TYC 2392-01288-1, Discovery of Stellar Duplicity During Asteroidal Occultation by (283) Emma

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Abstract: An occultation of TYC 2392-01288-1 by the minor planet (283) Emma on November 24, 2020 showed this star to be a previously unknown double star. The occultation of the main component alone was observed by one visual double station in Algeria. The occultation of the secondary component alone was observed by three stations in Czechia and Italy. Two negative observations were also reported from Slovakia and Switzerland. From a Gaia G magnitude of 8.73 for the target star, an estimated V magnitude of 12.8 for the asteroid, and a 0.18 mag drop measured for the occultation of the secondary component, we conclude that the approximate G (or V) magnitudes of the two components are 8.9 and 10.7. Two solutions for the separation and position angle of the components are derived from a fit of the chords on the 3D model DAMIT #1859 of the asteroid. The separation of the two components in solution 1 is found to be 0.7000 ± 0.0038 arcseconds at a position angle of 105.0 ± 0.2 degrees. The separation of the two components in solution 2 is found to be 0.7530 ± 0.0026 arcseconds at a position angle of 109.6 ± 0.2 degrees.

Circumstances

On November 24, 2020 an occultation of TYC 2392-01288-1 by (283) Emma and its moon S2003-283-1 was first predicted by Steve Preston (using Occult software) to pass across Russia, Europe and North Africa. Figure 1 shows the predicted path of the main body's shadow, and Figure 2 shows the predicted path of its moon's shadow, about 450 km to the northwest.

The predicted magnitude drop was 4.1 (V) with a predicted max duration of 11.5 s for Emma and 0.9 s for its moon.

Observations

Seven reports from six different stations were received for this event (summarized in Table 1). Three stations in Europe, one in Czechia and two in Italy, originally waiting for a possible short occultation by the asteroid's moon, recorded actually a ~10 s event with a very low 0.1-0.2 magnitude drop, suggesting that the target star is double and that the asteroid has occulted a faint companion from these locations (Figures 3, 4 and 5). Fortunately, the occultation of the main star was also observed by a team of observers in Algeria, divided in two groups to make a visual double station, who reported a 7 s occultation allowing the measurement of the double star. Two additional stations from

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Slovakia and Switzerland reported a negative observation. No occultation by Emma's moon was observed.

The three positive observations in Europe were recorded with analog or digital cameras, all linked directly to a GPS 1PPS time source allowing an accurate absolute timing. One of these observations was reported as uncertain because of a noisy recording, but is confirmed by another close positive.

The two visual observations in Algeria were audio-recorded on a smartphone using a NTP application as a time source. The raw occultation times, extracted with Audacity, have been corrected from a standard reaction time of 0.4 s, and the global uncertainties have been estimated to be ± 1 s.

#	Observers	Location	Aperture	Method	Exp. time	Result
1	S. Sposetti (CH)	E 09 01 26.5 N 46 13 53.2	280 mm	WAT-902H2 U VTI + GPS 1PPS	0.04 s	Negative
2	P. Zeleny (CZ)	E 17 58 24.5 N 49 27 47.9	254 mm	QHY-174M GPS	0.02 s	Positive 10.36 s
3	M. Bigi (IT)	E 10 08 19.0 N 44 01 33.9	200 mm	WAT-910BD VTI + GPS 1PPS	0.02 s	Positive 10.41 s
4	P. Baruffetti (IT)	E 10 07 56.7 N 44 01 17.0	300 mm	WAT-910HX VTI + GPS 1PPS	0.04 s	Uncertain positive 9.73 s
5	P. Nosal (SK)	E 19 17 49.3 N 48 33 24.8	250 mm	ZWO ASI120MM NTP	0.05 s	Negative
6	O. Bouazara, H. Rayane, A. Bendjeddou (DZ)	E 02 37 05.8 N 33 57 29.7	120 mm	Visual Audio recording NTP	-	Positive 7.0 s
7	A. Gacem, M. Khenifer, T. Selimi (DZ)	E 02 37 05.5 N 33 57 29.2	120 mm	Visual Audio recording NTP	-	Positive 7.0 s

Table 1. Summary of the observations received. The complete data set with occultation times is available at Euraster website and in the Occult database.

