A 12.961-day eclipsing binary whose depth changes: TIC 470019013

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Tustin, California. Research note from the 2.10°–2.20° ring around V345 Lac, 10 November 2026. Nothing in this note has been submitted to VSX.

Abstract. TESS QLP aperture photometry of TIC 470019013 shows a primary and a secondary on one clock from 2019 to 2024. Sixteen primary minima give the ephemeris below, with an O−C scatter of 13.2 minutes. The secondary sits at phase 0.503, 6.522 days later. The depth is not one number. The primary reaches 0.666 of the sector median in sector 16 and 0.960 in sectors 83 and 84. The same camera and CCD still disagree from 2022 to 2024. The nearest Gaia neighbor is 4.6 arcsec away and has under one percent of the light. The note is not a VSX submission.

The star

TIC 470019013 is TYC 3969-00494-1 and Gaia DR3 2005522201357433472. The catalog place is 22h 04m 22.22s, +53° 59′ 59.7″ (J2000). V = 10.722 and the TESS magnitude is 10.336. The star is 2.182° from V345 Lac, 131 arcmin to the west-southwest, in the 2.10°–2.20° ring. Gaia DR3 gives G = 10.62, BP − RP = 0.55, parallax 1.685 ± 0.022 mas, and RUWE 1.39. That parallax is about 590 parsecs. The absolute G magnitude, with no dust correction, is about 1.7. The TESS catalog lists 7597 K, log g 3.79, mass 1.77 solar masses, and radius 2.81 solar radii. The contamination ratio is 0.090. No other star brighter than V = 12.5 lies within 180 arcsec in that catalog.

How it was found

The search is the same one used for TIC 467546768: 414 stars in the 2.10°–2.20° ring, quality flag exactly zero, and a dip of about 1.2 percent or more. Sectors 16, 17, 56, 57, 76, 77, 83, and 84 have QLP files. Sectors 76 and 77 are the v02 files. The curves are SAP_FLUX divided by the sector median. Dividing by a 2-day out-of-eclipse baseline leaves the same change in depth, so the fade is in the delivered aperture flux. Catalog values are from the TESS Input Catalog and Gaia DR3. No new observations were obtained.

Ephemeris

$$\text{Min I} = \text{BTJD } 1745.38795 + 12.960690\ E$$

Sixteen primary minima, from BTJD 1745 to 3599, were fit by linear least squares. The root-mean-square residual is 13.2 minutes. The largest residual is 32.4 minutes, on cycle 126 in sector 76. The secondary phase, from twelve timed secondaries, has median 0.5032. That is 6.522 days after the primary. Three other predicted secondaries fall in gaps inside sectors 17, 57, and 77 and were not timed. In sector 56, when the floor is 0.825, the light stays under 98 percent for 6.3 hours and under half that depth for 4.1 hours. The later, shallower eclipses spend less time under 98 percent because the floor is higher. The centroid shifts by 0.014 pixel in the median, and by 0.046 pixel in sector 16.

Sector	Cycle	BTJD	UTC	Min. flux	O−C (min)
16	0	1745.389	2019-09-18 21:19	0.667	+1.2
16	1	1758.347	2019-10-01 20:19	0.664	-2.1
17	2	1771.305	2019-10-14 19:19	0.675	-5.7
17	3	1784.284	2019-10-27 18:49	0.693	+20.6
56	84	2834.071	2022-09-11 13:42	0.825	-21.4
56	85	2847.046	2022-09-24 13:05	0.825	-1.3
57	86	2860.009	2022-10-07 12:12	0.827	+2.0
57	87	2872.967	2022-10-20 11:12	0.833	-1.7
76	126	3378.412	2024-03-08 21:53	0.921	-32.4
76	127	3391.391	2024-03-21 21:23	0.919	-6.0
77	128	3404.352	2024-04-03 20:26	0.920	-6.1
77	129	3417.318	2024-04-16 19:38	0.918	+2.0
83	140	3559.893	2024-09-06 09:26	0.963	+12.7
83	141	3572.854	2024-09-19 08:30	0.962	+13.1

Sector	Cycle	BTJD	UTC	Min. flux	O−C (min)
84	142	3585.819	2024-10-02 07:40	0.959	+19.5
84	143	3598.771	2024-10-15 06:29	0.960	+5.9

The depth changes

The primary minimum, as a fraction of the sector median, is 0.666 in sector 16 (camera 1, CCD 1), 0.675 and 0.693 in sector 17 (camera 3, CCD 1), 0.825 in sector 56 (camera 3, CCD 2), 0.827 and 0.833 in sector 57 (camera 3, CCD 1), 0.920 in sectors 76 and 77 (camera 4), and 0.960 in sectors 83 and 84 (camera 3, CCD 2 and CCD 1). In magnitudes that is 0.44 mag in 2019 and 0.044 mag in 2024. The secondary follows the same fade: 0.802 in sector 16, 0.894 in sectors 56 and 57, 0.950 in sectors 76 and 77, and 0.977 in sectors 83 and 84. Sector 56 and sector 83 are the same camera and the same CCD, and the minimum still goes from 0.825 to 0.963. Sector 57 and sector 84 are the same camera and CCD, and the minimum goes from 0.83 to 0.96. Sectors 56, 57, 83, and 84 are all QLP v01, so the change is not the v02 reprocessing of sectors 76 and 77. The contamination ratio 0.090 is a catalog blend. It is not turned into an intrinsic depth, and a constant blend does not make a depth that changes by a factor of eight. The eclipse shape stays smooth in every sector. What changes is how far the light falls.

