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ROTATION PERIOD DETERMINATION FOR 203 POMPEJA – ANOTHER TRIUMPH OF GLOBAL COLLABORATION

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Early observations by the first author yielded a rotation period value for 203 Pompeja that was very close to being Earth commensurate. Additional observations by other observers widely spaced in longitude allowed full phase coverage and showed a unique rotation period 24.052 ± 0.001 hours, amplitude 0.10 ± 0.01 magnitudes.

Observations by F. Pilcher were obtained with a Meade 35 cm LX 200 GPS S-C, SBIG STL 1001-E CCD, clear filter, unguided exposures. Those by A. Ferrero were with a 30 cm f/8 Ritchey-Chretien and SBIG ST9 CCD. H. and H. Hamanowa used a 40 cm Newtonian with SBIG ST-8 CCD. Image measurement, lightcurve analysis, and sharing of data were done with *MPO Canopus* software.

According to Harris et al. (2011) the only previous period determination for 203 Pompeja is by Di Martino (1984) who found a descending branch of the lightcurve on each of 4 consecutive nights 1983 Sept. 10/11 through 13/14. He inferred a period of 46.6 hours, or possibly 23.3 hours if the lightcurve had only one maximum and minimum per cycle. There were no features such as maxima or minima which could be related on different nights, without which an accurate period determination could not be found.

Observations by first author Pilcher on four nights 2011 Nov. 10 - 26 all showed identical appearing maxima consistent with a period near 24.05 hours, although periods slightly greater than 16 hours or 48 hours satisfied the data equally well. With more than two maxima per cycle periods near 32 hours or 36 hours, or perhaps others, were also allowed. The only way to fill the large gap in phase coverage at a single observatory for an Earth commensurate object is to obtain data from other observatories widely spaced in longitude. Andrea Ferrero in Italy and Hiromi and Hiroko Hamanowa in Japan obtained at the first author's request the additional observations required to enable full phase coverage. A total of 14 sessions 2011 Nov. 10 - 2012 Jan. 25 showed a 24.052 ± 0.001 hour period, amplitude 0.10 ± 0.01 magnitude and unsymmetric bimodal lightcurve. A lightcurve phased to twice this period showed two halves which were within observational error the same as each other and as the 24.052 hour lightcurve. An irregularly shaped asteroid which was invariant over a 180 degree rotation would be required to produce the 48.1 hour lightcurve. The probability of such a symmetric shape for an otherwise irregular real asteroid is so small that it may be safely rejected. Hence we claim that the 24.052 hour period is the correct one. To make the lightcurve more legible the large number of data points have been binned in sets of three points with a maximum of five minutes between points.

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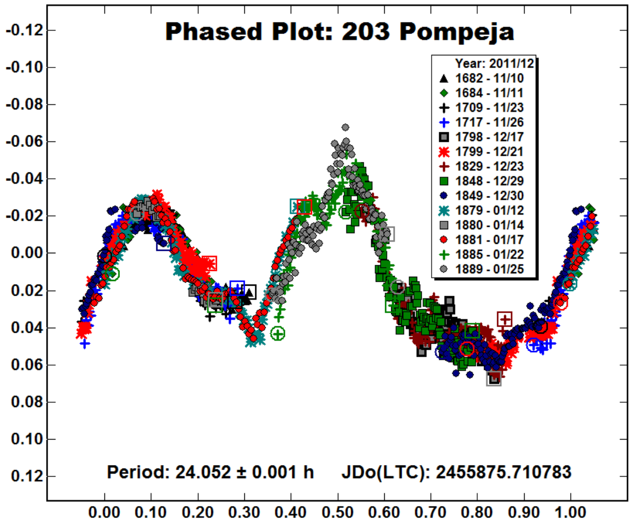

PERIOD OF ASTEROID 696 LEONORA REVISED

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We describe observations and results of the photometric research of the asteroid 696 Leonora. Observations were obtained by a semi-automated 0.61-m f/4.3 photometric telescope at the Skalnaté Pleso Observatory. This instrument is equipped with a SBIG ST-10XME-Class 1 CCD camera. The asteroid was previously observed, but short observation runs for each night were poorly linked to each other, allowing different solutions for the rotation period. We were able to determine a rotation period of 26.8964 ± 0.0008 h based on the observations from 2011 September to November.

The first photometric observations of asteroid 696 Leonora were made by Warner (2006). Six lightcurves obtained in 2005 September were used to estimate the rotational period of almost 18 hours with an amplitude of 0.10 mag. However, his lightcurves almost always covered only one extrema (maximum or minimum). We produced a composite lightcurve (Fig. 1) based on the original lightcurves from Warner obtained from the ALCDEF database (*http://minorplanetcenter.net/light_curve*). In 2011 September we obtained two lightcurves, which offered a possibility of improving of Warner's results (Fig. 2). Because the individual curves from 2005 cover relatively short time intervals, there is at least one additional, and more likely, solution for the rotation period of about 27-hour period (Fig. 3).

We performed photometric observations in 7 nights from 2011 September to November with 0.61-m *f*/4.3 reflector at the Skalnaté Pleso Observatory. 60-second CCD frames were acquired with an SBIG ST-10XME using 3×3 binning (1.6 arcsec/px). We applied the standard calibration with dark and flat field frames with *IRAF* tools. The observation circumstances and aspect data for each night are listed in Table I, which gives the date for the mid-time of the observations, the solar phase angle, and the J2000.0 ecliptic coordinates of the phase angle bisector (PAB), which is the vector connecting the center of the asteroid and the midpoint of the great circle arc between the sub-Earth and sub-solar points; for more information on the PAB, see Magnusson *et al.* (1989).

The period and amplitude analysis were performed following the procedure described by Harris *et al.* (1989). All data in the composite lightcurve are relative and light-time corrected. Due to the better homogeneity of the data from October to November (e.g. phase angle values from October to November were in the range of 8.1–12.4 degrees versus 22.0 to 22.7 degrees in September), we used only that subset to find a rotation period of 26.8964 ± 0.0008 h (Fig. 4).

Figure 5 shows our data forced to an 18-hour period, whereas Figure 6 shows Warner's data forced to the 27-hour period and the amplitude from our 2011 observations.

UT Date	α (deg)	LPAB (deg)	BPAB (deg)	Np	Cov (h)
2011 Sep 22.0	22.7	51.1	15.4	119	5.0
2011 Sep 26.0	22.0	51.9	15.5	310	8.7
2011 Oct 31.9	12.4	56.9	16.0	239	6.2
2011 Nov 03.0	11.7	57.1	15.9	363	9.6
2011 Nov 03.9	11.4	57.2	15.9	292	9.5
2011 Nov 18.0	8.1	58.0	15.6	224	5.6
2011 Nov 25.9	8.1	58.4	15.2	190	9.5

Table I. Observation circumstances in 2011 for 696 Leonora.

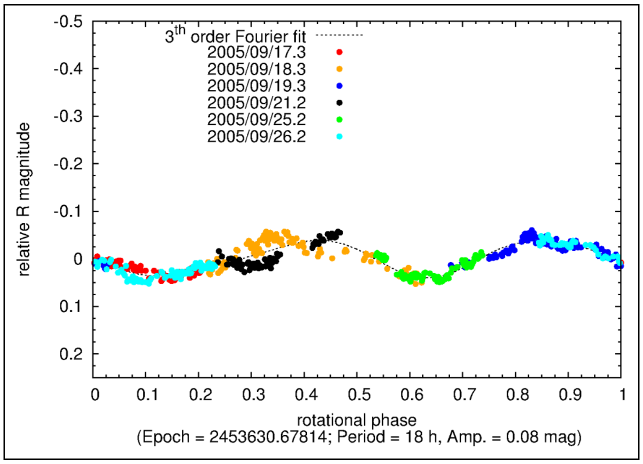

Figure 1: Composite lightcurve of 696 Leonora based on Warner's data from 2005 and the estimated rotational period of 18 hours.

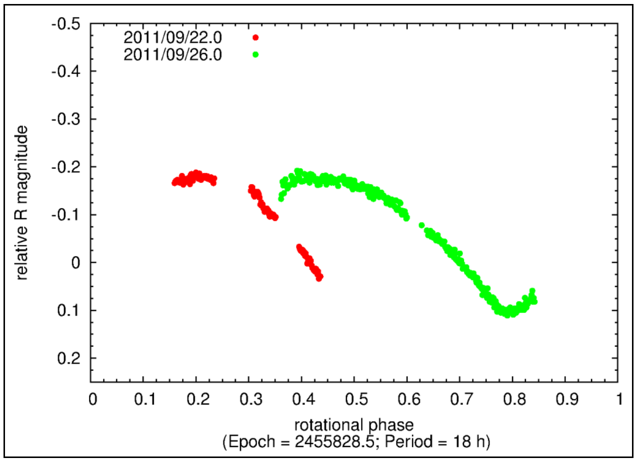

Figure 2: Two lightcurves from September 2011 which show a suspicion of irregularity of 18-hour period.

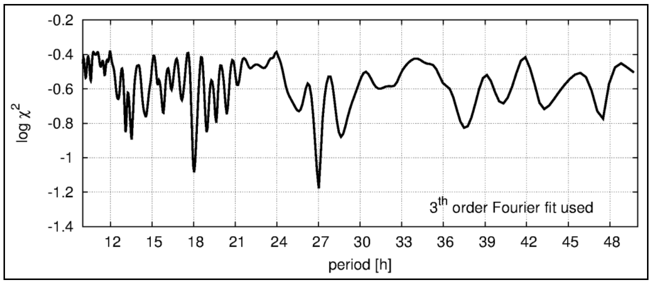

Figure 3: Periodogram used for data from 2005 where another rotational period about 27 hours is possible.

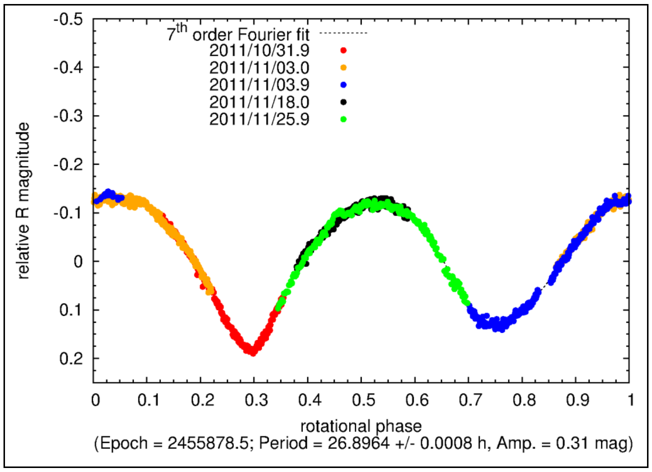

Figure 4: Composite lightcurve of 696 Leonora from 5 nights in 2011 obtained at Skalnaté Pleso Observatory.

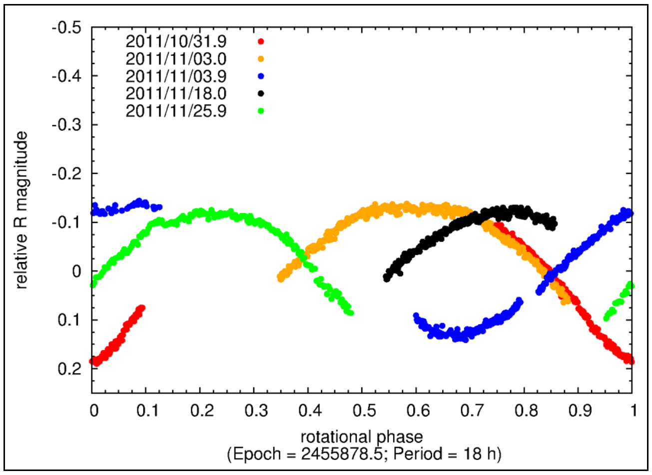

Figure 5: Strong evidence of incorrectness of 18-hour period with our lightcurves from 2011.

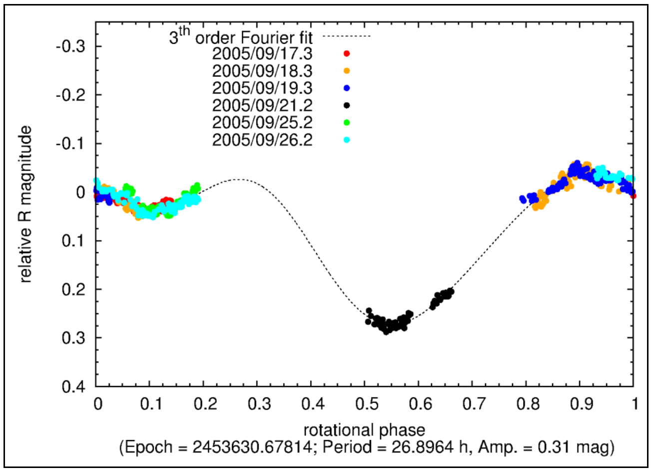

Figure 6: Composite lightcurve of 696 Leonora based on Warner's data from 2005 and approximated by our period and amplitude.

Acknowledgement

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ASTEROIDS LIGHTCURVE ANALYSIS AT THE ISON-NM OBSERVATORY: 3122 FLORENCE, (25916) 2001 CP44, (47035) 1998 WS, (137170) 1999 HF1

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We present lightcurve analysis for four asteroids, including three NEAs, 3122 Florence, (25916) 2001 CP44, and (137170) 1999 HF1, and one Mars-crossing asteroid, (25916) 1998 WS. We were able to determine the rotation period for all four objects. For two of them, these are the first reported values. For 3122 Florence and 1999 HF1, we confirmed earlier results.

All observations were carried out remotely at ISON-NM Observatory (NM, USA) in white light with 0.45-m *f*/2.8 astrograph and FLI ML09000-65 camera mounted at prime focus. The unbinned image scale is 1.95 arcsec/pixel. Because of severe vignetting on the image corners, we used only ~30% of image central area. All images were dark and flat field corrected. Analysis of images and rotation period search was carried out with the *MPO Canopus* package (Bdw Publishing).

3122 Florence. The well-known near-Earth asteroid (q = 1.02 AU) 3122 Florence has been observed at many oppositions. We confirmed the previously reported rotation period (Pravec *et al.*, 1998). Our estimate is P = 2.359 ± 0.003 h with lightcurve amplitude A = 0.27 mag. This asteroid was observed at our observatory on 2010 Oct. 28-29 (Table 1).

UT Date	Δ	r	phase	mag
2010-10-28	0.633	1.173	57.9	15.4
2010-10-29	0.635	1.178	57.5	15.4

Table 1. Observation circumstances for 3122 Florence.

(25916) 2001 CP44. Observations of near-Earth asteroid (25916) 2011 CP44 (q = 1.29 AU) were carried out from 2010 Oct. 30 to Nov 01. We obtained images on three different nights (Table 2).

UT Date	Δ	r	phase	mag
2010-10-30	1.093	2.019	13.8	15.9
2010-10-31	1.101	2.025	13.9	15.9
2010-11-01	1.109	2.031	14.0	16.0

Table 2. Observation circumstances for 2001 CP44.

We found the rotation period of (25916) 2001 CP44 to be P = 4.19 ± 0.01 h and amplitude A = 0.28 mag. We did not find any previously reported period in the LCDB (Warner *et al*., 2011).

(47035) 1998 WS. (47035) 1998 WS is a Mars-crossing asteroid with q = 1.61 AU and classified as S type in the SMASS II taxonomic system by Bus and Binzel (2002). Our estimate of the rotation period for 1998 WS is P = 7.98 ± 0.01 h with a lightcurve amplitude A = 0.15 mag. A search of the Asteroid Lightcurve Database did not reveal any previously reported results for this asteroid. (47035) 1998 WS was observed on three nights from 2012 Feb. 06 to 2012 Feb. 11 (Table 3).

UT Date	Δ	r	phase	mag
2012-02-06	0.855	1.653	28.2	14.6
2012-02-09	0.859	1.659	28.0	14.6
2012-02-11	0.862	1.663	27.8	14.6

Table 3. Observation circumstances for 1998 WS.

In all three epochs, there is a small depression clearly visible before the second minima. This may be linked with some feature on asteroid surface.

(137170) 1999 HF1. Our second observed NEA was (137170) 1999 HF1 (q = 0.44 AU), which had previously-reported period estimates in the LCDB (Asteroid Lightcurve Data Base, rev. 2011-Dec-17). Our value, P = 2.322 ± 0.002 h, is in good agreement with those earlier reports. The lightcurve amplitude was A = 0.26, or larger than previously reported values on ~0.03–0.1 mag. It should be noted that because our observations were noisy we can't precisely measure the amplitude. (137170) 1999 HF1 was classified as X: type by Bus and Binzel (2002). All observations were carried out from 2011 Apr. 15 to 18 (Table 4).

UT Date	Δ	r	phase	mag
2011-04-15	0.594	1.195	56.9	15.8
2011-04-16	0.592	1.196	56.9	15.8
2011-04-17	0.589	1.196	56.8	15.8
2011-04-18	0.587	1.197	56.8	15.8

Table 4. Observation circumstances for 1999 HF1.

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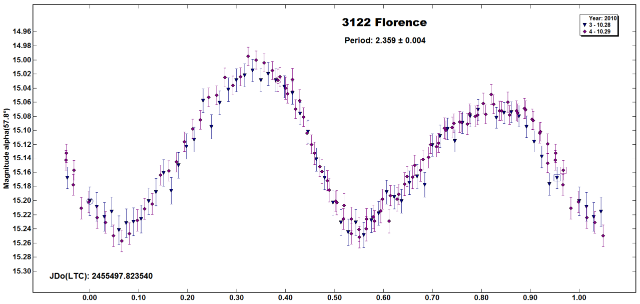

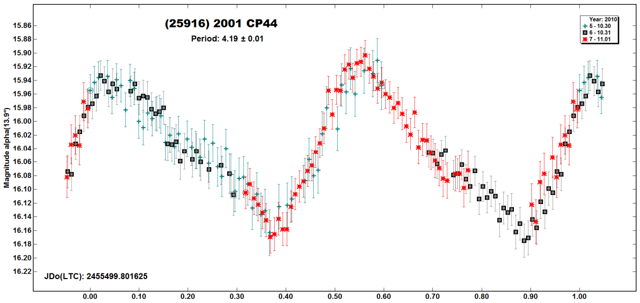

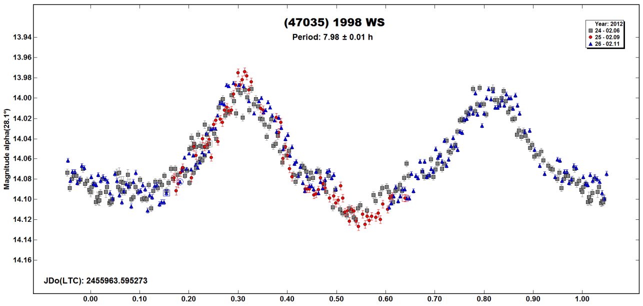

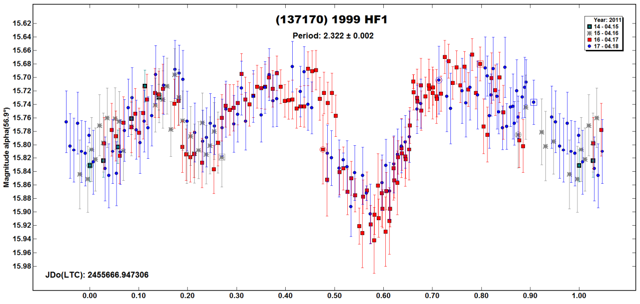

LIGHTCURVE ANALYSIS OF 266 ALINE, 664 JUDITH, (16959) 1998 QE17, AND (32910) 1994 TE15

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We present the rotation period of three main-belt asteroids: 266 Aline, (16959) 1998 QE17, and (32910) 1994 TE15. Data were obtained but no period found for 664 Judith. The observations were undertaken at Aristotle University's Astronomical Station and Skinakas Observatory during 2010 and 2011.

The Aristotle University's Astronomical Station was established nine years ago in order to fulfill the educational needs of its students. It is located at Mt. Holomon, Greece. Astronomical observations are undertaken using a fully-equipped telescope, which is a 0.28-m Schmidt-Cassegrain with either an ATIK 4000 or ATIK 11000 CCD camera using an R Bessel filter. The data reduction and photometry were done with *MPO Canopus* software.

266 Aline (a = 2.8 AU, e = 0.157). This asteroid probably belongs to the Gefion family and was observed during four nights in 2010. Its rotation period was found to be P = 13.05 ± 0.07 h with an approximate amplitude A = 0.08 mag. The period is very close to the one reported by Pilcher and Benishek (2011).

664 Judith (a = 3.21 AU, e = 0.22). A probable member of the Themis family, Judith was observed on 2010 August 5. Unfortunately, we were not able to obtain enough data to determine the period.

(16959) 1998 QE17 (a = 2.62 AU, e = 0.3). 1998 QE17 was discovered on 1998 August 17. We extracted the lightcurve and calculated its period, P = 3.227 ± 0.085 h, and amplitude, A = 0.45 mag.

(32910) 1994 TE15 (a = 2.18 AU, e = 0.25). This inner main-belt asteroid was discovered on 1994 October 13. The inner main-belt is very chaotic. This is caused by the mean motion resonances with Mars and three-body resonances, Mars-Jupiter-asteroid, which combine so that the asteroid orbits slowly migrate in eccentricity. This chaotic diffusion leads many bodies to become Mars-crossers. (32910) 1994 TE15 was selected because it has close encounters with Mars. The trajectory of the asteroid was numerically integrated using the *swift_whm* and *swift_rmvs3* routines from the *SWIFT* package (Levison & Duncan 1994). Only the eight major planets were considered in the integrations. As we can understand, from the changes of its semi-major axis versus time, it has close encounters with Mars, but not so strong in order for it to be ejected from the main belt.

It was observed at *Skinakas Observatory* on 2010 August 13, 15-16, using the 1.3-m telescope and an R Johnson-Cousins filter. The amplitude of the lightcurve is A = 0.13 mag and the period was calculated as P = 5.559 ± 0.0249 h.

Acknowledgements

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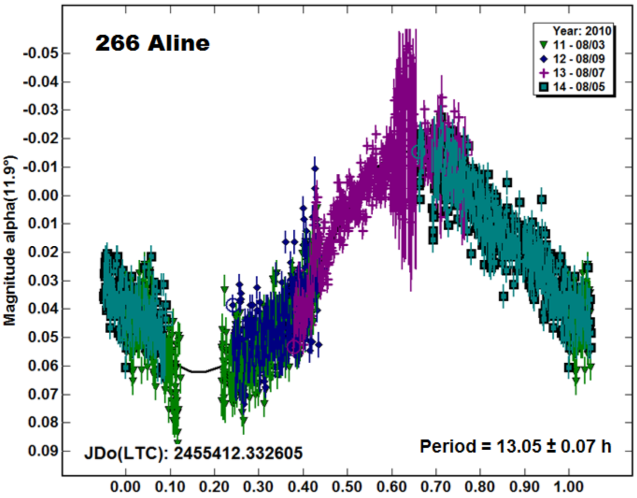

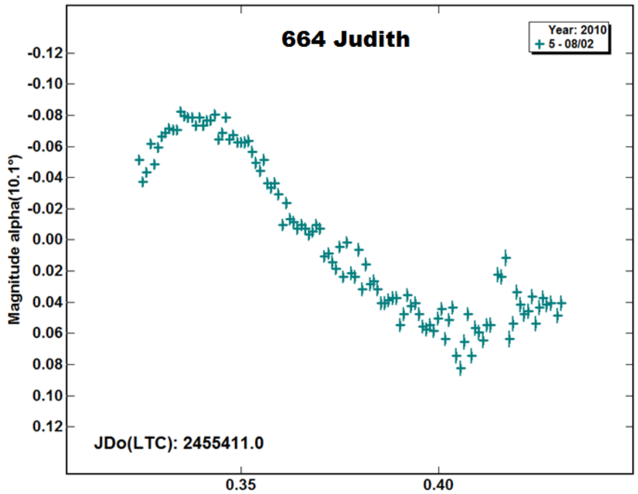

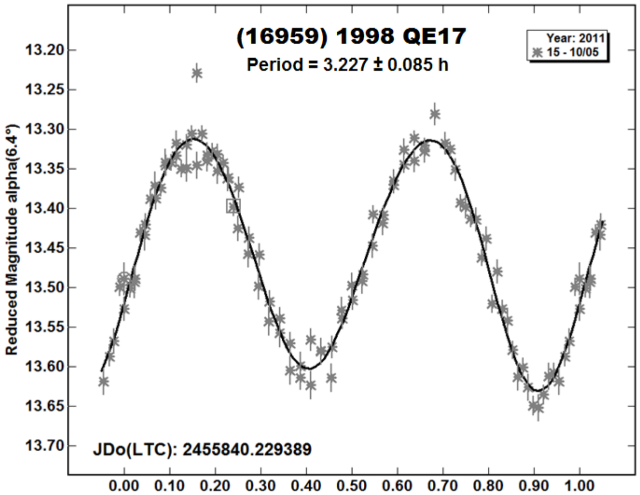

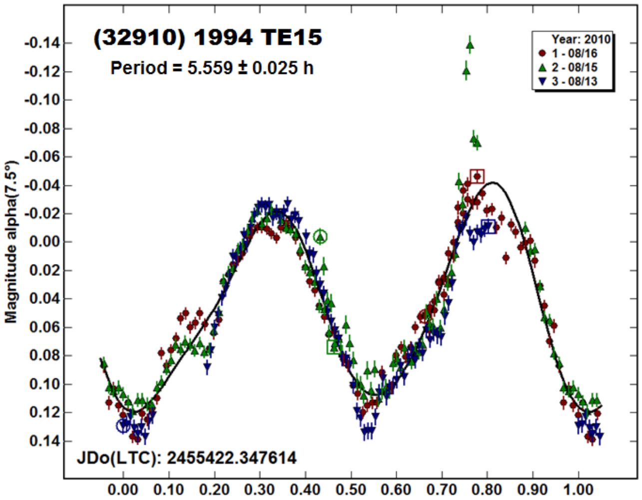

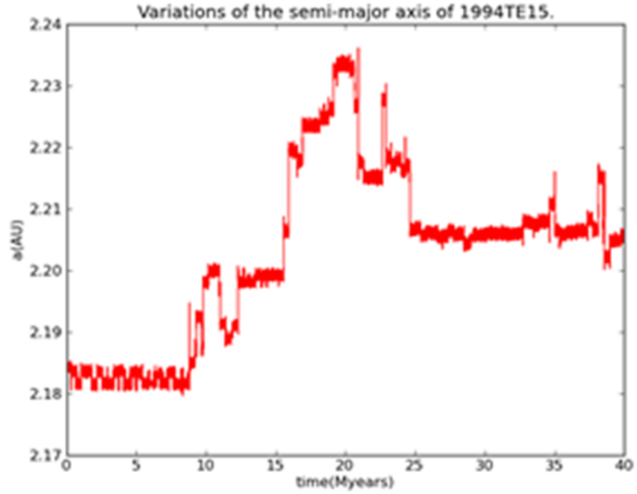

LIGHTCURVE ANALYSIS FOR 3017 PETROVIC

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The lightcurve for main-belt asteroid 3017 Petrovic was measured from observations during 2012 January 12 through 31. The derived synodic period is P = 4.0804 ± 0.0002 h and amplitude A = 0.60 ± 0.05 mag.

Observations of asteroid 3017 Petrovic were made at the Phillips Academy Observatory with a 0.4-m *f*/8 DFM Engineering telescope using an SBIG 1301-E CCD camera with a 1280x1024 array of 16-micron pixels. The resulting image scale was 1.0 arcsecond per pixel. Exposures were 300 s working primarily at –30° C. All images were dark and flat field corrected, guided, and unbinned. A clear filter was used. Observations at Celbridge Observatory were conducted with a Celestron C14 at *f*/11. Images were captured with an FLI Proline 1001E camera with a 1024x1024 array of 24-micron pixels. The resulting images scale was 1.3 arcseconds per pixel. Exposures were 90 s working at –20° C. All images were dark and flat field corrected, unguided, and unbinned. No filter was used.

Lightcurve images were captured with *Maxim DL* and measured in *MPO Canopus* (Bdw Publishing) with a differential photometry technique. Data merging and period analysis was done with *MPO Canopus* using an implementation of the Fourier analysis algorithm of Harris (Harris *et al.*, 1989). The combined set of 338 data points was analyzed by Odden. According to a geometric argument made by Harris (2012), it is nearly impossible for an asteroid in single axis rotation (i.e., not tumbling) to exhibit other than a bimodal lightcurve, one with two maximums and two minimums, when the phase angle is low and the amplitude exceeds

~0.4 magnitudes. Therefore, the rotation period must be 4.0804 ± 0.0002 h. The amplitude was measured to be 0.60 ± 0.05 mag. A period of 4.069 ± 0.006 h was reported by Angeli and Barucci (1996). According to the JPL Small-Body Database, this result was based on less than full coverage. Our result agrees with the period found by Angeli and Barucci.

Acknowledgments

Odden wishes to thank Frederick Picher, Allan Harris, and Brian Warner, all of whom provided guidance with this analysis.

