

A 28.24-day Eclipsing Binary Recovered from TESS QLP Photometry of TIC 330735422

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Abstract

A search of TESS Quick-Look Pipeline light curves within 0.5 degrees of the known eclipsing binary V345 Lac recovered a repeating eclipse on TIC 330735422 (TYC 3986-864-1), a star with no entry in the General Catalogue of Variable Stars, the AAVSO VSX, the Gaia DR3 eclipsing-binary table, or the TESS Objects of Interest list. Eight sectors (16, 17, 56, 57, 76, 77, 83 and 84) show eclipses at a period of 28.239 days, epoch BTJD 2840.696. The observed depth is 2.1 to 2.5 percent and the width below the 1.2 percent level is 0.17 days. The TIC contamination ratio is 0.75, so the undiluted depth is about 3.9 percent. For a central eclipse on the catalog radius of 1.95 solar radii that implies a companion of about 0.38 solar radii; the eclipse is shorter than a central transit at this period, so the geometry is grazing and the companion may be larger. Gaia DR3 gives a parallax of 1.569 ± 0.013 mas, an effective temperature of 6906 K, a surface gravity of 3.93, a metallicity of -0.57 , and a radial velocity of -15.3 ± 2.7 km s⁻¹. The renormalized unit-weight error is 0.90 and the non-single-star flag is zero. No secondary eclipse is detected in the phase fold. This note reports the ephemeris and the public catalog cross-match. It is not a validated orbit: no pixel-level centroid test and no ground-based confirmation have been done.

Keywords: eclipsing binary — TESS — TIC 330735422 — long-period eclipse

1. Introduction

TESS observes in sectors of about 27 days. Pipelines built to find a repeating signal, including SPOC and QLP, recover short periods efficiently and miss or mis-pair eclipses whose period is longer than a sector. A cone search was run around V345 Lac (22h 18m 43.34s, +54° 40′ 33.5″), an eccentric B5 eclipsing binary of period about 7.5 days, to look for single or sparsely sampled eclipses on stars brighter than $V = 12.5$. The search was expanded from 0.1 to 0.5 degrees. Known short-period systems in the field, including V345 Lac itself, AW Lac, ATO J334.6818+54.7874 and TYC 3986-2071-1, were recovered as a check. One additional object, TIC 330735422, showed a coherent eclipse in more than one sector and is not in the variable-star catalogs. This note collects the photometry and the catalog cross-match for that star.

The analysis uses public QLP light curves (Huang et al. 2020; Kunimoto et al. 2021) and catalog values from Gaia DR3 (Gaia Collaboration 2023), 2MASS (Cutri et al. 2003), AllWISE (Cutri et al. 2013) and Pan-STARRS1 (Chambers et al. 2016). No new observations were obtained.

2. Target and catalog properties

TIC 330735422 is TYC 3986-864-1, Gaia DR3 2005042432021371392, 2MASS J22155693+5428386 and AllWISE J221556.92+542838.5. It lies 26.9 arcmin from V345 Lac, at galactic coordinates $l = 101.535^\circ$, $b = -1.803^\circ$. SIMBAD types it as an ordinary F0 star. Four bibliographic links exist, all catalog papers; none discuss variability. ExoFOP lists no TOI, no community TOI and no time series.

Gaia DR3 measures a parallax of 1.5686 ± 0.0129 mas. The simple inversion is 638 pc; the Gaia photogeometric distance listed in the VizieR extract of DR3 is 616 pc. The absolute G magnitude is about 2.8, consistent with a main-sequence F star. The renormalized unit-weight error is 0.902, and the non-single-star flag is 0, so Gaia did not publish an astrometric or spectroscopic orbit. The source is absent from the Gaia DR3 variability summary and from the eclipsing-binary table. A single radial velocity, -15.29 ± 2.73 km s⁻¹, is

published, with a line broadening of 8.4 km s^{-1} .

