TYC 5780-308-1 Discovery of Stellar Duplicity During Asteroidal Occultation by (834) Burnhamia

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Abstract: An occultation of TYC 5780-308-1 by the asteroid (834) Burnhamia on August 23, 2017 (UT) showed this star to be a double star. Both components of the double star were occulted as recorded by four observers. The separation of the two components is 0.0143 ± 0.0004 arcseconds at a position angle of 73.8 ± 2.7 degrees. The magnitude of the primary component is estimated to be 9.8 +/- 0.03 (Tycho2 VT). The magnitude of the secondary component is estimated to be 9.92 +/- 0.03 (Tycho2 VT).

Observation

On August 23, 2017 (UT), four observers occupying or operating sites across the United States observed the asteroid (834) Burnhamia occult the star TYC 5780-308-1. See Figure 1 for the path map of the event. All four sites observed two step events. All recorded occultation times and data from the observers can be found in archived IOTA records for the event. The observations were made by the observers located at the sites and with the equipment shown in Table 1.

The target star is magnitude 9.103 (Tycho2 VT). This magnitude is derived from the Tycho system magnitude VT given in the Tycho-2 Catalogue contained in the VizieR database [1]. The asteroid magnitude as predicted by the Minor Planet Center as reported in Occult4 [2] was 13.1 (V). The combined magnitude of the asteroid and the star was calculated to be 9.08 (using both Tycho2 VT and MPC V). The expected magnitude drop at occultation was calculated to be 4.02 magnitudes. The star is not listed in the Washington Double Star Catalog. The star is listed the Fourth Catalog of Interferometric Measurements of Binary Stars [3]. The data from that inquiry are shown in Table 2 [headings were derived from format descriptions].

Analysis

The observations were analysed in the standard manner described by IOTA [4].

The finished plot of the double star fit to the data is shown in Figure 6. The double star has a separation of 0.0143 ± 0.0004 arcseconds at a position angle of 73.8 ± 2.7 degrees.

Of the data sets that recorded the occultation, Blank

Table 1. Observers, site locations, equipment, methods, and results

Chords	Observer(s)	City/ Location	State	Country	Telescope Type	Telescope Dia (cm)	Method	Result
1,2	S Messner	Big Lake	MO	USA			Video+GPS Time Inst	Two Events
3,4	P Maley	Hiawatha	KS	USA	Ref	8	Video+GPS Time Inst	Two Events
5,6	J Moore	Turpin	OK	USA			Video+GPS Time Inst	Two Events
8,9	T Blank	Tipton	IA	USA			Video+GPS Time Inst	Two Events

Table 2

211225.82-114906.7 BD-125932 SAO 164213 HD 201827 TYC 5780 0308 1 21124-1149								
Observation Date	PA (deg)	Separation (as)	Sep. Error (as)	Filters (nm)	Telescope Aperture (m)	Num. Obs.	Orig. Ref. Code	Tech Code
1974.7384	V45.1					1	Bvr1979b	O
1975.7153	V302.3	0.003	0.003	430		1	Afr1976	O
1994.8671		<0.038		558	3.6	1	Msn1996b	Sc

Table 3

Observer	Baseline	1st Drop	Bottom	1st Reapp	Baseline
Blank	181.56	100.54	4.77	86.66	183.07
Maley	115.14	47.73	2.75	44.4	114.98
Maley Normalized	181.56	75.26	4.34	70.01	181.31
Average	181.56	87.90	4.55	78.34	182.19

Table 4

Observer	Magnitude Change				Total Magnitude Change	
	1st D	2nd D	1st R	2nd R		
Blank	0.64	3.31	3.15	0.81	3.95	3.96
Maley	0.96	3.10	3.02	1.03	4.05	4.05
Average	0.80	3.20	3.09	0.92	4.00	4.01

and Maley recorded video without saturated stars. Therefore, the Blank and Maley events were suitable for calculating the stellar component magnitudes. The original videos for both observers were recorded with cameras using 0.45 gamma brightness compensation. This makes dim objects brighter and bright objects dimmer. This also affects the linearity of the light curve which also affects the magnitudes derived from the data. As a result, both videos were processed with inverse gamma correction to make the resulting light curve linear [5, 6]. Using the light curve data from these two observers, the magnitude drops of the two events were calculated using the brightness measurements derived by R-OTE [7], the Magnitude calculator routine in Occult4[2] (Method 3 – Magnitudes from light curve values), the combined VT magnitude from the Tycho-2 Catalogue and the predicted V magnitude of the asteroid as explained above. The results are shown in Table 3 and Table 4. Note that the measured brightness are ADU[†] values with no filters. The assumption is they are not much different from those in VT in calculating the magnitude of each component of the double star.