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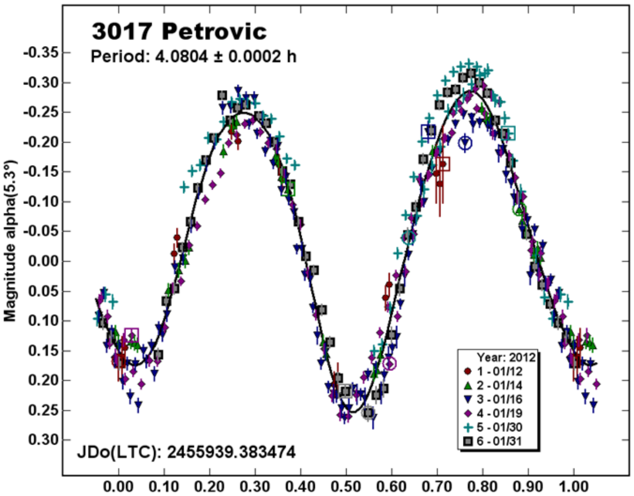

LIGHTCURVE PHOTOMETRY OF 132 AETHRA

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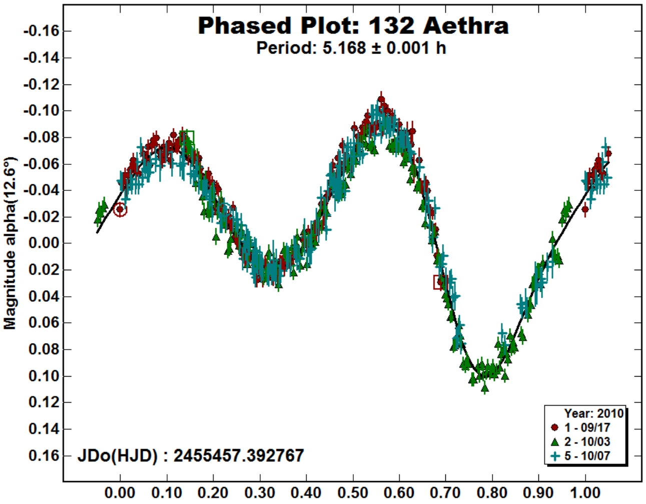
Photometric observations of 132 Aethra were obtained at Celbridge Observatory from 2010 September through October.

Observations of 132 Aethra were made at Celbridge Observatory (MPC Code J65) with a 0.36-m *f*/11 Schmidt-Cassegrain (SCT) and a FLI ProLine 1001E CCD imager. Images were acquired using *ACP* Observatory Control Software and were unguided, unbinned, and unfiltered. Exposure times were 60 s and the CCD temperature was held at –20° C. The images were calibrated and measured using *MPO Canopus*, which employs differential aperture photometry to determine the values used for analysis. Period analysis was also carried out using *MPO Canopus*, which incorporates the Fourier analysis algorithm developed by Harris (Harris *et al.*, 1989).

132 Aethra was chosen as a "proof-of-concept" target. The author had not done asteroid lightcurve analysis before and so, in order to ensure correct processes were followed, an asteroid with a well-known published lightcurve was chosen. A period of 5.168 h is reported on the IAU Minor Planet Center internet site (*http://www.minorplanetcenter.net/iau/lists/LightcurveDat.html*).

Analysis of the data from this study found a period of 5.168 ± 0.001 h. This agrees with the published results and shows that Celbridge Observatory and the author are capable of carrying out lightcurve photometry.



Acknowledgements

I would like to thank Brian Warner for his assistance, encouragement, software, book, and the CALL website.

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PERIOD DETERMINATION OF 617 PATROCLUS

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A photometric study of 617 Patroclus revealed a synodic period of 103.5h ± 0.3h and amplitude of 0.06 ± 0.02 mag. The difficulty in obtaining this result was overcome by using an unconventional method of linking the data with differential photometry.

617 Patroclus is a well-studied binary Trojan asteroid. For example, Berthier (2007) found a period of 102.94 ± 0.11 while Mueller (2010) reported a period 103.02 ± 0.40 h. The amplitude of the lightcurves was found to be very low, 0.07 ± 0.01 mag. The two components of the binary system have been determined to be nearly identical in shape and size, $D_1 = 112 \pm 16$ km and $D_2 = 103 \pm 15$ km with a separation of 654 ± 36 km (Berthier, 2007). Other details of the system are described by Mueller *et al.* (2010).

The data obtained for 617 Patroclus was from Kingsgrove and Leura Observatory. Kingsgrove Observatory used a 0.25-m *f*/11 Schmidt-Cassegrain telescope with a self-guiding ST-9XE SBIG CCD camera operating at 1x1 binning. The pixel resolution was 1.45 arc seconds/pixel. Exposures for the unfiltered images were 300 seconds. Leura Observatory used a 0.35-m *f*/7 Schmidt-Cassegrain telescope with an SBIG CCD camera at 2x2 binning, producing a 1.54 arc seconds/pixel resolution. All sessions were taken unfiltered at 300 seconds integration. Details of both observatories can be found in Oey (2011). *MPO Canopus* v.10.4.0.4 software was used for period analysis which incorporates the Fourier algorithm (FALC) developed by Harris (Harris *et al.*, 1989).

The observations from Kingsgrove observatory were initiated at the request of Fernando Mazzone in Argentina as part of a collaboration. Due to poor weather conditions in Argentina, only Oey could continue with observations, eliminating the advantage of a long longitudinal baseline between two observers. The data were reduced with Comp Star Selector (CSS) methodology in *MPO Canopus* v10. This finds up to five values for the target by using

$$M_{target} = (m_{target} - m_{comp}) + M_{comp} \qquad (1)$$

where m_{target} and m_{comp} are, respectively, the instrumental magnitudes of the target and comparison and M_{comp} is the catalog magnitude of the comparison. The final value for the target (M_{target}) is the mean of the intermediate results and the error is the standard deviation of the mean. This had the effect of linking all sessions to a standard scale with reported accuracy of 0.03–0.05 magnitudes.

Care was taken to maximize the SNR in order to achieve a precision of < 0.03 mag, which was required because of the known low amplitude and long period of the lightcurve. Despite a lengthy process in searching through the period spectrum generated by the Fourier analysis in *MPO Canopus*, no convincing period stood out even after extending the search to the known value of >100 h. It was clear that CSS method in *MPO Canopus* failed in this instance. Fortunately there were a number of consecutive nights of observations during the observing campaign. The data were reduced by using differential photometry to tie in groups of two nights per session using common comparison stars. In this way, the sessions would be lined up by arbitrarily adjusting the zero point of each session and overlapping the common data points (Stephens, 2008). This method gave an accuracy equivalent to that obtained with differential photometry and the errors were limited only by the scatter of the data points.

The first group of data points that were linked was the six consecutive nights from Aug 24-29. A period of 103 h was found when searching through the period spectrum. The next three lots of three consecutive nights (Aug 10-12, Aug 20-22, Sep 3-5) were added and adjusted, all the while making sure the chord and lightcurve shape were well-matched. The period search still held at 103 h with an RMS fit of 1.40 (in units of 0.01 mag). Finally, the remaining sessions were included to increase the density of the lightcurve. The search for longer period revealed a possible period of 160 h with RMS = 1.35. Despite the lower RMS value for the longer period, some of the consecutive night's sessions were not consistent with the shape of the lightcurve. Therefore, the longer period was rejected in favor of the one near 103 h. It was interesting to note that once the sessions had been arbitrarily adjusted to fit into the curve derived from the above method, the arbitrary offset was less than 0.05 mag for all sessions, except one, which is within the limit of accuracy for CSS method.

The final period was 103.5 ± 0.3 h and amplitude of 0.06 ± 0.02 mag. This is consistent with the results found from previous studies. The phase angle (α) changed from 6 to 10 degrees. The phase angle bisector (PAB) longitude and latitude were 312 and –24 degrees, respectively.

As noted above, 617 Patroclus is a known synchronous binary. However, for this apparition, no signs of eclipse events typical of synchronous binary were seen in the lightcurve. This might be due to an unfavourable viewing geometry that did not allow eclipses, or it could also be the effect of the low amplitude and long period compounded by having observations from only a single station.

Conclusion

Observations with higher precision linked to a standard photometric system (e.g., using filters and Landolt fields) as well as multiple collaborators spread out over the globe are required to determine with certainty the correct rotational period. The Comp Star Selector method in *MPO Canopus* is an excellent and easy approach to standardize multiple sessions including those from different observers and locations. However the above method can be used as a tool to improve the accuracy of link for challenging targets such as those with long period and low amplitude.

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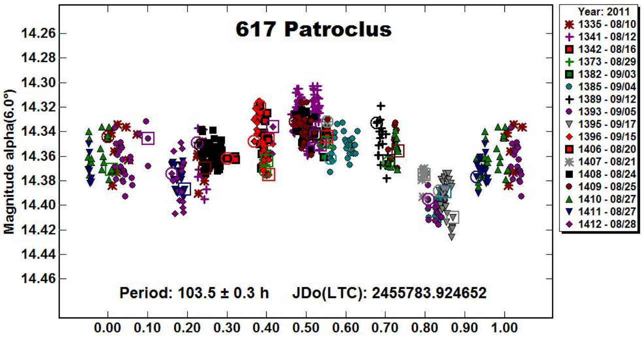

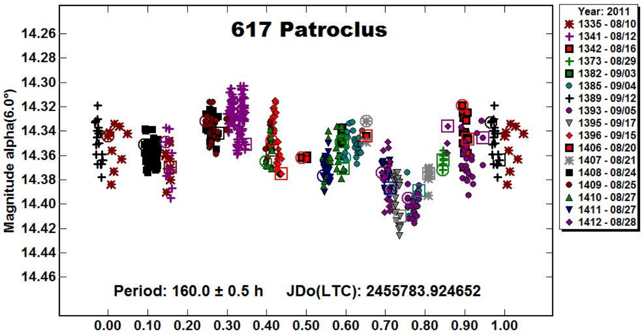

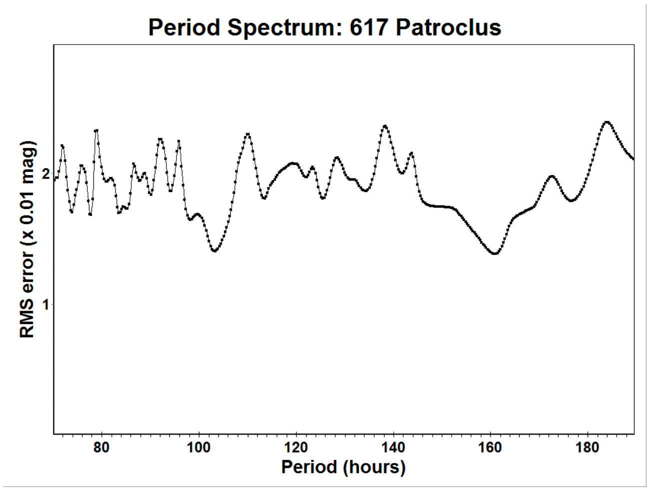

CCD LIGHTCURVES FOR ASTEROIDS 201 PENELOPE AND 360 CARLOVA

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Fourier analysis of CCD-derived lightcurves produced synodic period solutions for 201 Penelope (3.7491 ± 0.0012 h) and 360 Carlova (6.1894 ± 0.0003 h).

CCD photometric observations were made in late 2011 and early 2012 of asteroids 201 Penelope and 360 Carlova to determine their lightcurve parameters. The instrument used at UnderOak Observatory (UO) is a 0.2-m catadioptric OTA (*f*/7) equipped with an SBIG ST402ME CCD. The optical assembly produces a field-of-view ~11×17 arcmin, or 1.33 arcsec/pixel. See Alton (2010) for a more complete description of observing and data analysis procedures. Unfiltered 60-s (201 Penelope) or I_c-filtered 90-s (360 Carlova) exposures were continually captured during each session lasting from 3.5 to 6 h. Data were light-time corrected and reduced to instrumental magnitudes with *MPO Canopus* (Warner, 2010). At least 2 non-varying comparison stars were used to generate lightcurves by differential aperture photometry. Fourier analysis (Harris *et al.*, 1989) yielded a period solution from each folded dataset and then was independently verified using *Peranso* (Vannmunster, 2006) as previously described (Alton, 2011). Relevant aspect parameters for each of these main belt asteroids taken at the mid-point from each observing session are in Table I. Phased data are available upon request by contacting the author.

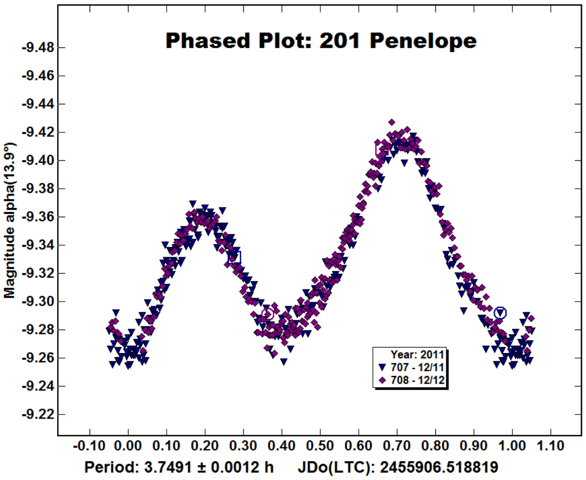
201 Penelope. Discovered in 1879 by Johan Palisa, this M-type asteroid (*D* = 68 km) has been studied by numerous investigators, mostly over the past three decades. Photometric studies that initially established the color index and/or determined its synodic period include Lagerkvist *et al.* (1981), Surdej *et al.* (1983), and Pfleiderer *et al.* (1987). A spectrophotometric analysis of surface material covering the range of 0.338-0.762 µm (Busarev 1998) revealed the presence of hydrated silicates. Physical modeling of this asteroid (Torppa *et al.* 2003) suggests a regular triaxial ellipsoid shape (a/b = 1.5 and b/c = 1.1). At UO, a total of 555 images were taken over 2 nights (2011 Dec 10 and 11). Lightcurve analysis produced the best folded fit at a slightly longer period (3.7491 h) than the value (3.7474 h) presently posted at the JPL Solar System Dynamics website (*http://ssd.jpl.nasa.gov/sbdb.cgi*). The peak-to-peak amplitude *A* = 0.16 mag observed during this most recent apparition was within the range (0.15-0.73 mag) reported for this object by Foglia *et al.* (2000).

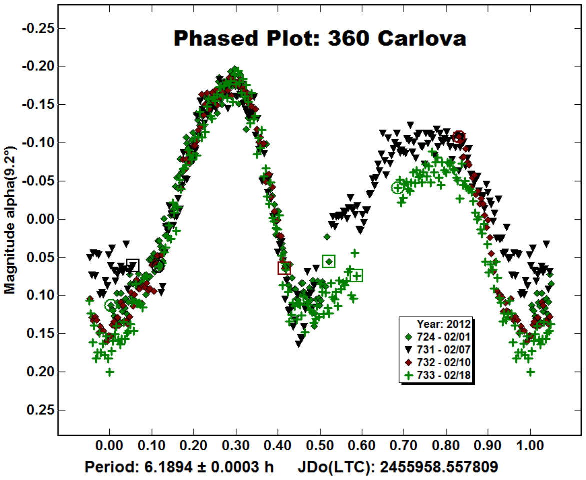
360 Carlova. This sizeable C-type asteroid (*D* = 116 km) was discovered by Auguste Charlois in 1893. Harris and Young (1983) published the earliest lightcurve followed by similar investigations from DiMartino *et al.* (1987), Michalowski *et al.* (2000), Wang

Object	Range Over Observation Period			
	UT Date	Phase Angle	L_{PAB}	B_{PAB}
201 Penelope	2011 Dec 10 - 2011 Dec 11	13.9 - 14.2	48.8 - 48.9	-7.2 - -7.2
360 Carlova	2012 Feb 01 - 2012 Feb 18	9.2 - 15.0	111.2 - 112.3	-4.4 - -3.2

Table I. Observation circumstances.

(2002), and Wang and Zhang (2006). More recently, Durech *et al.* (2009) published a spin-state solution for 360 Carlova using a combination of sparse and dense photometric data. During the CCD photometric study at UO, 750 images were acquired on four nights between 2012 Feb 01 and 18. The synodic period solution (6.1894 h) estimated by *MPO Canopus* was very similar to the composite value (6.1896 h) recently reported by Durech *et al.* (2009). This lightcurve exhibited a peak-to-peak amplitude *A* = 0.38 mag, which was within the range of 0.30-0.49 mag estimated from all the lightcurves referenced herein.





Acknowledgement

Many thanks to the SAO/NASA Astrophysics Data System and the Asteroid Lightcurve Database (LCDB), both of which proved indispensable for locating relevant literature references.

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THE ROTATIONAL PERIOD OF 328 GUDRUN

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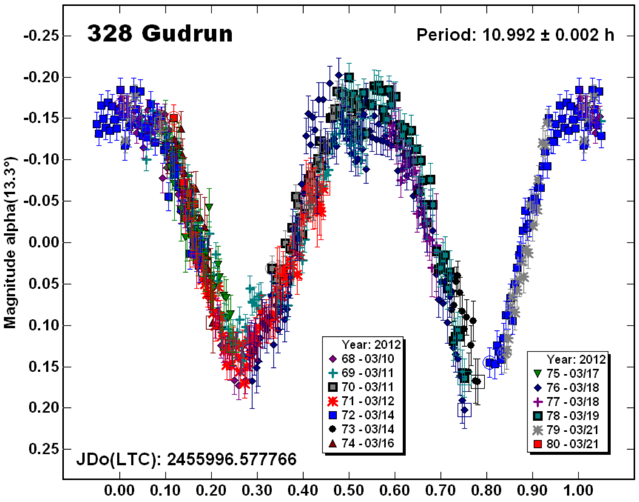
Lightcurve analysis of CCD observations for minor planet 328 Gudrun in 2012 March indicates P = 10.992 ± 0.002 h with A = 0.32 ± 0.03 mag in Cousins I band.

Max Wolf discovered 328 Gudrun on 1892 March 18 (Schmadel 2003). Photographic photometry by Lagerkvist (1978) suggested a period > 12 h and amplitude in B magnitude < 0.15. Behrend (2004, 2010) attempted to fit observations with limited coverage of the full lightcurve obtained by Bernasconi and Audejean to a period of 17.96 h.

In 2012 March, differential photometry of 328 Gudrun was conducted at Burleith Observatory using a PlaneWave 12.5-inch *f*/8 CDK, Astro-Physics AP900 mount, and self-guiding SBIG STL-1001E CCD at –5ºC. Image scale was 1.95 arc-seconds per 24-micron pixel, unbinned. Each exposure was 180 s using an *Astrodon* Cousins I-band filter (bandwidth 700-900 nm). Urban light in Washington, DC limits observing to the near-IR. Observations were bias and sky flat-field corrected using *CCDSoft* version 5.00.195. Photometry and period analysis was performed using *MPO Canopus* version 10.4.0.20 (Warner, 2011).

From 621 images over nine nights, analysis found the rotation period to be P =10.992 ± 0.002 h with Cousins I band A = 0.32 ± 0.03.



Acknowledgements

The author thanks James A. DeYoung for his independent period analysis and helpful suggestions.

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ASTEROID LIGHTCURVE ANALYSIS AT THE ETSCORN CAMPUS OBSERVATORY FOR JANUARY AND FEBRUARY 2012

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(Received: 27 February Revised: 16 April)

Three asteroids were observed at the Etscorn Campus Observatory during the first two months of 2012. Synodic periods ranging from 3 hours to 32 hours were obtained. The asteroids are: 2026 Cottrell, 3397 Leyla, and 4801 Ohre.

Photometric observations of three asteroids were made at the Etscorn Campus Observatory on the campus of New Mexico Institute of Mining and Technology. The observatory, which is used for research, teaching and public events, has two 0.35-m Celestron Schmidt-Cassegrain telescopes with SBIG STL-1001E CCD camera systems that were used to make the observations.

Depending on the brightness of the asteroid, image exposures were either 3, 5, or 6 minutes through a clear filter. 1x1 binning was used giving 1.25 arc seconds/pixel with a field of view of ~21.33 arc minutes. Telescope tracking and image collection were done with Software Bisque's (2011) *TheSky* v6 and *CCDSoft*. Flats were obtained using light reflected off the wall and dome of the enclosures. All images were dark subtracted, flat-field corrected, and aligned using *IDL* (Visual Information Solutions, 2012) procedures developed by the author. The lightcurve analysis was done using *MPO Canopus,* version 10.4.0.6 (Warner, 2011) which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.*, 1989). Final synodic periods were obtained using *8* orders in the Fourier series period determination.

The results are summarized in Table 1 below. The table columns are: asteroid number, asteroid name, date range of observations, number of nights observed, number of data points used, solar phase angle, synodic period, period error, amplitude and amplitude error. For the solar phase angle column, the first number is associated with the first night's observations and the last number is associated with the last night's observations. If there are three numbers, the middle one is the minimum solar phase angle. The phased plots are also shown below.

2026 Cottrell (1955 FF). This asteroid was discovered 1955 March 30 at Brooklyn, Indiana, by the Indiana Asteroid Program, Goethe Link Observatory, University of Indiana. (JPL Small-Body Database Browser). This program was conceived and directed by

#	Name	mm/dd 2012	Data points	Solar phase	period h	PE	Amp. mag	AE
2026	Cottrell	02/18 - 02/26	188	14.2,17.5	4.4994	0.0004	0.80	0.10
3397	Leyla	01/18 - 02/07	332	29.1,24.7	3.098	0.002	0.49	0.11
4801	Ohre	01/02 - 01/31	638	7.9,1.3,8.9	32.04	0.004	0.64	0.06

Table 1. Observation circumstances.

F. K. Edmondson; the plates were blinked and measured astrometrically by B. Potter, and – following her retirement – by D. Owings. The photometry was performed under the direction of T. Gehrels. A large number of people participated in various aspects of the program and, interestingly enough, the author was a member of that program in 1961 and 1962 as a graduate student. 2026 Cottrell has been linked to 1951 EL1 and 1972 TE1. It was observed at Etscorn for four nights from February 18 through 26. The solar phase angle varied from 14.2° to 17.5° after opposition.

3397 Leyla (1964 XA). Leyla was discovered in 1964 December by R. Burnham and N. G. Thomas at Lowell Observatory (JPL Small-Body Database). It was named after Nancy Leyla Lohmiller (b. 1985), daughter of Muazzez Kumrucu Lohmiller, administrative assistant at the Minor Planet Center. It is a Mars-crossing Asteroid. It was observed at Etscorn for six nights from January 18 through February 7. The solar phase angle varied from 29.1° to 26.4° before opposition.

4801 Ohre (1989 UR4). Discovery was 1989 October 22 by A. Mrkos at Klet. It is named for a Czech river rising in Germany near the Czech border and continuing through the towns of Karlovy Vary, Zatec, and Louny to its confluence with the Labe river (JPL Small-Body Database). It was observed at Etscorn for nine nights from January 1 through January 31. The solar phase angle varied from –7.0° through +8.9°. The minimum solar phase angle was 1.3°. Opposition was on 2012 January 15.

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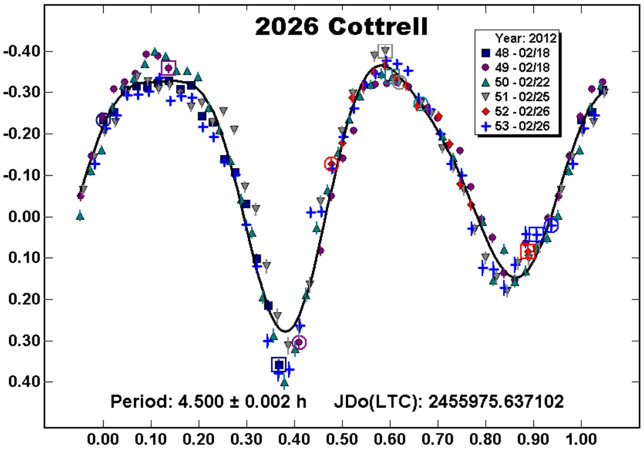

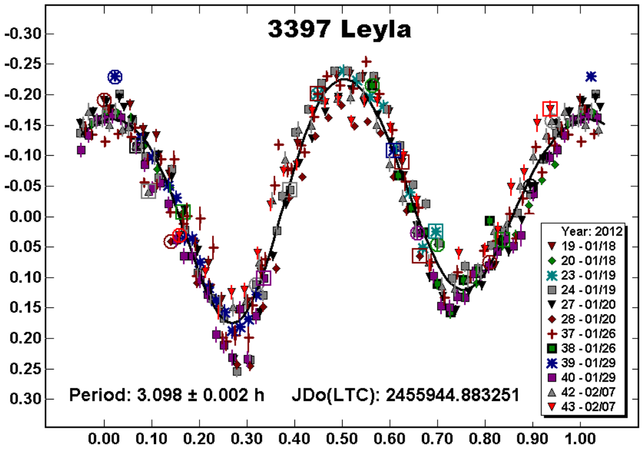

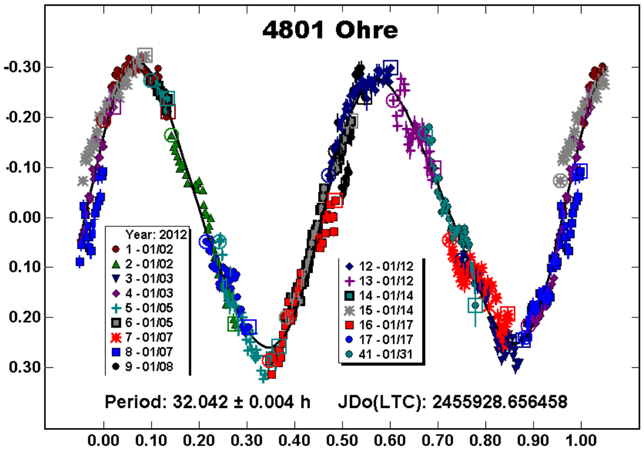

LOWELL OBSERVATORY NEAR-EARTH ASTEROID PHOTOMETRIC SURVEY (NEAPS) – 2008 MAY THROUGH 2008 DECEMBER

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We report the results of the Lowell Observatory Near-Earth Asteroid Photometric Survey (NEAPS) for the interval 2008-05-01 to 2008-12-31. We obtained photometric data for 46 asteroids including 1036 Ganymed, 1620 Geographos, 1627 Ivar, 1865 Cerberus, 1980 Tezcatlipoca, 2363 Cebriones, 4179 Toutatis, 4257 Ubasti, 5332 Davidaguilar, 7358 Oze, (8567) 1996 HW1, (16960) 1998 QS52, (39572) 1993 DQ1, (53430) 1999 TY16, (66146) 1998 TU3, (85774) 1998 UT18, (87684) 2000 SY2, (136849) 1998 CS1, (137032) 1998 UO1, (137805) 1999 YK5, (138852) 2000 WN10, (142348) 2002 RX211, (144901) 2004 WG1, (162900) 2001 HG31, (163000) 2001 SW169, (164400) 2005 GN59, (171576) 1999 VP11, (185851) 2000 DP107, (185854) 2000 EU106, (189700) 2001 TA45, (190135) 2005 QE30, (190491) 2000 FJ10, (231134) 2005 TU45, (248818) 2006 SZ217, (257744) 2000 AD205, 1998 SJ70, 2004 XK3, 2006 VB14, 2007 VQ4, 2008 EV5, 2008 QS11, 2008 SA, 2008 SE, 2008 SQ1, 2008 SR1, and 2008 US4.

The Lowell Observatory Near-Earth Asteroid Photometric Survey (NEAPS) was designed to obtain large numbers of rotational lightcurves for near-Earth asteroids (NEAs) in support of a statistical analysis of the rotational properties of NEAs. It was anticipated that the three-year program would involve a significant number of nights using all four telescopes at Lowell Observatory's Anderson Mesa site: 1.8-m Perkins, 1.1-m Hall, and 0.78-m robotic reflector; and the 0.55-m LONEOS Schmidt.

A majority of the observing was done using the LONEOS Schmidt. The existing camera, operated unfiltered at the f/1.9 prime focus, contains two 2k by 4k pixel E2V chips. The system is cooled by a Cryotiger chiller with a set-point temperature of –110 °C. Because of gradually deteriorating camera electronics, a central 1k by 1k pixel region was selected for the photometric survey. This provided a field of about 40' by 40' at an image-scale of 2.5 arcsec per pixel. The CCD is strongly red-sensitive yielding a very broad passband comprising much of the Johnson-Cousins V, R, and I photometric passbands. The chip is affected by night-sky emission, particularly running unfiltered at f/1.9, producing fringing in the background (about 5% peak-to-trough). The bias was also affected by a herringbone pattern from various sources of electronic noise in the system. Ordinary night-sky exposures show that the 1k by 1k pixel portion of the chip contains hundreds of small clumps of abnormal pixels which were flattened to varying degrees. There are also several sets of bad columns in the device. Other sections of two CCDs are even worse cosmetically or lie in the strongly vignetted portions of the telescope field.