The TIC radius is $1.955 R_{\odot}$ and the TIC effective temperature is 6620 K, with $\log g = 4.00$. Gaia GSP-Phot gives 6906 K and $\log g = 3.93$, with $[\text{Fe}/\text{H}] = -0.57$ and an extinction $A_0 = 0.50 \text{ mag}$. The two temperature scales differ by about 300 K; both are used below only as a stellar-type check, not as a fitted parameter. The TIC contamination ratio is 0.752, so neighboring flux inside the aperture is three-quarters of the target flux. Observed eclipse depths are diluted by a factor of about 1.75.

Quantity	Value	Source
Identifiers	TIC 330735422; TYC 3986-864-1; Gaia DR3 2005042432021371392	TIC, Tycho-2, Gaia
RA, Dec (ICRS)	22h 15m 56.933s, $+54^{\circ} 28' 38.68''$	Gaia DR3
Galactic l, b	101.535° , -1.803°	Gaia DR3
Parallax	$1.5686 \pm 0.0129 \text{ mas}$	Gaia DR3
Distance	616 pc (photogeometric); 638 pc (1/parallax)	Gaia DR3
Proper motion	-2.176 , $-9.005 \text{ mas yr}^{-1}$	Gaia DR3
RUWE / NSS	0.902 / 0	Gaia DR3
G, BP, RP	11.790, 12.060, 11.360	Gaia DR3
V, B, T	11.78, 12.54, 11.427	Tycho-2 / TIC
J, H, K	10.843, 10.708, 10.609 (AAA)	2MASS
W1, W2, W3	10.470, 10.523, 10.609; W4 an upper limit	AllWISE
PS1 g, r, i, z, y	11.98, 11.80, 11.74, 11.69, 11.66	Pan-STARRS1
Teff, log g	6906 K, 3.93 (Gaia); 6620 K, 4.00 (TIC)	GSP-Phot, TIC
$[\text{Fe}/\text{H}]$, A_0	-0.57 , 0.50 mag	Gaia DR3
Radius	$1.955 R_{\odot}$	TIC
Radial velocity	$-15.29 \pm 2.73 \text{ km s}^{-1}$	Gaia DR3
Contamination	0.752	TIC

Table 1. Catalog properties of TIC 330735422. Magnitudes are Vega for Tycho, 2MASS and WISE, and AB for Pan-STARRS.

The infrared colors are those of a bare photosphere. AllWISE variability flags are nnnn, and W4 is an upper limit (quality flag U). The star is not in the General Catalogue of Variable Stars or in VSX within 5 arcsec. A query of the public ZTF light-curve service at this position returned no rows, so no independent period check is available from that survey.

3. TESS photometry

QLP full-frame-image light curves were retrieved for every sector in which the star falls on a TESS camera: 16 and 17 at 30-minute cadence, and 56, 57, 76, 77, 83 and 84 at 200-second cadence. Fluxes are the QLP detrended series (KSPSAP in the early sectors, DET_FLUX later), normalized by the sector median. No quality cut was imposed for the final ephemeris test, so that clipped eclipses would not be removed; the discovery screen had used quality flag zero.

Four eclipses are unambiguous at 200-second cadence. Their mid-times, measured as the minimum of a 15-minute median smooth, depths, and widths below the 1.2 percent level are given in Table 2. The interval between the sector 56 and sector 57 events is 28.15 days. The interval between the sector 83 and sector 84 events is 28.34 days. The separation from sector 56 to sector 83 is 734.23 days, which is 26.00 cycles of 28.239 days. Adopting

$$T_0 = 2840.696 \text{ BTJD}, \quad P = 28.239 \text{ d},$$

where $\text{BTJD} = \text{BJD} - 2457000$, places an eclipse in every observed sector. Sectors 16, 17, 76 and 77, which looked empty in a first 1-percent screen, each have a shallow dip at the predicted time: the 30-minute cadence and the data-download gaps cut the early events, and the later ones sit near the noise of a single sector. The predicted epoch in sector 16, BTJD 1739.37, falls at the start of the sector and is only partly covered.

