CCD LIGHTCURVES FOR 4 MAIN BELT ASTEROIDS

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(Received: 25 July)

Unfiltered CCD-derived lightcurves for 93 Minerva, 287 Nephthys, 665 Sabine, and 762 Pulcova produced synodic period solutions by Fourier analyses for all objects except for 93 Minerva.

UnderOak Observatory (UO) is a privately-operated backyard observatory located in north-central New Jersey. The primary instrument is a 0.2-m catadioptric OTA (f/9) equipped with an SBIG ST402ME thermoelectrically-cooled CCD. The optical configuration, acquisition conditions, and image calibration/ registration methods have been previously described (Alton, 2010). Unfiltered 45-s exposures were continually captured during each session. Final data reduction with *MPO Canopus* (Warner, 2008) used at least 3 non-varying comparison stars for each object to generate lightcurves by differential aperture photometry. In all but one case, Fourier analysis (Harris *et al.*, 1989) yielded a period solution from each dataset. Period solutions (or lack thereof) were independently verified using *Peranso* (Vannmunster, 2006) by applying periodic orthogonals (Schwarzenberg-Czerny, 1996) to fit observations and analysis of variance to evaluate fit quality. Data were light-time corrected but not reduced to standard magnitudes. Relevant aspect parameters for each of these main belt asteroids (MBA) taken at the mid-point from each observing session are tabulated below. Phased data are available by request at http://underoakobservatory.com.

93 Minerva. This 142 km C-type asteroid was recently discovered to be a triple system (Marchis, 2009). In all, 1347 images were taken over six nights between 2009 Nov 8 and Dec 02 and reduced to instrumental magnitudes by ensemble photometry. In this case, lightcurve analysis was seeded using the synodic period (5.982 h) posted at the JPL Solar System Dynamics website. Overall, the resulting lightcurve was largely featureless and no meaningful period solution could be derived. Shape modeling by Torppa *et al.* (2008) revealed remarkable axial symmetry (b/a = 0.99 and c/b = 0.97). As would be expected, published lightcurves for Minerva rarely have amplitudes $A > 0.1$ mag.

287 Nephthys. This is believed to be an S-type asteroid with D = 68 km. A set of 1105 images was acquired on five nights between 2010 Feb 01 and Mar 08. The synodic period solution (7.6041 ± 0.00002 h) estimated by *MPO Canopus* was consistent with a previous determination by Alton (2008) and others referenced at the JPL Solar System Dynamics website. The amplitude of A = 0.41 mag from this data set was slightly larger than observed at the previous apparition in 2007 May (A = 0.36 mag).

665 Sabine. This intermediate-sized MBA (D = 51 km) has a rather high albedo of p_v = 0.39. A total of 829 images captured over 4 nights between 2009 Oct 22 and Nov 04 were used to produce a lightcurve and find a synodic period solution. The calculated period (4.294 ± 0.0001 h) was identical to that reported by Ditteon and Hawkins (2007) for a 2006 Nov data set and very close to that posted at the JPL Solar System Dynamics website (4.29 h). The amplitude of A = 0.55 mag in 2009 Oct-Nov exceeded that from 2006 Nov, A = 0.5 mag.

762 Pulcova. This somewhat uncommon F-type minor planet (D = 137 km) is another MBA discovered to be a binary system during the past decade (Merline *et al.*, 2000). Its satellite (D ~20 km) revolves around the primary every 4.44 d. A total of 754 images was collected during 3 sessions between 2009 Nov 29 and Dec 17 and reduced to generate a single phased lightcurve. Fourier analysis uncovered a synodic period of 5.839 ± 0.0001 h, which was identical to that posted on the JPL Solar System Dynamics website. The amplitude of the lightcurve, A = 0.38 mag, was nearly twice that observed in 2006 Mar by Oey (2006). Significant but seemingly correlated scatter is noted in the folded lightcurve (*phase* = 0.75) that is also observed in each of two different sessions separated by ~5 d. It is unknown whether this behavior is related to the binary nature of this asteroid.

