

Discovery of Stellar Duplicity of TYC 1957-01497-1 During Asteroidal Occultation by (362) Havnia

Tsutomu Hayamizu (haya@po2.synapse.ne.jp)

and Mitsuru Sôma, IOTA Japanese Coordinators.

Hayato Watanabe; Akira Asai; Hiroyuki Watanabe; Hidenori Nohara (Japan)

Abstract

An occultation of TYC 1957-01497-1 by the asteroid (362) Havnia on 2021 February 27 showed this star to be a double star. The occultation was observed by three observers in Japan and all of them recorded the occultation of both components. In addition one observer recorded a missed observation. The separation of the two components is found to be 0.0068 ± 0.0005 arcseconds at a position angle of 36.4 ± 3.5 degrees. The magnitude of the primary component is estimated to be 11.99 (V) and the magnitude of the secondary component is estimated to be 12.21 (V).

Observation

On 2021 February 27, four observers occupying or operating sites across Japan observed the asteroid (362) Havnia occult the star TYC 1957-01497-1. See Figure 1 for the path map of the event. Three of the four observers recorded the occultation and all the occultation light curves of

these three indicate that the star is a double star (see Figures 2, 3, and 4). 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.

Fig.5 Chords	Observer	Location	Prefecture	Telescope		Method	Result
				Type	Dia(cm)		
1,2	Hayato Watanabe	Inabe	Mie	Refr	13	Video+GPS Time Inst	Both comp
3,4	Akira Asai	Inabe	Mie	SCT	35.5	Video+GPS Time Inst	Both comp
5,6	Hiroyuki Watanabe	Tarui	Mie	SCT	35	Video+GPS Time Inst	Both comp
7	Hidenori Nohara	Utsunomiya	Tochigi	Refl	40	Video+GPS Time Inst	Miss

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

The target star is magnitude 11.34 ± 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 by the formula $V = VT - 0.090(BT - VT)$ [1]. The asteroid magnitude as predicted using the magnitude parameter values $H = 9.00$ and $G = 0.15$ was 12.79 (V). The combined magnitude of the asteroid and the star was calculated to be 11.09 (V). The expected magnitude drop at occultation was calculated to be 1.70 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 [2].

Discovery of Stellar Duplicity of TYC 1957-01497-1 During Asteroidal Occultation by (362) Havnia

The finished plot of the double star fit to the data is shown in Figure 5. The double star has a separation of 0.0068 ± 0.0005 arcseconds at a position angle of 36.4 ± 3.5 degrees. All of the three observers Hayato Watanabe, Akira Asai, and Hiroyuki Watanabe recorded the occultations of both components. Using the light curve data from all these observers, the

Observer	Magnitudes	
	Primary	Secondary
Ha. Watanabe	11.85	12.41
Akira Asai	12.07	12.12
Hi. Watanabe	12.05	12.12
Average	11.99 ± 0.09	12.21 ± 0.12

Table 2 – Calculated magnitudes

magnitude drops of the two events were calculated and using the combined V magnitude from the Tycho-2 Catalogue and the predicted V magnitude of the asteroid as explained above the magnitudes of the primary and the secondary stars were obtained for each observer as shown in Table 2. By averaging the magnitudes of the two stars, their individual magnitudes are estimated to be 11.99 ± 0.09 (V) for the primary star and 12.21 ± 0.12 (V) for the secondary star. The event was a BABA, i.e. both at the disappearance and reappearance the secondary event occurred first and then the primary except that only the reappearances of the both components at the site of Akira Asai occurred almost at the same time.

Based on the data presented in this report, the double star characteristics as shown in the plot in Figure 5 are:

Star TYCHO 1957-01497-1
 UCAC2 41539564
 UCAC4 590-046804
 NOMAD 1178-0223742
 PPMXL 4195146935747477964
 Spectral type G3 [3]

Coordinates (Gaia EDR3) RA 09h 16m 10.4048s
 Dec +27° 49' 42.268" (ICRS (J2000), Epoch 2021 Feb 27)

Mag A 11.99 ± 0.09 (Estimated from Tycho-2 V mag)

Mag B 12.21 ± 0.12 (Estimated from Tycho-2 V mag)