Magnitude Drops from R-OTE analysis

Based on the total magnitude drop estimates for the two components shown in Table 4, the average magnitude drop measured by both observers is within 0.015 of the predicted magnitude drop. This is excellent agreement from both observer light curves.

The magnitudes of the two component stars were derived by inputting the 'average' ADU brightness values into the Occult4 Magnitude Calculator. The results of this analysis are shown in Table 5.

The magnitudes of the two stars are estimated to be 9.8 ± 0.03 (VT) primary star and 9.92 ± 0.03 (VT) secondary star, and their magnitude difference is estimated to be 0.12 ± 0.04 (VT). The event was a BABA, with the secondary occulted first, then the primary, then the secondary reappearing and then the primary.

Based on the data presented in this report, the double star characteristics as shown in the plot in Figure 6 are shown in Table 6

Table 5. Occult4 Analysis of Average Brightness Changes

Assuming:
* a combined magnitude of 9.10
*Light levels at D of 182 => 88 => 5
Magnitudes for sequence B-A-B-A:
Mag B = 9.92, Mag A = 9.80

† Analog-to-Digital-Unit – the digital equivalent of the brightness of the analog star on the video screen as process through Limovie.

(Text continues on page 400)

TYC 5780-308-1 Discovery of Stellar Duplicity During Asteroidal Occultation by (834) Burnhamia

Table 6. Double Star Characteristics

Star	TYC 5780-308-1
	SAO 164213
	GaiaSrc6892019327085654272
	2UCAC 27763256
	3UC 157-284904
	UCAC4 391-130067
	UCAC5 689201932708565427 2
	URAT1 391-172137
	PPMXL 1310283915415980810 000
	PPMX 211225.8-114906
	NOMAD1 0781-0799491
	Spectral type G
Coordinates (UCAC5)	RA 21h 12m 25.8435s Dec -11d 49m 7.219s Current Epoch 2017.64)
Mag A	9.8 ± 0.03
Mag B	9.92 ± 0.03
Mag Difference	0.12 ± 0.04
Separation	0.0143 ± 0.0004 arcseconds
Position Angle	73.8 ± 2.7 degrees

