Duplicity Discovery of HIP 33753 from Asteroidal Occultation by (479)Caprera

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Abstract: An occultation of HIP 33753 by the asteroid (479) Caprera on December 10, 2018 showed this star to be a double star. Both components of the double star were occulted as recorded by eight observers. The separation of the two components is 0.0054 ± 0.0004 arc-seconds at a position angle of 46.4 ± 3.7 degrees. The magnitude of the primary component is estimated to be 8.4 ± 0.1 V. The magnitude of the secondary component is estimated to be 8.6 ± 0.1 V.

Observation

On 2018 December 10, eleven observers occupying or operating sites across the Japan observed the asteroid (479) Caprera occult the star HIP 33753. See Figure 1 for the path map of the event [1] and observer's site. Five sites (1, 5, 6, 7, 8 in Figure 1) observed a two-step drop in brightness by recording method to video camera, and three sites (2, 3, 4 in Figure 1) observed gradual events by visual method. These observed events are indicating double star. Three sites had a miss. All recorded occultation times and data from the observers can be found in IOTA records for the event, and mentioned in the "Tenmon-Nenkan (Astronomical annual book)" that will be published from Seibundo-Shinkosya every year in Japanese [2]. The observations were made at the each site and with the equipment shown in Table 1.

The target star is magnitude 7.73V (Hipparcos - VizieR). The asteroid magnitude as predicted by S. Preston was 12.9 V [1]. The calculated combined magnitude of the star and asteroid is 7.72 V. The expected magnitude drop at occultation was 5.8 magnitudes. The star is not listed in the Fourth Interferometric Catalogue, nor is it listed in the Washington Double Star catalog.

Analysis

The observations were analyzed in the standard manner described by R. L. Millis and J. L. Elliot [3]. The result of the calculation reduction is shown in Figure 2. The light curve in site 1 is shown in Figure 3. Similarly, the light curve in site 6 and site 8 is shown in Figure 4 and Figure 5 respectively. In these light curve figures, X-axis is shown the video frame number and Y-axis is shown the brightness [4].

In visual method, "a moment to completely disappear" and "a moment to appear" are judged at "D" and "R" each. So, for visual observers, Star A was observed at "D", but Star B was observed at "R", in this event. In figure 2, letter from "a" to "p" are shown with step events in figure 3 to Figure 5 for the light curves. Then, in Figure 6, Elliptic A is applicable to the observed points for Star A, and Elliptic B is applicable to the observed points for Star B. The dimensions of each elliptic A and B were estimated by the least-squares method [5], as follows.

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Table 1. Site number, Observers, equipment, methods, and results

Site No.	Observer(s)	Location	State	Telescope Type	Telescope Dia (cm)	Method	Fig. 2 Chords	Result
1	Shigeo Uchiyama	Kashiwa	Chiba	SCT	25	Video+GPS Time Inst.	1	Two-Step
2	Reijin Aikawa	Sakado	Saitama	SCT	20.3	Visual+SW Time Signal	2	Gradually
3	Akie Hashimoto	Chichibu	Saitama	SCT	40	Visual+SW GPS Signal	3	Gradually
4	Kazumi Terakubo	Fuchu	Tokyo	Refractor	7.6	Visual+Tape Time Sig.	4	Gradually
5	Mikiya Sato	Fuchu	Tokyo	Telephoto	(F2.8)	Movie+BPM Time Signal	5	Two-step
6	Toshio Hirose	Ohta-ku	Tokyo	Refractor	6.5	Video+JJY Time Inst.	6	Two-step
7	Kunihiro Shima	Fujimi	Nagano	SCT	45	Movie+NPT	7	Two-Step
8	Hideto Yamamura	Hakusan	Ishikawa	SCT	20	Video+GPS Time Inst.	8	Two-D/R
9	Toshihiro Horaguchi	Tsukuba	Ibaraki	SCT	50 6	Video+GPS Time Inst. Visual	-	Miss
10	Satoshi Watanabe	Oyama	Tochigi	SCT	30	Movie+JJY Time Signal	-	Miss
11	Hideto Watanabe	Inabe	Mie	Refractor	13	Video+GPS Time Inst.	-	Miss

