HIP 46249 Duplicity Discovery from Asteroidal Occultation by (160) Una

Tony George, Umatilla, OR, USA (triastro@oregontrail.net)
Brad Timerson, IOTA North American Coordinator
International Occultation Timing Association (IOTA)
Tom Beard, Reno, NV
Ted Blank, Hampton, NH
Ron Dantowitz, Boston, MA
Jack Davis, Dayton, NV
Dennis di Cicco, Sudbury, MA
David W. Dunham, Greenbelt, MD
Mike Hill, Marlboro, MA
Aaron Sliski, Boston, MA
Red Sumner, Dayton, NV

Abstract: An occultation of HIP 46249 by the asteroid (160) Una on 2011 January 24 showed this star to be a double star. Both components of the double star were occulted as recorded by three observers. The separation of the two components is 0.0065 ± 0.0011 arcseconds at a position angle of 50.2 ± 12.2 degrees. The magnitude of the primary component is estimated to be 9.2 ± 0.1 V. The magnitude of the secondary component is estimated to be 10.6 ± 0.1 V.

Observation

On 2011 January 24, nine observers occupying or operating eight sites across the United States observed the asteroid (160) Una occult the star HIP 46249. See Figure 1 for the path map of the event. Three sites in Massachusetts observed a two-step drop in brightness, indicating a double star (see Figures 2, 3, 4A and 4B). Three sites had only a primary drop in brightness with no steps visible. For these latter sites, the secondary star may have not been seen due to visual method used or because smaller telescopes or less sensitive video cameras were used resulting in lower signal-to-noise ratio and less ability to see the secondary star (see Figure 5). Two sites had a miss. All recorded occultation times and data from the observers can be found in IOTA records for the event. The observations were made at the sites and with the equipment shown in Table 1.

The target star is magnitude 8.93V (Hipparcos - VizieR). The asteroid magnitude as predicted by Occult4 was 12.8(v). The calculated combined magnitude of the star and asteroid is 8.90 V. The expected magnitude drop at occultation was 3.9 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 analysed in the standard manner described by IOTA[1].

Because an inversion model[2] of the asteroid was available, the fit of the double star data within Occult was modified as follows:

A. A circular asteroid rather than elliptical was used for the primary star event solution.
B. The inversion model was overlaid on the circular solution so it fit the primary star event data

(Continued on page 178)

HIP 46249 Duplicity Discovery from Asteroidal Occultation by (160) Una

Site No.	Observer(s)	Location	State	Telescope Type	Tele-scope Dia (cm)	Method	Figure 5 Chords	Result
1	D Dunham	Brattleboro (mobile)	VT	Refractor	8	Video+GPS Time Inst	1	Miss
2	D di Cicco	Sudbury	MA	SCT	40	Intensified Video+ Video WWV Time Inst	2,3	Two-step
3	M Hill	Marlboro	MA	Refractor	15	Visual+Tape Time Sig-nal	4	Primary
4	R Dantowitz / A Sliski	Clay Center	MA	Richey-Chretien	64	Video+GPS Time Inst	5,6	Two-step
5	T Blank	Westborough (mobile)	MA	SCT	20	Video+GPS Time Inst	7,8	Two-step
6	D Dunham	Holyoke (remote)	MA	Refractor	5	Video+GPS Time Inst	10	Primary
7	T Beard	Reno	NV	Newtonian	14	Video+GPS Time Inst	11	Primary
8	R Sumner / J Davis	Carson City	NV	SCT	20	Visual+Tape Time Sig-nal	12	Miss