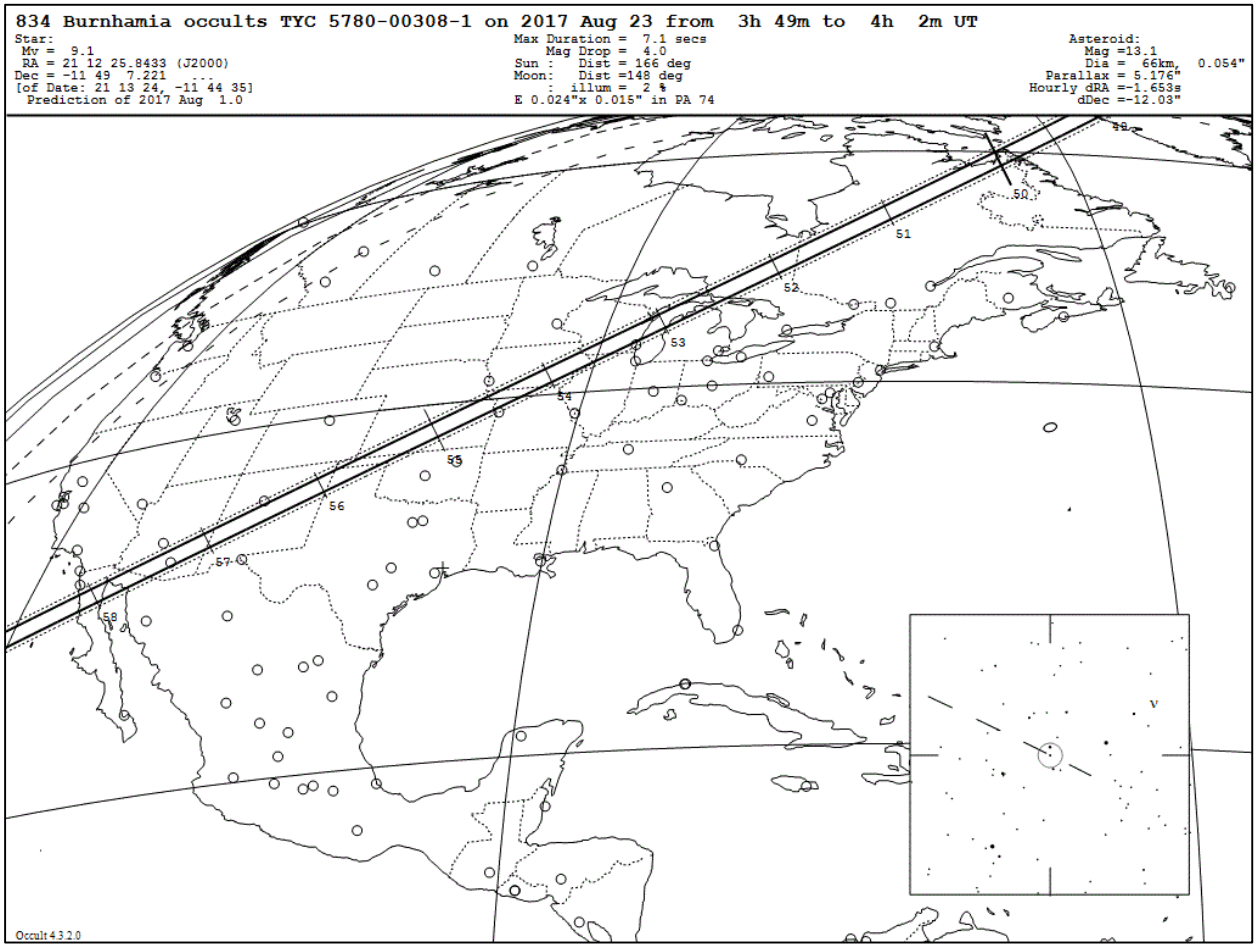

Figure 1. Occultation Path

TYC 5780-308-1 Discovery of Stellar Duplicity During Asteroidal Occultation by (834) Burnhamia

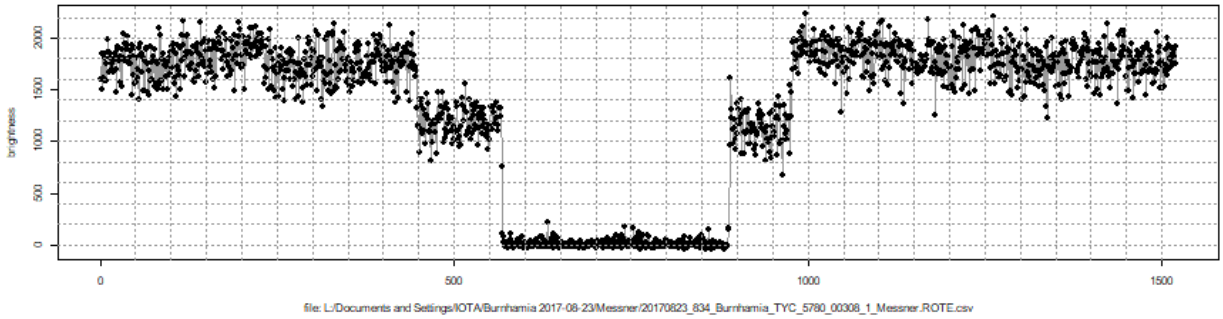

Figure 2. S. Messner light curve. Star was saturated, causing brightness fluctuations in the baseline and abnormal noise in the event bottom. Figure 2 – S. Messner light curve. Star was saturated, causing brightness fluctuations in the baseline and abnormal noise in the event bottom. Figure 2 – S. Messner light curve. Star was saturated, causing brightness fluctuations in the baseline and abnormal noise in the event bottom.