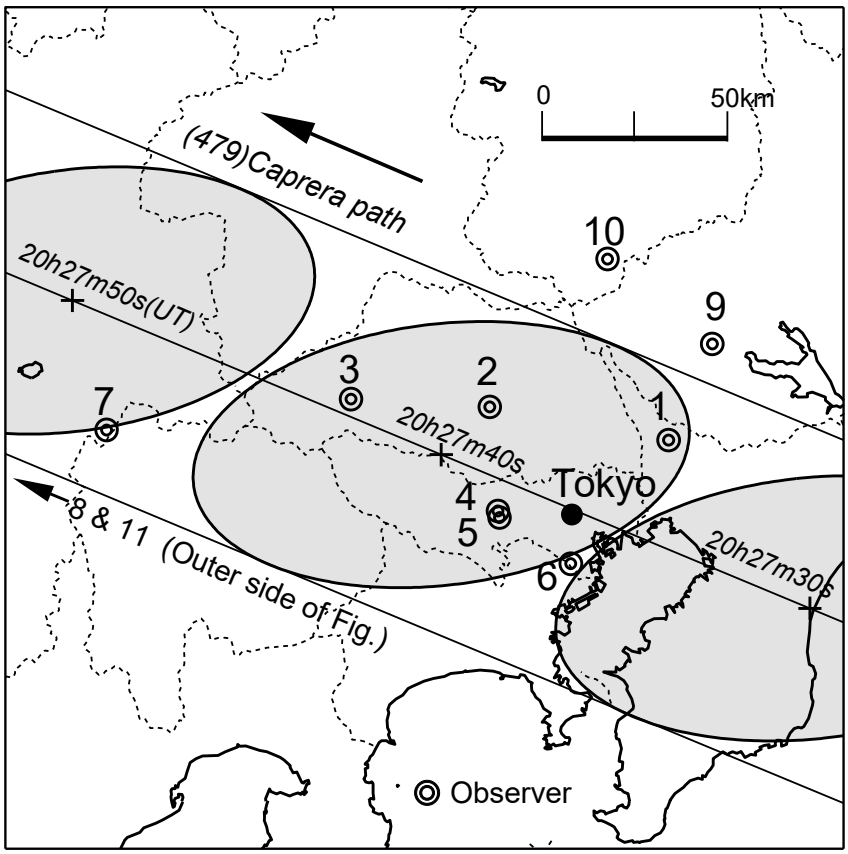

Figure 1: (479)Caprera Predicted path on 2018 December 10 (U.T.) & Observer's Site number

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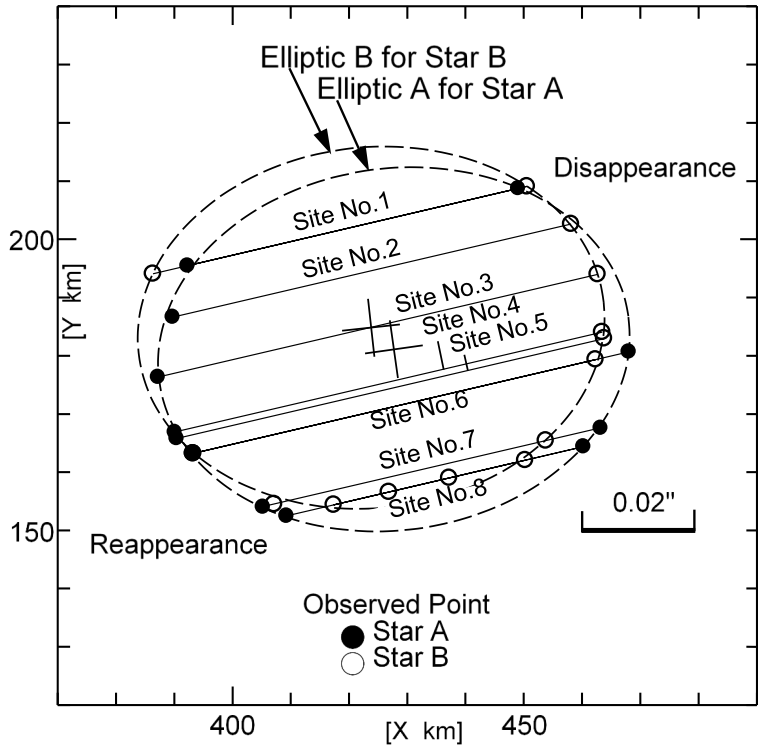

Figure 2. Occultation Reduction showing distinct step-event on D and R by Star A and B