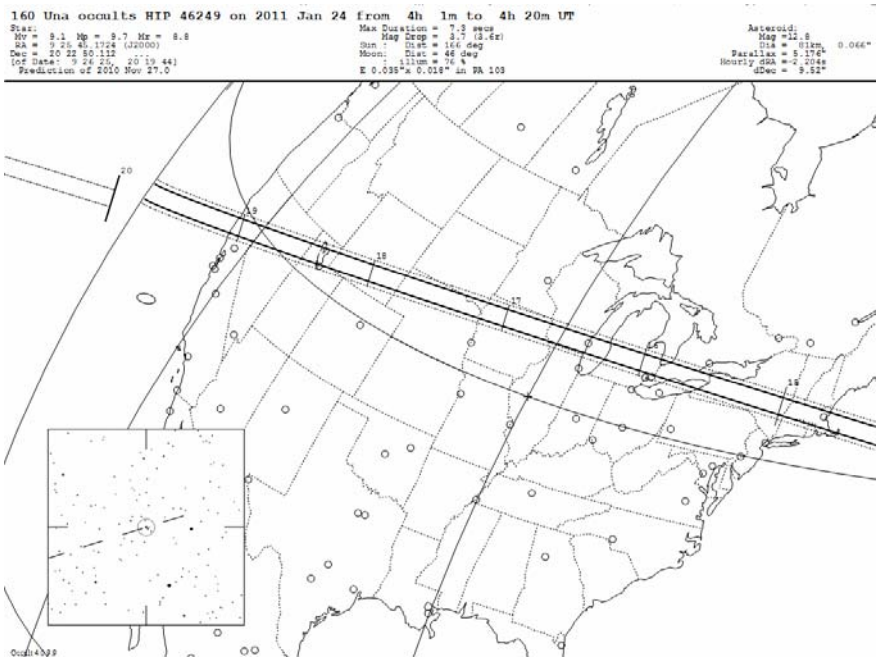

Figure 1: Occultation Path

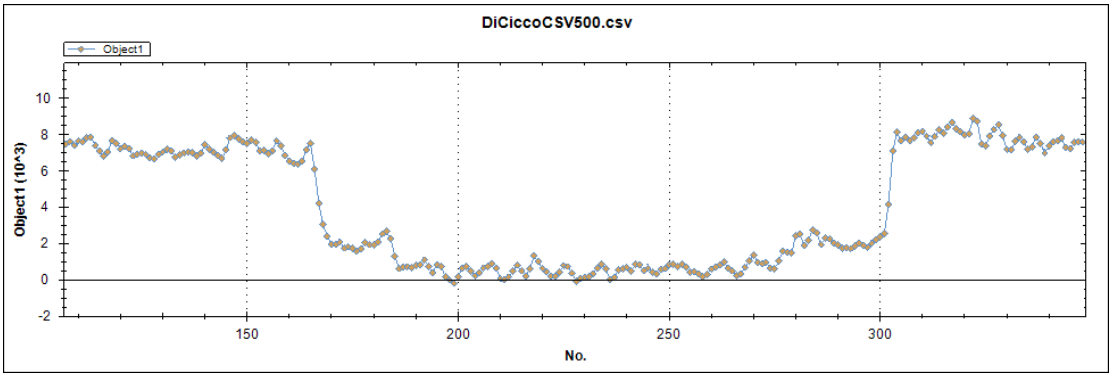

Figure 2: Di Cicco light curve showing distinct two-step event on D and R

HIP 46249 Duplicity Discovery from Asteroidal Occultation by (160) Una

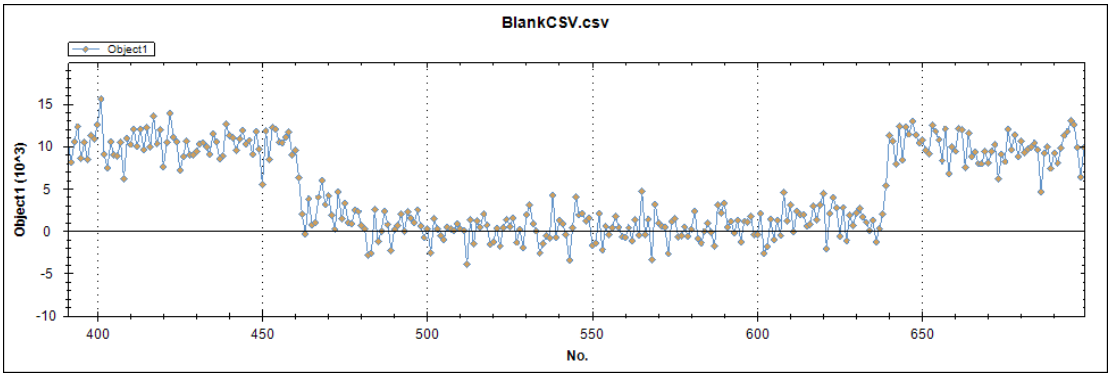

Figure 3: Blank light curve showing at least a distinct step on D