The photometry and the occultation time extraction of the video recordings have been performed with Tangra/AOTA and PyOTE/PyMovie. For convenience, the light curves presented in this paper are all plotted with PyOTE.

Magnitudes

The light curve with the best signal-to-noise ratio (P. Zeleny, Figure 3) has been used to measure a 0.18 magnitude drop for the secondary star occultation (unfiltered observation). Using this mag drop, a Gaia G magnitude for TYC 2392-01288-1 of 8.73 and a predicted V magnitude for (283) Emma of 12.8, we conclude that the approximate G (or V) magnitudes of the two components of the double star are 8.9 and 10.7.

Occultation fit and Spatial Separation

The double star parameters were determined by the alignment of the chords from the primary and secondary star events as described in Herald, *et al.* 2010. Since the low number of chords did not make possible the adjustment of an elliptical fit for any of the two primary and secondary star events, the chords were first roughly aligned using a circular fit. The alignment was then manually refined using the 3D model DAMIT #1859 (Viikinkoski, *et al.* 2017, Durech, *et al.* 2010) which is consistent with the available chords from the secondary star event. Two solutions were derived for the Separation and Position Angle (Table 2). Solution 1 gives a separation of 0.7000 ± 0.0038 arcseconds at a position angle of 105.0 ± 0.2 degrees

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(Figure 6). Solution 2 gives a separation of 0.7530 ± 0.0026 arcseconds at a position angle of 109.6 ± 0.2 degrees (Figure 7). For each solution above, uncertainties are estimated from an elliptical fit made on the aligned chords, once adjusted on the 3D model.

Asteroidal occultation observations usually discovering double stars with very small separations, it's worth noticing that this observation is the double star with the largest separation discovered by this technique.

Name	RA+Dec	Mags	PA	Sep	Date	N	Note
xxxxxxx	050153+3214	8.9 10.7	105.0	0.7000	2020.901	1	Soln 1
xxxxxxx	050153+3214	8.9 10.7	109.6	0.7530	2020.901	1	Soln 2

Table 2. Two possible solutions for the double star.