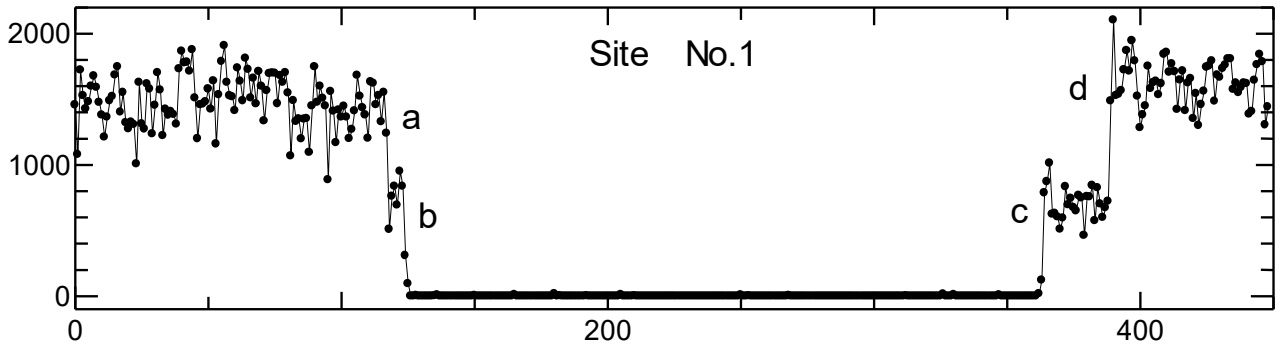

Figure 3. Site No.1 light curve showing distinct two-step event on D (a, b) and R (c, d)

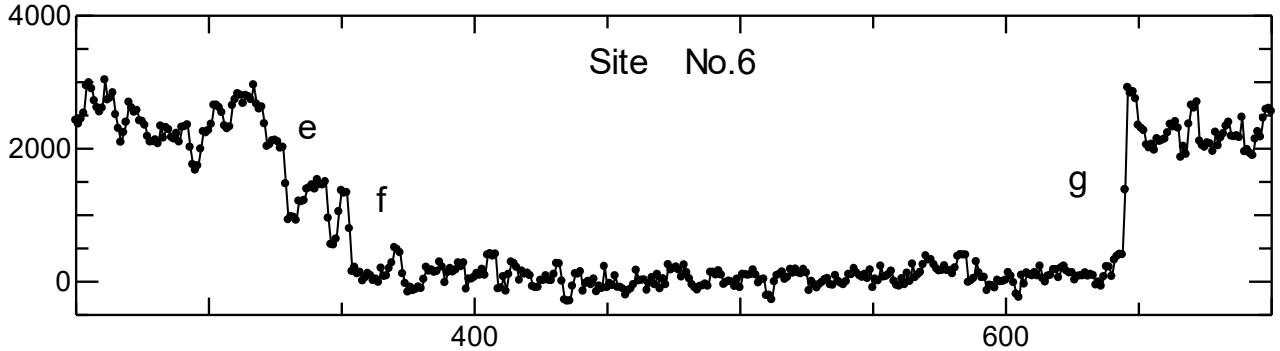

***Figure 4**: Site No.6 light curve showing two-event on D (e, f) and no step–event on R (g)*

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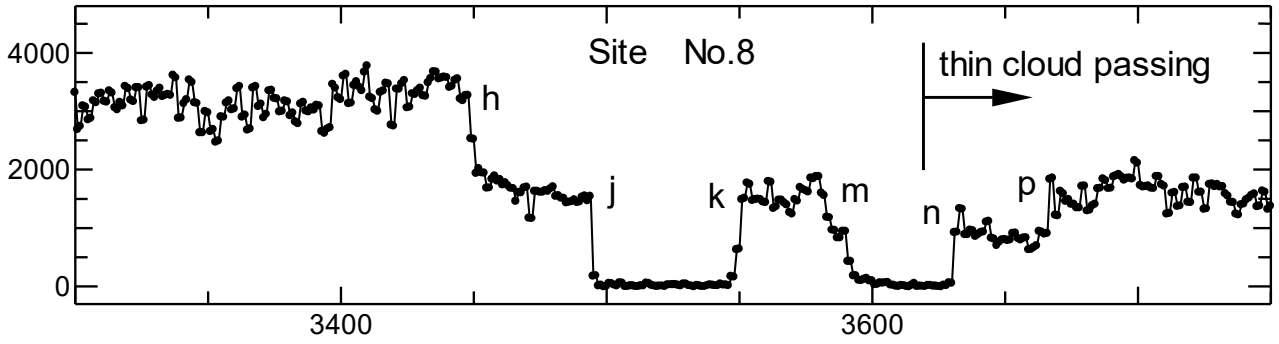

Figure 5. Site No.8 light curve showing two-event on D (j, m) & R (k, n) by Star B only