The nearest Gaia star is G = 15.80 at 4.6 arcsec, about 5.2 mag fainter, under one percent of the light. It cannot produce a dip of a third, and it cannot produce the 4 percent dip that remains in 2024 by itself. A star of G = 13.31 lies 60 arcsec away, about three TESS pixels, and has about 8 percent of the target’s light. The deep eclipse is in this aperture. On the catalog radius of 2.81 solar radii, even the shallow 2024 minimum, 4 percent, is a companion about 0.6 solar radii across. The 2019 minimum, 33 percent, is larger still. A Jupiter-sized body removes about a tenth of a percent of a star this size. The open question is why the depth changed. The clock itself is stable. The nearest VSX object is ZTF J220428.80+540114.8, type EW, period 0.284 days, 95 arcsec away. That clock is not this one.

Figures

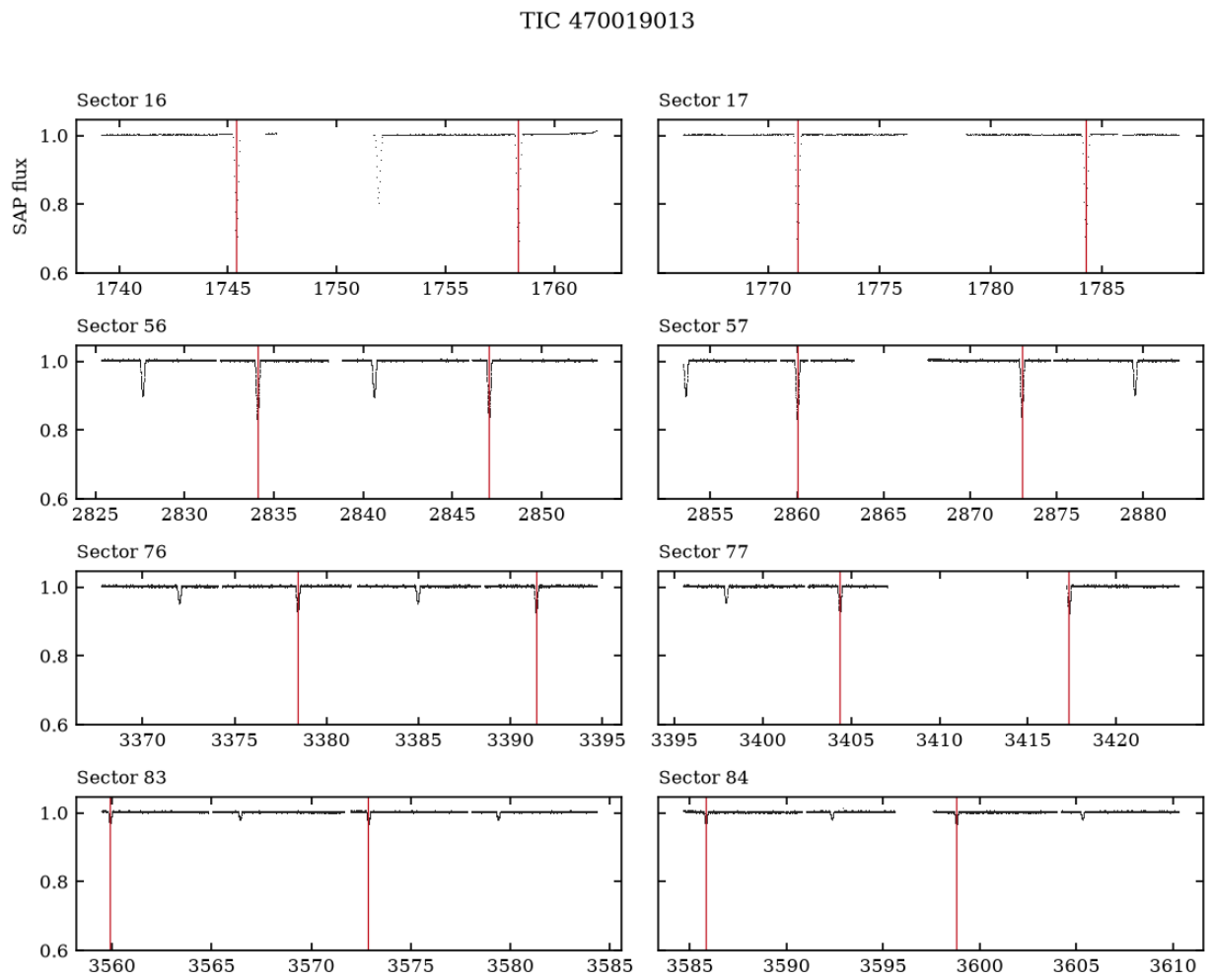


Figure 1. Eight TESS sectors. Red lines are the primary minima. The eclipse is deep in 2019 and shallow in 2024.

