS of 1.3 mmag (over a 1-day timescale), so the transit feature is clearly significant. We inspected individual calibrated TESS full-frame images for asteroids and searched for known exoplanets or eclipsing binaries which may be the source of the transit event. We found no reason that the transit event is a false-positive.

We produced a higher-quality lightcurve using the eleanor pipeline (Feinstein et al. 2019) which we use for the rest of this work. This aperture includes TIC-231005575 (\( T = 14.9277 \) 3.25'' away at a position angle of 126.93'' East of North. The difference in magnitude is 2.867 mag corresponding to 7.13% third light in the TESS transmission filter. We looked at centroiding information from a 15-pixel cut out of the TESS full-frame images around TIC-231005575 to see if there was a minor change to the photocenter during the eclipse event. We find no evidence of changes in the photocenter coincident with the eclipse and so we progressed assuming the transit is on the brighter star.

### 3 A SECOND EPOCH WITH NGTS

We crossmatched TIC-231005575 with archival data from the Wide-Angle Search for Planets (WASP; Pollacco et al. 2006). Unlike TIC-238855958 (Gill et al. 2020), there are no photometric data points for TIC-231005575 in the WASP archive despite having observations for stars of similar magnitudes within 3 arc minutes of TIC-231005575; the reasons for this are unclear.

In order to recover the orbital period, we used the NGTS telescopes located at the ESO Paranal Observatory in Chile. NGTS was designed for very high precision time-series photometry of stars, and thus is the perfect instrument to use for photometric follow-up of TESS single-transit candidates. Each NGTS telescope has a field-of-view of 8 square degrees, providing sufficient reference stars for
even the brightest TESS candidates. The telescopes have apertures of 20 cm and observe with a custom filter between 520-890 nm. Full details of the NGTS telescopes, cameras, and transmission throughput can be found in Wheatley et al. (2018).

The mon transit working group established within NGTS was commissioned to determine the physical properties of systems that appear to transit only once in TESS observations. Each target is monitored using a single NGTS telescope and is one of at least 12 single-transit candidates observed each night. The working group’s strategy is as follows:

(i) Monitor a TESS single transit candidate with NGTS until a second transit epoch is detected.
(ii) Stop monitoring a target with a second epoch and calculate the predicted epochs for the possible orbital period aliases.
(iii) Attempt to observe a third epoch corresponding to possible aliases of the orbital period to confirm the period of the system.
(iv) Simultaneously obtain spectroscopic observations for those with a second transit epoch to aid recovery of the orbital period and yield stellar atmospheric properties.

We started monitoring TIC-231005575 with NGTS on the night of 2019 Jul 14. We observed TIC-231005575 with 10-s exposures when the airmass was below 2 and data were reduced on-site the following day using standard aperture photometry routines. We used the template matching algorithm described in Gill et al. (2020) using the transit template to automatically search newly obtained NGTS photometric observations for transit events. The transit template was created by modelling the ELEANOR lightcurve assuming an orbital period of 60 days with limb-darkening parameters interpolated from the effective stellar temperature reported in TESS Input Catalogue 8 (Stassun et al. 2019) assuming solar surface metallicity ([Fe/H]) and surface gravity (log g). The expected values of $\Delta \log L$ from transit injection tests allowed for a threshold $\Delta \log L > 200$. We observed TIC-231005575 for 25 nights (35,467 exposures) before a second transit event was detected ($\Delta \log L = 952$) centred at JD=2458706.66152 (see Fig. 3).

The second transit event with NGTS contained approximately half the data in-transit and half out-of-transit. The inner plate-scale of NGTS combined with sub-pixel centroid positions for TIC-231005575 during aperture photometry provided an opportunity to discern if the transit occurred on TIC-231005575 or TIC-231005576. The centroids within transit were closer to TIC-231005576 and those out of transit were closer to TIC-231005575. This indicated that TIC-231005575 was the eclipsing star.