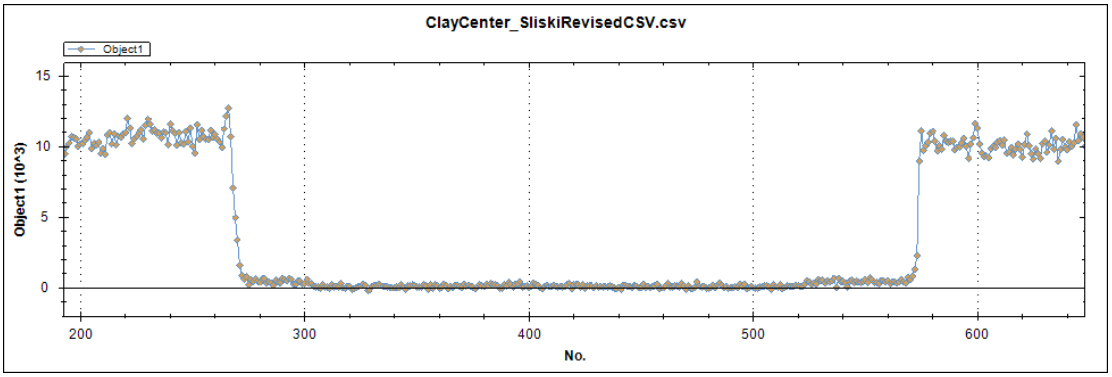

Figure 4A: Dantowitz/Sliski light curve showing two-step event on D and R (see expanded Y axis below)

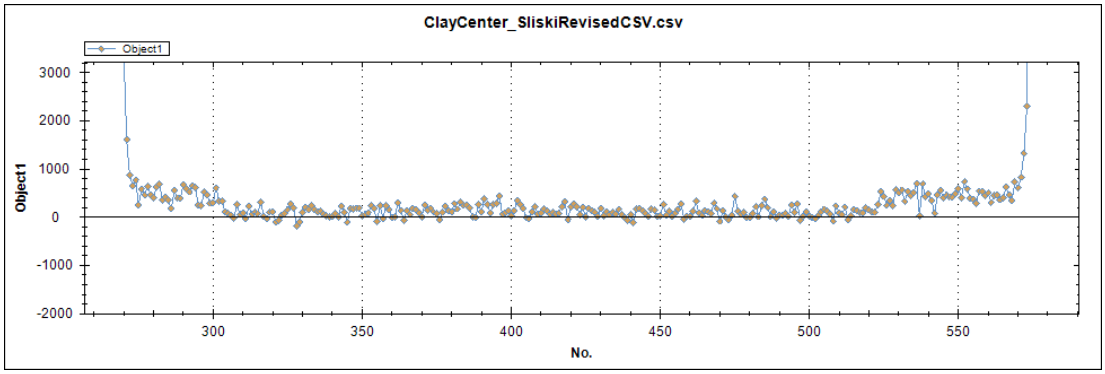

Figure 4B: Expanded view of Dantowitz/Sliski light curve showing two-step occultation

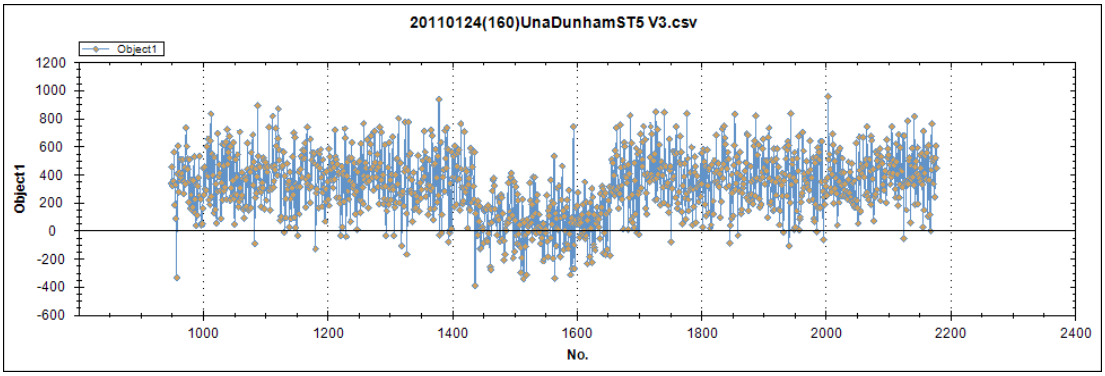

Figure 5: David Dunham Holyoke, MA light curve showing single step event occultation