Nearly all the observing during the first year of the project was done by Koehn and Sanborn. Koehn was also responsible for the care and feeding of the computer system and data-management. Sanborn did most of the early photometric reductions and bookkeeping, alas now abandoned. We will describe the instrumentation at the other telescopes in later reports in this series.

In the early days, we performed asteroid observation scheduling with an in-house automated scheduler involving the Lowell asteroid orbit file. After starting the system, the observer invoked the scheduler. The scheduler included biases and night-sky flats at the start of the night. The night-sky 'flat' exposures were 45 seconds, which produced a background less bright than twilight flats but generally adequate. The scheduler examined all the reasonably bright NEO asteroids accessible during a night, selecting the four “best” asteroids in any single cycle. However, the definition of “best asteroid” changed as the night progressed so the scheduler would sometimes visit as many as 15 asteroids during the night. Exposure times were set automatically using the predicted magnitudes of the asteroids, but with an upper limit of 180 seconds. When no brighter asteroids were available, the scheduler assigned most asteroids to the maximal exposure. Since there was no guider, these relatively long exposures yielded poorly-tracked images, and the fast-moving targets were often unmeasurable as a result. No account was taken of Moonlight, so on many nights the sky background was large and the asteroid images were unmeasurable because the available dynamic range became small.

An in-house photometric reduction pipeline was written to download the nightly batches of images, produce median bias and flats, and do quasi-aperture photometry using SExtractor. This did not work very well, and in July 2010 we adopted *MPO Canopus* for the reductions, but keeping the front-end of the pipeline to deal with the image-transfer within our computer network and to produce de-biased and flat-fielded images for *Canopus* to work on. We made no correction for the fringe pattern. The complete re-reductions, a backlog of some 50,000 images, were done by McClelland and Skiff while they also pressed ahead with nightly observing during the final year of the program, producing another 100,000 images.

We took advantage of the photometric catalog in *Canopus* to yield standard Sloan r' magnitudes. The catalog includes the combined entries from the Carlsberg Meridian Circle (CMC14) catalog (Evans, 2006) and the Sloan Digital Sky Survey DR6 (Adelman-McCarthy, 2008; Hogg, 2001; Fukugita, 1996; Ivezić, 2004; Padmanabhan, 2008; Tucker, 2006). CMC14 provides several million well-observed stars with reliable Sloan r' magnitudes around the sky in the declination range $-30° < \delta < +50°$ deg and magnitude range $9 \leq r' \leq 16$ mag. The Sloan survey covered much of the north galactic cap (the springtime sky) north of the Equator, including several hundred million stars from $15 \leq r' \leq 22$ mag.

This meant nearly all our fields had plenty of photometric reference stars irrespective of exposure time, and reductions directly to Sloan r' were made without intermediary observations of standard fields. We found no particular increase in errors on nights with cirrus using these on-chip standards as long as the clouds were not so thick as to ruin the photon statistics.

In some far-northern or far-southern fields there is no r' coverage from these catalogs, so we used the Cousins R magnitudes derived from the 2MASS survey (Skrutskie, 2006), which are also provided in Canopus for the whole sky (Warner, 2006). The zero-point is somewhat softer here, but this does not affect the internal errors of the measurements.

Because the camera is unfiltered, we tried to select reference stars of near-asteroidal color in order to minimize the effective color-term and also differential atmospheric extinction corrections in the photometric reductions. This was specifically in the approximate range $0.6 < B-V < 0.95$ or $0.3 < V-R < 0.55$, as shown by *Canopus*, though not always possible for all stars in every field. *Canopus* allows the use of up to five photometric reference stars in a field. Sometimes, in sparse or poorly-observed fields, we used fewer stars, and inevitably there were occasional hitherto unknown variable stars that had to be dropped from the reductions post-facto.

In our reductions we naturally tried to use the brightest unsaturated reference stars, and thus inevitably those stars are drawn mainly from CMC14. We made a test of a field having both Carlsberg and Sloan coverage, and found that the LONEOS instrumental magnitudes were linear and with very little offset transitioning between the two catalogs around $r' = 15$ mag. This mainly commends the Carlsberg data, which were taken with a refractor of a mere 17cm aperture, compared to the 2.5-m Sloan telescope.

More recently we also made a test of our derived magnitudes by measuring relatively bright equatorial Landolt standards that have also been turned into Sloan primary standards (Smith 2002). Making use of Carlsberg stars of near-asteroidal color as the reference, for about 20 Sloan stars (also of near-asteroidal color) in four Landolt fields we obtained a mean offset for the Sloan standards of 0.00 ± 0.02 mag RMS. Thus we conclude that our asteroid photometry should be systematically close to the standard Sloan r' system, barring zonal zero-point errors in the Carlsberg catalog in different parts of the sky.

The *Canopus* measurements were done with rather tight measuring apertures for both the stars and the asteroids in hopes of optimizing signal-to-noise and reducing the influence of bad pixels, fringing, field stars, and so on. Nearly always the aperture was 7 pixels (12.5 arcsec) diameter, or about 1.5 times the full width half maximum for LONEOS images when there was no significant trailing. Sometimes apertures of 9 pixels diameter were used for slightly trailed images or when the seeing was especially poor, and occasionally just 5 pixels for the very faintest targets. Oval apertures were used for the long trails of the fast-movers. Since tracking was poor these had to be rather larger than we preferred (sometimes up to 21 by 13 pixels) because the length and position-angle of the trails varied from frame to frame. In both circumstances the sky-background annuli were separated from the measuring aperture by 7 or 9 pixels, and were 11 pixels in width.

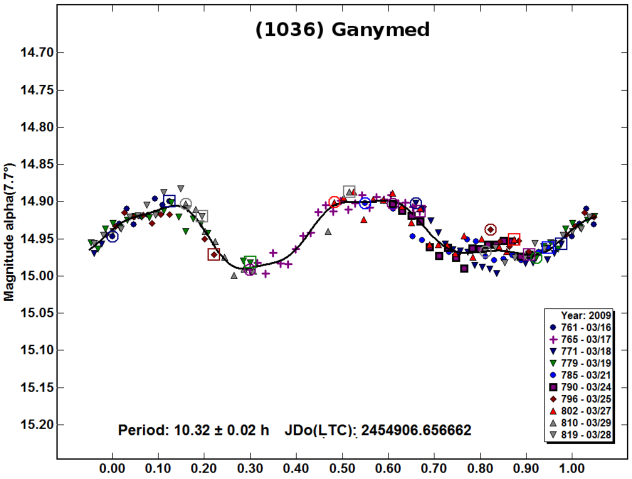
We nearly always made use of the 'Star-B-Gone' star-subtraction routine in *Canopus*. It did not always work well but allowed us to measure frames when an asteroid was closer to a field star than we might otherwise have included, and sometimes would accurately subtract a field star that an asteroid went directly over. The accuracy of the star-subtraction seems to be independent of the asteroid/star magnitude difference.

The error budget for the observations is poorly constrained. As noted above, the poor cosmetic quality and electronic instability of the chip introduced errors in the measurements of the sky background, the comparison stars, and the targets. Since the telescope was usually tracked at half the asteroidal rate of motion, both the stars and asteroid were moving across the chip during the course of the night and were thus variously affected by bad pixels, poor flat-fielding, the varying fringe level, etc. All this was made worse when we were forced to use the larger oval measuring apertures for the fast-moving objects.

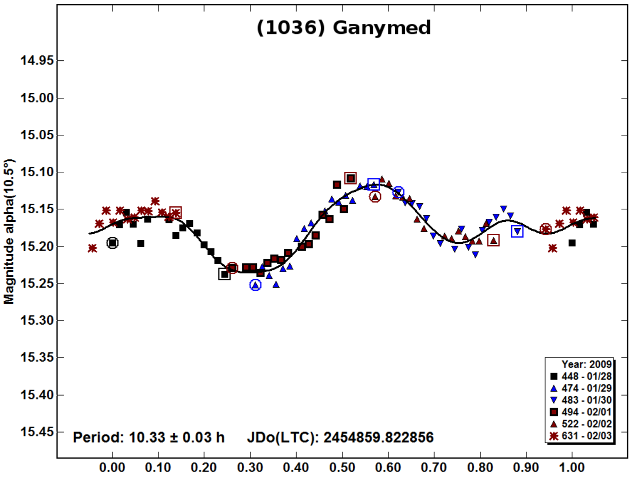
Typically, the internal mean RMS errors on the five comparison stars in a series were less than 0.02 mag, sometimes as low as 0.007 mag in favorable circumstances. This establishes a floor on the total errors. We estimate the cosmetic and electronic problems described above add at least 0.01 mag to the overall error budget. The targets were nearly always fainter than the comp stars. However, for most targets the straightforward photon-statistical errors do not dominate the uncertainties in the present series of observations, but instead all the other error sources do. Errors in the overall zero-point of the Carlsberg reference stars from field to field are unknown, but seem to be no more than about 0.05 mag globally around the sky, at least for stars observed on multiple nights by the meridian circle. The lightcurves to follow will show the internal errors of the results clearly, and we think the external zero-points should be reliable to ± 0.05 mag.

For the asteroid periods described in this paper, we felt that while the formal error produced by *Canopus* was mathematically accurate, it consistently suggested an optimistic accuracy for the asteroid periods. Therefore, we adopted the convention of estimating the period error as $\Delta P = \pm 0.05P/n$ where P is the period and n is the largest number of consecutive unambiguous periods available in the analysis. Whenever we obtained sufficient data to generate a lightcurve, we estimated the peak-to-peak amplitude and the mean magnitude from the fitted curve rather than the data itself. When we obtained insufficient data, we estimated the mean magnitude directly from an average of the existing data and the peak-to-peak amplitude as the difference between the extreme magnitude values.

1036 Ganymed. We observed this Amor asteroid, using the LONEOS Schmidt, on 24 nights between 2008-12-03 and 2009-04-22 obtaining a total of 381 measurements. The asteroid has a published period of 10.2936 h, U = 3 produced by Behrend (Behrend, 2011). Others have produced similar periods, notably Kaasalainen and Hahn (Kaasalainen, 2002; Hahn, 1989). We have taken all references to periods and period quality, U, from the LC_DAT_PUB.TXT file produced by Warner (Warner, 2009a).

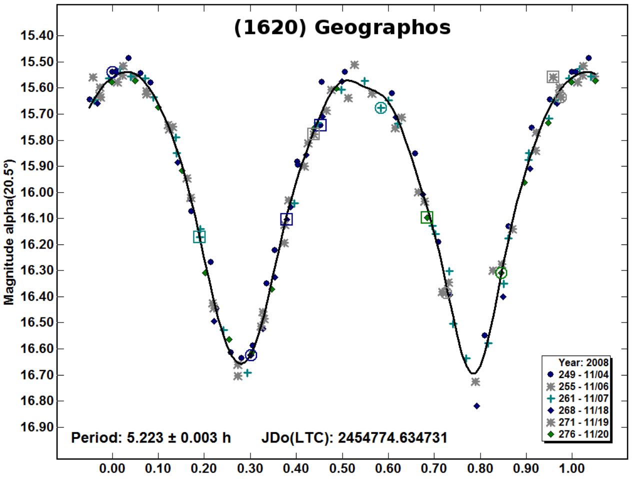


The first graph shows data from 10 nights of a single lunation 2009-03-16 to 2009-03-29. The peak to peak amplitude is 0.08 mag and the mean magnitude is r' = 15.04 mag (normalized to 2009-03-16). We added 0.05 mag to the apparent mean magnitude shown in the graph because the average offset for all nights was -0.05 mag. The period of 10.32 ± 0.02 h, generated with an order 7 fit, is in good agreement with the currently accepted value of 10.2936 h.



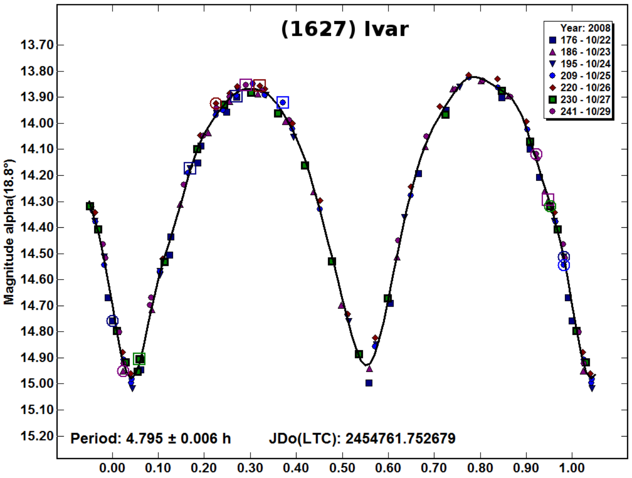
The second lightcurve of Ganymed shows six nights from a second lunation 2009-01-28 to 2009-02-03. The peak-to-peak amplitude is 0.12 mag and the mean magnitude is r' = 15.18 mag (normalized to 2011-01-28). We subtracted 0.02 mag from the mean shown on the graph to account for the average offset used over the six nights. In this case, the period is 10.33 ± 0.03 h, generated with an order 7 fit. When we combine the data from both graphs, we have unambiguous data from a 61 day interval which produces a period of 10.315 ± 0.004 h. We did not use data from 8 nights because they were either extremely noisy or temporally isolated from other nights.

<u>1620 Geographos.</u> We observed this Apollo (PHA) asteroid, using the LONEOS Schmidt, on six nights between 2008-11-04 and 2008-11-20 obtaining a total of 135 usable measurements. Hamanowa published a period of 5.22204, U = 3 for this asteroid (Hamanowa, 2011). Others have found similar periods, notably Higgins and Behrend (Higgins, 2008; Behrend, 2008).

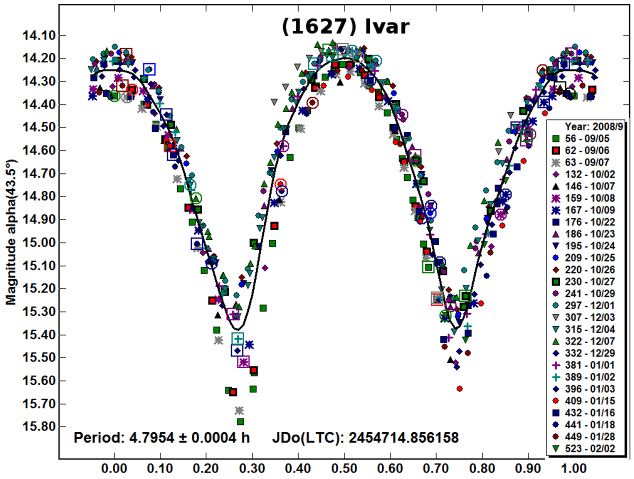


We used no offsets and obtained a period of 5.223 ± 0.003 h with an order 9 fit including all our data in the graph. The mean magnitude, normalized to 2008-11-04, is r' = 16.12 mag with an amplitude of 1.14 mag. Our period is in good agreement with the currently accepted value.

<u>1627 Ivar.</u> We observed this Amor asteroid using the LONEOS Schmidt, on 29 nights between 2008-09-05 and 2009-02-02 obtaining a total of 516 usable measurements. Kaasalainen found a period 4.795 h, U = 3 for this asteroid (Kaasalainen, 2004). Several other have published a similar period including Szabó, Kiss and Pravec (Szabó, 2001; Kiss, 1999; Pravec, 1996).

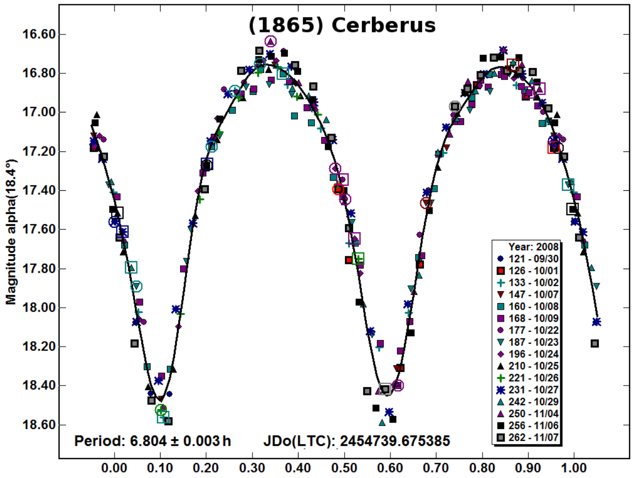


The first graph shows data from 7 nights from a single lunation 2008-10-22 to 2008-10-29. The peak to peak amplitude is 1.11 mag and the mean magnitude is r' = 14.44 mag (normalized to 2009-10-22). The period of 4.795 ± 0.006 h, generated with an order 9 fit, is in good agreement with the currently accepted value.



In order to reduce the error of the period, we found a second solution, shown in the graph, using all the available data. Since the time interval likely involves significant aspect changes, the mean magnitude and amplitude have little meaning. The period of 4.7954 ± 0.0004 h, gained a significant digit.

<u>1865 Cerberus.</u> We observed this Apollo asteroid on 16 nights between 2008-09-30 and 2008-11-07 obtaining a total of 268 usable measurements. Pravec published period of 6.810 h, U = 3 for this asteroid (Pravec, 1999). Wisniewski and Harris have published similar values for the period (Wisniewski, 1997; Harris, 1989).



The graph shows all the available data and produced a period of 6.804 ± 0.003 h using an order 7 fit. The period matches the currently accepted value. The mean magnitude, normalized to 2008-09-30 is r' = 17.61 mag with an amplitude of 1.72 mag.

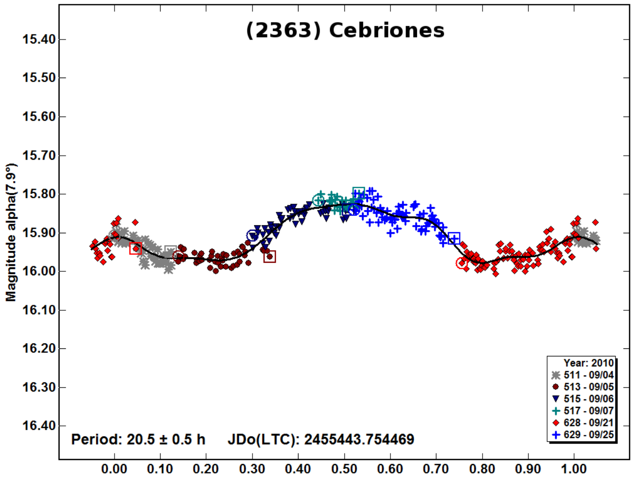
<u>1980 Tezcatlipoca.</u> We observed this Amor asteroid, using the LONEOS Schmidt, on three nights between 2008-09-07 and 2008-09-22 obtaining a total of 12 usable measurements. Behrend published a period for this asteroid of 7.24612 h, U = 3 (Behrend, 2006). Wisniewski and Kaasalainen have published similar periods. (Wisniewski, 1997; Kaasalainen, 2004).

The available data are insufficient to produce a lightcurve but we can provide average absolute magnitudes for each of the three nights.

UT Date	Number of obs.	Mean r'	Amplitude Δr'
2008-09-07	2	16.77	0.10
2008-09-20	5	16.71	0.22
2008-09-22	5	16.55	0.12

Wisniewski reported an amplitude of 0.78 mag. The small amplitudes we found might indicate that our observations were made with a more a polar alignment to the asteroid.

<u>2363 Cebriones.</u> We observed this Jupiter Trojan asteroid, using both the LONEOS Schmidt, and Hall, on 8 nights between 2008-06-10 and 2008-09-25 obtaining a total of 866 usable measurements. This asteroid has a published period of 20.081 h, U = 2+ (Galád, 2008). Mottola recently published a similar period (Mottola, 2011).



Our data can be forced to approximately match the period produced by Galád and Mottola but their periods are compelling and ours, 20.5 ± 0.5 h, is not. The RMS error graph produced by Canopus had a very broad minimum near 20.5 hours. Additionally, our data have almost no overlap from night to night, so we consider the fit to be of poor quality. We are, however, confident in the mean magnitude, r' = 15.90 mag, and amplitude, 0.15 mag, normalized to the night of 2010-09-04.

All the data we used to determine the period came from the NURO telescope. We have two other nights from the LONEOS Schmidt but we could not force those data into a solution compatible with the known period.

<u>4179 Toutatis.</u> We observed this Apollo (PHA) asteroid, using the LONEOS Schmidt, on 29 nights between 2008-09-05 and 2009-02-19 obtaining a total of 684 usable measurements. This asteroid has a published period of 176 h, U = 3 (Pravec, 2005).

Pravec performed an extensive analysis on this well known tumbler and found $P_1 = 175$ h and $P_2 = 130$ h. Several other researchers, notably Hudson and Mueller studied the tumbling nature of this asteroid (Hudson, 2003; Mueller, 2002). We did not perform any other analysis on this asteroid but simply note that all the data are available from the Minor Planet Center Lightcurve Database. The change in magnitude within a single night and from night to night indicates the amplitude of the lightcurve is more than a magnitude. Since we cannot present a meaningful lightcurve, we present our summary data in the following table.

UT Date	Number of obs.	Mean r'	Amplitude Δr'
2008-09-05	34	14.19	0.16
2008-09-06	31	14.47	0.13
2008-09-07	32	14.00	0.09
2008-09-20	5	14.36	0.08
2008-09-24	4	13.85	0.01
2008-09-25	9	14.85	0.06
2008-09-26	7	14.93	0.17
2008-11-19	2	13.50	0.00
2008-11-24	11	14.99	0.11
2008-12-01	15	14.05	0.05
2008-12-03	16	13.10	0.16
2008-12-04	5	13.42	0.04
2008-12-07	14	13.42	0.06
2008-12-29	39	13.61	0.16
2009-01-01	40	13.81	0.36
2009-01-02	37	13.79	0.19
2009-01-03	7	13.58	0.02
2009-01-08	53	14.36	0.14
2009-01-15	45	14.65	0.45
2009-01-16	33	14.33	0.09
2009-01-18	40	14.23	0.10
2009-01-28	34	14.26	0.05
2009-01-29	30	14.95	0.21
2009-01-30	29	15.20	0.21
2009-02-01	27	14.85	0.18
2009-02-02	47	14.93	0.26
2009-02-03	21	14.85	0.05
2009-02-04	7	15.25	0.03
2009-02-19	6	15.68	0.04

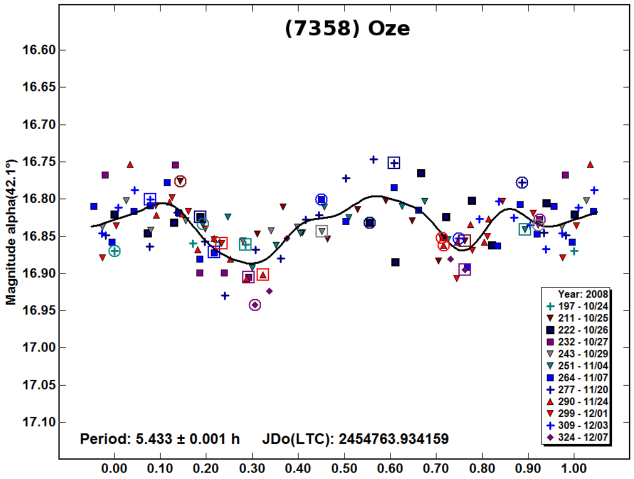
4257 Ubasti. We observed this Apollo asteroid, using the LONEOS Schmidt, on one night, 2008-09-24, obtaining five usable measurements. This asteroid has no published period. The mean magnitude for 2008-09-24 was r' = 17.54 mag and the amplitude was 0.36 mag.

5332 Davidaguilar. We observed this Amor asteroid, using the LONEOS Schmidt, on three nights between 2008-09-05 and 2009-02-02 obtaining a total of 20 usable measurements. This asteroid has a published period of 5.803, U = 3 (Binzel, 1990). Wisniewski found a similar period (Wisniewski, 1997).

Since each of the three nights of observation were in a different lunation, we could not obtain a convincing hint about the period although single nights are vaguely consistent with a period of 3 to 5 hours. We summarize our data in a table.

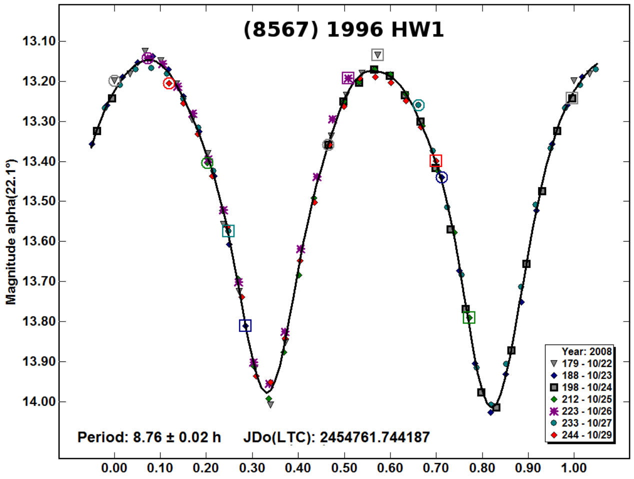
UT Date	Number of obs.	Mean r'	Amplitude Δr'
2008-09-05	8	16.76	0.20
2009-01-30	6	16.70	1.10
2009-02-02	6	16.68	0.65

7358 Oze. We observed this Amor asteroid, using the LONEOS Schmidt, on 13 nights between 2008-10-24 and 2008-12-07 obtaining a total of 131 usable measurements. This asteroid has a published period of 5.488 h, U = 2-. (Pravec, 1998)



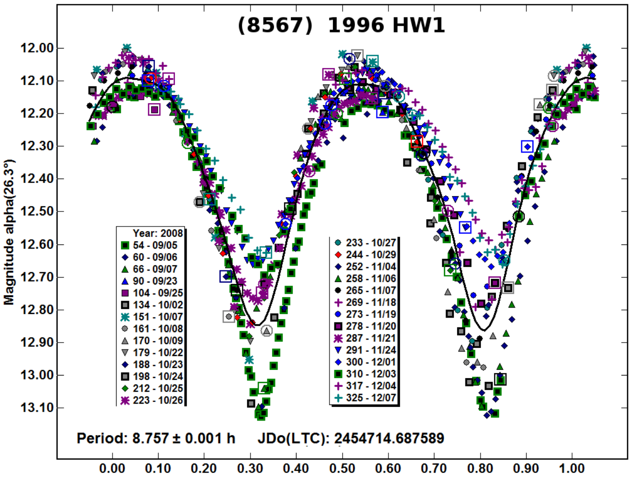
The mean magnitude of this asteroid, normalized to 2008-10-24, is r' = 16.86 mag and its amplitude is 0.10 mag. Our period of 5.433 ± 0.001 h differs from Pravec's by 0.055 h. That difference corresponds to two rotations in the 45 day period over which we made observations. Because the data are so noisy, and because we had a long interval during which the asteroid was not observed (2008-11-07 to 2008-11-20) we should expect such discrepancies.

(8567) 1996 HW1. We observed this Amor asteroid, using the LONEOS Schmidt, on 30 nights between 2008-08-23 and 2009-01-03 obtaining a total of 1294 usable measurements. This asteroid has a published period of 8.7573 h, U = 3 (Higgins, 2006a). Benishek and Magri have published similar periods (Benishek, 2009; Magri, 2011).

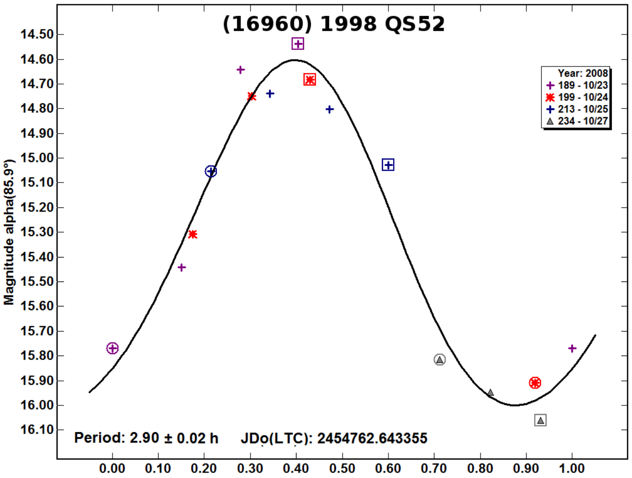


The first lightcurve shows the data from a seven day interval 2008-10-22 through 2008-10-29. The curve is from an order 9 fit and yields a period of 8.76 ± 0.02 h. The mean magnitude, normalized to 2011-10-22 is r' = 13.60 mag with an amplitude of 0.86 mag. Although this fit had exceptionally small residuals, the period did not match Higgins' as well as we would like.

In order to increase the accuracy of the period, we performed a second reduction using all the data except the last day. The additional observations permitted us to add another significant digit to the period, 8.757 ± 0.001 h and match Higgins' value quite well. The effect of the asteroid's changing aspect is quite apparent in the second graph.



(16960) 1998 QS52. We observed this Apollo (PHA) asteroid, using the LONEOS Schmidt, on five nights between 2008-10-23 and 2008-10-27 obtaining a total of 15 usable measurements. This asteroid has a published period of 2.90 h, U = 3 (Warner, 2009b).