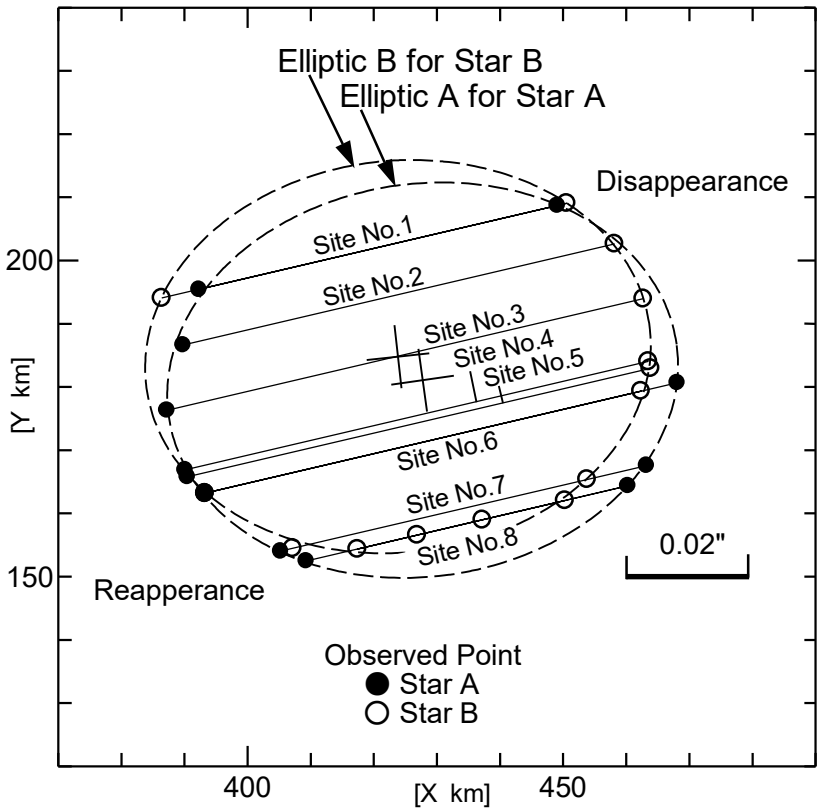

Figure 6. Elliptic A and B adapts to the observed point for Star A and Star B each

Table 2:Star A and Star B, Magnitude from the brightness level

Points on the light curve in Figs. 3-5	Brightness Level	Calculated Star Magnitude
a	1482±132	Star A= 8.44 Star B= 8.51
b	763±103	
c	706±82	Star A= 8.34 Star B= 8.63
d	1626±114	
e & g	2385±247	Star A= 8.38 Star B= 8.57
f	1094±212	
h	3223±308	Star A= 8.42 Star B= 8.53
j,k,m	1526±136	

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Elliptic A

Dimension (80.3 ± 0.3) km x (62.0 ± 0.6) km
Axis Angle 6.3 ± 0.8 degree
Center Coordinates
X (423.825 ± 0.132) km, **Y**(184.799 ± 0.178) km

Elliptic B

Dimension (81.3 ± 0.7) km x (62.1 ± 1.1) km
Axis Angle 8.0 ±1.5 degree
Center Coordinates
X (427.734 ± 0.270) km, **Y**(181.075 ± 0.340) km

As for these two shapes, the dimensions should accord when they suppose that the form of the asteroid has a geometric ellipse. However, the different dimensions may be caused by the irre-gularity on the rim of the asteroid, otherwise. So the difference of two central locations in the coordinate means elongation of the double star.

Based on the data presented in these values and the equatorial horizontal parallax of the asteroid (6.558 arcsecond), the separation of the two components is 0.0054 ± 0.0004 arc-seconds at a position angle of 46.4 ± 3.7 degrees.

Magnitude estimates for each component were made using the brightness measurements provided by the values on Table 2. The magnitudes of the two stars are estimated to be 8.40 V and 8.56 V [6].

The finished plot of the double Based on the data presented in this report, the double star characteristics are:

Star: HIP 33753 – magnitude 7.73
SAO 96373
TYCHO 2 0756-01375-1
PPM 123384
HD 52154
UCAC4 514-035495
Spectral type A2
Coord. (J2000) 07 00 39.3118
+12 44 24.054 (Simbad [7])
Mag A 8.4 ± 0.1 V (Estimated from HIP)
Mag B 8.6 ± 0.1 V (Estimated from HIP)
Sep. 0.0054 ± 0.0004 arc-seconds
P.A. 46.4± 3.7degrees
Epoch 2018.945

Finally, point of “m” may show another star within Star B, in figure 5.

References

1. Asteroid Occultation Updates, Steve Preston, http://www.asteroidoccultation.com/
2. Tenmon-Nenkan p226-223, Toshio Hirose et al. Seibundo-Shinkosya, 2018
3. Asteroid p98-118, Tom Gehrels, University of Arizona Press, 1979
4. Limovie software, Light curve measurement tool http://astrolimovie.info/
5. Data Analysis, Takashi Awaya, Gakkai Press Center, 1991
6. The Observer’s Guide To Astronomy Vol.1, p533 , Patrick Martinez, Cambridge University Press, 1994
7. Coordinates ICRS (equinox and epoch=J2000.0) as reported in Simbad