Separation 0.0068 ± 0.0005 arcseconds

Position Angle 36.4 ± 3.5 degrees

Discovery of Stellar Duplicity of TYC 1957-01497-1 During Asteroidal Occultation by (362) Havnia

362 Havnia occults TYC 1957-01497-1 on 2021 Feb 27 from 8h 57m to 9h 18m UT

Star:
 Mag V = 11.0
 RA = 9 16 10.4048 (astrometric)
 Dec = 27 49 42.268
 [of Date: 9 17 26, 27 44 24]
 Prediction of 2020 Dec 31.0

Max Duration = 9.9 secs
 Mag Drop = 2.1 (0.0r)
 Sun : Dist = 152°
 Moon: Dist = 27°
 : illum = 100 %
 E 0.029"x 0.015" in PA 109

Asteroid:
 Mag = 12.9
 Dia = 92 ± 5km, 0.077"
 Parallax = 5.347"
 Hourly dRA = -2.103s
 dDec = -0.68"

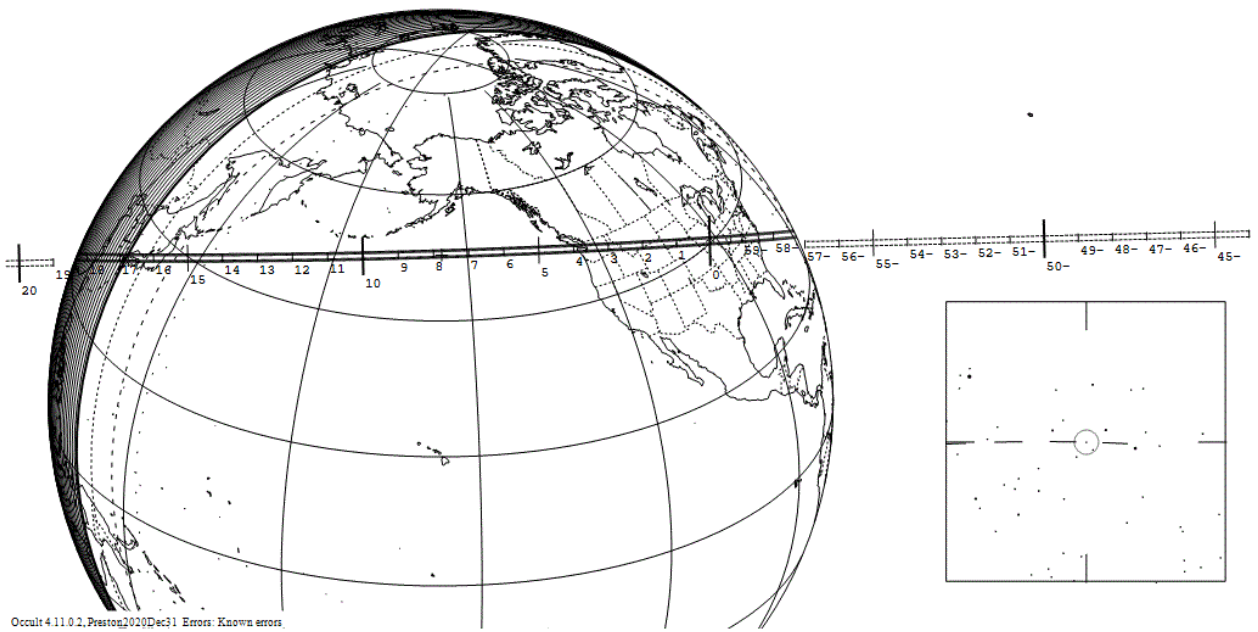
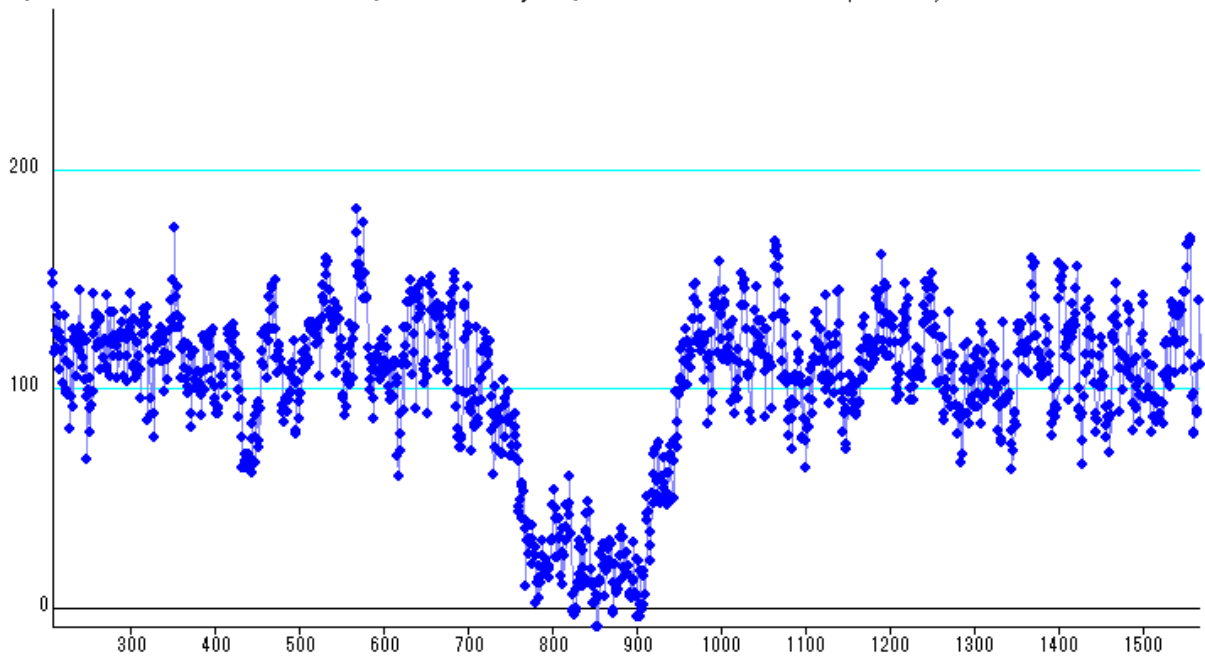
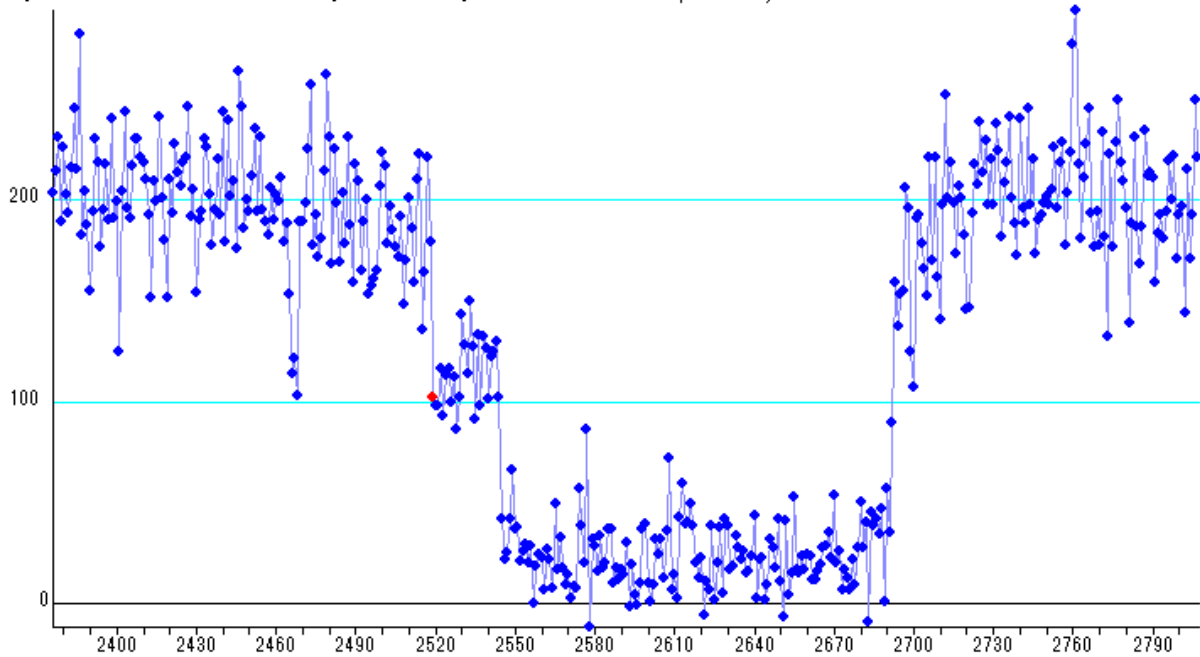


