

# Discovery of Stellar Duplicity of TYC 1950-02320-1 During Asteroidal Occultation by (141) Lumen

Japan

Mitsuru Sôma ([Mitsuru.Soma@nao.ac.jp](mailto:Mitsuru.Soma@nao.ac.jp))

and Tsutomu Hayamizu, IOTA Japanese Coordinators.

M. Ishida; M. Owada; M. Ida; R. Aikawa, A. Hashimoto, T. Horaguchi,  
K. Kitazaki, S. Uchiyama, S. Uehara, and A. Yaeza; observers

USA

Brad Timerson, IOTA North American Coordinator; T. George, W. Morgan; observers

Netherlands

E. Edens, (observed from USA)

**Abstract:** An occultation of TYC 1950-02320-1 by the asteroid (141) Lumen on 2013 December 28 showed this star to be a double star. Both components of the double star were occulted as recorded by one observer, one component of the double star was occulted by three observers, and 9 observers recorded miss observations. The separation of the two components is  $0.1529 \pm 0.0008$  arcseconds at a position angle of  $105.8 \pm 0.7$  degrees. The magnitude of the primary component is estimated to be 11.25 (V). The magnitude of the secondary component is estimated to be 11.47 (V).

## Observation

On 2013 December 28, thirteen observers occupying or operating sites across the United States and Japan observed the asteroid (141) Lumen occult the star TYC 1950-02320-1. See Figure 1 for the path map of the event. One site in Arizona, USA (George) observed two-separate drops in brightness, neither of which had a mag drop as large as predicted, indicating a double star (see Figure 2). Three sites in Japan (Ishida; Owada; Ida) had only a single drop in brightness (see Figures 3, 4, and 5). For these latter sites, the magnitude drop measured was consistent with observation of the secondary star only. Nine sites had a miss. 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  $10.60 \pm 0.09$ . This is a V magnitude in the Johnson system derived from the

Tycho system magnitudes VT and BT given in the Tycho-2 Catalogue. The asteroid magnitude as predicted by the Minor Planet Center using the magnitude parameter values  $H = 8.4$  and  $G = 0.15$  was 12.54 (V). The combined magnitude of the asteroid and the star was calculated to be 10.43 (V). The expected magnitude drop at occultation was calculated to be 2.11 magnitudes. The star is not listed in the Fourth Interferometric Catalog, nor is it listed in the Washington Double Star Catalog.

## Analysis

The observations were analysed in the standard manner described by IOTA [1].

The finished plot of the double star fit to the data is shown in Figure 6. The double star has a separation of  $0.1529 \pm 0.0008$  arcseconds at a position angle of  $105.8 \pm 0.7$  degrees. Of the data sets that recorded the occul-

*(Continued on page 243)*

### Discovery of Stellar Duplicity of TYC 1950-02320-1 During Asteroidal Occultation by (141) Lumen

141 Lumen occults TYC 1950-02320-1 on 2013 Dec 28 from 13h 13m to 13h 36m UT

Star:	Max Duration = 16.4 secs	Asteroid:
Mv = 10.6 Mp = 11.5 Mr = 10.1	Mag Drop = 2.0 (2.0r)	Mag = 12.4
RA = 9 5 39.253 (J2000)	Sun : Dist = 144 deg	Dis = 145km 0.110"
Dec = 22 34 52.828	Moon: Dist = 91 deg	Parallax = 4.855"
[of Date: 9 6 29, 22 31 15]	: illum = 20 %	Hourly dRA = -1.746s
Prediction of 2013 Dec 12.0	E 0.031"x 0.030" in PA 103	dDec = 0.95"