4 CONSTRAINTING THE ORBITAL PERIOD WITH LCO

The transit epoch from TESS and the second recovered epoch from NGTS are separated by 308.88353 days. The true orbital period can be no longer than 308 days but can be integer divisions smaller (aliases of the orbital period). Aliases that are permitted depend on the photometric baseline of observations with TESS and NGTS. We established that the orbital period could be one of seven orbital periods: 308.88353, 154.44183, 102.96105, 77.22086, 61.77665, 51.48062, and 44.12619 days. Smaller aliases of the orbital period would have been observed in either TESS or NGTS monitoring observations.

Establishing the real orbital period required further, time-critical observations of TIC-231005575. The first opportunity arose on the night of 2019-09-23 for the 44.13-day alias from Cerro Paranal with NGTS; this did not go ahead due to technical issues. The second opportunity arose on the night of 2019-10-11 for the 61.77-day alias from the South African Astronomical Observatory (SAAO). We scheduled Las Cumbres Observatory 1-m telescope node (Brown et al. 2013) at SAAO to observe TIC-231005575 between 19:30 UT and 23:51 UT on the night of 2019-10-11. We obtained 107 science frames using a r’ filter with exposure times of 120s and a defocus of 2 mm. Photometry of TIC-231005575 was extracted using standard aperture photometry routines producing a lightcurve with RMS of 2.17 mmag (over 30 minutes in-transit) where a clear partial transit can be seen (see Fig. 3). This observation confirmed the 61.77-day alias is the only possible orbital period for TIC-231005575.

5 SPECTROSCOPIC OBSERVATIONS

Following the successful recovery of the orbital period of TIC-231005575 using NGTS and LCO, we took ten 600 s spectroscopic observations of TIC-231005575 using CORALIE - a fiber-fed échelle spectrograph installed on the 1.2-m Leonid Euler telescope at the ESO La Silla Observatory (Queloz et al. 2001). The spectra...
Table 3. Stellar atmospheric parameters of the primary G-star, orbital solution, and physical properties of the TIC-231005575 system. Symmetric errors are reported with ± and asymmetric errors are reported in brackets and correspond to the difference between the median and the 16th (lower value) and 84th (upper value) percentile.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectroscopy</td>
<td></td>
</tr>
<tr>
<td>$T_{\text{eff}}$ (K)</td>
<td>5500 ± 85</td>
</tr>
<tr>
<td>log $g$ (dex)</td>
<td>4.49 ± 0.13</td>
</tr>
<tr>
<td>$\xi_t$ (km s$^{-1}$)</td>
<td>1.17 ± 1.50</td>
</tr>
<tr>
<td>$v_{\text{max}}$ (km s$^{-1}$)</td>
<td>4.67 ± 1.50</td>
</tr>
<tr>
<td>$V_{\text{sini}}$ (km s$^{-1}$)</td>
<td>≤ 0.5</td>
</tr>
<tr>
<td>[Fe/H]</td>
<td>−0.44 ± 0.06</td>
</tr>
</tbody>
</table>

Orbital solution

| $T_0$ [JD] | 2458397.777839(730) |
| Period [d] | 61.777360(163)      |
| $R_1/a$   | 0.0426(5)            |
| $R_2/R_1$ | 0.4440(1)            |
| $b$       | 0.573(6)             |
| $h_1,R$   | 0.7791(13)           |
| $h_2,R$   | 0.8500(3)            |
| $h_1,L$   | 0.7316(14)           |
| $h_2,L$   | 0.80431(1)           |
| $\sigma_{\text{TESS}}$ | 0.00093(16)          |
| $\sigma_{\text{NGTS}}$ | 0.00824(32)          |
| $\sigma_{\text{LCO}}$  | 0.00216(10)          |
| $K_1$ [km s$^{-1}$] | 8.108(1)              |
| $f_0$     | 0.073(10)            |
| $f_c$     | −0.799(20)           |
| $e$       | 0.298(14)            |
| $\omega$ [°] | −3.3(2.1)           |
| $V_0$ [km s$^{-1}$] | −14.17(27)           |
| $J$ [km s$^{-1}$]  | 0.0176(6)            |