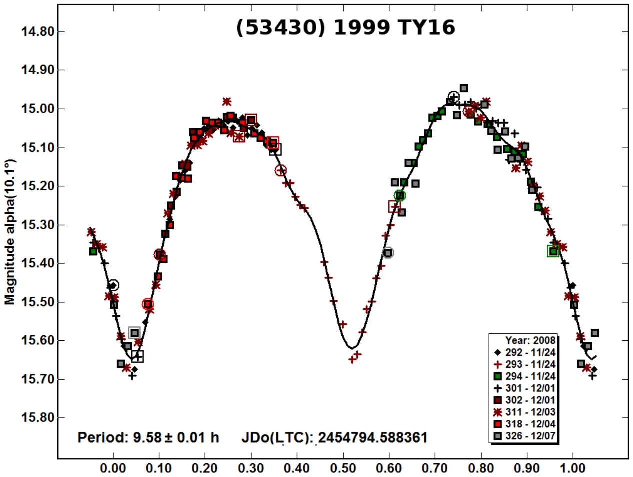


The period we show, 2.90 ± 0.02 h, matches the period published by Warner. The amplitude is 1.40 mag and the mean magnitude is r' = 15.30 mag. The lightcurve shows only a single maximum so we are unsure of this analysis.

(39572) 1993 DQ1. We observed this Amor (PHA) asteroid, using the LONEOS Schmidt, on five nights between 2008-10-07 and 2008-10-25 obtaining a total of 34 usable measurements. This asteroid has no published period. We were unable to produce a convincing lightcurve so we present only the summary data.

UT Date	Number of obs.	Mean r'	Amplitude Δr'
2008-10-07	3	17.23	0.14
2008-10-08	7	17.49	0.29
2008-10-22	9	17.06	0.16
2008-10-24	8	17.13	0.18
2008-10-25	7	17.17	0.10

(53430) 1999 TY16. We observed this Amor asteroid, using the LONEOS Schmidt, on five nights between 2008-11-24 and 2008-12-07 obtaining a total of 180 usable measurements. This asteroid has a published period of 9.582 h, U = 2+ (Ye, 2009).

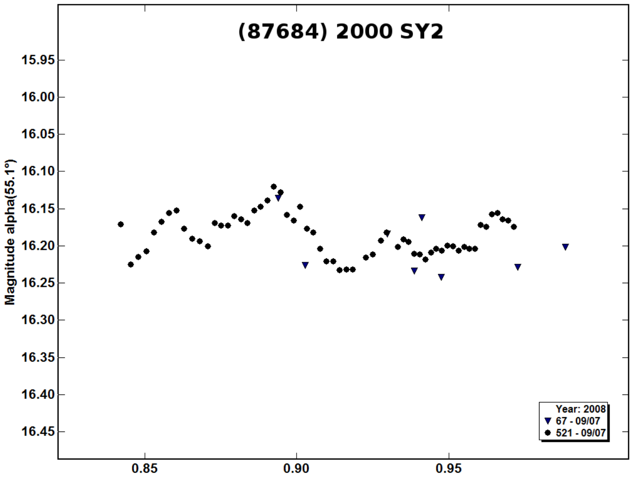


We found a period of 9.58 ± 0.01 h. It matches Ye's value quite well. The mean magnitude, normalized to 2008-11-24, is r' = 15.34 mag and the amplitude is 0.67 mag.

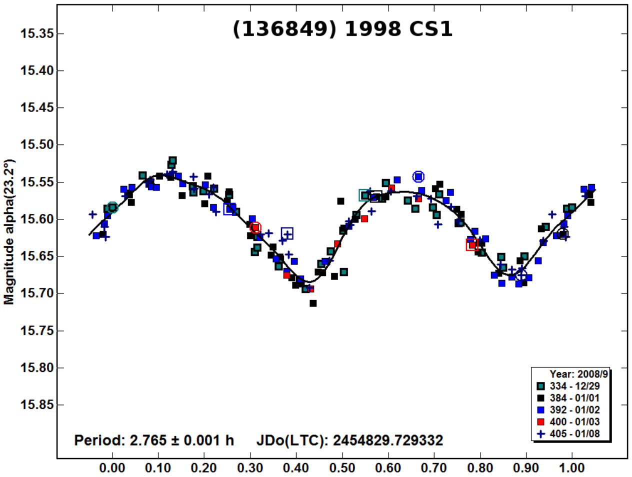
(66146) 1998 TU3. We observed this Aten asteroid, using the LONEOS Schmidt, on one night, 2008-10-22, obtaining 4 usable measurements. This asteroid has a published period of 2.375 h, U = 3 (Higgins, 2011). Several others have published similar periods for this asteroid including Hicks and Richards (Hicks, 2010; Richards, 2007). On the single night we observed, we found a mean magnitude of r' = 14.86 mag and an amplitude of 0.13 mag.

(85774) 1998 UT18. We observed this Apollo (PHA) asteroid, using the LONEOS Schmidt, on one night, 2008-11-20, obtaining nine usable measurements. This asteroid has a published period of 34 h, U = 1 (Krugly, 2002). We found a mean magnitude of r' = 16.91 mag and an amplitude of 0.34 mag.

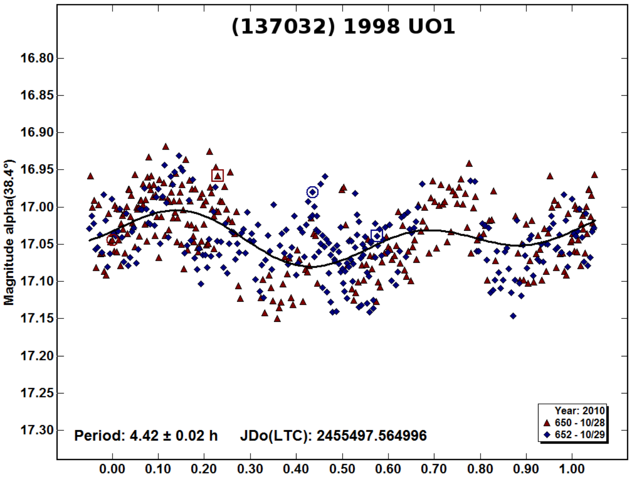
(87684) 2000 SY2. We observed this Aten (PHA) asteroid, using the LONEOS Schmidt, on one night, 2008-09-07, obtaining a total of 68 usable measurements. This asteroid has a published period of 8.80 h, U = 2 (Higgins 2005). We had insufficient data to produce a meaningful lightcurve but we found a mean magnitude of r' = 16.19 mag and an amplitude of 0.10 mag.



(136849) 1998 CS1. We observed this Apollo (PHA) asteroid, using the LONEOS Schmidt, on five nights between 2008-12-29 and 2009-01-08 obtaining a total of 163 usable measurements. This asteroid has a published period of 2.765 h, U = 3 (Ye, 2010). Our period, 2.765 ± 0.001 h, matched Ye's quite well.



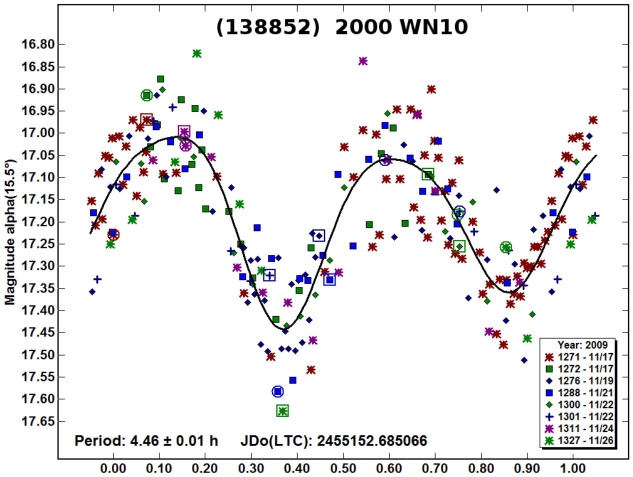
(137032) 1998 UO1. We observed this Apollo asteroid, using the LONEOS Schmidt, on seven nights between 2008-10-22 and 2010-10-29 obtaining a total of 504 usable measurements. This asteroid has a published period of 3.0 h, U = 2 (Wolters 2008). Both Behrend and Pravec have published periods for this asteroid (Behrend, 2006; Pravec, 2004) but there is significant disagreement between the values.



The first five nights of observation were in 2008 October and we obtained insufficient data in that interval to produce a lightcurve. The last two nights were in 2010 October and are plotted in the graph. Although our value and formal error for the period are 4.42 ± 0.02 h, (and in general agreement with Behrend's value) our period is almost meaningless because the RMS error is large and almost constant over a large range of possible periods. The mean magnitude, normalized to 2010-10-28, is r' = 17.04 mag. The amplitude is small, 0.08 mag, and the noise is large so the reader should put more trust in the Wolters value for period.

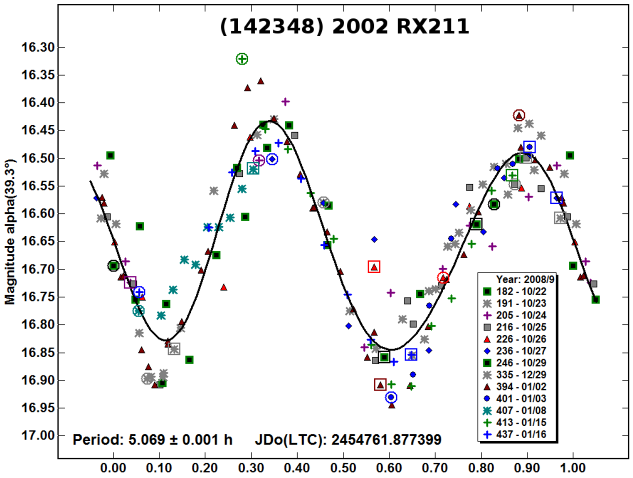
(137805) 1999 YK5. We observed this Aten asteroid on one night, 2008-11-24, obtaining five usable measurements. This asteroid has no published period. We obtained a mean magnitude of r' = 17.23 mag and an amplitude of 0.38 mag but no estimate of the period.

(138852) 2000 WN10. We observed this Apollo asteroid, using the LONEOS Schmidt, on seven nights between 2008-11-20 and 2009-11-26 obtaining a total of 240 usable measurements. Two oppositions are represented in this data set with most of the data from late 2009. Pravec has published a period of 4.4622 h (Pravec, 2011).



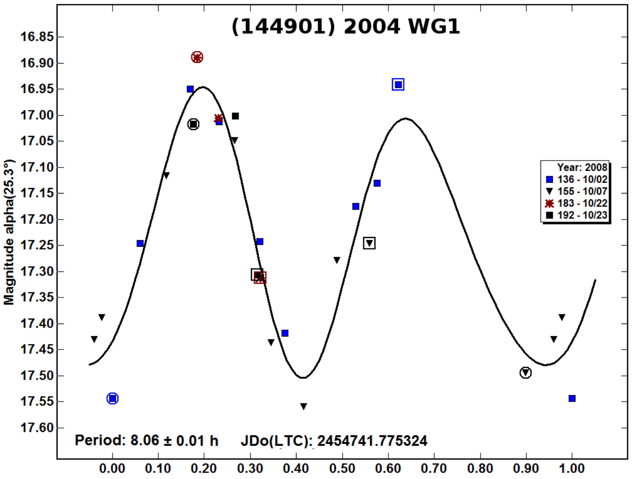
Although the data are noisy, the period is secure at 4.46 ± 0.01 h. The mean magnitude is r' = 17.30 mag after taking into account the mean offsets from each night. The lightcurve amplitude is 0.44 mag.

(142348) 2002 RX211. We observed this Amor asteroid, using the LONEOS Schmidt, on 14 nights between 2008-10-07 and 2009-01-16 obtaining a total of 178 usable measurements. This asteroid has a published period of 5.0689 h, U = 3 (Higgins, 2006b).



The period of 5.069 ± 0.001 h that we obtained closely matches Higgins' value. The mean magnitude is r' = 16.54 mag after accounting for the mean offset of all the data. The amplitude is 0.41mag.

(144901) 2004 WG1. We observed this Apollo asteroid, using the LONEOS Schmidt, on 4 nights between 2008-10-02 and 2008-10-23 obtaining a total of 24 usable measurements. This asteroid has no published period.



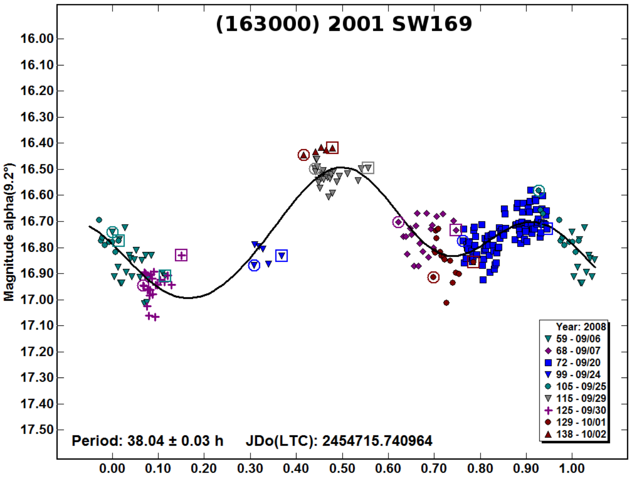
The graph indicates the asteroid has a period of 8.06 ± 0.01 h but, because there are so few data, the period has to be considered low reliability. The mean magnitude, normalized to 2008-10-02 is r' = 17.18 mag and the amplitude is 0.65 mag.

(162900) 2001 HG31. We observed this Amor asteroid, using the LONEOS Schmidt, on 25 nights between 2008-10-07 and 2009-03-24 obtaining a total of 669 usable measurements. This asteroid has a published period of 60.61 h, U = 3 (Warner, 2009d). Carbognani and Behrend have published periods that are in close agreement (Carbognani, 2011; Behrend, 2008).

This tumbler has been carefully analyzed by Pravec (2005) and others. We simply restate that our data are available at the Minor Planet Center Lightcurve Database and present our summary.

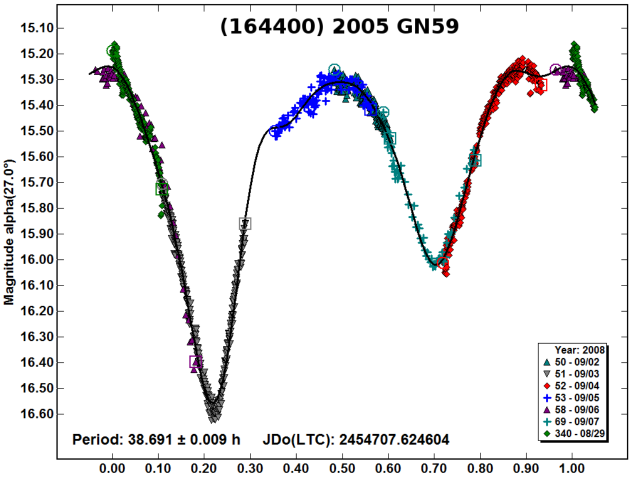
UT Date	Number of obs.	Mean r'	Amplitude Δr'
2008-10-02	13	17.45	0.26
2008-10-07	8	17.29	0.26
2008-10-08	5	17.19	0.10
2008-10-09	11	16.98	0.34
2008-10-22	14	16.62	0.20
2008-10-23	15	16.41	0.21
2008-10-24	23	16.11	0.14
2008-10-25	6	16.07	0.22
2008-10-26	18	16.02	0.17
2008-10-27	23	16.09	0.18
2008-10-29	25	15.73	0.17
2008-11-04	24	15.60	0.33
2008-11-06	25	15.60	0.06
2008-11-07	29	15.33	0.15
2008-11-18	27	15.95	0.24
2008-11-19	32	15.02	0.41
2008-11-20	18	15.05	0.08
2008-11-21	61	14.93	0.42
2008-11-24	78	15.03	0.18
2008-12-01	54	14.85	0.19
2008-12-03	46	15.01	0.06
2008-12-04	49	14.98	0.25
2008-12-07	49	14.80	0.33
2009-03-17	3	16.73	0.06
2009-03-24	10	17.50	0.15

(163000) 2001 SW169. We observed this Amor asteroid, using the LONEOS Schmidt, on nine nights between 2008-09-06 and 2008-10-02 obtaining a total of 224 usable measurements. This asteroid has no published period.



Although we obtained a period of 38.04 ± 0.03 h, the reader can see the period is not convincing. We have very little overlap between segments and the scatter is quite large. This asteroid needs more photometric observations. The mean magnitude on the night of 2008-09-20 is r' = 16.95 mag and the amplitude is 0.30 mag.

(164400) 2005 GN59. We observed this Apollo (PHA) asteroid, using the LONEOS Schmidt, on seven nights between 2008-08-29 and 2008-09-07 obtaining a total of 1331 usable measurements. This asteroid has a published period of 38.62 h, U = 3– (Vander Haagen, 2011).



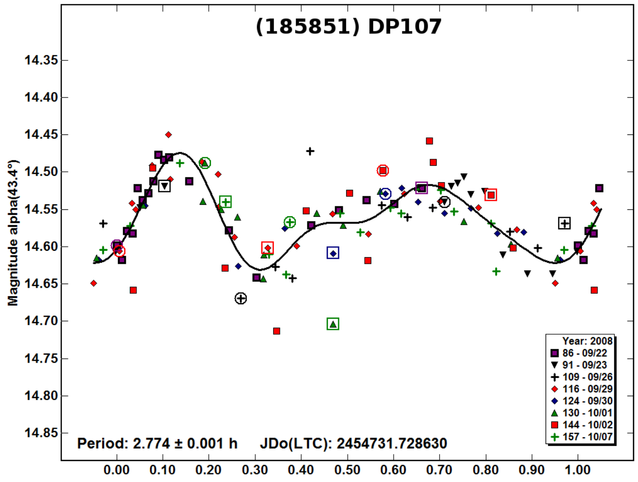
The period of 38.691 ± 0.009 h is a re-evaluation of the same data that resulted in a period posted on the CALL site. The revised period is from a ninth order fit. The asteroid has a mean magnitude of r' = 15.90 mag and an amplitude of 1.30 mag, normalized to 2008-09-02. The error, generated by Canopus, is probably optimistic but the error generated by our standard method, 0.4 h, is probably pessimistic. Because the asteroid is rotating rather slowly, only four revolutions are represented in the data. Covering so few revolutions can lead to a substantial error in the period. The graph shows an obvious problem near the far right (and far left) side. The nights of 2008-08-29, 2008-09-04, and 2008-09-06 all meet near the top of the curve and they don't match well. The mismatch could be due to the asteroid's changing aspect or the asteroid could be slowly tumbling with a very long period on the second axis. The ephemeris for the observing interval indicates that the phase angle was –27 ± 2°, and the distance from Earth was 0.22 ± 0.03 AU so the aspect could not have changed significantly. Based on this scant evidence, we believe the asteroid might be tumbling. We need more observations to confirm this conjecture.

(171576) 1999 VP11. We observed this Apollo (PHA) asteroid, using the LONEOS Schmidt, on two nights between 2008-10-26 and 2008-10-27 obtaining a total of 6 usable measurements. This asteroid has no published period.

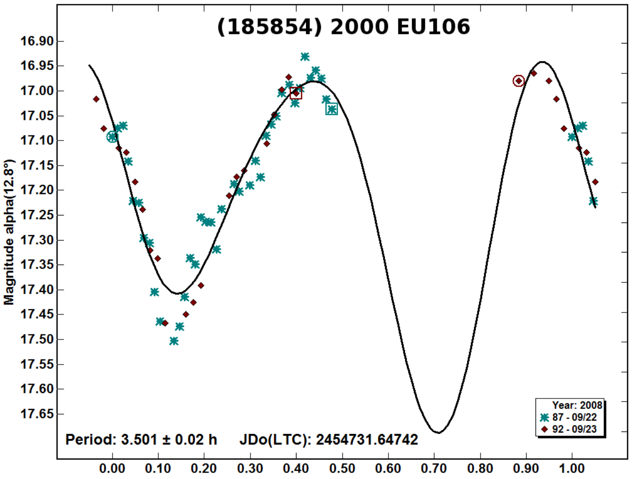
With so few measurements we could make no estimate of the period so we present only our summary data.

UT Date	Number of obs.	Mean r'	Amplitude Δr'
2008-10-26	3	17.02	0.02
2008-10-27	3	16.93	0.08

(185851) 2000 DP107. We observed this Apollo (PHA) asteroid, using the LONEOS Schmidt, on 17 nights between 2008-09-22 and 2008-10-29 obtaining a total of 277 usable measurements. This asteroid has a published period of 2.7754 h, U = 3 (Pravec, 2006). Warner and Yang produced confirming periods (Warner, 2009d; Yang, 2003). This asteroid is a well studied binary so the published periods are quite accurate. We participated in gathering data for analyzing the period of the secondary but produced nothing helpful. Our lightcurve analysis produces the period of the primary (2.774 ± 0.001 h) but we observed no mutual events. In general, our data were extremely noisy so we picked a subset of the data that led to the correct period in our period analysis. The mean magnitude, normalized to 2008-09-22, is r' = 14.55 mag. The amplitude is 0.17 mag.

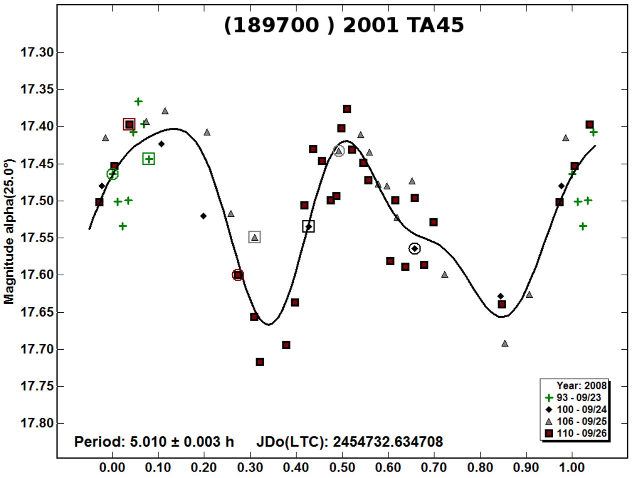


(185854) 2000 EU106. We observed this Mars-crossing asteroid, using the LONEOS Schmidt, on two nights between 2008-09-22 and 2008-09-23 obtaining a total of 61 usable measurements. This asteroid has no published period.



We discovered that the predicted period for this asteroid changes significantly with the order of the fit. Using orders 3 through 7 we found 3.06 h < *P* < 3.79 h. However, we believe that 3.50 ± 0.02 h is the most likely period because we found a strong minimum in the residuals at 1.75 h. Doubling that period produces the two "required" maxima in the lightcurve and the period we believe is correct. We must have more observations to secure the period. The mean magnitude, normalized to 2008-09-22 is r' = 17.20 mag and the amplitude is 0.60 mag. We used actual data rather than the fitted curve for the mean magnitude and amplitude because the fitted curve is not well constrained by data.

(189700) 2001 TA45. We observed this Amor asteroid, using the LONEOS Schmidt, on four nights between 2008-09-23 and 2008-09-26 obtaining a total of 55 usable measurements. This asteroid has no published period.



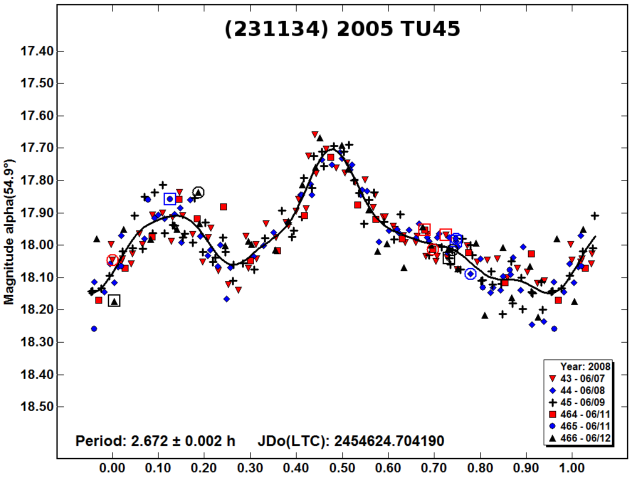
This asteroid also significantly changes period with changing order of fit. We selected an order 4 fit as the most appealing and found a period of 5.010 ± 0.003 h. Again, we must have more observations are to secure the period. The mean magnitude, normalized to 2008-09-23 is r' = 17.54 mag and the amplitude is 0.27 mag.

(190135) 2005 QE30. We observed this Apollo asteroid on one night, 2008-09-24, obtaining seven usable measurements. This asteroid has no published period. Although we obtained too few data to estimate the period, the mean magnitude is r' = 17.89 mag and the amplitude is 0.45 mag.

<u>(190491) 2000 FJ10.</u> We observed this Apollo asteroid on five nights between 2008-10-01 and 2008-10-09 obtaining a total of 36 usable measurements. This asteroid has no published period. We could not determine a meaningful period for this asteroid so we present its summary data.

UT Date	Number of obs.	Mean r'	Amplitude Δr'
2008-10-01	4	17.22	0.21
2008-10-02	7	16.89	0.16
2008-10-07	7	16.73	0.35
2008-10-08	5	16.63	0.14
2008-10-09	13	16.71	0.44

<u>(231134) 2005 TU45.</u> We observed this Apollo asteroid, using the LONEOS Schmidt, on six nights between 2008-06-07 and 2008-06-12 obtaining a total of 588 usable measurements. This asteroid has no published period.



We believe the period of 2.672 ± 0.002 h is secure. The mean magnitude, normalized to 2008-06-07 is r' = 17.92 mag and the amplitude is 0.45 mag.

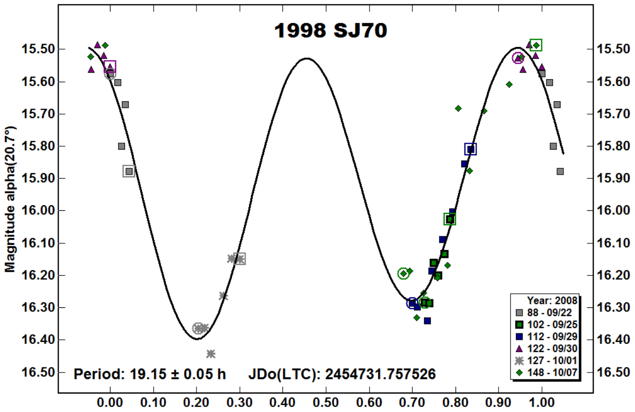
<u>(248818) 2006 SZ217.</u> We observed this Amor asteroid, using the LONEOS Schmidt, on four nights between 2008-12-01 and 2008-12-07 obtaining a total of 32 usable measurements. This asteroid has a published period of 3.2474 h, U = 2 (Ye, 2009). We obtained too few measurements to produce a believable lightcurve so we present our summary data.

UT Date	Number of obs.	Mean r'	Amplitude Δr'
2008-12-01	13	15.26	0.09
2008-12-03	11	15.86	0.14
2008-12-04	3	15.98	0.02
2008-12-07	5	16.27	0.10

<u>(257744) 2000 AD205.</u> We observed this Apollo asteroid, using the LONEOS Schmidt, on 3 nights between 2008-11-24 and 2008-12-08 obtaining a total of 607 usable measurements. This asteroid has no published period. Data on all nights were rather noisy. Each individual night was either flat or showed a slow monotonic trend. We concluded this asteroid may have a period of about 27 h but we observed it on too few nights to be sure. We present only our summary data.

UT Date	Number of obs.	Mean r'	Amplitude Δr'
2008-06-03	214	17.26	0.28
2008-06-04	168	16.93	0.18
2008-06-06	225	17.03	0.17

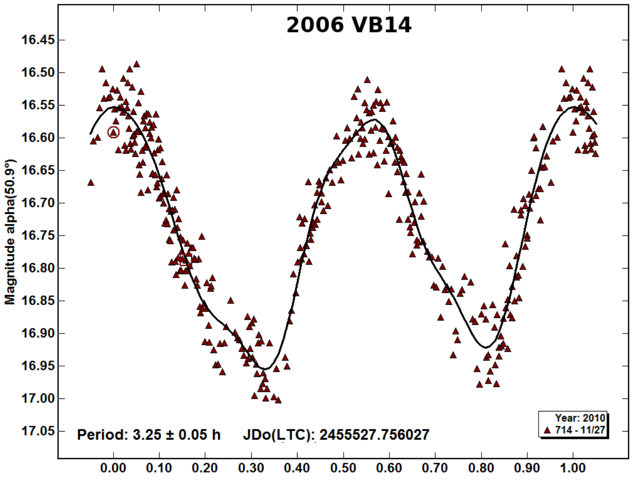
<u>1998 SJ70.</u> We observed this Apollo (PHA) asteroid, using the LONEOS Schmidt, on seven nights between 2008-09-22 and 2008-10-07 obtaining a total of 47 usable measurements. This asteroid has no published period.