Sector	Mid-time (BTJD)	Depth	Width	Notes
16	1739.37 (predicted)	partial	—	sector edge; points to 3% low
17	1767.61 (predicted)	partial	—	30-min cadence; points to 2% low
56	2840.696	2.5%	0.167 d	clean
57	2868.847	2.2%	0.167 d	clean
76	3377.24 (predicted)	~1.7%	—	present, lower contrast
77	3405.48 (predicted)	~1.8%	—	present, lower contrast
83	3574.926	2.2%	0.167 d	clean
84	3603.262	2.1%	0.167 d	clean

Table 2. Eclipse times. Clean mid-times are minima of a 15-minute median. Predicted times use $P = 28.239$ d and $T_0 = 2840.696$.

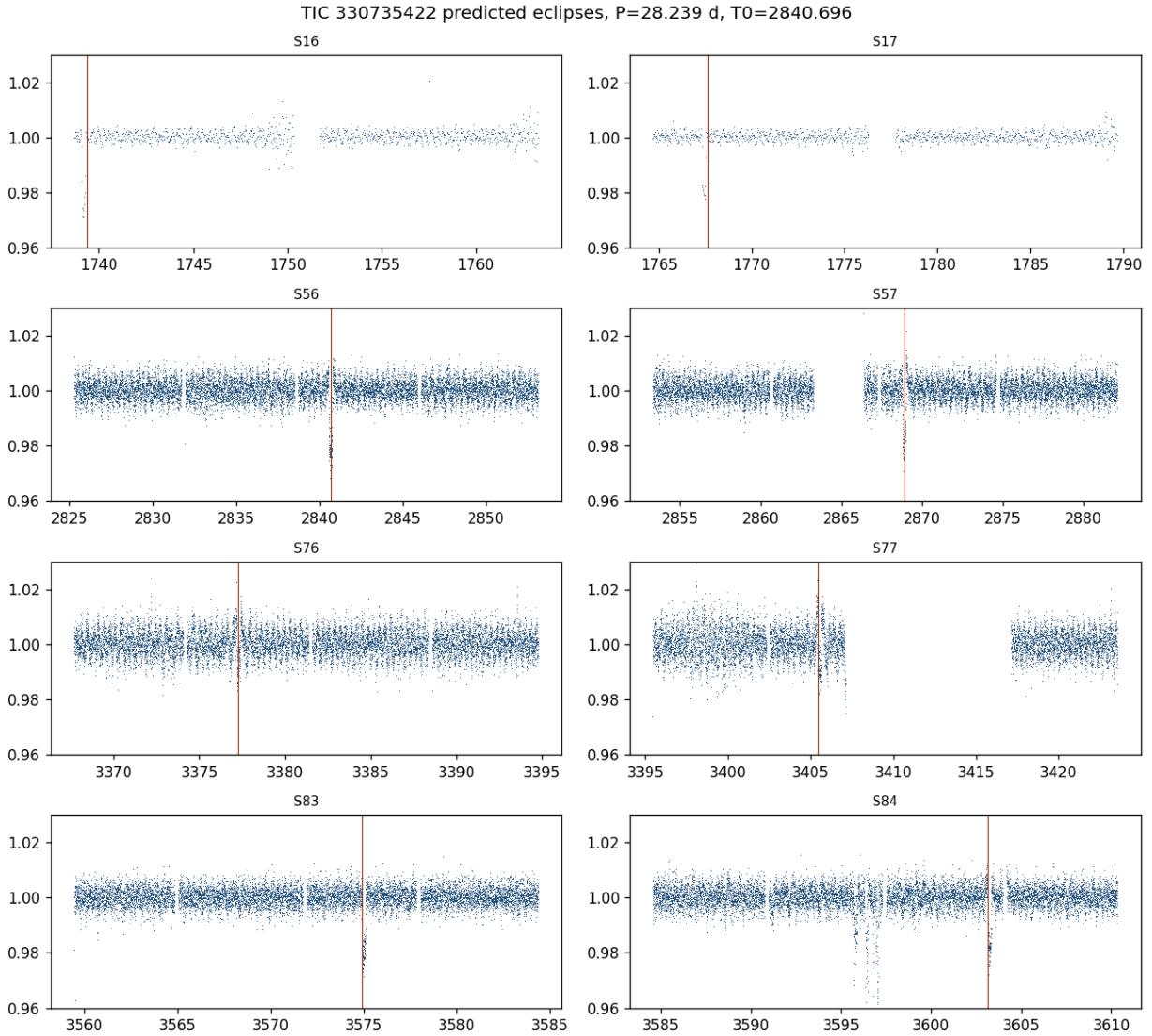


Figure 1. QLP light curves of TIC 330735422 in eight sectors, sector-median normalized. Vertical lines mark the ephemeris $T_0 = 2840.696$, $P = 28.239$ d. The y-axis is clipped at 4 percent; single-point outliers are not astrophysical.

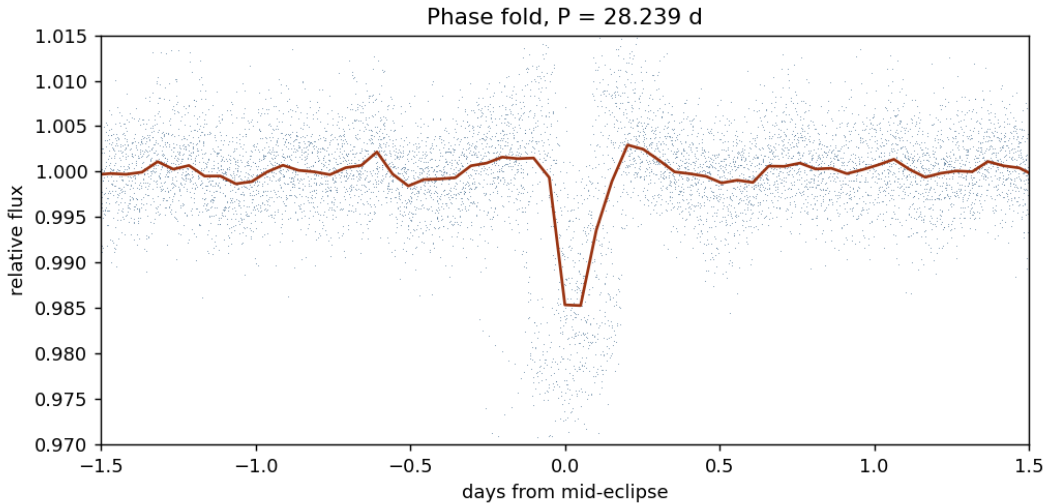


Figure 2. Phase fold of all eight sectors on $P = 28.239$ d. Points are individual cadences; the line is a median in phase. The eclipse is about 1.5 percent in the binned curve because the bin is wider than the bottom of the event and because several sectors are diluted by gaps. No secondary is visible within ± 1.5 days of phase 0.5 at the sensitivity of this fold.

4. Period and geometry

The first inspection paired the sector 56 event at BTJD 2840.67 with a dip at BTJD 3377.25 and reported a 536.6-day separation. That separation is 19 cycles of 28.239 days. The half, third and quarter of 536.6 days were aliases of a single pair of sectors; they are closed by the events in sectors 57, 83 and 84. A formal uncertainty is not quoted. The cycle-to-cycle scatter of the four clean mid-times is about 0.1 day, set by the binning and by the data gaps rather than by a timing fit.

A central eclipse on a $1.95 R_{\odot}$ star at 28.24 days lasts about 10 hours if the stellar mass is $1.4 M_{\odot}$. The semi-major axis from Kepler's law is then 0.20 AU. The observed width below 1.2 percent is 0.17 days, about 4 hours, so the eclipse is grazing or the contact points are lost in the noise. Grazing geometry also lowers the observed depth relative to the companion's true radius.