Physical properties

| $M_1$ [$M\odot$] | 1.045 ± 0.035 |
| $R_1$ [$R\odot$] | 0.992 ± 0.050 |
| $M_2$ [$M\odot$] | 0.128 ± 0.003 |
| $R_2$ [$R\odot$] | 0.154 ± 0.008 |
| Age [Gyr]        | 3.9 ± 1.2     |

were reduced using the standard reduction pipeline, and radial velocity measurements derived from standard cross-correlation techniques with a numerical G2 mask. This data is presented in Table 2 and plotted in Fig. 3. We found a semi-amplitude consistent with a stellar transiting companion on an eccentric orbit. We inspected potential dependencies between radial velocities and bisector spans and found little evidence of correlation.

6 ANALYSIS

6.1 Stellar atmospheric parameters

We corrected each CORALIE spectra into the laboratory reference frame before co-adding and re-sampling to produce a spectrum between 450-650 nm with 217 values. We use the wavelet method described in Gill et al. (2018) to extract stellar atmospheric parameters. This method can determine $T_{\text{eff}}$ to a precision of 85 K, [Fe/H] to a precision of 0.06 dex and $V \sin i$ to a precision of 1.35 km s$^{-1}$. Values of log $g$ determined from wavelet analysis are imprecise. To overcome this, we used spectral synthesis (with fixed values of $T_{\text{eff}}$, [Fe/H] and $V \sin i$) to model the wings of the magnesium triplets and sodium doublet. Uncertainties for log $g$ were calculated by perturbing log $g$ until the solution was no longer acceptable (Gill et al. 2019). All our derived parameters for TIC-231005575 are set out in full in Table 3.

6.2 Global modelling

We modelled all photometric datasets with CORALIE radial velocities. Initial modelling showed that the transit depths from NGTS and LCO data sets were consistent to better than 1–σ and so we decided to fit a common value of $R_2/R_1$. We used the binary star model described by Gill et al. (2020) to calculate models of radial velocity and transit photometry. This model utilises the analytical transit model for the power-2 limb-darkening law presented by Maxted & Gill (2019). We fit decorrelated limb-darkening parameters $h_1$ and $h_2$ (from Eqn. 1 & 2 of Maxted 2018) with Gaussian priors centred on values interpolated from Table 2 of Maxted (2018) and widths of 0.003 and 0.046 respectively. The subtle difference between NGTS, TESS, and LCO transmission filters are such that we fitted independent values of $h_1$ and $h_2$ for each photometric dataset.

Our model vector included the transit epoch, $T_0$, the orbital period, $P$, $R_1/a$, $k = R_2/R_1$, $b$, independent values of the photometric zero-point, $z$, $h_1$ and $h_2$ for each filter, the semi-amplitude, $K_1$, and the systematic radial velocity of the primary star, $\gamma$. Instead of fitting the argument of the periastron ($\omega$) and the eccentricity ($e$), we used $f_c = \sqrt{e} \cos \omega$ and $f_\omega = \sqrt{e} \sin \omega$ since these have a uniform prior probability distribution and are not strongly correlated with each other. We also include a jitter term added in quadrature to radial velocity uncertainties ($J$) to account for spot activity, pulsations, and granulation which can introduce noise into the radial velocity measurements (Ford 2006). This was added in quadrature to the uncertainties associated with each RV measurement. We fit a similar term for each photometric data set, $\sigma$, which was also added in quadrature to photometric uncertainties. We assume a common third light contribution of 7.13% in all transmission filters.

We used the ensemble Bayesian sampler EMCee (Foreman-Mackey et al. 2013) to sample parameter space. We initiated 50 Markov chains and generated 100,000 trial steps, discarding the first 50,000 steps as part of the burn-in phase. We visually inspected each Markov chain to ensure convergence well before the 50,000th draw. The trial step with the highest log-likelihood was selected as our measurement for each fitted parameter. We adopted the difference between each measured parameter and the 16th and 84th percentiles of their cumulative posterior probability distributions as a measurement of asymmetric uncertainty. Fitted parameters are reported in Table 3 and shown in Fig. 3.