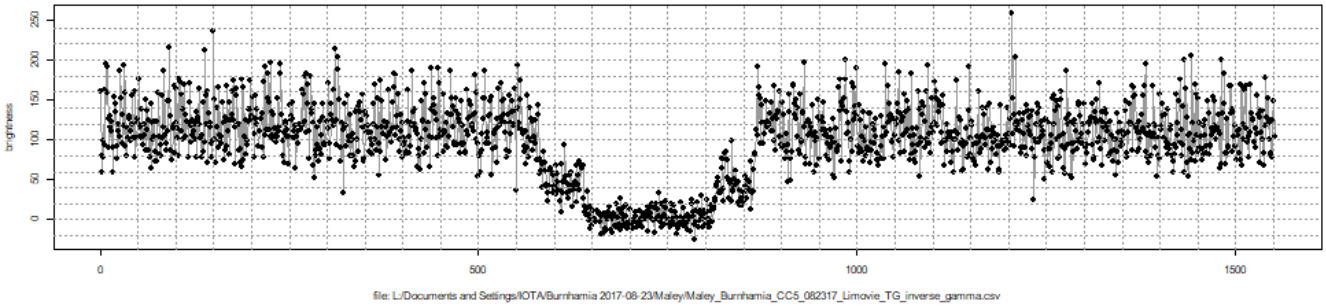

Figure 3. P. Maley light curve. Star was not saturated. Light curve is inverse gamma corrected. First step down is brighter than third step up. Noise in baseline and event bottom is normally distributed.

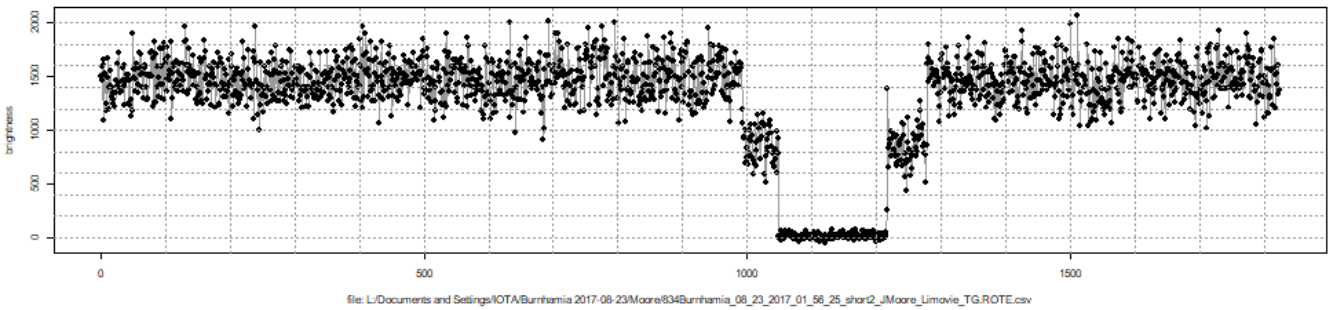

Figure 4. J. Moore light curve. Star was saturated, causing brightness fluctuations in the baseline and abnormal noise in the event bottom.

TYC 5780-308-1 Discovery of Stellar Duplicity During Asteroidal Occultation by (834) Burnhamia

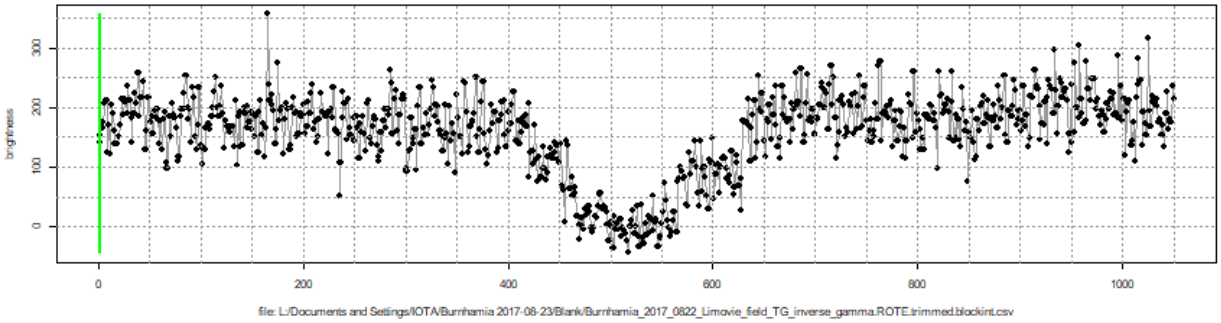

Figure 5. T. Blank light curve. Star was not saturated. Light curve is inverse gamma corrected. First step down is brighter than third step up. Noise in baseline and event bottom is normally distributed.