Acknowledgement

Many thanks to the Jet Propulsion Laboratory for providing a friendly public interface via the Solar System Dynamics small-body database browser to a wealth of minor planet data and orbital simulations.

References

Alton, K.B. (2008). "Lightcurve Analysis of 287 Nephthys." *Minor Planet Bulletin* **35**, 33-34.

Alton, K.B. (2010). "A Unified Roche-Model Light Curve Solution for the W UMa Binary AC Bootis." *JAAVSO* **38**.

Ditteon, R. and Hawkins, S. (2007). "Asteroid Lightcurve Analysis at the Oakley Observatory – October-November 2006." *Minor Planet Bulletin* **34**, 59-64.

Harris, A.W., Young, J.W., Bowell, E., Martin, L. J., Millis, R. L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H. J., Debehogne, H, and Zeigler, K. (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.

JPL Solar System Dynamics website:
http://ssd.jpl.nasa.gov/sbdb.cgi

Marchis, F. (2009). "The discovery of a new triple asteroid - (93) Minerva." Cosmic Diary Blog.
http://www.cosmicdiary.org/blogs/nasa/franck_marchis/?p=465.

Asteroid	Range Over Observation Period			
	UT Date	Phase Angle	L_{PAB}	B_{PAB}
93 Minerva	2009 Nov 8 - 2009 Dec 2	9.9 - 16.5	21.8 - 23.2	+4.1 - +4.6
287 Nephthys	2010 Feb 1 - 2010 Mar 8	18.2 - 24.1	92.0 - 98.0	-8.3 - -6.0
665 Sabine	2009 Oct 22 - 2009 Nov 4	15.9 - 17.5	340.4 - 341.9	+13.0 - +13.0
762 Pulcova	2009 Nov 29 - 2009 Dec 17	10.9 - 14.9	39.4 - 40.3	+15.5 - +14.8

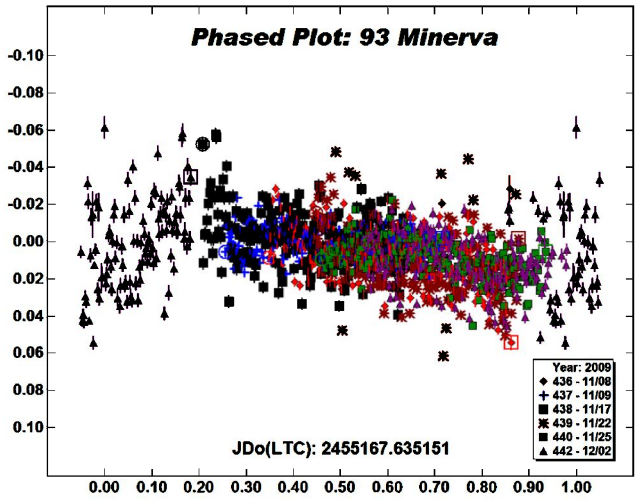
Merline, W.J., Close, L.M., Dumas, C., Shelton, J.C., Menard, F., Chapman, C.R., and Slater, D.C. (2000). "Discovery of Companions to Asteroids 762 Pulcova and 90 Antiope by Direct Imaging." *Bulletin of the American Astronomical Society* **32**, 1017.

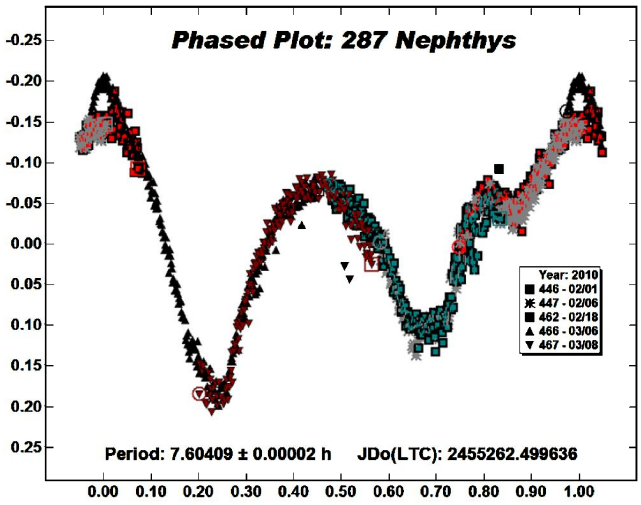
Schwarzenberg-Czerny, A. (1996). "Fast and Statistically Optimal Period Search in Uneven Sampled Observations." *Astrophys J.* **460**, L107.