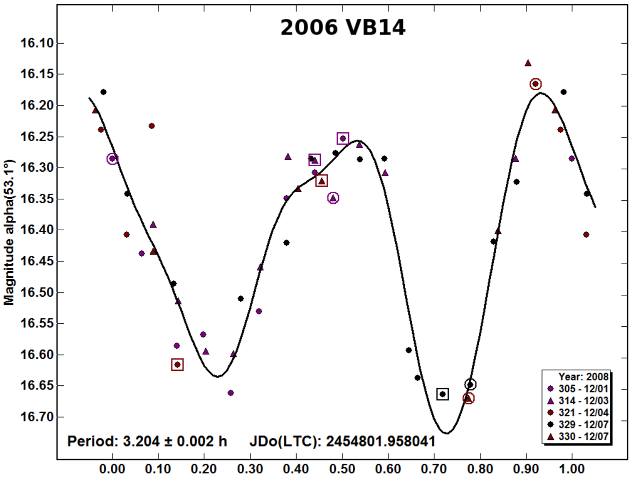
The period of 19.15 ± 0.05 h is tentative. There are extended segments of the lightcurve with no data. Some of the existing data have to be vertically shifted significantly to make the fit work. The mean magnitude is r' = 15.95 mag and the amplitude is 0.90 mag.

<u>2004 XK3.</u> We observed this Apollo asteroid, using the LONEOS Schmidt, on one night, 2008-11-21, obtaining 39 usable measurements. This asteroid has no published period. We were unable to make any estimate of the period. However, the mean magnitude is r' = 15.40 mag and the amplitude is 0.32 mag.

<u>2006 VB14.</u> We observed this Aten asteroid on five nights between 2008-11-27 and 2008-12-07 obtaining a total of 399 usable measurements. This asteroid has no published period. We obtained the bulk of the measurements (352) in a single night using the Hall telescope. The rest were obtained by the LONEOS Schmidt. The periods we obtained using the two data sets are slightly different and the difference is interesting.

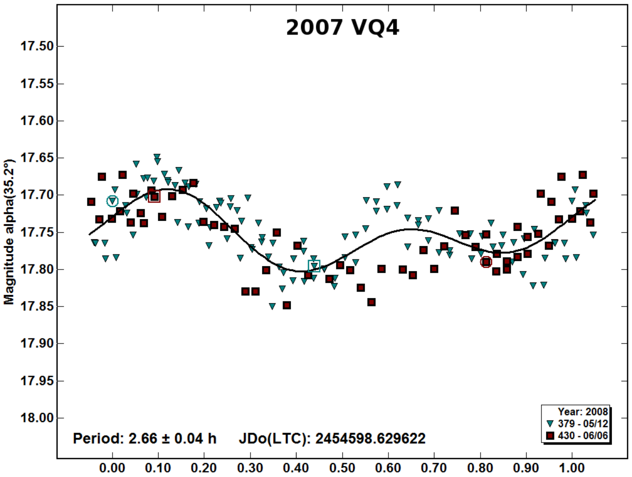


In spite of the 399 data used in creating the graph for the 2010-11-27 observations (order 7 solution with period of 3.25 ± 0.05 h) the uncertainty remains rather large because the observations cover only two periods and are somewhat noisy. The mean magnitude is r' = 16.75 mag, and the amplitude is 0.40 mag.



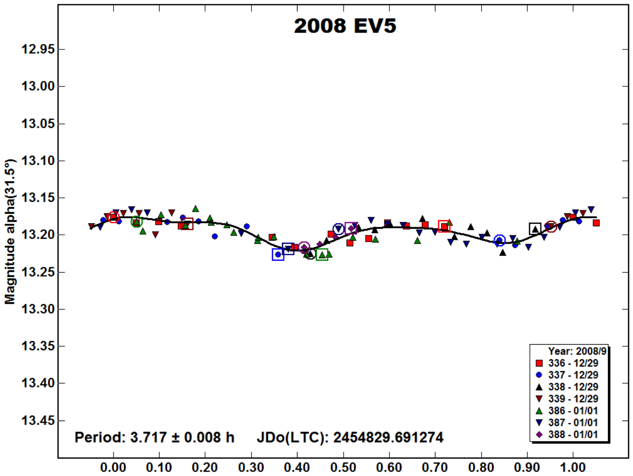
The sparser data set from 2008-12 indicates a period of 3.204 ± 0.002 h (order 4 solution). The mean magnitude, normalized to 2008-12-01, is r' = 16.44 mag and the amplitude is 0.55 mag.

2007 VQ4. We observed this Amor asteroid, using the Hall telescope, on 2 nights between 2008-05-12 and 2008-06-06 obtaining a total of 159 usable measurements. This asteroid has no published period.

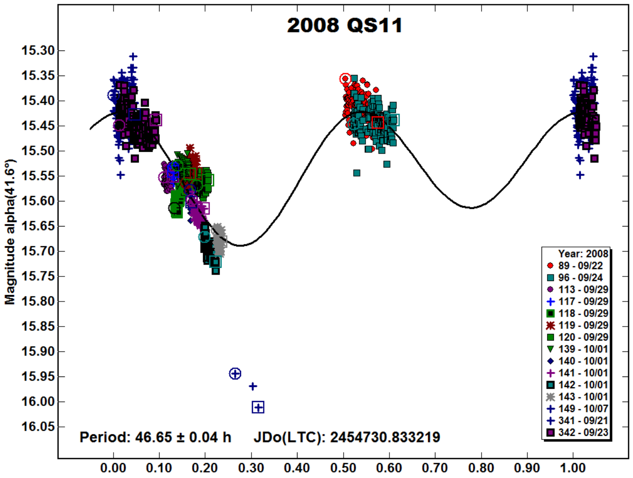


We found a period of 2.66 ± 0.04 h for the single night of 2008-05-12 and when both nights were combined. Since the nights are almost a month apart, the error remains large because the phasing between nights is ambiguous. The fit for 2008-05-12 has fairly large residuals and adding the data from 2008-06-06 makes the residuals even larger so this period is not firm. The mean magnitude, normalized to 2008-05-12, is r' = 17.75 mag and the amplitude is 0.11 mag.

2008 EV5. We observed this Aten (PHA) asteroid, using the LONEOS Schmidt, on two nights between 2008-12-29 and 2009-01-01 obtaining a total of 87 usable measurements. This asteroid has a published period of 3.725 h, U = 3 (Galád, 2009). Behrend has published a confirming period (Behrend, 2008). We found a period of 3.717 ± 0.008 h which matches Galád's value within the formal error. The mean magnitude, normalized to 2008-05-12, is r' = 13.20 mag and the amplitude is 0.04 mag. Even though the amplitude is small, the asteroid was fairly bright so the individual magnitude errors were small. We are confident in our value for the period.

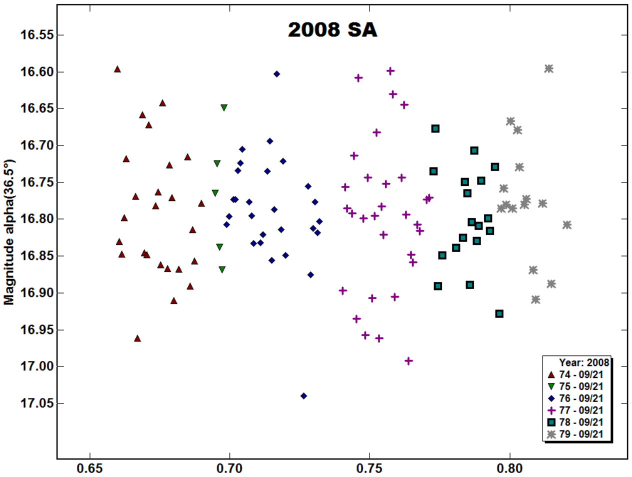


2008 QS11. We observed this Apollo (PHA) asteroid, using both the Hall and the LONEOS Schmidt, on 7 nights between 2008-09-21 and 2008-10-07 obtaining a total of 1223 usable measurements. This asteroid has no published period.

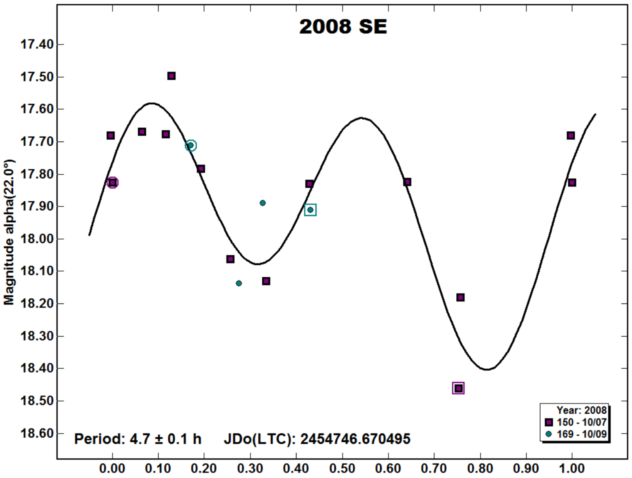


We found a period of 46.65 ± 0.04 h for this asteroid. Our error estimate is optimistic because we have no night-to-night continuity. Individual nights show almost no change is brightness. Although we have lots of data, the period we present is very uncertain. The mean magnitude, normalized to 2008-09-22, is r' = 15.55 mag and the amplitude is 0.30 mag.

2008 SA. We observed this Apollo asteroid, using the LONEOS Schmidt, on one night, 2008-09-21, obtaining 183 usable measurements. This asteroid has no published period. The data we obtained seem flat and are noisy. We present only the raw plot. The mean magnitude is r' = 16.78 mag and the amplitude is 0.35 mag. The amplitude is more likely a measure of the error in the individual magnitudes. We tried to fit both extremely short periods and standard length periods. We found nothing.



2008 SE. We observed this Amor asteroid, using the LONEOS Schmidt, on two nights between 2008-10-07 and 2008-10-09 obtaining a total of 16 usable measurements. This asteroid has a published period of 4.57 h, U = 2+ (Warner, 2009c).



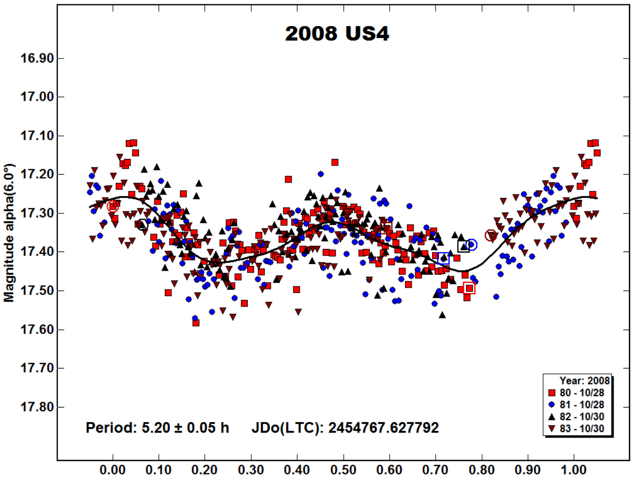
We obtained a period of 4.7 ± 0.1 h using very sparse data from a time when the asteroid was very faint. In spite of that, our period is within the specified error limits of Warner's published period. The deep amplitude of the lightcurve helped us significantly. We found a mean magnitude, normalized to 2008-10-07, of r' = 17.99 mag and an amplitude of 0.82 mag.

2008 SQ1. We observed this Amor asteroid, using the LONEOS Schmidt, on 10 nights between 2008-10-22 and 2008-11-30 obtaining a total of 301 usable measurements. This asteroid has no published period. The magnitudes were flat within the noise limits. On the night of 2008-11-30, the mean magnitude was r' = 17.11 mag and the magnitude fluctuation was 0.20 mag. All of the magnitudes in October were consistently flat and all the magnitudes in November were consistently flat but we found an unexplained magnitude difference 0.45 between the mean of the two months. If we allow periods in excess of 1000 h, we can find solutions that are, not coincidentally, multiples of the length of the observing run.

2008 SR1. We observed this Apollo (PHA) asteroid, using the LONEOS Schmidt, on two nights between 2008-09-29 and 2008-09-30 obtaining a total of 11 usable measurements. This asteroid has no published period. The raw data displayed no helpful features of a lightcurve; each night was monotonically changing by a relatively small amount. We list the summary data.

UT Date	Number of obs.	Mean r'	Amplitude Δr'
2008-09-29	6	16.75	0.30
2008-09-30	5	17.27	0.26

2008 US4. We observed this Apollo asteroid, using the LONEOS Schmidt, on two nights between 2008-10-28 and 2008-10-30 obtaining a total of 564 usable measurements. This asteroid has no published period.



We produced the graph using all the data. Because the asteroid was moving rapidly, we had to use two sets of comparison stars on both nights. We applied no offsets to any of the resulting data sets. We found an order 5 fit produced the smallest residuals and a period of 5.20 ± 0.05 h. The mean magnitude is r' = 17.34 mag with an amplitude 0.17 mag.

1. Acknowledgments

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The SDSS is managed by the Astrophysical Research Consortium for the Participating Institutions. The Participating Institutions are the American Museum of Natural History, Astrophysical Institute Potsdam, University of Basel, University of Cambridge, Case Western Reserve University, University of Chicago, Drexel University, Fermilab, the Institute for Advanced Study, the Japan Participation Group, Johns Hopkins University, the Joint Institute for Nuclear Astrophysics, the Kavli Institute for Particle Astrophysics and Cosmology, the Korean Scientist Group, the Chinese Academy of Sciences (LAMOST), Los Alamos National Laboratory, the Max-Planck-Institute for Astronomy (MPIA), the Max-Planck-Institute for Astrophysics (MPA), New Mexico State University, Ohio State University, University of Pittsburgh, University of Portsmouth, Princeton University, the United States Naval Observatory, and the University of Washington.

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Minor Planet	Date of Observation	Sun Distance (AU)	Earth Distance (AU)	Phase Angle (deg)	BPAB (deg)	LPAB (deg)	Observer
1036 Ganymed	2008-12-03	3.882	3.878	-14.60	-24.2	161.1	Sanborn
	2008-12-29	3.930	3.555	-13.97	-25.0	163.1	Sanborn
	2009-01-01	3.935	3.519	-13.75	-25.1	163.2	Koehn
	2009-01-08	3.947	3.439	-13.12	-25.3	163.4	Koehn
	2009-01-15	3.958	3.365	-12.34	-25.5	163.4	Sanborn
	2009-01-18	3.963	3.335	-11.96	-25.6	163.4	Sanborn
	2009-01-28	3.978	3.247	-10.54	-25.8	163.2	Sanborn
	2009-01-29	3.980	3.240	-10.39	-25.8	163.2	Koehn
	2009-01-30	3.981	3.232	-10.24	-25.8	163.1	Sanborn
	2009-02-01	3.984	3.218	-9.93	-25.8	163.0	Koehn
	2009-02-02	3.985	3.211	-9.78	-25.8	163.0	Sanborn
	2009-02-03	3.987	3.205	-9.63	-25.8	163.0	Koehn
	2009-02-19	4.008	3.134	-7.47	-25.8	162.0	Sanborn
	2009-03-16	4.036	3.166	7.74	-25.1	160.2	Koehn
	2009-03-17	4.037	3.171	7.85	-25.1	160.2	Sanborn
	2009-03-18	4.038	3.176	7.97	-25.1	160.1	Sanborn
	2009-03-19	4.039	3.181	8.10	-25.0	160.1	Sanborn
	2009-03-21	4.041	3.193	8.36	-24.9	159.9	Koehn
	2009-03-24	4.043	3.213	8.78	-24.8	159.8	Koehn
	2009-03-25	4.044	3.220	8.92	-24.7	159.7	Sanborn
	2009-03-27	4.046	3.235	9.21	-24.6	159.6	Sanborn
	2009-03-28	4.047	3.242	9.36	-24.5	159.6	Sanborn
	2009-03-29	4.048	3.251	9.51	-24.5	159.5	Sanborn
	2009-04-22	4.066	3.505	12.69	-23.0	159.1	Sanborn
1620 Geographos	2008-11-04	1.529	0.598	20.46	21.7	36.5	Koehn
	2008-11-06	1.536	0.608	20.77	21.7	36.5	Koehn
	2008-11-07	1.539	0.613	20.97	21.7	36.5	Sanborn
	2008-11-18	1.569	0.681	24.21	21.3	36.7	Koehn
	2008-11-19	1.572	0.688	24.55	21.2	36.8	Sanborn
	2008-11-20	1.574	0.695	24.90	21.2	36.8	Koehn
1627 Ivar	2008-09-05	1.430	0.822	-43.54	-11.2	38.2	Koehn
	2008-09-06	1.435	0.820	-43.17	-11.3	38.6	Koehn
	2008-09-07	1.441	0.818	-42.80	-11.4	39.0	Koehn
	2008-10-02	1.576	0.769	-31.17	-13.2	46.4	Koehn
	2008-10-07	1.603	0.762	-28.27	-13.4	47.2	Koehn
	2008-10-08	1.609	0.761	-27.67	-13.5	47.4	Koehn
	2008-10-09	1.614	0.760	-27.06	-13.5	47.5	Koehn
	2008-10-22	1.684	0.761	-18.86	-13.8	48.6	Sanborn
	2008-10-23	1.690	0.762	-18.24	-13.8	48.6	Koehn
	2008-10-24	1.695	0.764	-17.61	-13.8	48.7	Sanborn
	2008-10-25	1.701	0.765	-17.00	-13.8	48.7	Koehn
	2008-10-26	1.706	0.767	-16.40	-13.8	48.7	Koehn
	2008-10-27	1.711	0.769	-15.81	-13.8	48.7	Sanborn
	2008-10-29	1.722	0.773	-14.67	-13.8	48.8	Koehn
	2008-12-01	1.891	0.976	15.49	-12.3	49.6	Sanborn
	2008-12-03	1.901	0.996	16.28	-12.1	49.8	Sanborn
	2008-12-04	1.906	1.006	16.67	-12.0	49.9	Koehn
	2008-12-07	1.921	1.038	17.81	-11.8	50.1	Koehn
	2008-12-29	2.023	1.315	24.15	-10.2	53.4	Sanborn

Minor Planet	Date of Observation	Sun Distance (AU)	Earth Distance (AU)	Phase Angle (deg)	BPAB (deg)	LPAB (deg)	Observer
	2009-01-01	2.037	1.358	24.70	-10.0	54.0	Koehn
	2009-01-02	2.041	1.372	24.87	-9.9	54.2	Koehn
	2009-01-03	2.046	1.387	25.03	-9.8	54.4	Sanborn
	2009-01-15	2.097	1.568	26.42	-9.0	57.1	Sanborn
	2009-01-16	2.102	1.583	26.50	-9.0	57.4	Sanborn
	2009-01-18	2.110	1.615	26.63	-8.9	57.9	Sanborn
	2009-01-28	2.151	1.774	26.94	-8.3	60.4	Sanborn
	2009-01-29	2.155	1.790	26.94	-8.2	60.7	Koehn
	2009-01-30	2.159	1.806	26.94	-8.2	61.0	Sanborn
	2009-02-02	2.171	1.854	26.90	-8.0	61.8	Sanborn
1865 Cerberus	2008-09-30	1.522	0.565	-18.39	8.8	24.7	Koehn
	2008-10-01	1.519	0.558	-17.54	8.7	24.7	Sanborn
	2008-10-02	1.516	0.551	-16.68	8.5	24.5	Koehn
	2008-10-07	1.502	0.520	-12.17	7.7	23.9	Koehn
	2008-10-08	1.499	0.514	-11.27	7.6	23.8	Koehn
	2008-10-09	1.495	0.509	-10.37	7.4	23.6	Koehn
	2008-10-22	1.449	0.464	9.77	4.7	20.9	Sanborn
	2008-10-23	1.445	0.463	10.80	4.4	20.7	Koehn
	2008-10-24	1.441	0.461	11.89	4.2	20.4	Sanborn
	2008-10-25	1.437	0.460	13.01	3.9	20.2	Koehn
	2008-10-26	1.433	0.460	14.17	3.7	20.0	Koehn
	2008-10-27	1.429	0.459	15.34	3.4	19.8	Sanborn
	2008-10-29	1.420	0.459	17.72	2.9	19.4	Koehn
	2008-11-04	1.393	0.464	24.86	1.3	18.3	Koehn
	2008-11-06	1.384	0.468	27.17	0.8	18.1	Koehn
	2008-11-07	1.379	0.470	28.30	0.5	18.0	Sanborn
1980 Tezcatlipoca	2008-09-07	1.367	1.293	44.41	18.3	259.0	Koehn
	2008-09-20	1.303	1.316	45.09	21.0	266.8	Sanborn
	2008-09-22	1.294	1.318	45.19	21.4	268.1	Sanborn
2363 Cebriones	2008-06-10	4.988	4.088	5.95	19.6	239.7	Skiff
	2008-06-11	4.988	4.093	6.09	19.6	239.6	Skiff
	2010-09-04	5.059	4.278	7.87	33.7	319.6	Skiff
	2010-09-05	5.059	4.283	7.94	33.7	319.6	Skiff
	2010-09-06	5.059	4.289	8.01	33.6	319.6	Skiff
	2010-09-07	5.059	4.295	8.08	33.6	319.6	Skiff
	2010-09-21	5.063	4.399	9.16	32.9	319.6	Skiff
	2010-09-25	5.064	4.436	9.47	32.6	319.7	Skiff
4179 Toutatis	2008-09-05	1.254	0.306	32.15	-0.6	317.6	Koehn
	2008-09-06	1.246	0.302	33.41	-0.6	317.7	Koehn
	2008-09-07	1.238	0.297	34.69	-0.6	317.9	Koehn
	2008-09-20	1.137	0.245	51.74	-0.9	320.6	Sanborn
	2008-09-24	1.109	0.230	57.19	-1.1	321.7	Koehn
	2008-09-25	1.102	0.226	58.57	-1.1	322.0	Koehn
	2008-09-26	1.095	0.222	59.96	-1.1	322.4	Sanborn
	2008-11-19	0.958	0.073	-112.67	-5.0	117.1	Sanborn
	2008-11-24	0.974	0.093	-95.63	-3.1	115.3	Sanborn
	2008-12-01	1.003	0.123	-78.40	-1.9	115.5	Sanborn
	2008-12-03	1.013	0.132	-74.25	-1.7	115.8	Sanborn
	2008-12-04	1.018	0.136	-72.26	-1.6	116.0	Koehn
	2008-12-07	1.035	0.149	-66.59	-1.4	116.7	Koehn
	2008-12-29	1.185	0.247	-31.78	-0.4	121.3	Sanborn
	2009-01-01	1.209	0.263	-27.61	-0.4	121.8	Koehn
	2009-01-02	1.217	0.268	-26.25	-0.3	121.9	Koehn
	2009-01-03	1.225	0.273	-24.90	-0.3	122.0	Sanborn
	2009-01-08	1.265	0.302	-18.40	-0.2	122.7	Koehn
	2009-01-15	1.324	0.347	-10.04	-0.1	123.7	Sanborn
	2009-01-16	1.332	0.354	-8.92	-0.1	123.8	Sanborn
	2009-01-18	1.349	0.369	-6.74	-0.1	124.1	Sanborn
	2009-01-28	1.435	0.451	2.96	0.0	125.5	Sanborn
	2009-01-29	1.444	0.461	3.81	0.1	125.7	Koehn
	2009-01-30	1.453	0.470	4.65	0.1	125.8	Sanborn
	2009-02-01	1.470	0.489	6.27	0.1	126.2	Koehn
	2009-02-02	1.479	0.499	7.04	0.1	126.3	Sanborn
	2009-02-03	1.488	0.509	7.80	0.1	126.5	Koehn
	2009-02-04	1.496	0.519	8.54	0.1	126.7	Sanborn
	2009-02-19	1.627	0.693	17.47	0.2	129.7	Sanborn
4257 Ubasti	2008-09-24	1.527	0.698	31.79	11.7	325.6	Koehn
5332 Davidaguilar	2008-09-05	1.783	0.852	-18.08	-20.2	356.7	Koehn
	2009-01-30	1.179	0.696	56.60	-28.9	69.8	Sanborn
	2009-02-02	1.181	0.695	56.46	-27.5	72.7	Sanborn
7358 Oze	2008-10-24	1.478	1.022	-42.16	1.2	95.9	Sanborn

Minor Planet	Date of Observation	Sun Distance (AU)	Earth Distance (AU)	Phase Angle (deg)	BPAB (deg)	LPAB (deg)	Observer
	2008-10-25	1.484	1.020	-41.86	1.1	96.3	Koehn
	2008-10-26	1.491	1.017	-41.56	1.1	96.7	Koehn
	2008-10-27	1.498	1.015	-41.26	1.0	97.1	Sanborn
	2008-10-29	1.511	1.010	-40.63	0.9	97.9	Koehn
	2008-11-04	1.551	0.993	-38.58	0.6	100.1	Koehn
	2008-11-06	1.564	0.988	-37.85	0.5	100.7	Koehn
	2008-11-07	1.571	0.985	-37.47	0.4	101.1	Sanborn
	2008-11-20	1.659	0.949	-31.79	-0.3	104.5	Koehn
	2008-11-24	1.686	0.939	-29.75	-0.5	105.3	Sanborn
	2008-12-01	1.733	0.925	-25.80	-0.9	106.3	Sanborn
	2008-12-03	1.746	0.922	-24.59	-1.0	106.5	Sanborn
	2008-12-07	1.773	0.917	-22.06	-1.2	106.9	Koehn
(8567) 1996 HW1	2008-08-23	1.151	0.165	-29.79	14.2	344.0	Koehn
	2008-09-05	1.131	0.139	-26.26	7.7	357.7	Koehn
	2008-09-06	1.130	0.138	-25.98	7.1	358.8	Koehn
	2008-09-07	1.130	0.137	-25.72	6.4	359.9	Koehn
	2008-09-23	1.132	0.143	-23.91	-4.3	15.1	Sanborn
	2008-09-25	1.134	0.146	-23.92	-5.6	16.8	Koehn
	2008-10-02	1.145	0.160	-23.92	-9.3	22.1	Koehn
	2008-10-07	1.156	0.174	-23.71	-11.4	25.5	Koehn
	2008-10-08	1.158	0.177	-23.64	-11.7	26.1	Koehn
	2008-10-09	1.161	0.180	-23.56	-12.1	26.7	Koehn
	2008-10-22	1.201	0.226	-22.07	-15.2	34.1	Sanborn
	2008-10-23	1.205	0.230	-21.94	-15.3	34.6	Koehn
	2008-10-24	1.208	0.234	-21.83	-15.5	35.1	Sanborn
	2008-10-25	1.212	0.239	-21.71	-15.6	35.6	Koehn
	2008-10-26	1.216	0.243	-21.60	-15.7	36.1	Koehn
	2008-10-27	1.220	0.248	-21.50	-15.8	36.5	Sanborn
	2008-10-29	1.228	0.257	-21.32	-16.0	37.5	Koehn
	2008-11-04	1.254	0.286	21.01	-16.4	40.3	Koehn
	2008-11-06	1.263	0.297	21.00	-16.4	41.2	Koehn
	2008-11-07	1.267	0.302	21.01	-16.4	41.7	Sanborn
	2008-11-18	1.321	0.369	21.90	-16.3	46.4	Koehn
	2008-11-19	1.326	0.376	22.05	-16.3	46.8	Sanborn
	2008-11-20	1.331	0.382	22.20	-16.3	47.3	Koehn
	2008-11-21	1.337	0.389	22.36	-16.2	47.7	Sanborn
	2008-11-24	1.353	0.411	22.88	-16.1	48.9	Sanborn
	2008-12-01	1.391	0.464	24.27	-15.6	51.8	Sanborn
	2008-12-03	1.402	0.481	24.69	-15.5	52.7	Sanborn
	2008-12-04	1.408	0.489	24.90	-15.4	53.1	Koehn
	2008-12-07	1.425	0.515	25.54	-15.2	54.3	Koehn
	2009-01-03	1.584	0.796	30.34	-13.0	65.4	Sanborn
(16960) 1998 QS52	2008-10-23	0.977	0.261	86.26	55.3	8.0	Koehn
	2008-10-24	0.960	0.259	90.07	56.6	6.5	Sanborn
	2008-10-25	0.943	0.257	93.97	57.8	4.8	Koehn
	2008-10-27	0.908	0.258	101.93	60.3	1.0	Sanborn
(39572) 1993 DQ1	2008-10-07	1.257	0.399	42.38	16.5	340.9	Koehn
	2008-10-08	1.263	0.407	42.06	16.5	341.8	Koehn
	2008-10-22	1.352	0.533	38.92	16.1	352.9	Sanborn
	2008-10-24	1.365	0.553	38.61	16.0	354.3	Sanborn
	2008-10-25	1.371	0.563	38.47	15.9	355.0	Koehn
(53430) 1999 TY16	2008-11-24	1.273	0.292	10.12	6.6	57.7	Sanborn
	2008-12-01	1.288	0.327	19.76	-6.0	54.1	Sanborn
	2008-12-03	1.292	0.346	23.80	-9.1	53.4	Sanborn
	2008-12-04	1.295	0.356	25.67	-10.4	53.1	Koehn
	2008-12-07	1.302	0.392	30.54	-14.5	52.5	Koehn
(66146) 1998 TU3	2008-10-22	0.940	0.350	-88.69	-11.2	93.9	Sanborn
(85774) 1998 UT18	2008-11-20	1.036	0.111	-61.34	-1.1	94.8	Koehn
(87684) 2000 SY2	2008-09-07	1.174	0.374	-55.12	-15.5	28.0	Koehn
(136849) 1998 CS1	2008-12-29	1.179	0.217	-23.22	-3.7	114.0	Sanborn
	2009-01-01	1.150	0.183	-22.29	-3.1	115.8	Koehn
	2009-01-02	1.140	0.172	-22.01	-2.9	116.4	Koehn
	2009-01-03	1.131	0.161	-21.77	-2.6	117.0	Sanborn
	2009-01-08	1.082	0.107	-21.74	-0.5	121.3	Koehn
(137032) 1998 UO1	2008-10-22	1.326	0.427	33.00	21.1	7.2	Sanborn
	2008-10-23	1.338	0.444	32.94	21.0	7.4	Koehn
	2008-10-24	1.350	0.461	32.89	20.9	7.6	Sanborn
	2008-10-25	1.362	0.478	32.85	20.8	7.8	Koehn
	2008-10-27	1.386	0.513	32.80	20.7	8.2	Sanborn
	2010-10-28	1.329	0.487	38.34	19.4	2.6	McLelland
	2010-10-29	1.341	0.505	38.09	19.4	3.0	Skiff