6.3 Physical properties of TIC-231005575

We used the method described in Gill et al. (2020) along with the ISOCRONES python package (Morton 2015) to measure the physical properties of the host star. This method combines Gaia magnitudes $BP$ and $GP$ and parallax with Gaussian priors centred on values reported from GAIA DR2 (Gaia Collaboration et al. 2018), spectroscopically determined values of $T_{\text{eff}}$, log $g$, and [Fe/H], and posterior
probability distributions for $e$ and $K_1$ to measure the masses, radii, and age of the system.

7 DISCUSSION

7.1 The TIC-231005575 system

The primary star in the TIC-231005575 system has a spectral type of G7/8 with physical properties similar to the Sun. Spectral analysis did not reveal anything unusual about the primary star except a relatively metal-poor atmosphere ([Fe/H] = -0.44 ± 0.06) which is approximately 1-$\sigma$ away from the median metallicity of stars from Gaia-ESO data release 3 (Smiljanic et al. 2017; see Fig. 4 of Gill et al. 2018)). The transiting companion is an M-dwarf with spectral type M5. We interpolated evolutionary models to determine the physical properties of the M-dwarf and found a radius which is inflated by 1.15-$\sigma$ when directly comparing to predicted radius from the best fitting isochrone ($0.145 R_\odot$). A more robust measurement of inflation is discussed in Sect. 7.2. The best-fitting radial velocity model resulted in a single radial velocity point (JD = 2458885.523264) that is ~ 2-$\sigma$ higher than expected. The exact reasons for this are unclear, but this point has significantly reduced contrast in the cross-correlation function suggesting moon contamination despite being over 100° away from TIC-231005575 at the time of exposure. Unfortunately, TIC-231005575 has set from Paranal making further spectroscopic observations impossible for this season.

The proper motion of TIC-231005575 is $\Delta RA = 52.658 \pm 0.038$ mas yr$^{-1}$ and $\Delta Dec = -20.588 \pm 0.039$ mas yr$^{-1}$. TIC-231005575 is resolved in Gaia (Source ID 4912474299133826688) and has a parallax of 3.0332 ± 0.0815 and similar common proper motion of $\Delta RA = 52.699 \pm 0.105$ mas yr$^{-1}$ and $\Delta Dec = -20.592 \pm 0.111$ mas yr$^{-1}$. Lindegren et al. (2018) noted that during scanning of close sources the components can become confused due to a changing photocentre. Gaia DR2 assumes that TIC-231005575 and TIC-231005576 are a single source and they are the primary and secondary source respectively in that solution. We assessed the quality of these astrometric solutions using Eqn.s 1 & 2 in Arenou et al. (2018). Both solutions pass the first test, but not the second indicating that the astrometric solutions are of poor quality. In addition, astrometric excess noises (ASTROMETRIC_EXCESS_NOISE_SIG) for TIC-231005575 and TIC-231005576 are 0 mas and 30 mas respectively. This indicates that TIC-231005575 requires no extra noise to the single source solution to fit the observed behaviour, while TIC-231005576 does. We assume that the astrometric solution for TIC-231005575 is reliable and that the respective solution for TIC-231005576 is influenced by the proximity and position relative to TIC-231005575.
7.2 Inflation of long-period eclipsing M-dwarfs