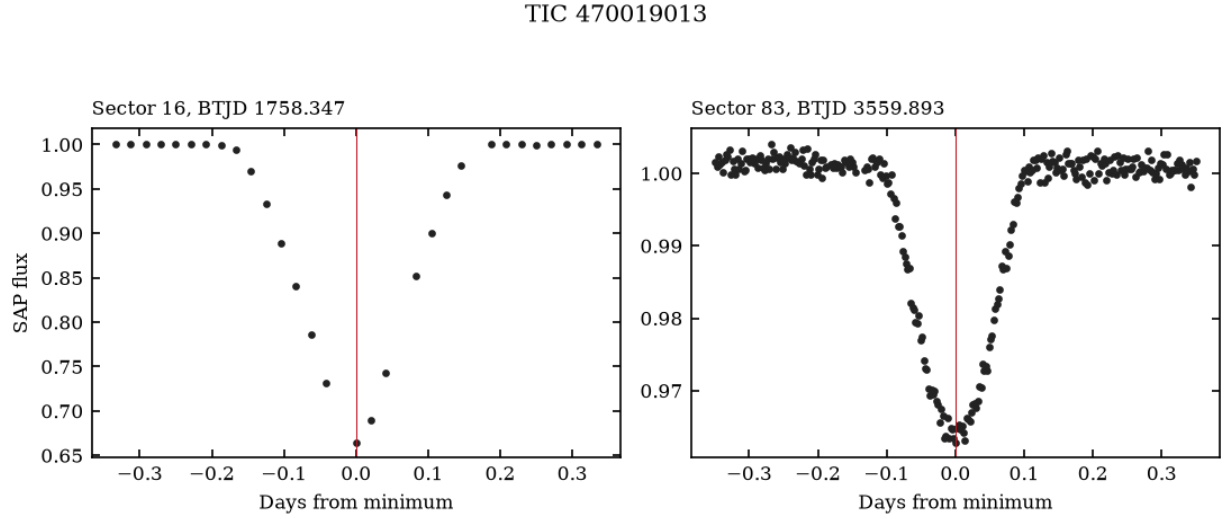


Figure 2. The deep primary in the early sectors and a shallow primary in the late sectors, on the same ephemeris.

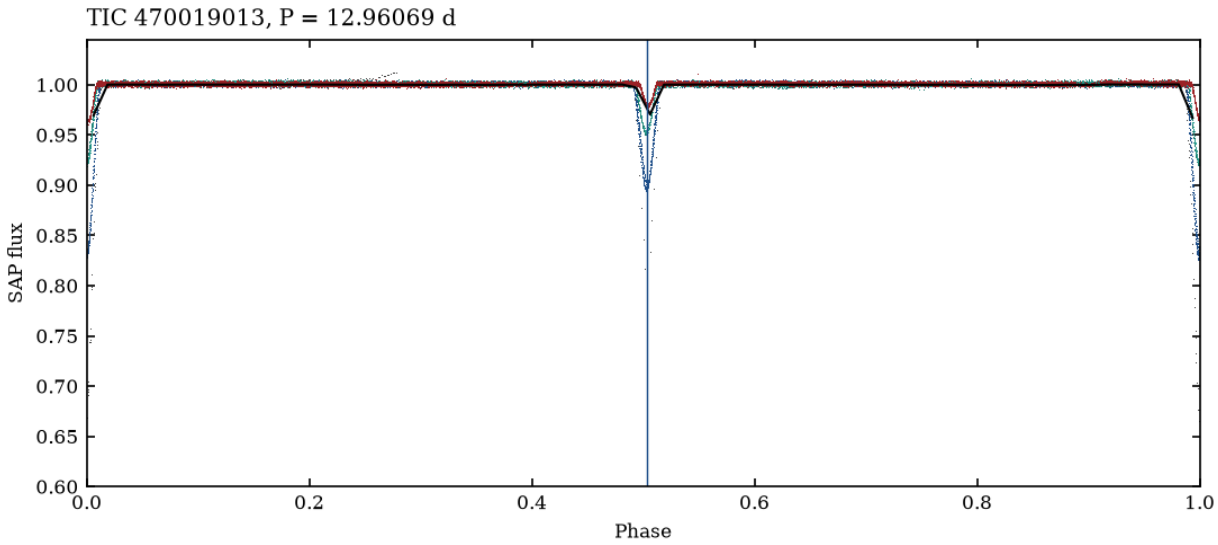


Figure 3. Folded on 12.960690 days. The spread at phase 0 is the change in depth from sector to sector. The blue line is the secondary at phase 0.503.

Nothing in this note has been submitted to VSX. TIC 330739083 is still the one New submission on this account, so this star stays unfiled.

References

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Stassun K. G. et al., 2019, Astron. J., 158, 138 (TIC)
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