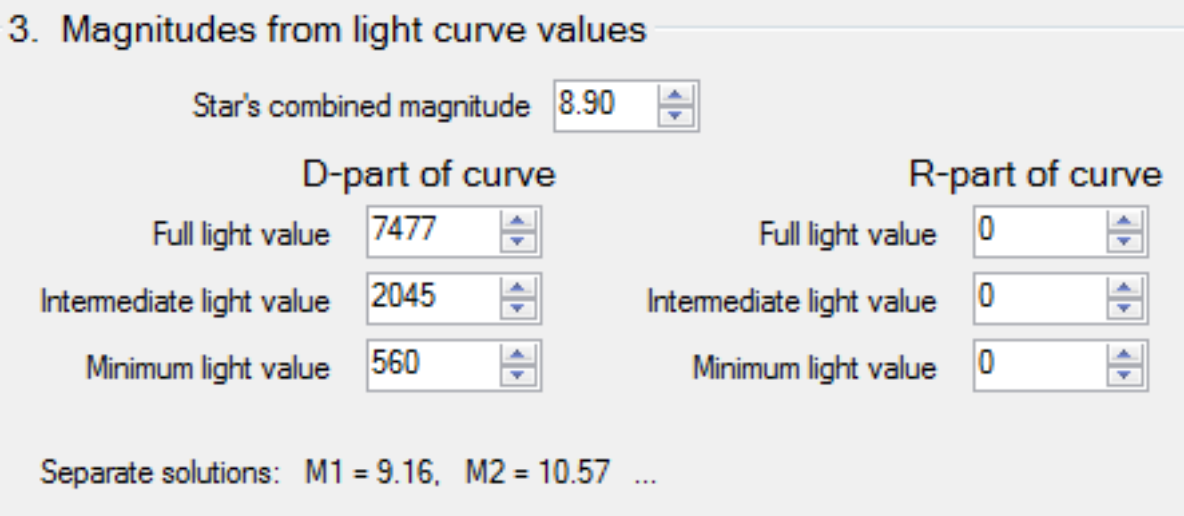

Figure 6: Occult4 magnitude calculator using di Cicco light curve data

(Continued from page 175)

as well as possible.

C. All the automatic adjustments for the size, shape and position parameters (except the PA and separation parameters) were turned off so as not to accidentally change those settings
D. The secondary star event data was displayed. PA and Separation were adjusted for the secondary star event data until the best fit to the inversion model was obtained.
E. All events, primary and secondary star, were displayed to verify the PA and Separation fit.
F. the uncertainties for PA and separation were derived by a trial-and-error approach of how much change in PA and separation (separately) could be made before the fit is visually not right.

Of the three data sets that recorded the occultation of both stars, the di Cicco data had the most normally distributed brightness data suitable for calculating magnitudes in the step events. Using the di Cicco data, the magnitude drop of the two step disappearance and reappearance was calculated using the brightness measurements derived by Occular 4.0, the Magnitude calculator routine in Occult4 (Method 3 – Magnitudes from light curve values) and the combined magnitude from the HIP catalogue (see Figure 6). The magnitudes of the two stars are estimated to be 9.2 V and 10.6 V. The finished plot of the double star fit to the data is shown in Figure 7. Based on the data presented in this report, the double star characteristics are:

Star	HIP 46249 – magnitude 8.93 V
	SAO 80827
	TYCHO 2 1409-26-1
	UCAC2 38973426
	UCAC3 74142266
	NOMAD 1103-0008300
	PPMX 092545.1+202250
	Spectral type G5
Coordinates (J2000)	09 25 45. 1705
	+20 22 50.463 (Simbad [3])
Mag A	9.2 ± 0.1 V (Estimated from HIP)
Mag B	10.6 ± 0.1 V (Estimated from HIP)
Sep.	0.0065 ± 0.0011 arcseconds
P.A.	50.2± 12.2degrees

Acknowledgements

The authors would like to acknowledge Scott Degenhardt for his help in analysing David Dunham's video recordings; Dave Herald, Murrumbateman, Australia for his assistance in resolving the correct Position Angle and Separation estimates for this report; and, Josef Durech, Prague, Czech Republic for the creation of the DAMIT inversion model used in the analysis.