There is some tension between measured physical properties of M-dwarfs and predictions from evolutionary models. M-dwarfs across the entire spectral type are reported to have a higher radius than expected by ~ 5% (Chabrier et al. 2000; Torres & Ribas 2002; Ribas 2003; López-Morales & Ribas 2005; Ribas et al. 2008; Torres et al. 2014; Baraffe et al. 2015; Lubin et al. 2017) and over luminous (Otí et al. 2012; Gómez Maqueo Chew et al. 2014; Beatty et al. 2018). This is most apparent for masses whereby M-dwarfs transition from partly-convective to full convective cores (~ 0.35M⊙; López-Morales 2007). Magnetic fields are thought to be induced by tidal interactions, enhancing rotation and dynamo mechanisms. This inhibits convection in the core and may be responsible for inflating some stellar radii above those predicted by evolutionary models (Kraus et al. 2011). However, studies of single M-dwarfs with interferometry (Boyajian et al. 2012) and those in double-lined eclipsing binaries (Feiden & Chaboyer 2012) are comparably inflated by around 3% making it unclear whether tidal interactions can be blamed (Spada et al. 2013). The TIC-231005575 system is well separated and there is little tidal interaction making it an excellent test of tidally-induced inflation.

The TIC-231005575 system has a semi-major axis of 23.28 ± 1.37 R⊙. The minimum separation between the primary star and the M-dwarf at perihelion and aphelion is 16.33 ± 0.96 R⊙ and 30.23 ± 1.78 R⊙ respectively. Consequently, we expect little tidal interaction to occur and so a robust assessment of inflation for this object provides a unique test of models of stellar evolution for an M-dwarf with accurate physical properties in quasi-isolation. Such assessment requires diligent analysis of M1, R2, Age, and [Fe/H] with their respective uncertainties. We follow the method described by Gill et al. (2019) to calculate the posterior probability distribution for the fractional radius residual, ΔR2 / R2, which we briefly describe here. We calculate the posterior probability distribution for the surface gravity of the M-dwarf, log g2, and combine it with M2 to get a measured value for the radius of the M-dwarf, R2,m. The corresponding draw for age and [Fe/H] was used to interpolate a MESA isochrone (Dotter 2016; Choi et al. 2016) from which an expected radius of the M-dwarf, R2,exp, is interpolated when combined with M2. Finally, the posterior probability distribution fractional radius residual compared to MESA isochrones can be calculated,

\[
\frac{\Delta R_2}{R_2} = \frac{R_{2,m} - R_{2,exp}}{R_2}.
\]

We calculated the nominal fractional radius residual by binning the posterior probability distribution into 100 bins and fitted a Gaussian model (Fig. 5): we took the mean of the fitted Gaussian to be the measurement of ΔR2 / R2 with uncertainty equal to the standard deviation. As stated by Gill et al. (2019), the Gaussian shape is not a perfect fit to the PPDs of ΔR2 / R2; there are asymmetric discrepancies where one side of the Gaussian model is lower than the PPD, whilst the other is too high. On average, the under-prediction on one side and over-prediction on the other are of the same magnitude and we assume the widths still accurately represent the mean uncertainty of ΔR2 / R2. We measured a value of ΔR2 / R2 = 0.054 ± 0.055 and so conclude that the inflation of the eclipsing M-dwarf in the TIC-231005575 system is not statistically significant (0.98-σ).

8 CONCLUSION

TIC-231005575 represents the first object to have an orbital period recovered by blind photometric survey as part of the NGTS mono-transit working group. TIC-231005575 was initially identified as a single transit candidate from TESS differential imaging light curves. The TESS single-transit event had shape and depth consistent with a Jovian planet and so was monitored with a single NGTS photometer until a second transit event was observed. We excluded all but seven possible aliases of the orbital period which required time-critical photometric observations to either exclude or confirm the true orbital period. We observed a third transit event with LCO from Sutherland, South Africa, confirming the 61.77-day orbital period. Spectroscopic observations were used to confirm the primary star’s spectral type of G8 with mass and radius consistent with the Sun.

Joint analysis of photometric and spectroscopic datasets revealed the transiting companion to be a mid-M-dwarf (M2 = 0.128 ± 0.003 M⊙, R2 = 0.154 ± 0.008 R⊙). This is one of the longest period EBLM (eclipsing binary, low mass) systems with accurate physical properties and so we performed a robust assessment of M-dwarf inflation accounting for uncertainties in mass, radius and age of the system. We found that the radius of the eclipsing M-dwarf is consistent with models of stellar evolution to better than 1-σ.

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