Minor Planet	Date of Observation	Sun Distance (AU)	Earth Distance (AU)	Phase Angle (deg)	BPAB (deg)	LPAB (deg)	Observer
(137805) 1999 YK5	2008-11-24	0.950	0.277	89.42	56.7	33.7	Sanborn
(138852) 2000 WN10	2008-11-20	1.143	0.157	-6.98	-3.3	61.2	Koehn
	2009-11-17	1.127	0.144	-15.79	-8.4	60.4	Bevins
	2009-11-19	1.135	0.149	-9.94	-5.9	59.5	McLelland
	2009-11-21	1.143	0.156	5.35	-3.5	58.6	Bevins
	2009-11-22	1.147	0.160	4.41	-2.3	58.2	McLelland
	2009-11-24	1.155	0.169	6.56	-0.1	57.5	Bevins
	2009-11-26	1.162	0.179	10.49	1.8	57.0	Bevins
(142348) 2002 RX211	2008-10-07	1.206	0.273	-36.38	-17.0	36.3	Koehn
	2008-10-22	1.156	0.220	-39.25	-18.0	50.7	Sanborn
	2008-10-23	1.153	0.217	-39.43	-18.0	51.6	Koehn
	2008-10-24	1.151	0.215	-39.60	-18.0	52.7	Sanborn
	2008-10-25	1.148	0.212	-39.77	-17.9	53.7	Koehn
	2008-10-26	1.146	0.210	-39.93	-17.9	54.8	Koehn
	2008-10-27	1.144	0.208	-40.07	-17.9	55.8	Sanborn
	2008-10-29	1.139	0.203	-40.34	-17.7	57.9	Koehn
	2008-12-29	1.207	0.231	-12.38	1.3	106.8	Koehn
	2009-01-02	1.224	0.244	-9.28	2.3	108.4	Koehn
	2009-01-03	1.228	0.248	-8.58	2.5	108.8	Sanborn
	2009-01-08	1.250	0.269	-5.89	3.7	110.7	Koehn
	2009-01-15	1.284	0.302	6.42	4.9	113.3	Sanborn
	2009-01-16	1.289	0.308	6.87	5.0	113.6	Sanborn
(144901) 2004 WG1	2008-10-02	1.346	0.399	-25.51	-12.4	28.3	Koehn
	2008-10-07	1.386	0.419	-19.02	-10.8	27.9	Koehn
	2008-10-22	1.502	0.512	6.73	-6.4	26.8	Sanborn
	2008-10-23	1.509	0.520	6.86	-6.2	26.8	Koehn
(162900) 2001 HG31	2008-10-02	1.652	0.769	-24.19	-1.6	39.8	Koehn
	2008-10-07	1.620	0.713	-22.60	-1.2	41.5	Koehn
	2008-10-08	1.613	0.702	-22.26	-1.1	41.8	Koehn
	2008-10-09	1.607	0.692	-21.90	-1.1	42.1	Koehn
	2008-10-22	1.525	0.566	-16.27	0.3	46.4	Sanborn
	2008-10-23	1.519	0.557	-15.75	0.4	46.7	Koehn
	2008-10-24	1.513	0.549	-15.23	0.5	47.0	Sanborn
	2008-10-25	1.507	0.540	-14.70	0.6	47.4	Koehn
	2008-10-26	1.501	0.532	-14.15	0.8	47.7	Koehn
	2008-10-27	1.495	0.524	-13.60	0.9	48.0	Sanborn
	2008-10-29	1.484	0.508	-12.46	1.2	48.6	Koehn
	2008-11-04	1.449	0.465	-8.88	2.0	50.5	Koehn
	2008-11-06	1.438	0.452	-7.68	2.4	51.1	Koehn
	2008-11-07	1.432	0.446	-7.10	2.5	51.4	Sanborn
	2008-11-18	1.374	0.388	5.27	4.5	54.7	Koehn
	2008-11-19	1.369	0.384	5.78	4.7	55.1	Sanborn
	2008-11-20	1.364	0.380	6.36	4.9	55.4	Koehn
	2008-11-21	1.360	0.376	7.00	5.1	55.7	Sanborn
	2008-11-24	1.345	0.364	9.14	5.7	56.7	Sanborn
	2008-12-01	1.315	0.343	14.66	7.1	59.2	Sanborn
	2008-12-03	1.306	0.339	16.28	7.6	59.9	Sanborn
	2008-12-04	1.302	0.337	17.08	7.8	60.3	Koehn
	2008-12-07	1.291	0.331	19.47	8.4	61.5	Koehn
	2009-03-17	1.392	0.607	38.83	9.6	135.6	Sanborn
	2009-03-24	1.430	0.668	38.42	8.7	140.4	Koehn
(163000) 2001 SW169	2008-09-06	1.207	0.202	-9.19	-5.0	348.0	Koehn
	2008-09-07	1.207	0.202	-8.34	-4.8	348.2	Koehn
	2008-09-20	1.216	0.216	10.01	-2.6	350.9	Sanborn
	2008-09-24	1.219	0.223	13.60	-2.0	351.8	Koehn
	2008-09-25	1.219	0.225	14.50	-1.9	352.1	Koehn
	2008-09-29	1.222	0.235	18.08	-1.2	353.2	Sanborn
	2008-09-30	1.223	0.238	18.95	-1.1	353.5	Koehn
	2008-10-01	1.224	0.240	19.81	-0.9	353.8	Sanborn
	2008-10-02	1.225	0.243	20.65	-0.8	354.1	Koehn
(164400) 2005 GN59	2008-08-29	1.231	0.252	-25.64	17.6	343.3	Skiff, Koehn
	2008-09-02	1.203	0.224	-26.97	18.6	345.0	Skiff
	2008-09-03	1.196	0.217	-27.41	18.9	345.5	Skiff
	2008-09-04	1.189	0.210	-27.90	19.2	345.9	Skiff
	2008-09-05	1.182	0.203	-28.44	19.5	346.3	Koehn
	2008-09-06	1.176	0.197	-29.03	19.8	346.8	Koehn
	2008-09-07	1.169	0.190	-29.67	20.1	347.2	Koehn
(171576) 1999 VP11	2008-10-26	1.148	0.204	-37.84	-12.3	56.2	Koehn
	2008-10-27	1.157	0.209	-35.42	-12.7	55.4	Sanborn
(185851) 2000 DP107	2008-09-22	1.064	0.085	-43.45	4.4	24.2	Sanborn
	2008-09-23	1.070	0.089	-40.60	5.2	23.5	Sanborn

Minor Planet	Date of Observation	Sun Distance (AU)	Earth Distance (AU)	Phase Angle (deg)	BPAB (deg)	LPAB (deg)	Observer
	2008-09-26	1.087	0.103	-33.31	7.0	22.1	Sanborn
	2008-09-29	1.105	0.118	-27.60	8.3	21.1	Sanborn
	2008-09-30	1.111	0.123	-25.99	8.7	20.9	Koehn
	2008-10-01	1.116	0.128	-24.52	9.0	20.7	Sanborn
	2008-10-02	1.122	0.134	-23.19	9.4	20.6	Koehn
	2008-10-07	1.152	0.162	-18.35	10.5	20.4	Koehn
	2008-10-08	1.158	0.168	-17.73	10.6	20.4	Koehn
	2008-10-09	1.164	0.175	-17.22	10.8	20.4	Koehn
	2008-10-22	1.242	0.263	18.05	11.9	22.3	Sanborn
	2008-10-23	1.248	0.270	18.44	12.0	22.5	Koehn
	2008-10-24	1.254	0.278	18.85	12.0	22.7	Sanborn
	2008-10-25	1.259	0.286	19.28	12.1	22.9	Koehn
	2008-10-26	1.265	0.293	19.71	12.1	23.2	Koehn
	2008-10-27	1.271	0.301	20.15	12.1	23.4	Sanborn
	2008-10-29	1.283	0.317	21.05	12.1	23.9	Koehn
(185854) 2000 EU106	2008-09-22	1.796	0.829	-12.75	5.8	15.4	Sanborn
	2008-09-23	1.800	0.830	-12.02	5.5	15.4	Sanborn
(189700) 2001 TA45	2008-09-23	1.203	0.225	24.96	16.1	352.4	Sanborn
	2008-09-24	1.204	0.226	24.65	15.6	352.9	Koehn
	2008-09-25	1.205	0.227	24.37	15.1	353.3	Koehn
	2008-09-26	1.207	0.228	24.13	14.6	353.7	Sanborn
(190135) 2005 QE30	2008-09-24	1.589	0.607	11.83	11.3	354.9	Koehn
(190491) 2000 FJ10	2008-10-01	1.088	0.095	-23.52	-0.2	22.2	Sanborn
	2008-10-02	1.085	0.092	-23.63	-0.9	23.3	Koehn
	2008-10-07	1.071	0.080	-25.52	-4.2	28.5	Koehn
	2008-10-08	1.069	0.078	-26.21	-5.0	29.7	Koehn
	2008-10-09	1.066	0.076	-27.03	-5.8	30.8	Koehn
(231134) 2005 TU45	2008-06-07	1.194	0.413	-54.95	45.6	269.2	Koehn
	2008-06-08	1.200	0.411	-54.05	44.9	269.7	Koehn
	2008-06-09	1.206	0.409	-53.13	44.2	270.1	Skiff
(248818) 2006 SZ217	2008-12-01	1.226	0.258	-19.43	-14.6	72.2	Sanborn
	2008-12-03	1.229	0.267	-21.49	-16.6	72.4	Sanborn
	2008-12-04	1.231	0.272	-22.54	-17.5	72.5	Koehn
	2008-12-07	1.237	0.288	25.61	-20.0	72.9	Koehn
(257744) 2000 AD205	2008-06-03	1.204	0.244	35.29	25.4	248.9	Skiff
	2008-06-04	1.194	0.237	36.73	25.9	248.9	Skiff
	2008-06-06	1.175	0.222	39.91	27.3	249.0	Skiff
1998 SJ70	2008-09-22	1.170	0.180	-20.85	-10.6	8.7	Sanborn
	2008-09-25	1.204	0.209	-14.53	-8.6	8.1	Koehn
	2008-09-26	1.216	0.220	-12.82	-8.0	8.0	Sanborn
	2008-09-29	1.250	0.252	-8.87	-6.5	7.8	Sanborn
	2008-09-30	1.261	0.263	-8.00	-6.1	7.8	Koehn
	2008-10-01	1.272	0.274	7.39	-5.7	7.8	Sanborn
	2008-10-07	1.340	0.346	8.44	-3.8	8.2	Koehn
2004 XK3	2008-11-21	1.001	0.013	6.29	1.2	56.4	Sanborn
2006 VB14	2008-12-01	1.075	0.163	-53.41	4.6	103.4	Sanborn
	2008-12-03	1.071	0.147	-51.41	1.8	103.7	Sanborn
	2008-12-04	1.069	0.140	-50.35	0.2	103.8	Koehn
	2008-12-07	1.062	0.119	-47.23	-5.5	103.6	Koehn
	2010-11-27	1.087	0.175	-51.10	18.2	93.2	Skiff
2007 VQ4	2008-05-12	1.087	0.175	-51.10	21.3	198.1	Skiff
	2008-06-06	1.087	0.175	-51.10	9.1	210.1	Skiff
2008 EV5	2008-12-29	1.005	0.026	-31.56	13.1	108.1	Sanborn
	2009-01-01	1.009	0.031	-34.31	17.7	105.5	Koehn
2008 QS11	2008-09-21	1.059	0.075	-41.39	-23.3	2.0	Koehn
	2008-09-22	1.054	0.069	-41.61	-23.0	3.8	Sanborn
	2008-09-23	1.049	0.063	-41.83	-22.7	5.7	Sanborn
	2008-09-24	1.045	0.057	-42.08	-22.3	8.0	Koehn
	2008-09-29	1.024	0.033	-47.61	-16.1	26.4	Koehn
	2008-10-01	1.016	0.028	-57.44	-8.7	37.9	Sanborn
	2008-10-07	0.996	0.043	-93.63	19.9	60.8	Koehn
2008 SA	2008-09-21	1.013	0.012	36.99	7.0	341.1	Koehn
2008 SE	2008-10-07	1.217	0.239	-22.04	8.2	28.3	Koehn
	2008-10-09	1.218	0.238	-20.70	7.4	29.5	Koehn
2008 SQ1	2008-10-22	1.313	0.340	17.74	14.7	26.9	Sanborn
	2008-10-24	1.306	0.333	18.03	14.6	27.9	Sanborn
	2008-10-25	1.302	0.329	18.20	14.6	28.4	Koehn
	2008-10-27	1.295	0.323	18.55	14.5	29.4	Sanborn
	2008-11-04	1.270	0.302	20.16	13.9	33.8	Koehn
	2008-11-06	1.265	0.298	20.58	13.6	35.0	Koehn
	2008-11-07	1.263	0.297	20.80	13.5	35.5	Sanborn

Minor Planet	Date of Observation	Sun Distance (AU)	Earth Distance (AU)	Phase Angle (deg)	BPAB (deg)	LPAB (deg)	Observer
	2008-11-19	1.241	0.282	23.18	11.4	43.1	Sanborn
	2008-11-20	1.240	0.282	23.36	11.2	43.8	Koehn
	2008-11-30	1.236	0.283	25.00	8.7	50.8	Skiff
2008 SR1	2008-09-29	1.134	0.137	15.48	-8.5	1.3	Sanborn
	2008-09-30	1.143	0.148	16.35	-9.1	2.0	Koehn
2008 US4	2008-10-28	1.141	0.148	5.89	3.2	33.0	Koehn
	2008-10-30	1.124	0.133	10.13	5.4	33.6	Koehn

Table I. Observing circumstances.

Minor Planet	NEAPS Period	NEAPS Period Uncert.	NEAPS Period Quality	Period (h) Published Elsewhere	Published Period Quality	Reference
1036 Ganymed	10.32	0.02	3	10.2936	3	Behrend 2011
1620 Geographos	5.223	0.003	3	5.22204	3	Hamanowa 2011
1627 Ivar	4.7954	0.0004	3	4.795	3	Kaasalainen 2004
1865 Cerberus	6.804	0.003	3	6.810	3	Pravec 1999
1980 Tezcatlipoca	-	-	-	7.24612	3	Behrend 2006
2363 Cebriones	20.5	0.5	2	20.081	2+	Galád 2008
4179 Toutatis	-	-	-	175,130	3(T)	Pravec 2005
4257 Ubasti	-	-	-	-	-	-
5332 Davidaguilar	-	-	-	5.803	3	Binzel 1990
7358 Oze	5.433	0.001	2+	5.488	2-	Pravec 1998
(8567) 1996 HW1	8.757	0.002	3	8.7573	3	Higgins 2006a
(16960) 1998 QS52	2.90	0.02	2	2.90	2+	Warner 2009b
(39572) 1993 DQ1	9.58	0.01	3	-	-	-
(53430) 1999 TY16	-	-	-	9.582	2+	Ye 2009
(66146) 1998 TU3	-	-	-	2.375	3	Higgins 2011
(85774) 1998 UT18	-	-	-	34	1	Krugly 2002
(87684) 2000 SY2	-	-	-	8.80	2	Higgins 2005
(136849) 1998 CS1	2.765	0.001	3	2.765	3	Ye 2010
(137032) 1998 UO1	4.42	0.02	2-	3.0	2	Wolters 2008
(137805) 1999 YK5	-	-	-	-	-	-
(138852) 2000 WN10	4.46	0.01	3	-	-	-
(142348) 2002 RX211	5.069	0.001	3	5.0689	3	Higgins 2006b
(144901) 2004 WG1	8.06	0.01	2	-	-	-
(162900) 2001 HG31	-	-	-	60.61	3(T)	Warner 2009d
(163000) 2001 SW169	38.04	0.03	1+	-	-	-
(164400) 2005 GN59	38.691	0.009	3-	38.62	3-	Vander Haagen 2011
(171576) 1999 VP11	-	-	-	-	-	-
(185851) 2000 DP107	2.774	0.001	3-	2.7754	3	Pravec 2006
(185854) 2000 EU106	3.501	0.002	2	-	-	-
(189700) 2001 TA45	5.010	0.003	2	-	-	-
(190135) 2005 QE30	-	-	-	-	-	-
(190491) 2000 FJ10	-	-	-	-	-	-
(231134) 2005 TU45	2.672	0.002	3	-	-	-
(248818) 2006 SZ217	-	-	-	3.2474	2	Ye 2009
(257744) 2000 AD205	-	-	-	-	-	-
1998 SJ70	19.15	0.05	2	-	-	-
2004 XK3	-	-	-	-	-	-
2006 VB14	3.204	0.002	3-	-	-	-
2007 VQ4	2.66	0.04	-	-	-	-
2008 EV5	3.727	0.008	3	3.725	3	Galád 2009
2008 QS11	46.65	0.04	2-	-	-	-
2008 SA	-	-	-	-	-	-
2008 SE	4.7	0.1	2-	-	-	-
2008 SQ1	-	-	-	-	-	-
2008 SR1	-	-	-	-	-	-
2008 US4	5.2	0.05	3	-	-	-

Table II. Summary of results.

ASTEROID LIGHTCURVE ANALYSIS AT THE OAKLEY SOUTHERN SKY OBSERVATORY: 2011 NOVEMBER-DECEMBER

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Photometric data for 26 asteroids were collected over 20 nights of observing during 2011 November through December at the Oakley Southern Sky Observatory. The asteroids were: 664 Judith, 739 Mandeville, 781 Kartvelia, 871 Amneris, 971 Alsatia, 1577 Reiss, 2068 Dangreen, 2745 San Martin, 2870 Haupt, 2909 Hoshi-no-ie, 3041 Webb, 4359 Berlage, 4363 Sergej, 4804 Pasteur, 5870 Baltimore, (5874) 1989 XB, 6121 Plachinda, 6172 Prokofeana, 6402 Holstein, (10765) 1990 UZ , 12738 Satoshimiki, 16358 Plesetsk, (23276) 2000 YT101, (24475) 2000 VN2, (96487) 1998 JU1, (98129) 2000 SD25.

Twenty six asteroids were observed from the Oakley Southern Sky Observatory in New South Wales, Australia, on the nights of 2011 November 1-5, 7, 14, 15, 18, 19, 26-28 and December 1-3, 13, 14, 16, and 20. From the data, we were able to find lightcurves for only 12 asteroids. During this period, we experienced marginal weather with frequent high, thin clouds. The weather caused our data to be noisy and unreliable. Of the twelve lightcurves found, eight were for asteroids with no previously published periods. Our results for three of the four remaining asteroids agreed with the previously published periods.

The selection of asteroids was based primarily on their sky position about one hour after sunset. The next criterion for selecting asteroids was that those without previously published periods were given higher priority than asteroids with known periods. Finally, asteroids with uncertain periods were also selected with the hopes that improvements of previous results could be made. We used an *f*/8.1 0.5-meter Ritchey-Chretien optical tube assembly on a Paramount ME mount mounted with a Santa Barbara Instrument Group (SBIG) STL-1001E CCD camera and clear filter. The image scale was 1.2 arcseconds per pixel. Exposure times varied between 20 and 210 seconds. Calibration of the images was done using master twilight flats, darks, and bias frames. All calibration frames were created using *CCDSoft*. *MPO Canopus* was used to measure the processed images.

As far as we are aware, these are the first reported periods for 4359 Berlage, 4363 Sergej, 4804 Pasteur, 6121 Plachinda, 6172 Prokofeana, (10765) 1990 UZ, 16358 Plesetsk, and (23276) 2000 YT101.

664 Judith. Our data are inconsistent with the period of 10.6829 ± 0.0005 h found by Hosek (2011).

781 Kartvelia. Our results are close to the period of 19.06 ± 0.01 h found by Behrend (2012) but not within experimental uncertainty.

971 Alsatia. Our results agree within experimental uncertainty with the period of 9.60 ± 0.07 h found by Behrend (2012).

1577 Reiss. Our results agree within experimental uncertainty with the period of 4.5051 ± 0.0002 h found by Pravec (2012).

Number	Name	Dates mm/dd 2011	Data Points	Period (h)	Period Error (h)	Amp (mag)	Amp Error (mag)
664	Judith	11/1 - 11/4	74	19.35	0.06	0.35	0.02
739	Mandeville	12/13, 12/14, 12/16, 12/20	72			0.14	0.03
781	Kartvelia	12/13, 12/14, 12/16, 12/20	69	19.02	0.02	0.27	0.03
871	Amneris	11/26 - 11/28, 12/1 - 12/3	98			0.06	0.08
971	Alsatia	11/1 - 11/5, 11/7	100	9.61	0.02	0.21	0.01
1577	Reiss	11/1 - 11/5, 11/7	92	4.505	0.002	0.20	0.05
2068	Dangreen	11/14, 11/15, 11/18, 11/19	66			0.04	0.01
2745	San Martin	12/13, 12/14, 12/16, 12/20	78			0.04	0.04
2870	Haupt	11/1 - 11/5, 11/7	69			0.14	0.02
2909	Hoshi-no-ie	11/26 - 11/28, 12/1 - 12/3	104			0.23	0.03
3041	Webb	11/14, 11/15, 11/18, 11/19	61			0.05	0.04
4359	Berlage	11/26 - 11/28, 12/1 - 12/3	96	7.413	0.002	0.90	0.05
4363	Sergej	11/14, 11/18, 11/19	53	13.04	0.01	0.50	0.04
4804	Pasteur	11/1 - 11/4	75	13.69	0.02	0.28	0.02
5870	Baltimore	12/13, 12/14, 12/16, 12/20	78			0.3	0.1
5874	1989 XB	11/14, 11/18, 11/19	42			0.06	0.01
6121	Plachinda	11/26 - 11/28, 12/1 - 12/3	100	4.0863	0.0006	0.35	0.02
6172	Prokofeana	11/26 - 11/28, 12/1 - 12/3	98	6.540	0.001	0.35	0.02
6402	Holstein	11/1 - 11/4, 11/7	81			0.10	0.05
10765	1990 UZ	11/14, 11/15, 11/18. 11/19	59	4.378	0.003	0.17	0.01
12738	Satoshimiki	12/13, 12/14, 12/16, 12/20	64			0.20	0.08
16358	Plesetsk	11/1 - 11/5, 11/7	101	6.560	0.002	0.47	0.06
23276	2000 YT101	11/1 - 11/5, 11/7	89	3.661	0.004	0.22	0.06
24475	2000 VN2	11/14, 11/15, 11/18, 11/19	76			0.04	0.01
96487	1998 JU1	12/13, 12/14, 12/16, 12/20	73			0.06	0.04
98129	2000 SD25	11/26 - 11/28, 12/1 - 12/3	119			0.11	0.03

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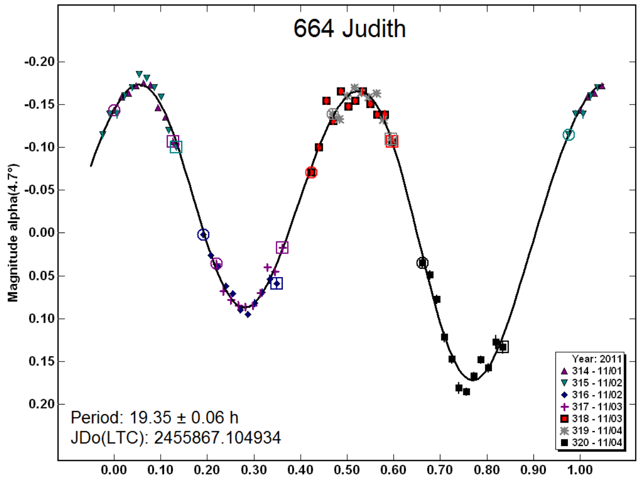
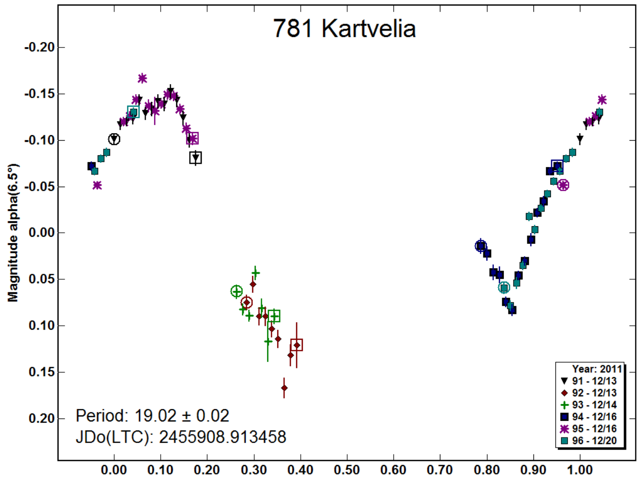
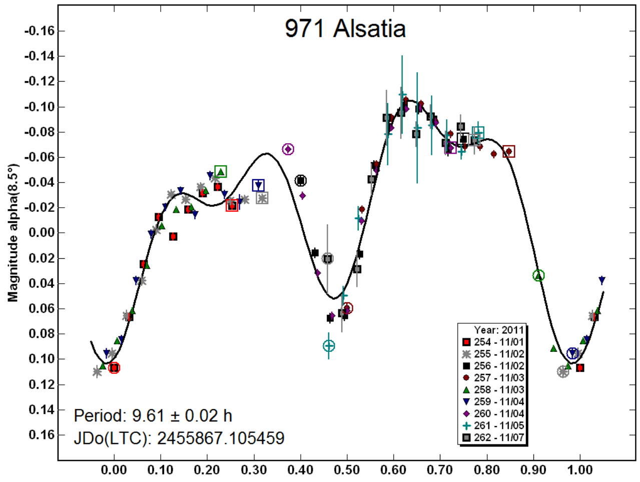
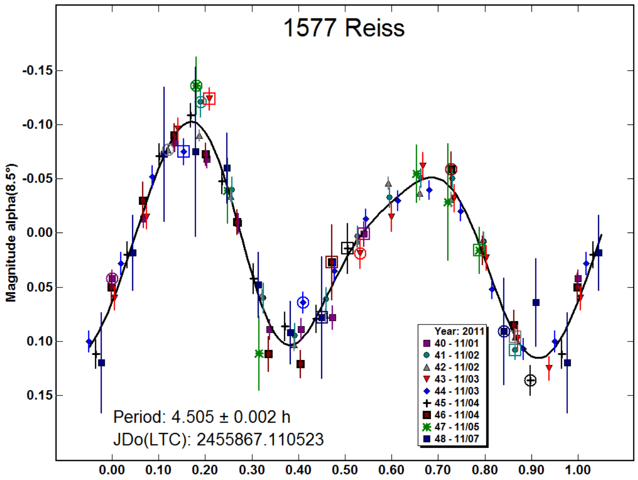
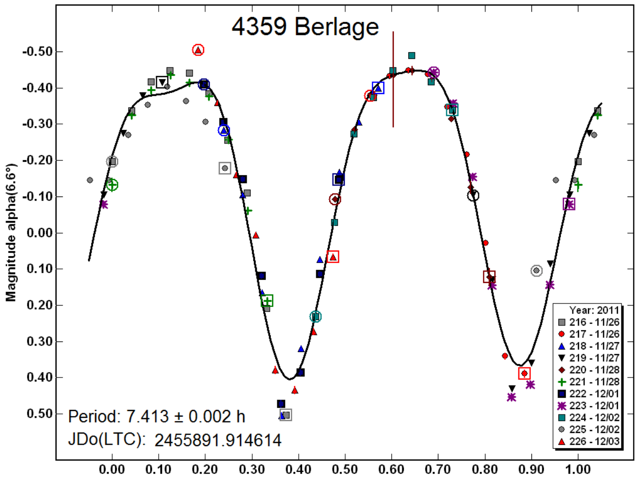
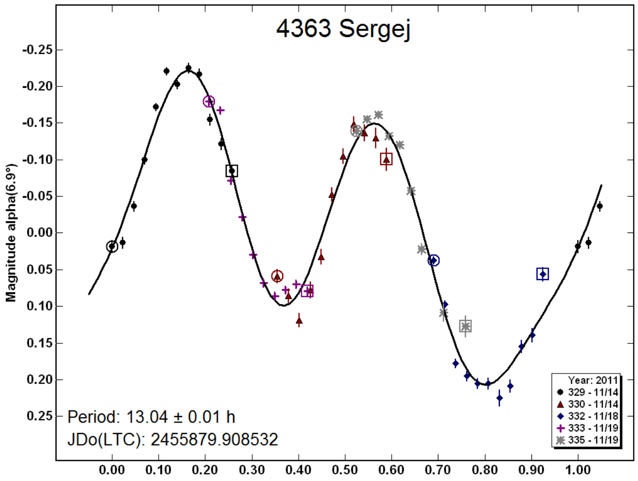