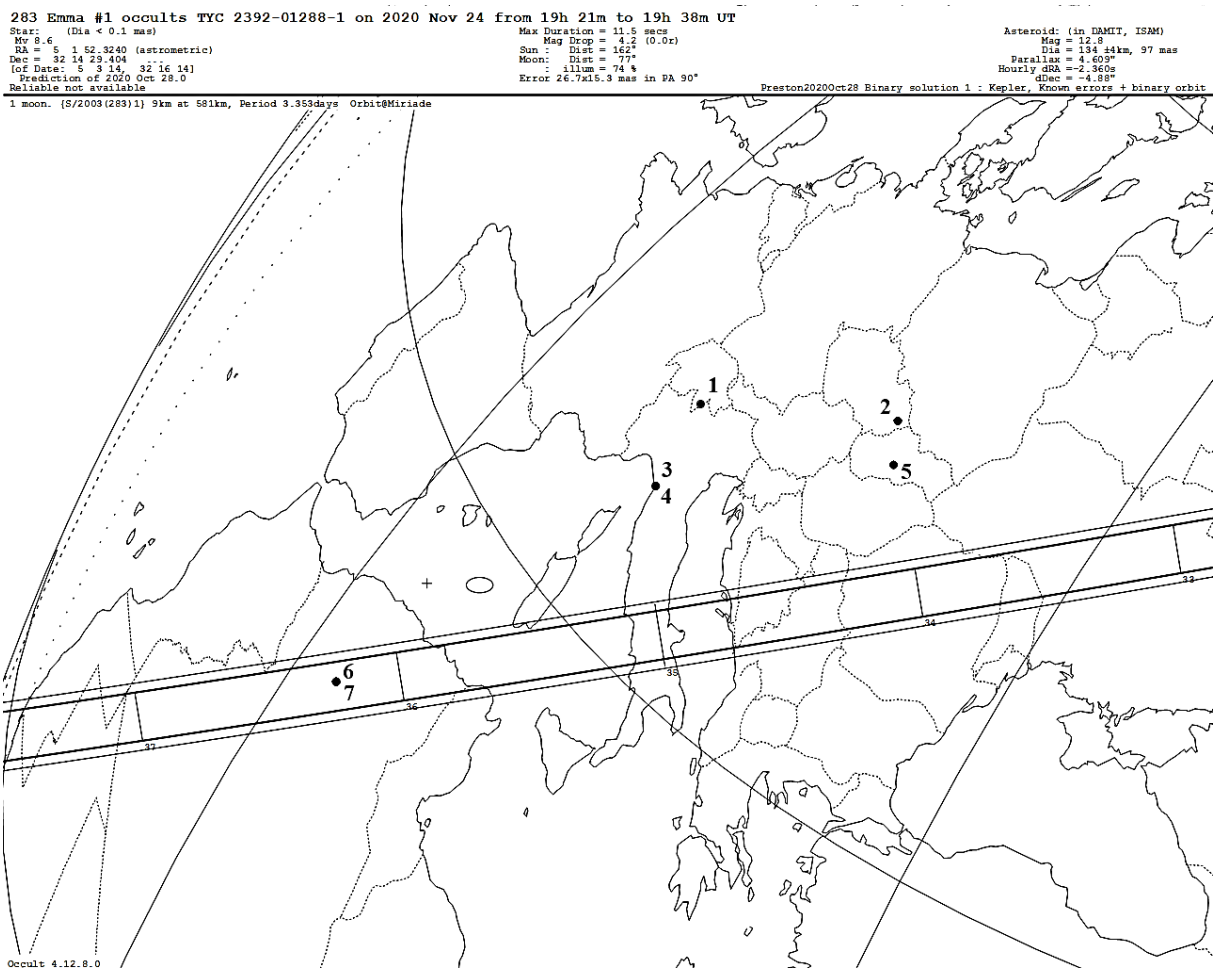

Figure 1. Predicted path for the occultation by (283) Emma on November 24, 2020 (Steve Preston). The observing stations are reported on the map. The station numbers are those visible in Table 1.

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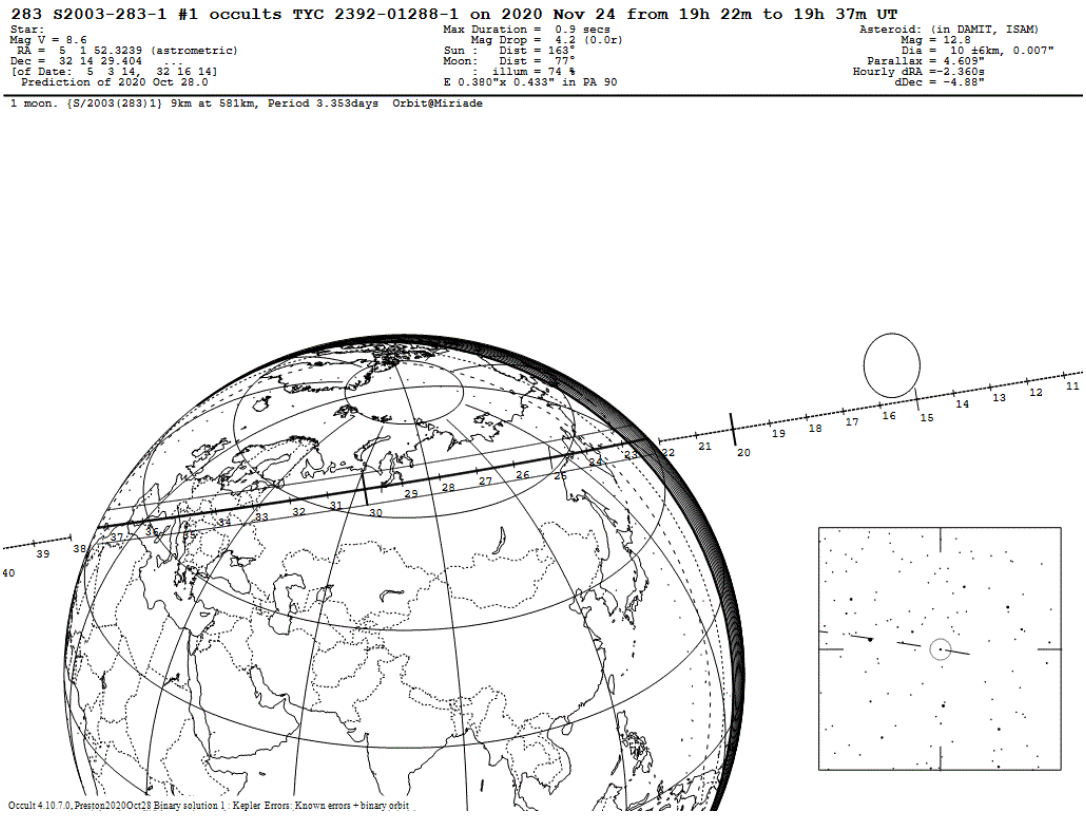