The observed depth is 2.2 percent in the clean events. Dividing by the dilution factor $1 / (1 + 0.752)$ raises it to 3.9 percent. A central eclipse at that depth on a $1.95 R_{\odot}$ star requires a companion radius of $0.38 R_{\odot}$, about 3.8 Jupiter radii. That is a late M dwarf or a brown dwarf if the transit is central. A grazing eclipse of a larger star produces the same depth, and is the more likely reading given the short duration. Either way the companion is stellar or substellar, not a planet. No secondary eclipse is detected. A cool companion at phase 0.5 would be expected to be shallow; the fold does not constrain it below about half a percent.

The next eclipse on this ephemeris after the last observed event (BTJD 3603.26) falls at BTJD 3631.5. Later TESS sectors of this field, if obtained after sector 84, can test the ephemeris directly.

5. What this is not

The signal survives eight sectors at one period, which makes a one-off instrumental glitch unlikely. It has not been shown to be on the target rather than on a neighbor. The contamination ratio of 0.75 means a neighbor is bright enough to matter, and no difference-image centroid or pixel-level test was performed. A blend with a deeper eclipse on a fainter star remains possible. Gaia RUWE of 0.90 argues against a luminous companion at a separation Gaia can resolve, but it does not rule out a blend inside the TESS pixel.

The period is not a least-squares ephemeris. Depths are sector-median measurements, not a Mandel-Agol fit. The stellar radius is the TIC value, not a fit to the spectral energy distribution. No radial-velocity orbit exists; the

single Gaia velocity cannot separate the components. The object should not be cited as a confirmed binary until a centroid test or a ground-based eclipse confirms that the dip belongs to TIC 330735422.

6. Conclusions

TIC 330735422, an F star at about 620 pc with $V = 11.78$, shows eclipses at $P = 28.239$ days in TESS QLP photometry from sectors 16 through 84. The ephemeris is $T_0 = 2840.696$ BTJD. The observed depth is 2.1 to 2.5 percent, corresponding to about 3.9 percent after the catalog dilution correction, and the duration is shorter than a central transit. The companion is consistent with a grazing late-type dwarf. The star is absent from VSX, GCVS, the Gaia eclipsing-binary table and the TOI list. The result is an ephemeris and a cross-match, offered for follow-up, not a validated system.

References

- Chambers, K. C., Magnier, E. A., Metcalfe, N., et al. 2016, arXiv:1612.05560, Pan-STARRS1 Surveys.
- Cutri, R. M., Skrutskie, M. F., van Dyk, S., et al. 2003, 2MASS All-Sky Catalog of Point Sources, VizieR II/246.
- Cutri, R. M., Wright, E. L., Conrow, T., et al. 2013, AllWISE Data Release, VizieR II/328.
- Gaia Collaboration. 2023, A&A, 674, A1, Gaia DR3.
- Huang, C. X., Vanderburg, A., Pál, A., et al. 2020, RNAAS, 4, 204, the TESS QLP.
- Kunimoto, M., Huang, C., Tey, E., et al. 2021, RNAAS, 5, 234, QLP on FFI light curves.
- Ricker, G. R., Winn, J. N., Vanderspek, R., et al. 2015, JATIS, 1, 014003, the TESS mission.
- Stassun, K. G., Oelkers, R. J., Paegert, M., et al. 2019, AJ, 158, 138, the TESS Input Catalog.
- Data. QLP light curves from archive.stsci.edu, product hlsp_qlp, TIC 330735422, sectors 16, 17, 56, 57, 76, 77, 83, 84. Catalog values from Gaia DR3, 2MASS, AllWISE, Pan-STARRS1 and the TIC as served by SIMBAD, VizieR and ExoFOP on 9 October 2026.