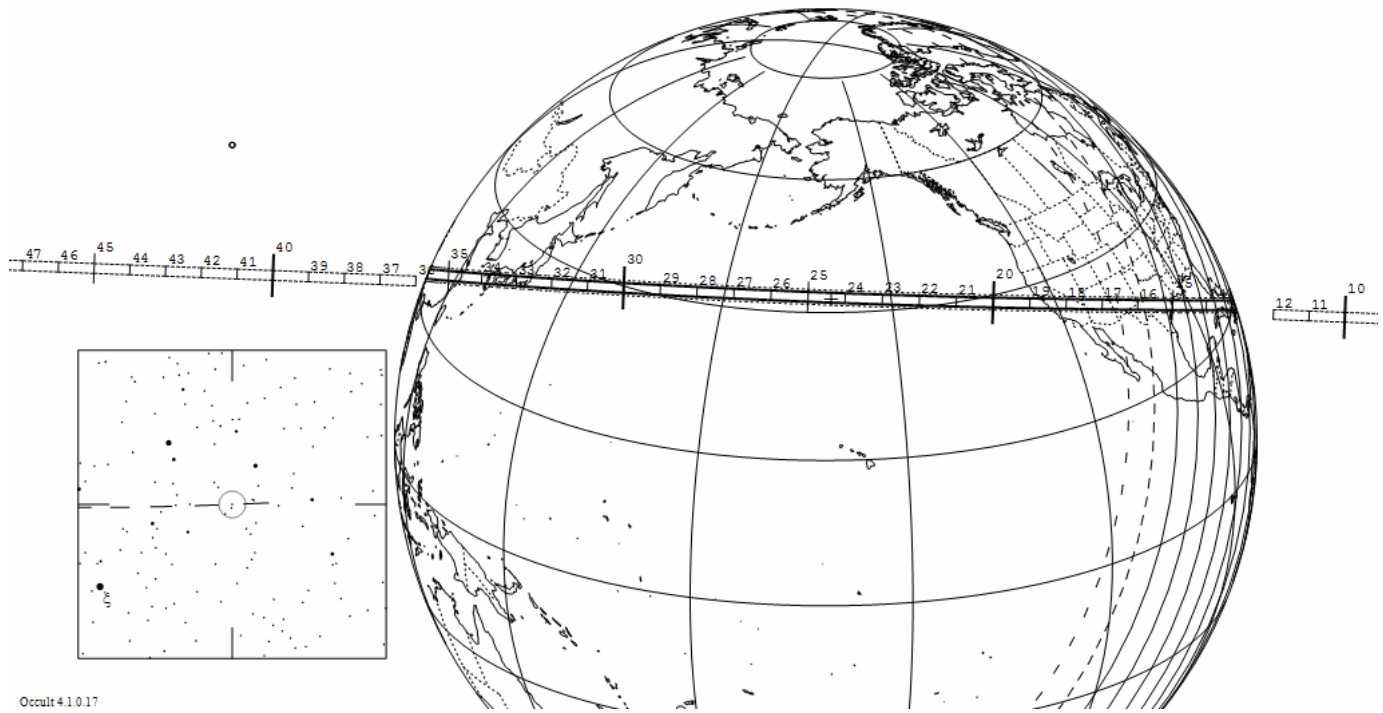
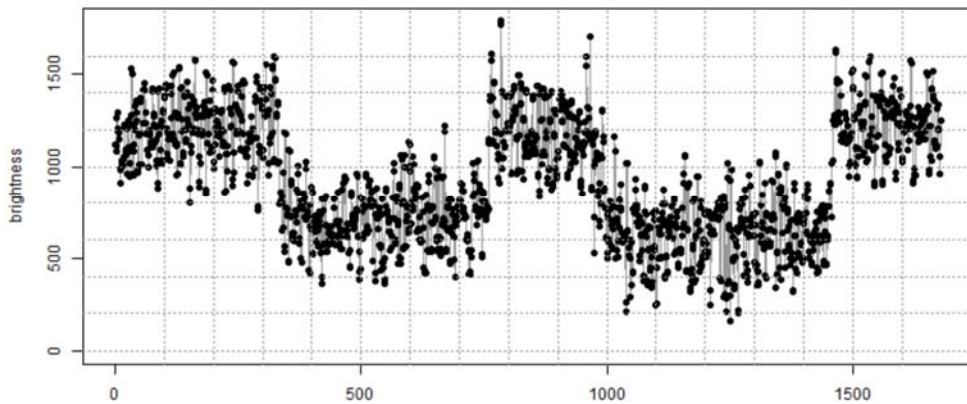