Figure 2. Global map of the predicted path for the occultation by S2003-283-1 (Miriade).

Figure 3. P. Zeleny light curve. Occultation of the secondary star. The 0.18 magnitude drop used in this paper has been measured with this light curve.

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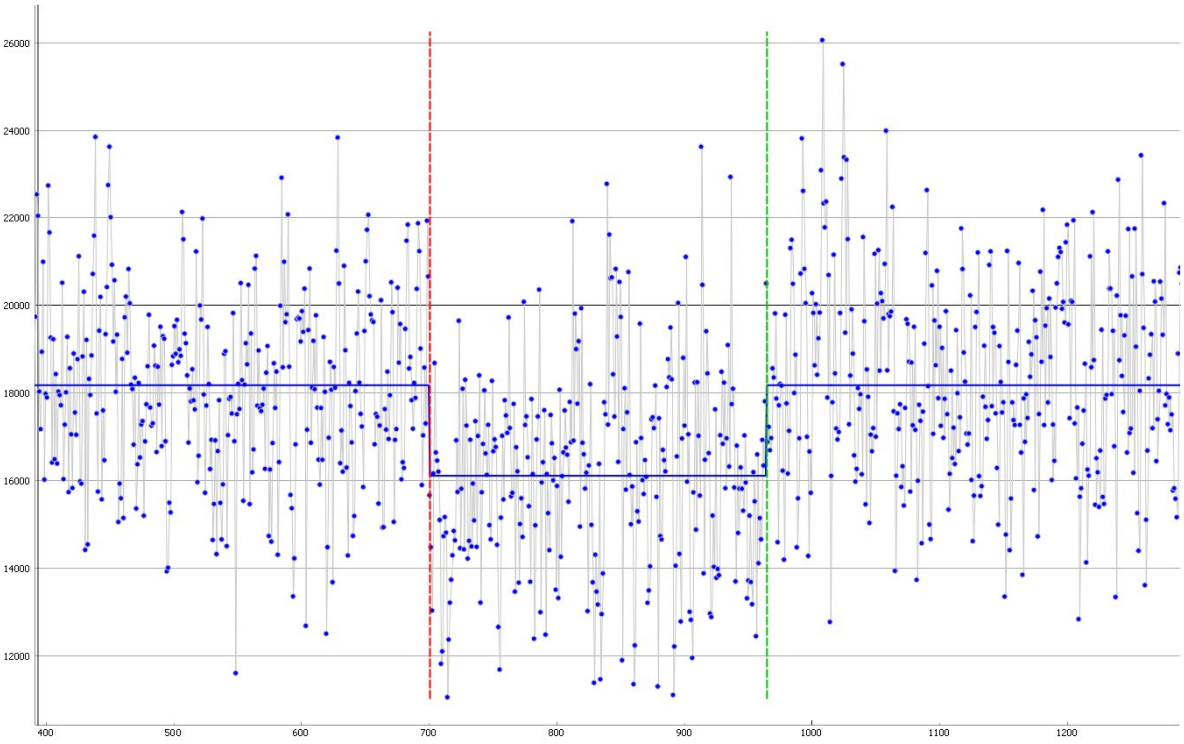