Figure 1 -- Occultation Path

Discovery of Stellar Duplicity of TYC 1957-01497-1 During Asteroidal Occultation by (362) Havnia**(362)Havnia occults TYC1957-1497-1 : 2021 February 27 : Ha Watanabe / PSF-Frame photometry /***Figure 2 – Light curve obtained by Hayato Watanabe***(362)Havnia / TYC 1957-01497-1 : 2021Feb27 : A. Asai / PSF-Frame photometry /**

Frame No.2519.0 / Frame Centre= 9h16m12.6623s, Frame End= 12.6862s

Figure 3 – Light curve obtained by Akira Asai

Discovery of Stellar Duplicity of TYC 1957-01497-1 During Asteroidal Occultation by (362) Havnia

(362)Havnia_TYC1957-01497-1 : 2021 February 27 : Hi. Watanabe / PSF-Frame photometry /

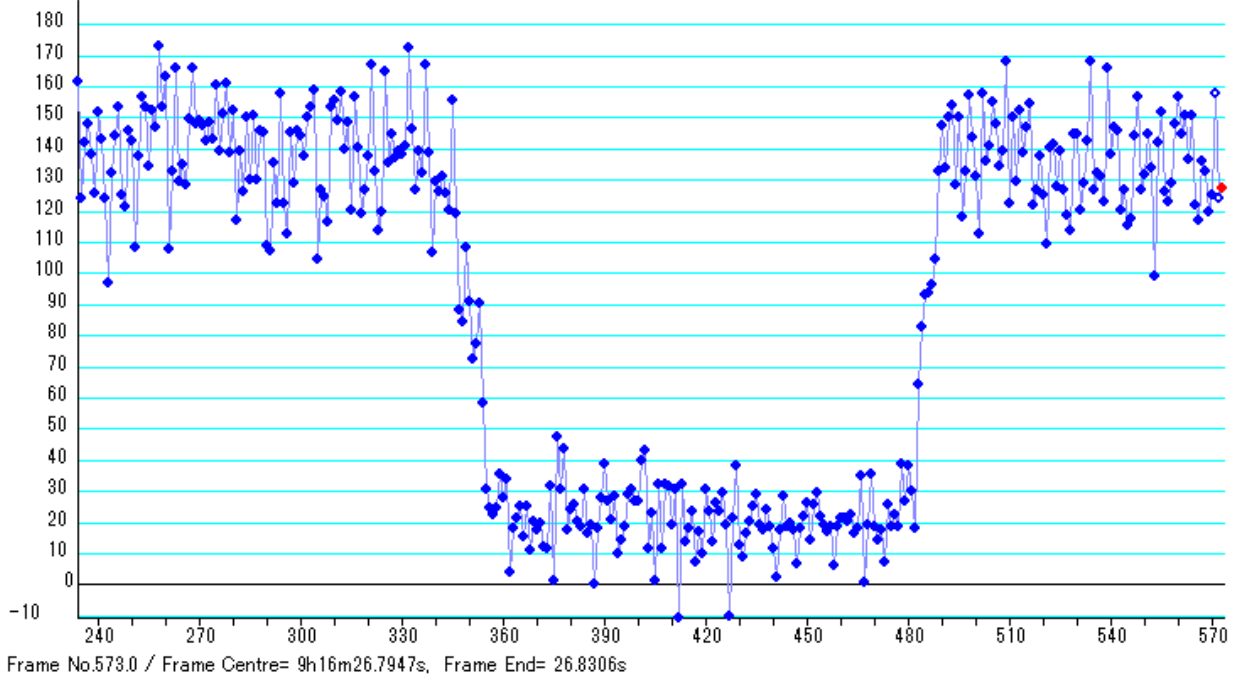