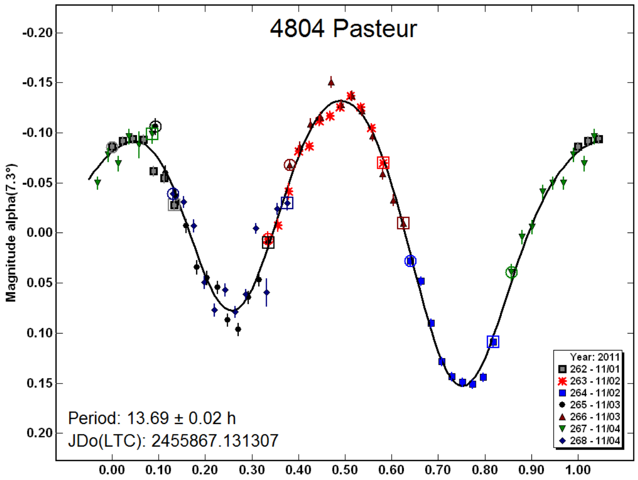


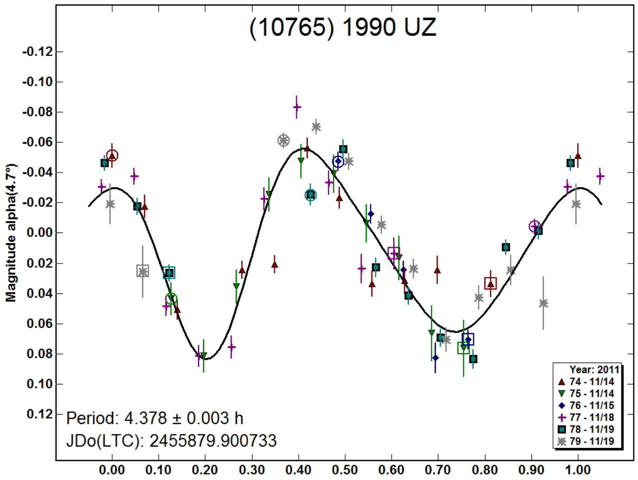


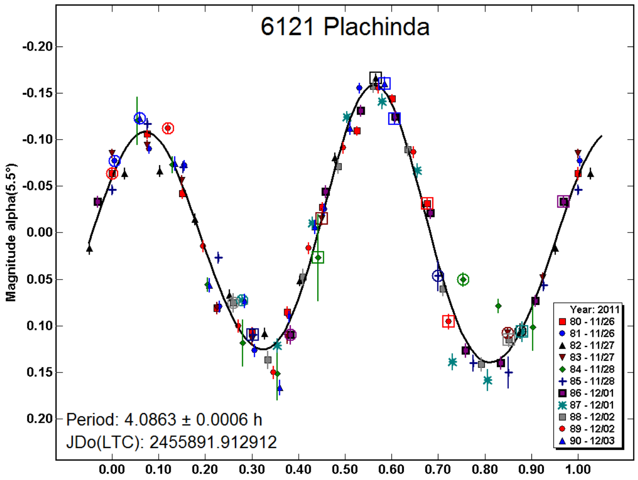


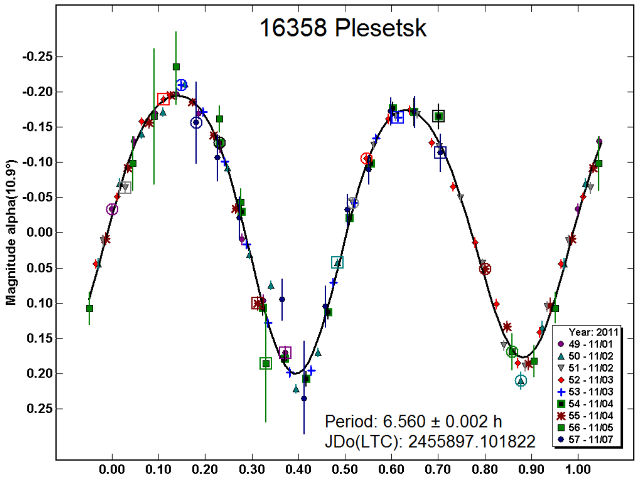


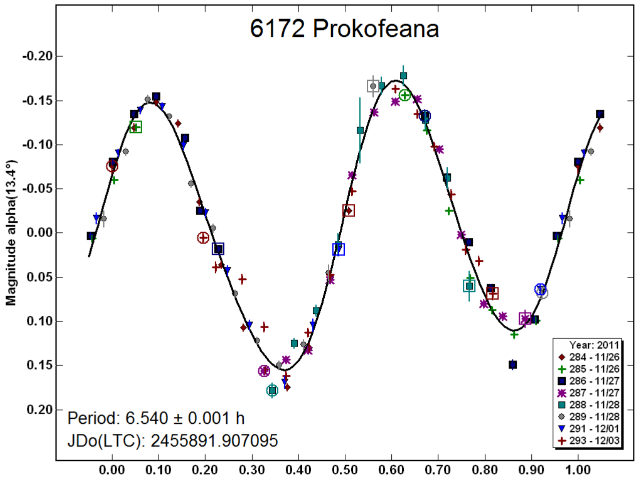


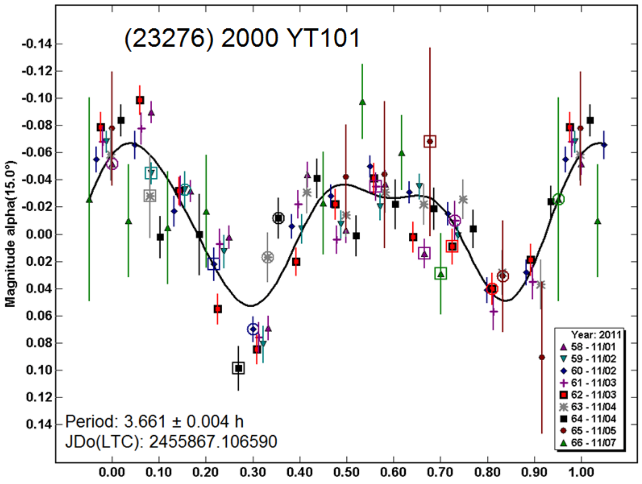

4804 Pasteur
Magnitude alpha(7.3°)
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
Period: 13.69 ± 0.02 h
JDo(LTC): 2455867.131307
Year: 2011
262 - 11/01
263 - 11/02
264 - 11/02
265 - 11/03
266 - 11/03
267 - 11/04
268 - 11/04
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


(10765) 1990 UZ
Magnitude alpha(4.7°)
-0.12
-0.10
-0.08
-0.06
-0.04
-0.02
0.00
0.02
0.04
0.06
0.08
0.10
0.12
Period: 4.378 ± 0.003 h
JDo(LTC): 2455879.900733
Year: 2011
74 - 11/14
75 - 11/14
76 - 11/15
77 - 11/18
78 - 11/19
79 - 11/19
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


6121 Plachinda
Magnitude alpha(5.5°)
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
Period: 4.0863 ± 0.0006 h
JDo(LTC): 2455891.912912
Year: 2011
80 - 11/26
81 - 11/26
82 - 11/27
83 - 11/27
84 - 11/28
85 - 11/28
86 - 12/01
87 - 12/01
88 - 12/02
89 - 12/02
90 - 12/03
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


16358 Plesetsk
Magnitude alpha(10.9°)
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
Period: 6.560 ± 0.002 h
JDo(LTC): 2455897.101822
Year: 2011
49 - 11/01
50 - 11/02
51 - 11/02
52 - 11/03
53 - 11/03
54 - 11/04
55 - 11/04
56 - 11/05
57 - 11/07
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


6172 Prokofeana
Magnitude alpha(13.4°)
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
Period: 6.540 ± 0.001 h
JDo(LTC): 2455891.907095
Year: 2011
284 - 11/26
285 - 11/26
286 - 11/27
287 - 11/27
288 - 11/28
289 - 11/28
291 - 12/01
293 - 12/03
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


(23276) 2000 YT101
Magnitude alpha(15.0°)
-0.14
-0.12
-0.10
-0.08
-0.06
-0.04
-0.02
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Period: 3.661 ± 0.004 h
JDo(LTC): 2455867.106590
Year: 2011
58 - 11/01
59 - 11/02
60 - 11/02
61 - 11/03
62 - 11/03
63 - 11/04
64 - 11/04
65 - 11/05
66 - 11/07
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

140 SIWA – A PROBLEMATIC ASTEROID

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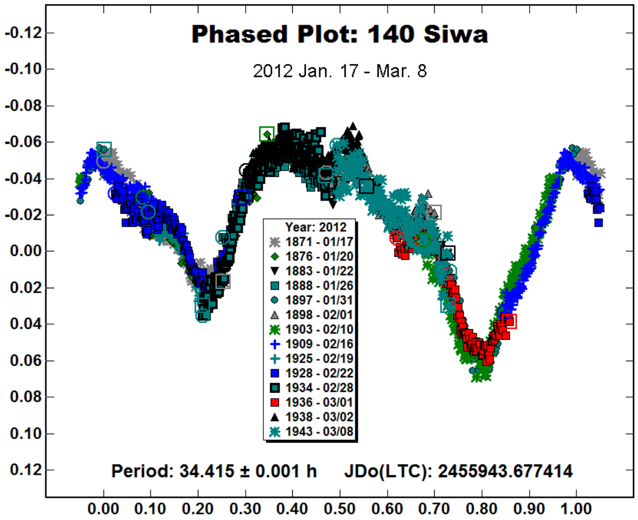
Analysis of observations of 140 Siwa obtained between 2012 Jan 17 and Mar 8 shows a synodic rotation period of 34.415 hours, amplitude 0.12 ± 0.01 mag. However, the subset in the interval Jan 17 – Feb 1 shows a period 34.362 ± 0.007 h, and one in the interval Feb 10 – Mar 8 a period 34.445 ± 0.003 h. With allowance for this large shift of synodic period with changing viewing aspect and phase angle, the synodic rotation period with reasonable error should be stated as 34.41 ± 0.04 hours.

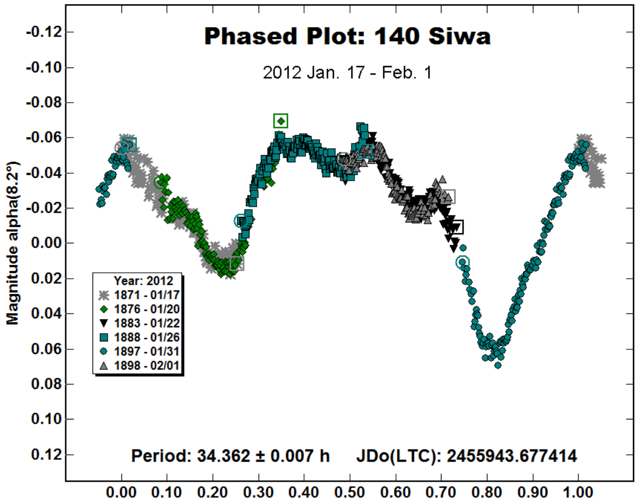
Nearly every previous investigation of 140 Siwa has yielded a different period. Harris and Young (1980) and Schober and Stanzel (1979) independently obtained single night 7-hour lightcurves separated by 32 hours which looked similar and surmised a 32 hour period. Other periods were obtained by Lagerkvist *et al.* (1992; 18.5 h), Le Bras *et al.* (2001; 18.495 h), Riccioli *et al.* (2001; 14.654 h), Behrend (2012; 17.16 h with one maximum and minimum per cycle), Pilcher (2011; 34.407 h), and Durech *et al.* (2011; a sidereal period of 11.38834 h). New observations by the author were made at the Organ Mesa Observatory with a Meade 0.35-m LX-200 GPS Schmidt-Cassegrain and SBIG STL-1001E CCD. Exposures used a clear filter and were unguided. Differential photometry was used to determine instrumental magnitudes for the asteroid. Image measurement and lightcurve analysis were done with *MPO Canopus* software.

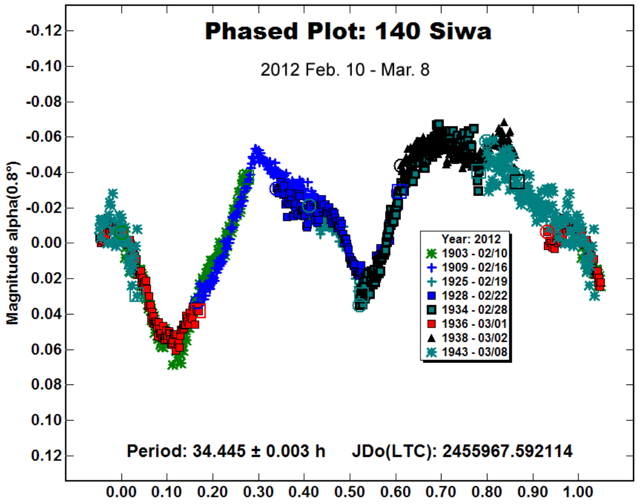
Observations were obtained on 14 nights between 2012 Jan 17 and Mar 8. When phased to a single set over the entire interval, the result was a period of 34.415 ± 0.001 h, amplitude 0.12 ± 0.01 mag with the usual two asymmetric maxima and minima per cycle. However, a large change in the synodic period, accompanied with very small changes in the overall shape of the lightcurve, was noted during the full interval of observations. The subset of six nights, 2012 Jan 17 – Feb 1, shows a period 34.362 ± 0.007 h. A second subset of eight nights, 2012 Feb 10 – Mar 8, shows a period 34.445 ± 0.003 h. The phase angle bisector changed very little and with nearly uniform time rate of motion over the entire interval of observation, as summarized in Table 1. Hence the observed change in synodic period is caused almost entirely by changes in the *viewing aspect*, i.e., the direction of the asteroid pole versus the line of sight, and phase angle. This result is consistent with the 34.407-hour rotation period found by the author (Pilcher 2011) at the 2010 apparition, and would seem to rule out all the other period determinations. While the period itself now seems reliably established, the error is still large and may reasonably be expressed as 34.41 ± 0.04 h.

UT Date	Phase	PABL	PABB
2012 Jan 17	8.2	140.7	1.8
2012 Feb 01	3.2	140.4	2.0
2012 Feb 10	0.7	140.0	2.1
2012 Mar 08	9.5	139.4	2.2

Table 1. All values are degrees. Phase = phase angle; PABL = longitude of phase angle bisector; PABB = latitude of phase angle bisector.







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SPECTROPHOTOMETRIC CLASSIFICATION AND LIGHTCURVE ANALYSIS OF 9983 RICKFIENBERG

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We have obtained contemporaneous BVR photometry and lightcurve measurements for the main-belt asteroid 9983 Rickfienberg, which came to opposition in 2011 November. Photometric images were obtained using the WIYN 0.9-meter telescope at Kitt Peak National Observatory; the facility's S2KB CCD camera; and Harris B, V, and R filters. Landolt reference stars were used to calibrate the imaging system. These observations were conducted in parallel with CCD imaging done at Phillips Academy Observatory and Smith River Observatory to determine a rotational lightcurve and to further calibrate the photometry. The asteroid's lightcurve has a period of 5.2963 ± 0.0001 h and an amplitude of 1.4 ± 0.1 mag. The object is unusually blue as a result of strong absorption in the red, but more data are needed to pin down its taxonomic classification.

Main-belt asteroid 1995 DA was discovered by Dennis di Cicco from Sudbury, Massachusetts, and was eventually numbered 9983 and named Rickfienberg for the former editor in chief of *Sky & Telescope* magazine (now press officer of the American Astronomical Society). A search of the Asteroid Lightcurve Database (LCDB) and the SAO/NASA Astrophysics Data System (ADS) failed to turn up any published lightcurves, multicolor photometric data, or spectra. Noting that his namesake asteroid would come to opposition in 2011 November, coauthor Fienberg made plans to collect lightcurve data from Smith River Observatory (IAU code 459) in New Hampshire. He enlisted his colleague Odden to do the same from Phillips Academy Observatory (IAU code I12) in Massachusetts. Coauthors Arion and Tatge were already scheduled to use the WIYN 0.9-m telescope at Kitt Peak National Observatory in mid-November, and they agreed to obtain BVR photometry of the asteroid.

Lightcurve Analysis

Observations. Imaging at Phillips Academy Observatory (PAO) was done with a DFM Engineering 0.4-m f/8 Cassegrain reflector and an SBIG STL-1301E CCD camera with a 1280 x 1024 array of 16-micron pixels and a clear filter. At Smith River Observatory (SRO) unfiltered imaging was done with a Meade RCX400 0.35-m aplanatic Schmidt-Cassegrain telescope at f/5 and an SBIG ST-8XME CCD camera with a 1530 x 1050 array of 9-micron pixels. Both setups provided an unbinned image scale of 1.0 arcsec per pixel. Autoguided exposures were 300 s (PAO) or 360 s (SRO) at a CCD temperature of –30° C. All images were calibrated with dark frames and flat fields.

Method. Image capture and calibration for all the lightcurve data was accomplished with Diffraction Limited's *MaxIm DL5* software. Lightcurve analysis was accomplished with Bdw Publishing's *MPO Canopus* software; the asteroid's varying brightness was measured against the fixed brightness of field stars using differential photometry. Data merging and period analysis were done with *MPO Canopus* using an implementation of the Fourier analysis algorithm of Harris et al. (1989).

Results. The combined set of 439 brightness measurements collected during the period 2011 November 5–22 was analyzed by Odden and is presented in Figure 1. According to A. Harris

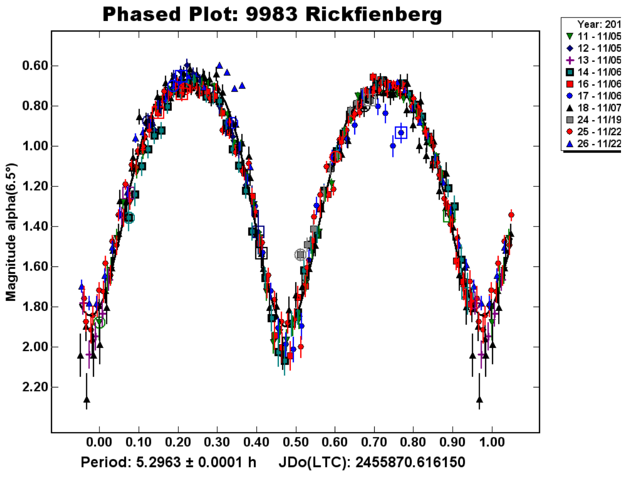

Figure 1. Lightcurve of 9983 Rickfienberg.

(personal communication), geometrical considerations indicate that a symmetric bimodal lightcurve with an amplitude exceeding ~0.4 mag, such as that of 9983 Rickfienberg, is the inevitable result of the rotation of an elongated prolate spheroid at low phase angle. We therefore conclude that this asteroid has a rotation period of 5.2963 ± 0.0001 h and an amplitude of 1.4 ± 0.1 mag.

Spectrophotometry

Observations. Images of 9983 Rickfienberg were captured on 2011 November 13 with the WIYN 0.9-m telescope. The S2KB camera has a field of 20 x 20 arcmin and an unbinned image scale of 0.6 arcsec/pixel. Numerous 240-s exposures were made through Harris B, V, and R filters. Flats and biases were obtained for calibration; the S2KB has such low dark current at liquid-nitrogen temperature that dark frames are not needed. Also for calibration, observations of the asteroid were interleaved with observations of Landolt standard stars 95 301, 95 302, 95 317, and 95 263.

Method. All of the images were captured and calibrated with *MaxIm DL5,* and aperture photometry was performed with Willmann-Bell's *AIP4WIN* to obtain instrumental magnitudes for the asteroid and the Landolt standards. The collaboration to obtain lightcurve and photometric data simultaneously was advantageous, as it was found that the asteroid had a significant brightness variation of a factor of more than 2.5 over a 5-h period. The lightcurve was therefore used to correct the raw instrumental magnitudes of the asteroid for each exposure in each filter. The differences between the measured B–V and V–R and the cataloged B–V and V–R for the Landolt standard stars were then averaged to obtain corrections. These factors were B–V: 0.029 ± 0.116 (Table I) and V–R: –0.007 ± 0.170 (Table II).

Results. The measurements (Table III) yielded values of B–V = 0.698 ± 0.192 and V–R = –2.524 ± 0.262 for the asteroid. The V–R value indicates that 9983 has very strong absorption in the red, which is uncommon for most asteroid spectral classes. Initially we were concerned that the exposures through the R filter might have been affected by a systematic error. After reviewing the Landolt corrections for V–R, which were very small, we determined that the asteroid R magnitudes were probably correct. To further rule out the possibility of a systematic error, we measured B–V and V–R colors for random field stars in the B, V, and R images. These showed reasonable values consistent with *M* and *K* dwarfs, the most likely types of stars to lie in the field. Therefore, we have confidence that our B–V and V–R values for 9983 are correct.

Discussion. We have combed the literature to examine all possible classes of asteroids and meteorites with spectral characteristics similar to those of 9983 Rickfienberg. The class exhibiting the largest drop in reflectivity from the V band to the R band is the Vesta family, or V type (Bus and Binzel 2002). The orbital elements of 9983, however, are not consistent with membership in the Vesta family. There are several other taxonomic classes with decreasing reflectivity in the red, such as A, O, R, and Q, but matching one of these with 9983 would require photometry across a broader range of wavelengths, from the U band to the near infrared to cover the 1-μm silicate absorption band. We conclude that our measured colors for 9983 Rickfienberg are not obviously consistent with those of any known asteroid class and that more comprehensive spectrophotometry is called for at the next opposition in March 2013.

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Landolt Stars	**Catalog B-V**	**Measured B-V**	**Correction**
95 301	1.290	1.109	0.18
95 302	0.825	0.768	0.06
95 317	1.320	1.402	-0.08
95 263	1.500	1.540	-0.04
Average Correction:			0.029 ± 0.116

Table I. B–V Correction for Landolt Standards.

Landolt Stars	**Catalog V-R**	**Measured V-R**	**Correction**
95 301	0.692	0.500	0.19
95 302	0.471	0.511	-0.04
95 317	0.768	0.984	-0.22
95 263	0.801	0.766	0.04
Average Correction:			-0.007 ± 0.170

Table II. V–R Correction for Landolt Standards.

B Filter		**V Filter**		**R Filter**	
Instrumental Magnitude	**Adjusted for Lightcurve**	**Instrumental Magnitude**	**Adjusted for Lightcurve**	**Instrumental Magnitude**	**Adjusted for Lightcurve**
17.648	16.178	16.907	15.417	19.802	18.312
17.321	16.231	17.026	15.606	19.679	18.029
17.213	16.133	16.887	15.477	19.792	17.892
17.136	16.336	16.909	15.699	19.909	18.059
				19.770	18.170
				19.770	17.940
Average Mag:	16.219 ± 0.087		15.549 ± 0.126		18.067 ± 0.154

Table III. 9983 Rickfienberg Magnitudes Through Each Filter and Adjusted for the Lightcurve.

ANOTHER LIGHT CURVE ANALYSIS FOR 198 AMPELLA

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Observations of main-belt minor planet 198 Ampella were undertaken by Lenomiya Observatory from November 2011 through February 2012, revealing a period of 10.379 ± 0.001 h.

Observations at the Lenomiya Observatory were conducted with a Celestron CPC1100 0.28-m Schmidt-Cassegrain with a focal length of 1.943 m, and a ratio of f/6.3 using a focal reducer. The CCD used was a Santa Barbara Instruments Group ST8XME, unfiltered, guided, at -12 C to -27 C and binned by 2 resulting in an array of 765 x 510 at 18-micron per pixels and 1.92 arcseconds per pixel. The Nov. 27 and 28 observations were made by second author Pilcher at the Organ Mesa Observatory with a Meade 35 cm LX200 GPS S-C, SBIG STL-1001E CCD, clear filter, unguided, with 1.46 x 1.46 arcsecond pixel size. The 2,764 images were exposed in a range of 10 s to 35 s, based on atmospheric conditions and maximizing the SNR. They were calibrated using *CCDSoft* version 5.00.205 and measured using *MPO Canopus* version 10.4.0.20 (Warner, 2011).

198 Ampella is a main-belt asteroid, discovered in 1879 by A. Borrelly at Marseilles, and probably named after Ampelos, friend of Dionysus the god of wine and revelry (Schmadel 2003). The asteroid was selected due to a request from Frederick Pilcher, Organ Mesa Observatory, to collaborate and attempt to resolve the current ambiguity in observed rotational periods.

Previous observations on record are by DeYoung, J. A., and Schmidt, R. E. (1993), , who show a period 10.383 hours, amplitude 0.22 magnitude based on observations 1993 Feb. 3 - Mar. 19; and by Warner, B. D., and Stephens, R. D. (2009), , who show a period twice as great, 20.778 hours, amplitude 0.12 magnitudes with only 85% phase coverage based on observations 2009 Apr. 8 - 30.

The authors considered it necessary to obtain full phase coverage for the longer period and inspect the lightcurve carefully to determine whether the two halves appeared identical within reasonable errors of observation and changes in lightcurve shape, with a changing phase angle. Table 1 shows the phase angle for each date data was recorded.

The analysis of the data disclosed a bimodal lightcurve with a period of 10.379 ± 0.001 hrs, and an amplitude of 0.11 ± 0.01mag. Individual sessions spanned the complex section of the curve ruling out any trimodal or monomodal fit.

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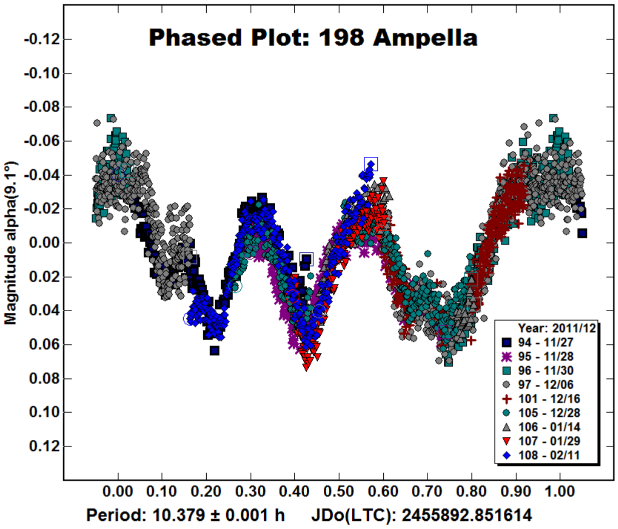

DATE	PHASE ANGLE
11/27/11	9.1
11/28/11	8.56
11/30/11	7.55
12/06/11	4.27
12/16/11	1.70
12/28/11	7.81
01/14/12	15.09
01/29/12	19.53
02/11/12	21.91

Table 1. Phase angles

LIGHTCURVE PHOTOMETRY OF SIX ASTEROIDS

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(Received: 25 March)

Observations from 2012 January to March lead to the determination of the rotation periods for six main-belt asteroids: 33 Polyhymnia, P = 18.604 ± 0.004 h; 467 Laura, P = 37.4 ± 0.1 h; 825 Tanina, P = 6.940 ± 0.001 h; 1421 Esperanto, P = 21.982 ± 0.005 h; 3481 Xianglupeak, P = 5.137 ± 0.003 h; and 4350 Shibecha, which had two possible solutions, P = 2.890 ± 0.001 h and P = 5.778 ± 0.002 h.

During the firsts three month of 2012, the Bigmuskie Observatory worked to find the synodic period of six asteroids. Unfortunately for two of them, 467 Laura and 4350 Shibecha, the result is not secure. For all the targets the setup was the same: a 0.3-m *f*/8 Ritchey-Chretien coupled to a SBIG ST9 CCD and R filter that provided a field of view of about 15x15 arcminutes and a resolution of 1.7 arcseconds per pixel. *MPO Canopus* v10 was used to calibrate and measure the images, while *CCDsoft* v5 controlled the CCD camera. Comparison stars where chosen with the assistance of the Comparison Star Selector in *MPO Canopus*, which leads to a linkage between the sessions on the order of ±0.05 mag. In addition, whenever possible, only solar-colored comparison stars were used to minimize color correction errors between each star and the asteroid. Due to the small field of view of the CCD, this wasn't always possible.