Figure 4. M. Bigi light curve. Occultation of the secondary star.

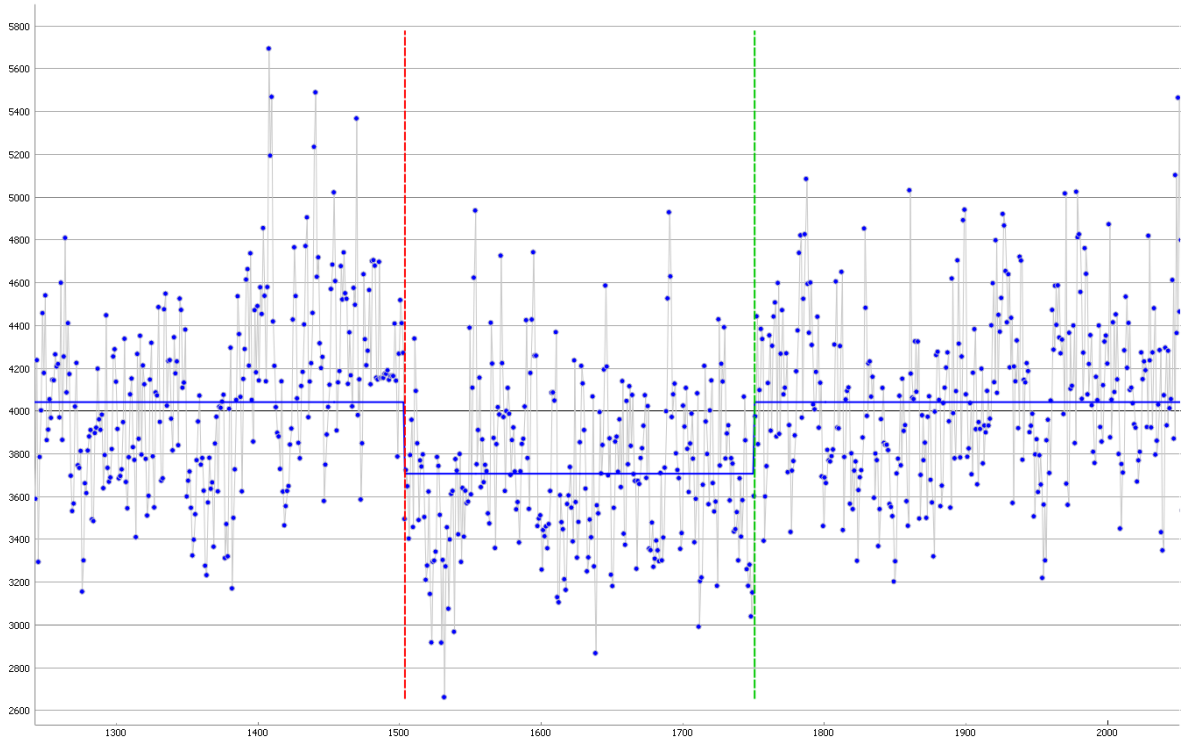

Figure 5. P. Baruffetti light curve. Occultation of the secondary star, reported as uncertain but confirmed by M. Bigi observation.