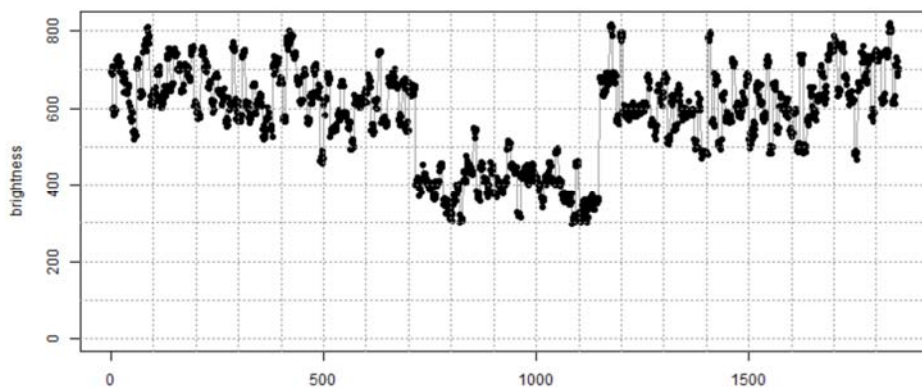
Figure 1. Occultation Path



file: F:/Documents and Settings/NOTA/(141) Lumen 12-28-2013/(141) Lumen 12-28-2013 a3.ROTE.csv

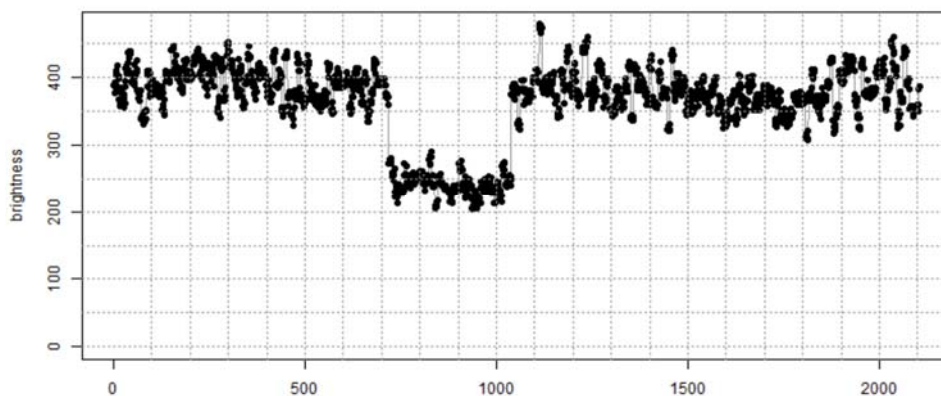
Figure 2. George light curve showing two distinct events

### Discovery of Stellar Duplicity of TYC 1950-02320-1 During Asteroidal Occultation by (141) Lumen



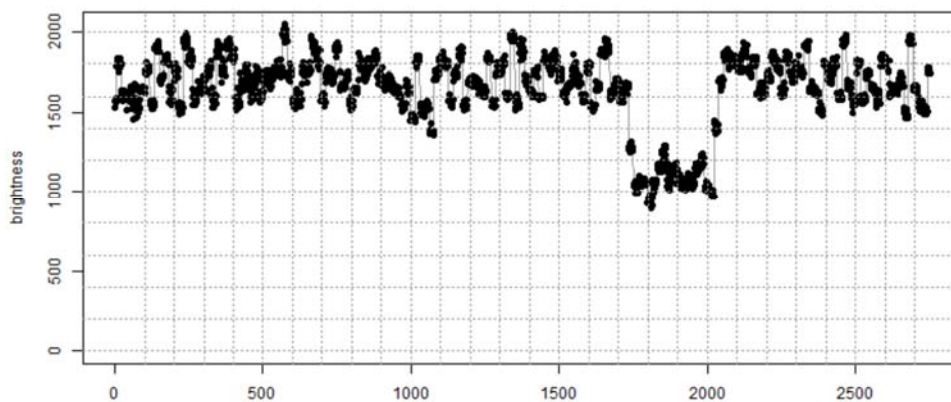
file: F:/Documents and Settings/OTA/(141) Lumen 12-28-2013/Japanese Observations/Masayuki Ishida 2013-12-29 06.43.51 (start 750).