HIP 46249 Duplicity Discovery from Asteroidal Occultation by (160) Una

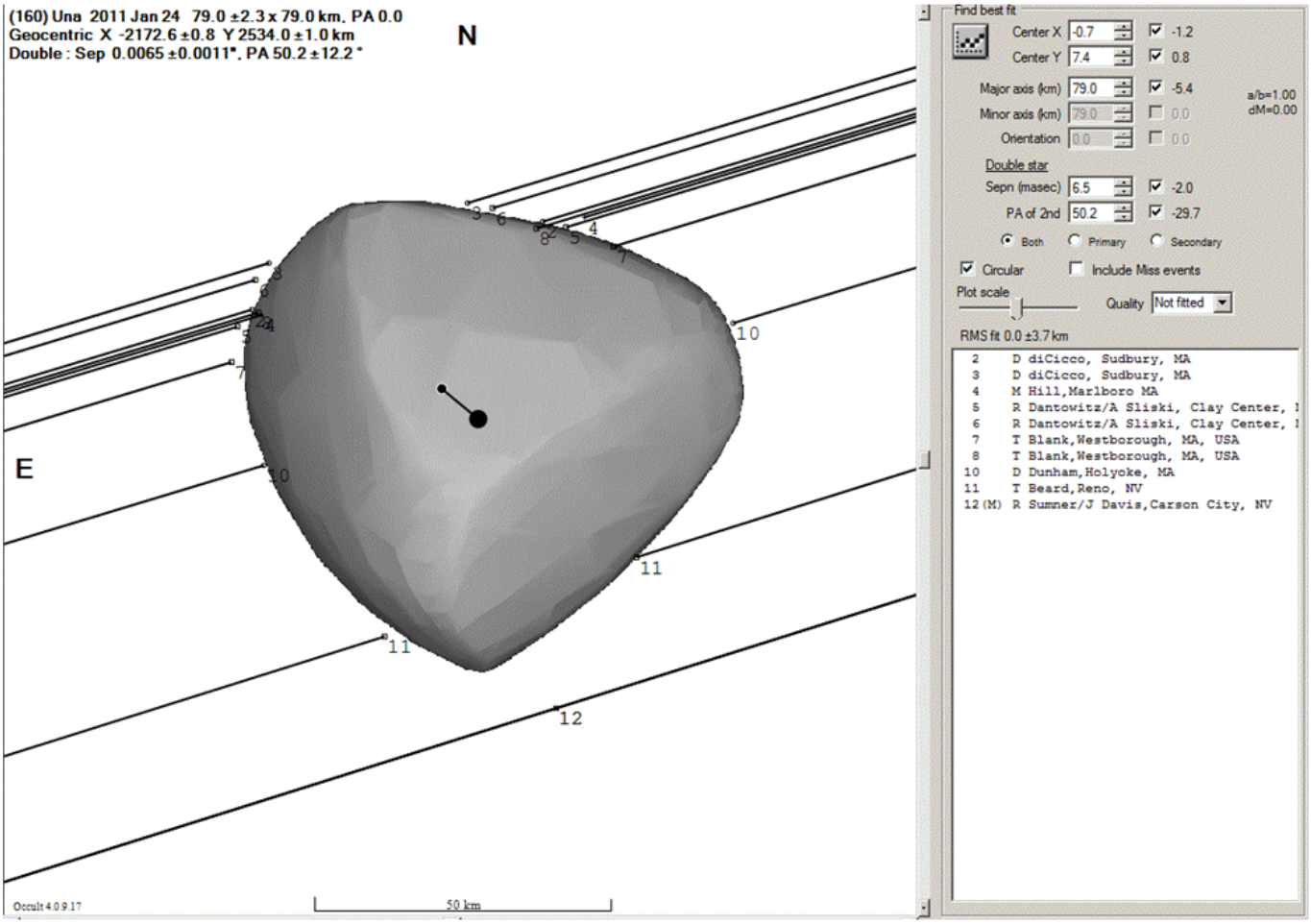

Figure 7: Occultation (160) Una occultation of HIP 46249 and DAMIT inversion model plot. Note that Chord 1 (a miss) was left off the plot to avoid conflict with other plot text. The direction of travel of the asteroid in the diagram is from upper right to lower left.

References

1. New Double Stars from Asteroidal Occultations, 1971 – 2008, Dave Herald, Canberra, Australia, Journal of Double Star Observations, Volume 6 Number 1 January 1, 2010

2. " Additional tools such as asteroidal light curves (Warner) and asteroidal models derived from inversion techniques (Durech) can be combined with occultation results to yield high resolution profiles. The asteroid light curve inversion method was developed by Kaasalainen and Torppa (2001) and Kaasalainen et al. (2001). It enables one to derive asteroid shape, spin axis direction, and rotation period from its light curves observed over several apparitions. The shape is usually modeled as a convex polyhedron. When the shape model and its spin state are known, its orientation with respect to an observer (sky plane projection) can be computed. Such a predicted silhouette can then be compared with the occultation chords and scaled to give the best fit." See: Durech, J. (2009) Database of Asteroid Models from Inversion Techniques (DAMIT) web site. http://astro.troja.mff.cuni.cz/projects/asteroids3D .

3. Coordinates ICRS (equinox and epoch = J2000.0) as reported in Simbad.