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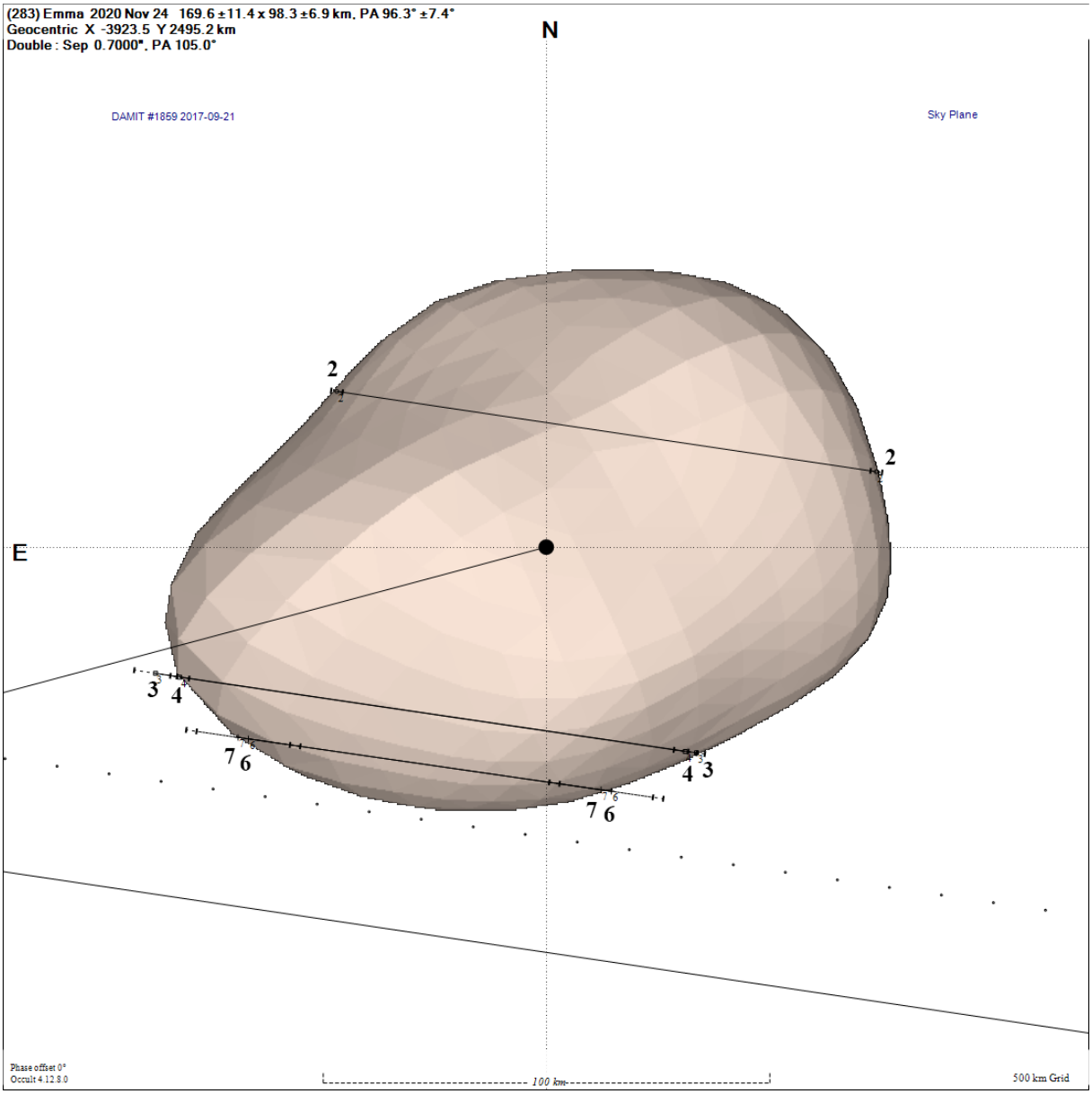

Figure 6. Fit on the 3D model DAMIT #1859 leading to solution 1. The station numbers are those visible in Table 1.