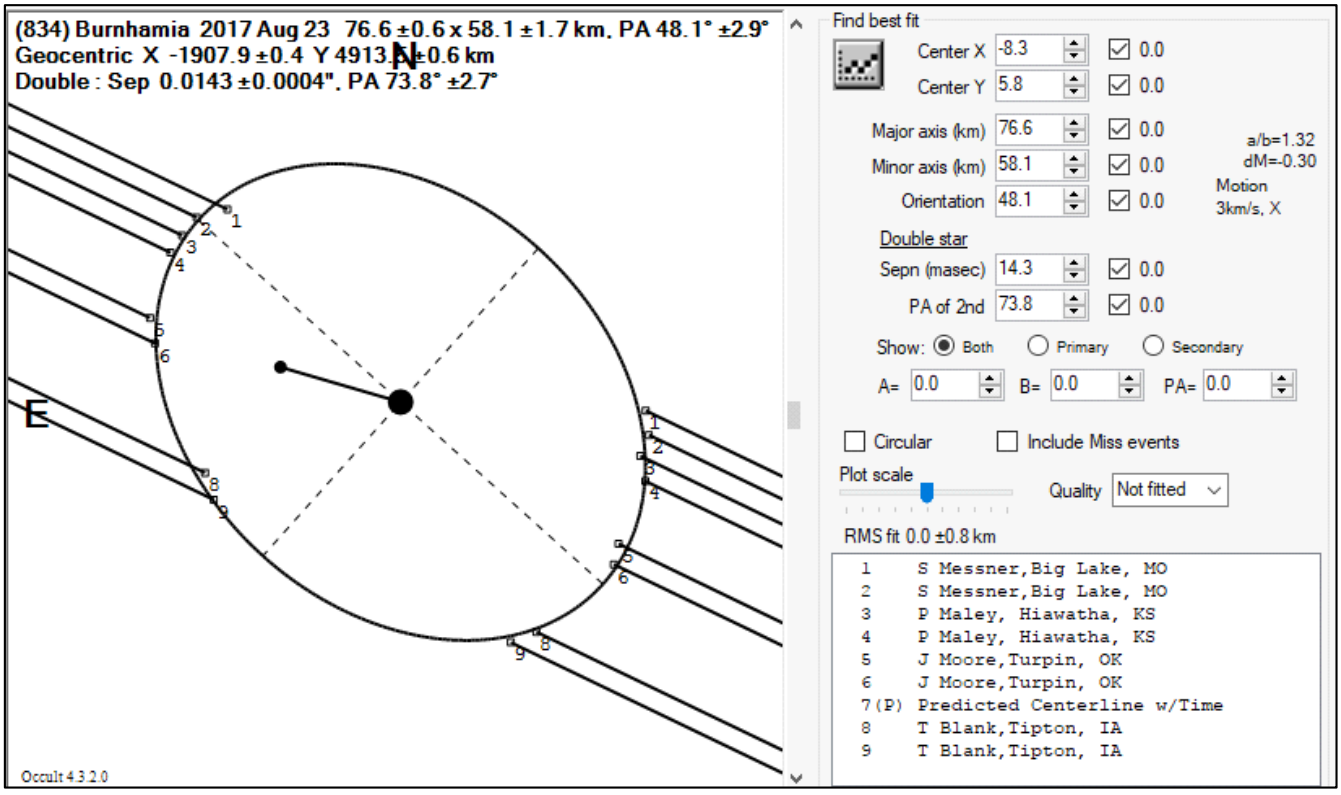

Figure 6. Occultation of TYC 5780-308-1 by (834) Burnhamia

(Continued from page 396)

References

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4. Herald, Dave, et al., "New Double Stars from Asteroidal Occultations, 1971 – 2008", *Journal of Double Star Observations*, **6**(1), 88-96, 2010.
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