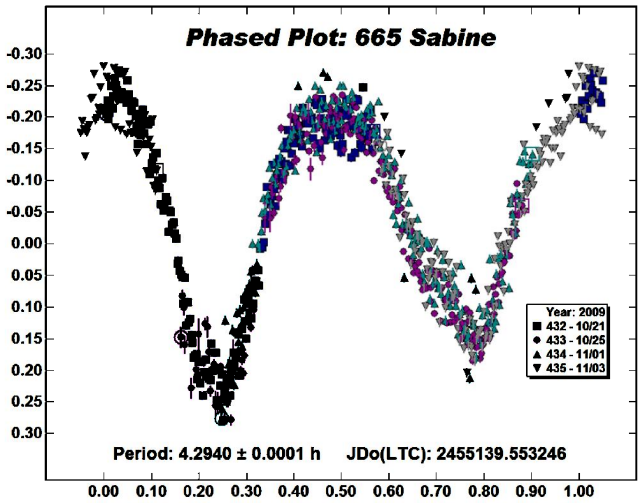
Torppa, J., Hentunen, V.-P., Pääkkönen, P., Kehusmaa, P., and Muinonen, K. (2008). "Asteroid shape and spin statistics from convex models." *Icarus* **198**, 91-107.

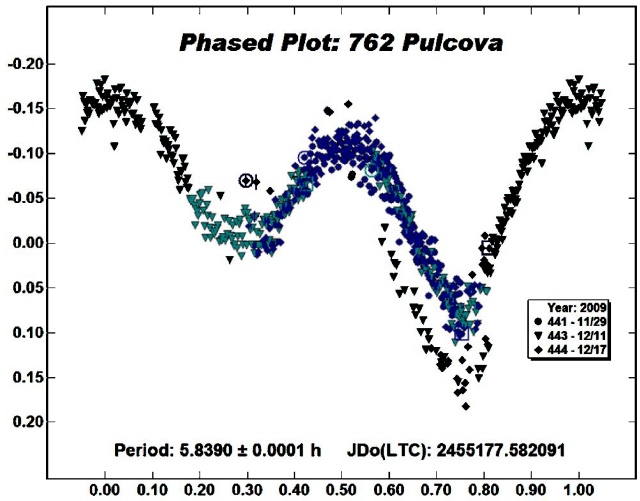
Vannmunster, T. (2006). *Peranso* Period Analysis Software, version 2.31. CBA Belgium Observatory.

Warner, B.D. (2008). *MPO Canopus,* version 9.5.0.3, Bdw Publishing, Colorado Springs, CO.









LIGHTCURVES FOR 869 MELLENA, 2375 RADEK, AND (19261) 1995 MB

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(Received: 24 August)

CCD observations have yielded lightcurve period determinations for the following asteroids: 869 Mellena, 6.510 ± 0.001 h; 2375 Radek, 16.877 ± 0.002 h; and (19261) 1995 MB, 4.5911 ± 0.0008 h.

Photometric data were collected at Barnes Ridge Observatory in northern California, USA, using a 0.43-m f/6.8 Planewave CDK17 and Apogee U9 camera. The camera was binned 2x2 with a resulting image scale of 1.26 arc-seconds per pixel. All images were taken through a clear filter with exposures of 120 seconds at –25°C. The images were obtained with *MaxIm DL* V5 driven by *ACP* v5 and then analyzed using *MPO Canopus* v10.0 (Warner, 2010). All comparison stars and asteroid targets had SNR > 200.