Figure 3. Ishida light curve



file: F:/Documents and Settings/OTA/(141) Lumen 12-28-2013/Japanese Observations/Minoru Owada (141)Lumen20131228.csv

Figure 4 – Owada light curve



file: F:/Documents and Settings/OTA/(141) Lumen 12-28-2013/Japanese Observations/Miyoshi Ida 20131228(141)Lumen02.ROTE.cs

Figure 5 -- Ida light curve

**Discovery of Stellar Duplicity of TYC 1950-02320-1 During Asteroidal Occultation by (141) Lumen**

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

Figure 6 Chords	Observer	Location	State Prefecture	Country	Telescope Type	Telescope Dia (cm)	Method	Result
1	E. Edens	Magdalena	NM	USA/Holland	SCT	15	Video + GPS Time Inst	Miss
2	A. Yaeza	Hitachi	Ibaraki	Japan	SCT	20	Visual + Stop Watch	Miss
3	A. Hashimoto	Chichibu	Saitama	Japan	SCT	40	Visual + Stop Watch	Miss
4	W. Morgan	Pleasanton	CA	USA	SCT	20	Video + GPS Time Inst	Miss
5	R. Aikawa	Sakado	Saitama	Japan	SCT	20	Visual + Stop Watch	Miss
6	T. Horaguchi	Tsukuba	Ibaraki	Japan	Reflector	50	Video + GPS Time Inst	Miss
7	S. Uehara	Tsukuba	Ibaraki	Japan	Reflector	20	Visual + Stop Watch	Miss
8	S. Uchiyama	Kashiwa	Chiba	Japan	SCT	25	Video + GPS Time Inst	Miss
9	K. Kitazaki	Musashino	Tokyo	Japan	Cass	40	Video + GPS Time Inst	Miss
11	M. Ida	Odai	Mie	Japan	SCT	20	Video + GPS Time Inst	One Event
12	M. Owada	Hamamatsu	Shizuoka	Japan	SCT	25	Video + GPS Time Inst	One Event
13	M. Ishida	Taiki	Mie	Japan	SCT	20	Video + GPS Time Inst	One Event
14,15	T. George	Scottsdale	AZ	USA	SCT	30	Video + GPS Time Inst	Two Events

(Continued from page 240)

tation, George recorded both events with magnitude drops suitable for calculating the stellar component magnitudes. Using the light curve data from all observers, the magnitude drops of the two events were calculated using the brightness measurements derived by ROTE [2], the Magnitude calculator routine in Occult4 [3] (Method 3 – Magnitudes from light curve values), the combined V magnitude from the Tych-2 Catalogue and the predicted V magnitude of the asteroid as explained above. The results are shown in Table 2. Note that the measured magnitude drops are instrumental magnitudes with no filters, and we assume that they are not much different from those in V in calculating the magnitude of each component of the double star.

*Table 2 – Calculated magnitude drops*

Observer	1st Event	2nd Event
George	0.56 ± 0.03	0.69 ± 0.03
Owada	0.52 ± 0.02	
Ida	0.49 ± 0.03	
Ishida	0.51 ± 0.03	
Average	0.52 ± 0.02	0.69 ± 0.03

Based on the average magnitude drop estimates for the two components shown in Table 2, the combined magnitude of each component star + asteroid was calculated. The magnitudes of the two component stars were derived by adjusting for the brightness of the asteroid in the light curve. The magnitudes of the two stars are estimated to be 11.25 ± 0.1 (V) primary star and 11.47 ± 0.1 (V) secondary star, and their magnitude difference is estimated to be 0.22 ± 0.06 (V). The event was a BBAA, with the secondary occulted first, then the primary.

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

- Star** TYCHO 1950-02320-1
- UCAC2 39846549
- UCAC4 563-047083
- NOMAD 1125-0200778
- PPMXL 4181982505129551400
- Spectral type F5III [4]
- RA 09h 05m 39.2553s
- Dec +22° 34' 52.828"
- (ICRS(J2000), Epoch 2013 Dec 28)
- 11.25 ± 0.1 (Est. Tycho-2 V mag)
- 11.47 ± 0.1 (Est. Tycho-2 V mag)
- 0.22 ± 0.06
- 0.1529 ± 0.0008 arcseconds
- 105.8 ± 0.7 degrees
- Coordinates (UCAC4)**
- Mag A**
- Mag B**
- Mag Difference**
- Separation**
- Position Angle**