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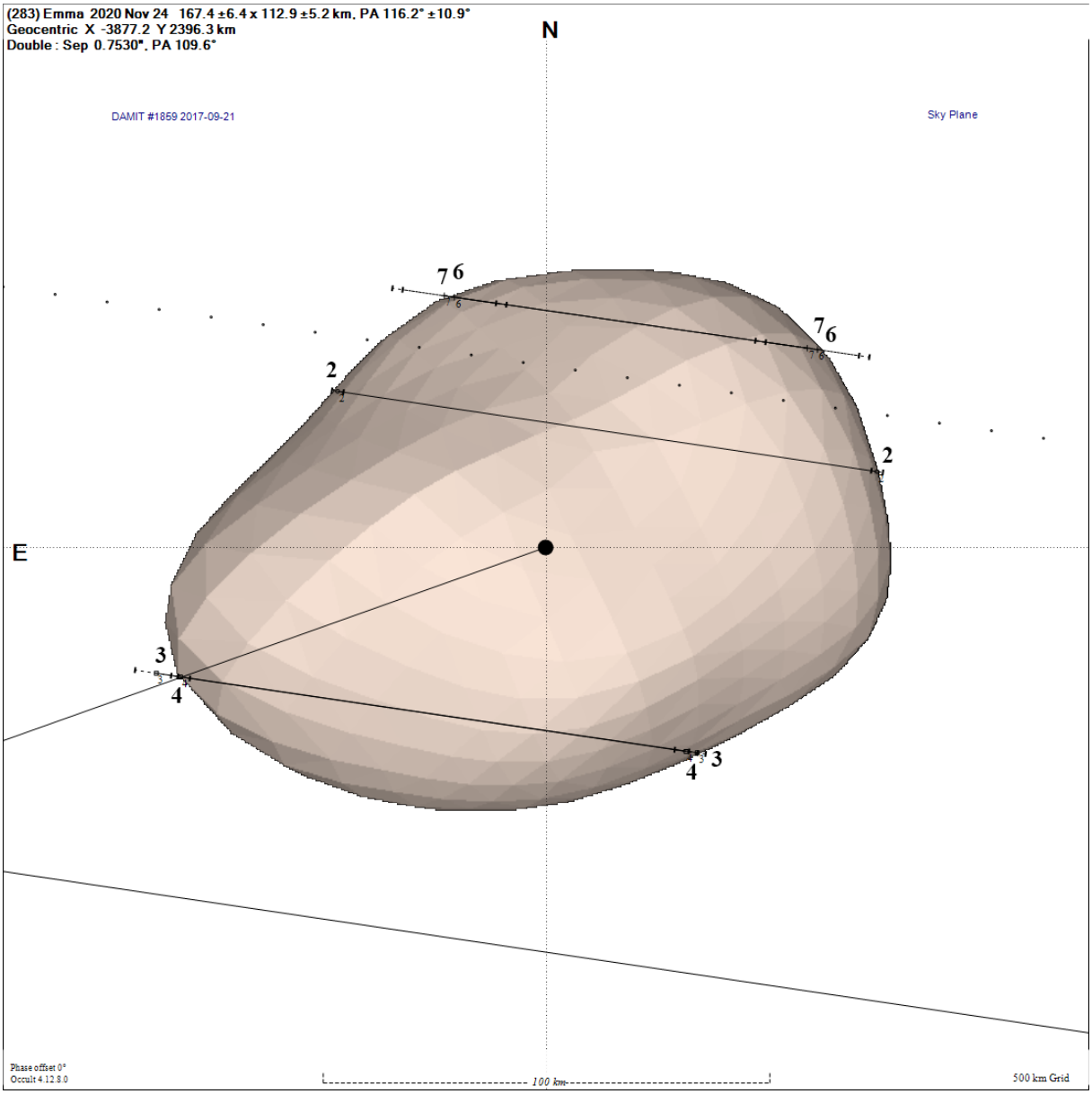

Figure 7. Fit on the 3D model DAMIT #1859 leading to solution 2. The station numbers are those visible in Table 1.

Acknowledgments

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