Figure 4 – Light curve obtained by Hiroyuki Watanabe

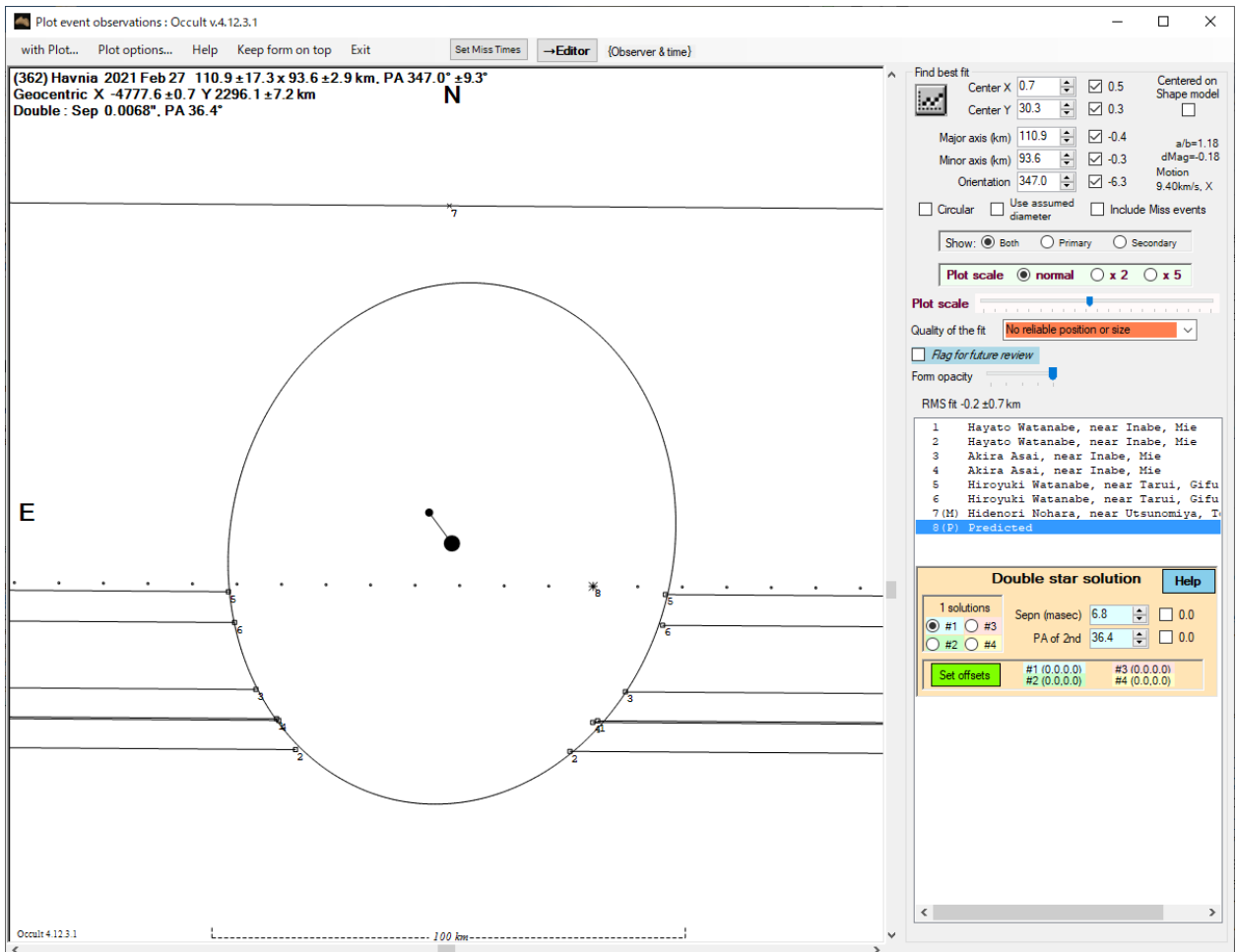


Figure 5: Occultation of TYC 1957-01497-1 by (362) Havnia

Discovery of Stellar Duplicity of TYC 1957-01497-1 During Asteroidal Occultation by (362) Havnia**Acknowledgements**

The authors are most grateful to Dave Herald of Australia, who helped the authors analyzing the occultation results.

References

1. European Space Agency, *Hipparcos and Tycho Catalogues*, 1, Sect. 1.3, Appendix 4, 1997.
2. Herald, David, "New Double Stars from Asteroidal Occultations, 1971 – 2008", *JDSO* 6, 88-96, 2010.
3. Bai, Yu et al., "The UV emission of stars in the LAMOST survey. I. Catalogs", *ApJS*, 235:16, 2018.