## Discovery of Stellar Duplicity of TYC 1950-02320-1 During Asteroidal Occultation by (141) Lumen

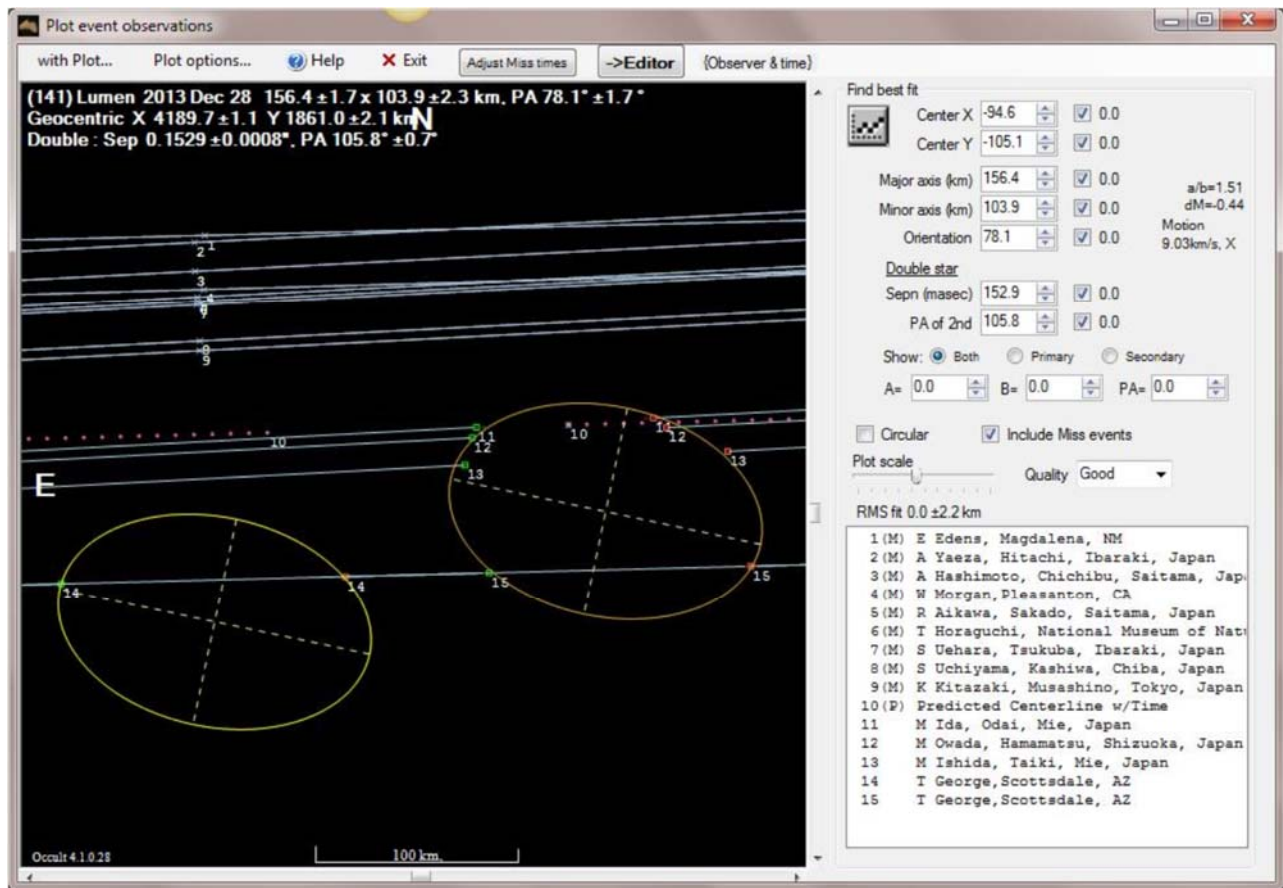


Figure 6. Occultation of TYC 1950-02320-1 by (141) Lumen

## References

1. Herald, David, "New Double Stars from Asteroidal Occultations, 1971 – 2008", *JDSO*, **6**, 88-96, 2010.
2. ROTE – R-Code Occultation Timing Extractor – Presentation at the 2013 Annual IOTA Meeting, October 4–6, 2013; Toronto, Ontario, Canada. <http://www.asteroidoccultation.com/observations/NA/2013Meeting/R-OTE%202013%20IOTA%20Conference.pdf>
3. Occult v4.1.0. Occultation prediction software by David Herald. <http://www.lunar-occultations.com/iota/occult4.htm>
4. Pickles, A. and E. Depagne, "All-Sky Spectrally Matched UBVRI – ZY and u'g'r'i'z' Magnitudes for Stars in the Tycho2 Catalog", *PASP*, **122**, 1437-1464, 2010.