33 Polyhymnia. This target was previously measured in 2008 and 2010/2011 as reported by Pilcher (2012), who found periods of 18.609 h and 18.608 h, respectively. After a private communication, he kindly provided an additional session worked on 2012 March 11. This session exactly overlays session 101 in the plot, which was affected by scattered results due to clouds. The result is a period *P* = 18.604 ± 0.004 h with an amplitude of 0.13 mag, or in very good agreement with previous results.

467 Laura. Because of a prolonged period of bad weather in February, it was impossible to go on with observations after January. Two more sessions kindly provided by Frederick Pilcher from his database helped to reach a preliminary lightcurve. With 7 sessions, a possible period seems to be *P* = 36.79 ± 0.02h with an amplitude of 0.17 mag

825 Tanina. With three sessions of low noise, the result is a secure period *P* = 6.940 ± 0.001 h and an amplitude of 0.54 mag.

1421 Esperanto. A period a little under 24 h appeared soon after the first two sessions recorded on 2012 March 1 and 3. The shifting of session 88 compared to session 87 suggested that period was very likely a little shorter than 24 h. After 9 sessions, the final result for the period is *P* = 21.982 ± 0.005 h with an amplitude of 0.15 mag.

3481 Xianglupeak. A period *P* = 5.137 ± 0.003 h and amplitude of 0.30 mag were determined after two observing nights.

4350 Shibecha. This target produced two ambiguous periods: a longer classical bimodal lightcurve with a period *P* = 5.778 ± 0.002 h and amplitude 0.10 mag, and a period of *P* = 2.890 ± 0.001 h, amplitude 0.12 mag with a monomodal lightcurve. From the period spectrum, it is evident that the shorter solution is the preferred one. From a visual inspection of the longer period lightcurve, it seems that there are little differences between the shapes of the two maxima. To test this appearance, the period for each single session was plotted. In this case, every session produced a period near to 2.90 h with an evident very good overlaying of the two peaks. It is difficult when two solutions seem equally likely. However, the evidence appears to favor the shorter period.

Acknowledgments

Thanks to Frederick Pilcher for his support to interpret the results on 4350 Shibecha and providing additional observations of 33 Polyhymnia on 2012 March 11 and 467 Laura on 2011 November 30, 2011 December 04.

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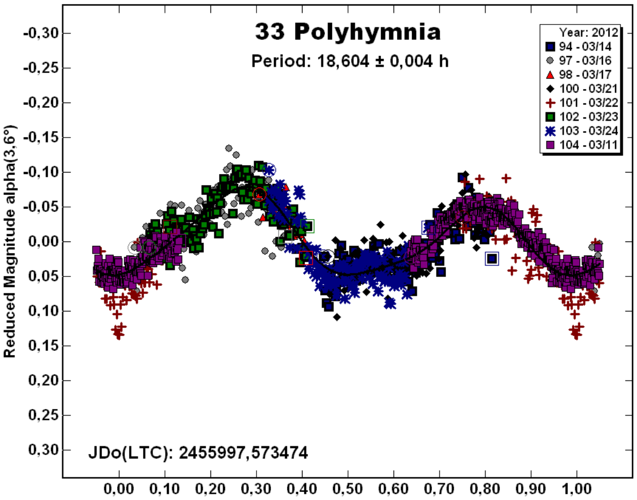

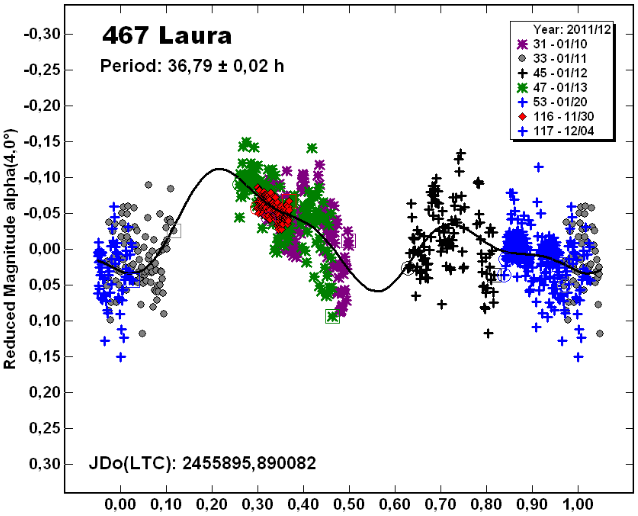

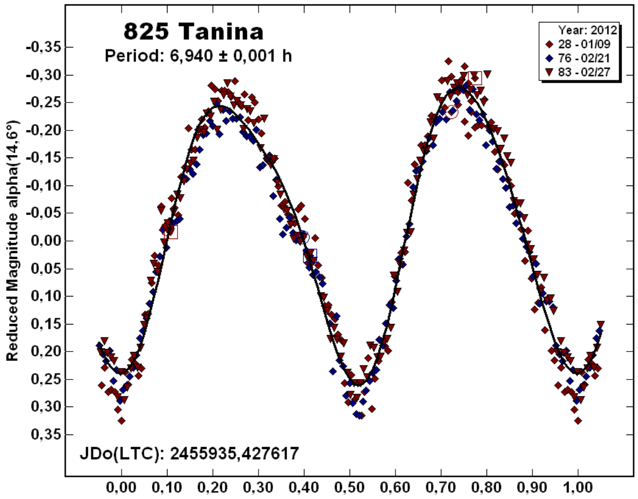
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Period: 6,940 ± 0,001 h
Year: 2012
28 - 01/09
76 - 02/21
83 - 02/27
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-0,30
-0,25
-0,20
-0,15
-0,10
-0,05
0,00
0,05
0,10
0,15
0,20
0,25
0,30
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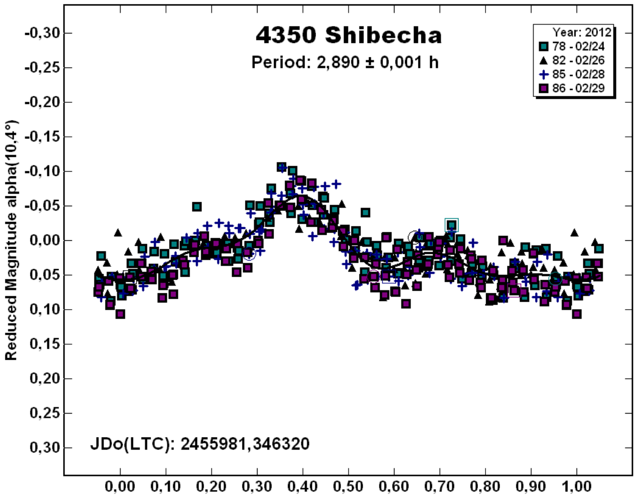
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Period: 2,890 ± 0,001 h
Year: 2012
78 - 02/24
82 - 02/26
85 - 02/28
86 - 02/29
Reduced Magnitude alpha(10,4°)
-0,30
-0,25
-0,20
-0,15
-0,10
-0,05
0,00
0,05
0,10
0,15
0,20
0,25
0,30
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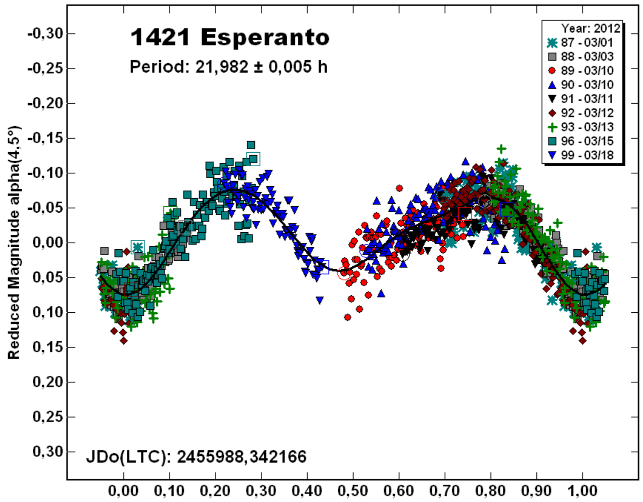
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Period: 21,982 ± 0,005 h
Year: 2012
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88 - 03/03
89 - 03/10
90 - 03/10
91 - 03/11
92 - 03/12
93 - 03/13
96 - 03/15
99 - 03/18
Reduced Magnitude alpha(4,5°)
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-0,25
-0,20
-0,15
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0,10
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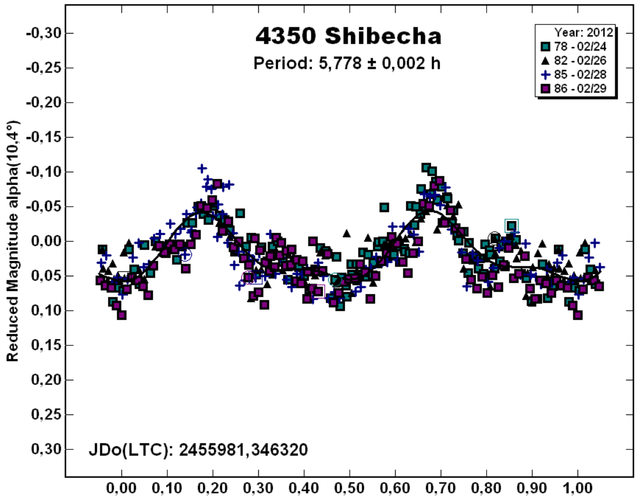
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Period: 5,778 ± 0,002 h
Year: 2012
78 - 02/24
82 - 02/26
85 - 02/28
86 - 02/29
Reduced Magnitude alpha(10,4°)
-0,30
-0,25
-0,20
-0,15
-0,10
-0,05
0,00
0,05
0,10
0,15
0,20
0,25
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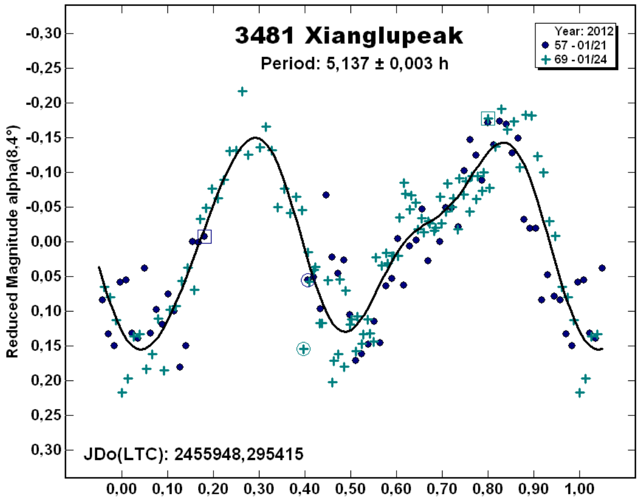
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Period: 5,137 ± 0,003 h
Year: 2012
57 - 01/21
69 - 01/24
Reduced Magnitude alpha(8,4°)
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-0,20
-0,15
-0,10
-0,05
0,00
0,05
0,10
0,15
0,20
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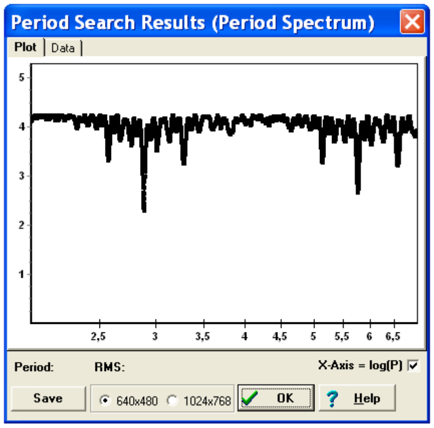
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Plot
Data
5
4
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4,5
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6
6,5
Period:
RMS:
X-Axis = log(P) ☑
Save
● 640x480
○ 1024x768
OK
Help

LIGHTCURVE ANALYSIS OF NEA 2011 YH40

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CCD photometry observations of the near-Earth asteroid, 2011 YH40, were made during a close approach in 2012 January. Analysis of the data indicates the probability that the asteroid is in non-principal axis rotation. One of several possible solution sets gives P1 = 2.9301 h and P2 = 3.356 h.

In 2012 January, the near-Earth asteroid 2011 YH40 made a fly-by of Earth (~0.13 AU). Radar observers made a call for astrometric and photometric data to help with their observations. The authors collaborated to obtain the requested data about ten days prior to the close approach. Although fainter at the time, the asteroid's sky motion was considerably slower; this allowed obtaining longer exposures with a minimum of trailing and so higher SNR for photometric analysis.

CCD photometric data were obtained by Warner at the Palmer Divide Observatory (PDO) on 2012 January 5-6 using a 0.5-m Ritchey-Chretien and FLI-1001E camera. All exposures were unfiltered. The data, measured with differential photometry in *MPO Canopus*, were placed onto an internal system close to Cousins R using 2MASS J-K magnitudes converted to Rc using formulae developed by Warner (2007). Sherrod at Arkansas Sky Observatory (ASO) observed on 2012 January 4-5 using a 0.51-m Dall-Kirkham and ST-2000XM, binned 2x2. Approximate sky magnitudes for the asteroid were obtained by applying an offset between instrumental and catalog V magnitudes to the raw instrumental magnitudes in *Project Pluto Guide*. The observations by Pollock on 2012 January 1 used the 0.8-m Cassegrain at Appalachian's Dark Sky Observatory with an Apogee Alta 2Kx2K binned 2x2. A luminance filter was used. Relative magnitudes were obtained using aperture photometry in *Mira*.

The data showed significantly different amplitudes on the three nights: Jan 4, 0.8 mag; Jan 5, 0.6 mag; and Jan 6, 0.9 mag. These indicated the possibility that the asteroid was in non-principal axis rotation ("tumbling"). Pravec used his custom software to analyze the data set since it is capable of handling such cases (see Pravec *et al.* 2005). The relatively large errors and short duration of the data set prevented finding a unique solution. One set includes P_1 = 2.9301 h and P_2 = 3.356 h. It is noted that 8*P_1 = 23.44 h and 7*P_2 = 23.49, leaving open the possibility that the true periods have a commensurability with an Earth day. It's hoped that the eventual combination of the photometric and radar data will lead to a more definitive solution.

Acknowledgements

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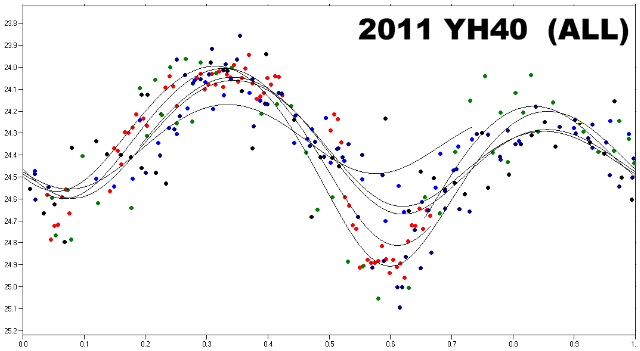

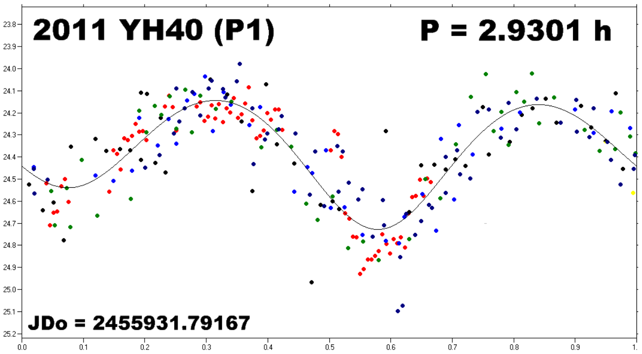

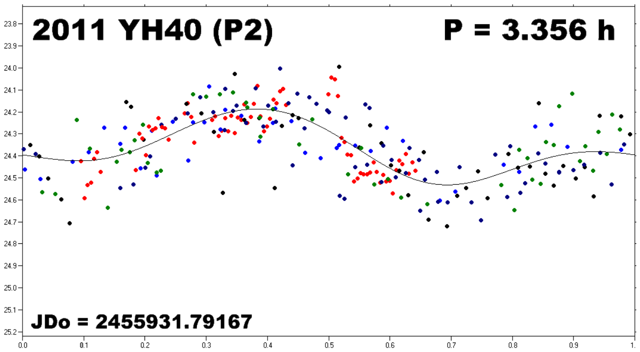

EIGHT MONTHS OF LIGHTCURVES OF 1036 GANYMED

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Minor Planet 1036 Ganymed, the largest Mars crosser, made its closest approach to Earth in the 21st century in 2011 October, and was continuously observed over a path length exceeding 100 degrees from 2011 May to 2012 January. The shape of the lightcurve changed greatly during this interval, with a mean synodic period 10.3031 hours over the interval 2011 May to October and amplitude varying from 0.10 mag to 0.30 mag and increasing roughly linearly with increasing phase angle.

Minor planet 1036 Ganymed is the largest and brightest Amor type object with approximate orbital elements a = 2.665, e = 0.534, i = 26.7 deg. Closest approach to Earth was 2011 Oct. 13 at 0.359 AU, smaller than on any other date in the 21st century, and brightest magnitude was 8.3 on 2011 Oct. 28, again brighter than on any other date in the 21st century. The path in the sky, shown in Fig. 1, enabled observation from 2011 May 16 - 2012 Jan. 18 at phase angles ranging from 52 degrees in late August to 1 degree Oct. 28. Fig. 2 graphs the distance and the phase angle versus time for the interval of observation. Six observers, Vladimir Benishek, John Briggs, Andrea Ferrero, Daniel Klinglesmith, Frederick Pilcher, and Curtis Warren all contributed lightcurves with R or V filters. Their telescopes and CCDs are: Benishek, Meade 40 cm Schmidt-Cassegrain, SBIG ST-10 XME; Briggs, DFM Engineering 40 cm f/8 Ritchey-Chretien, Apogee Alta U47; Ferrero, 30 cm Ritchey-Chretien, SBIG ST9; Klinglesmith and Warren, Celestron 35 cm f/11 Schmidt-Cassegrain, SBIG STL-1001E; Pilcher, 35 cm Meade Schmidt-Cassegrain, SBIG STL-1001E.

Several previous studies all show a period near 10.3 hours. Synodic periods have been found by Harris and Young (1985), 12 h; Lupishko et al. (1987), 10.308 h; Lupishko et al. (1988), 10.304 h; Hahn et al. (1989), 10.31h; Gaftonyuk and Krugly (2004), 10.31 h; Behrend (2011), 10.2936 h. Kaasalainen et al. (2002) obtain a sidereal period of 10.313 h from a partial lightcurve inversion model, which is also shown by Durech (2011).

It is not productive with such large changes in phase angle and lightcurve shape to draw a single lightcurve representing all observations. We present 15 separate lightcurves, Figures 3 - 17, each over a fairly small time interval, which show the evolution of lightcurve shape. The synodic period for each of these intervals ranged from 10.280 to 10.345 hours, and the amplitude from a maximum of 0.30 magnitudes at phase angle 52 degrees to 0.10 magnitudes at phase angle 1 degree. To obtain a single mean synodic period for the entire interval, we proceeded as follows. The JD of highest maximum was obtained on dates separated by not more than two weeks. The interval between successive maxima was divided by an approximate period 10.3 hours, and in all cases yielded a result close to an integer. The integer then represents the number of cycles between dates. The time interval between successive maxima was then divided by this interval to obtain the synodic period over this interval, and the results are on the table below. Between Oct. 14 and Oct. 23 the position in the sky, phase angle, and appearance of the lightcurve were changing too rapidly for a particular feature of the lightcurve to be sufficiently stable for this technique to be applied. With the much sparser observations in 2011 Nov. and 2012 Jan. changes in the lightcurve likewise rendered the phases of readily identifiable features unstable. The technique could be applied only to the interval 2011 May 16 - Oct. 14.

Columns headers: A = JD of first maximum + 2455000.00, B = JD of second maximum + 2455000.00, C = time interval in days between maxima, D = number of cycles between maxima, E = mean synodic period in hours.

A	B	C	D	E
702.89	723.94	21.05	49	10.310
723.94	739.83	15.89	37	10.307
739.83	753.55	13.72	32	10.290
753.55	763.43	9.88	23	10.310
763.43	777.60	14.17	33	10.305
777.60	788.74	11.14	26	10.283
788.74	799.49	10.75	25	10.320
799.49	817.51	18.02	42	10.297
817.51	831.66	14.15	33	10.291
831.66	848.85	17.19	40	10.314

For the entire interval JD 2455702.89 to 2455848.85 there are 340 cycles for a mean synodic period 10.3031 hours. Examination of the table shows individual values which appear to vary randomly with no systematic trend.

Acknowledgements

Work at HUT Observatory is supported by the Mittelman Foundation.

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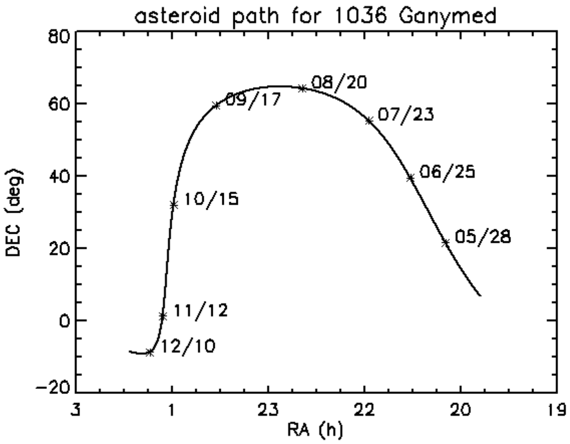

Figure 1. Path of 1036 Ganymed in sky, 2011 May - December.

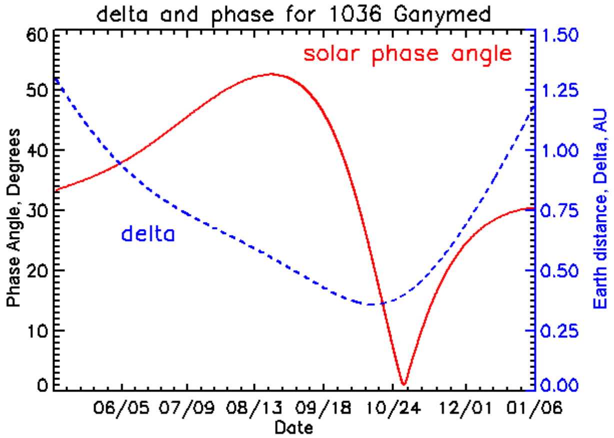

Figure 2. Phase angle and Earth distance Delta for 1036 Ganymed, 2011 May - 2012 January.

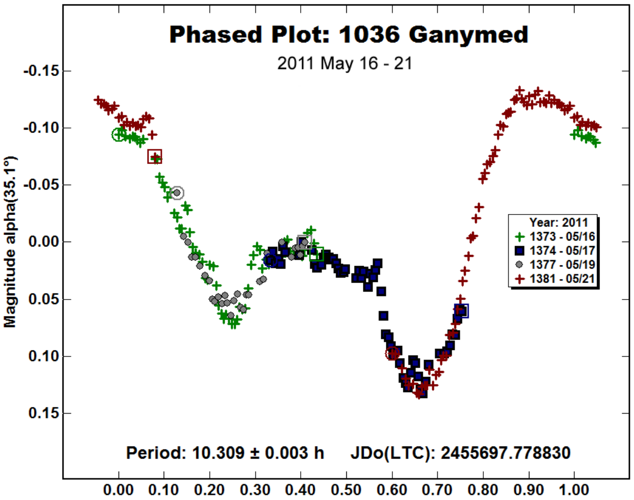

Figure 3. Lightcurve of 1036 Ganymed 2011 May 16 - 21.

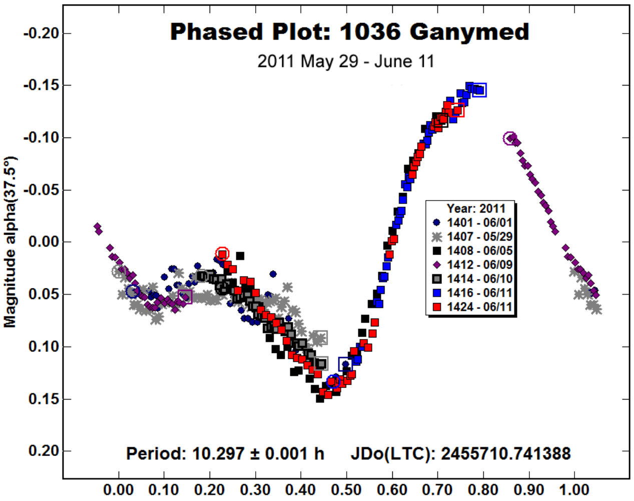

Figure 4. Lightcurve of 1036 Ganymed 2011 May 29 - June 11.

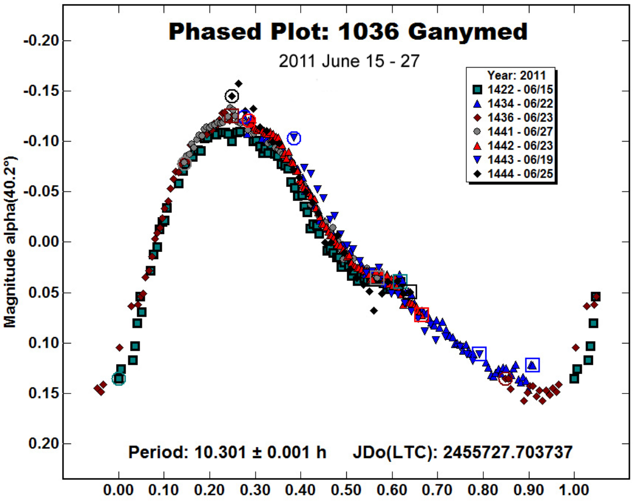

Figure 5. Lightcurve of 1036 Ganymed 2011 June 15 - 27.

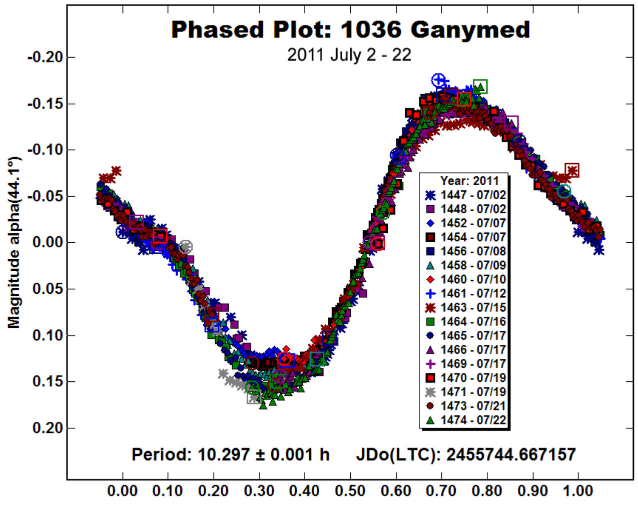

Figure 6. Lightcurve of 1036 Ganymed 2011 July 2 - 22.

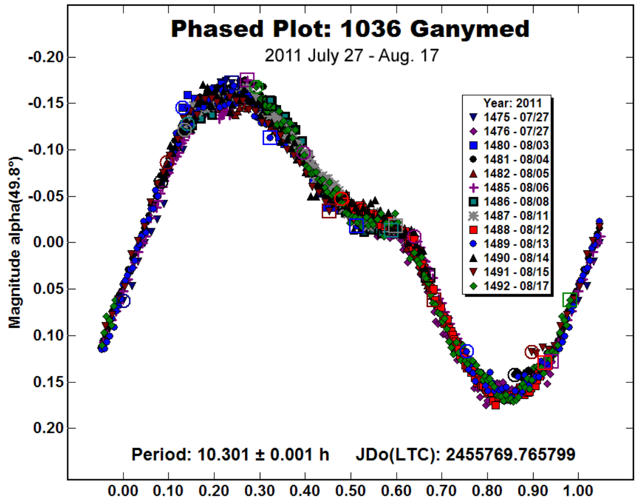

Figure 7. Lightcurve of 1036 Ganymed 2011 July 27 - Aug. 17.

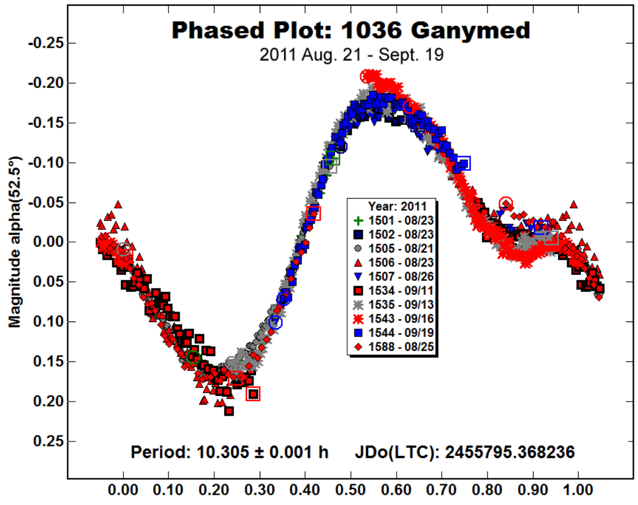

Figure 8. Lightcurve of 1036 Ganymed 2011 Aug. 21 - Sept. 19.

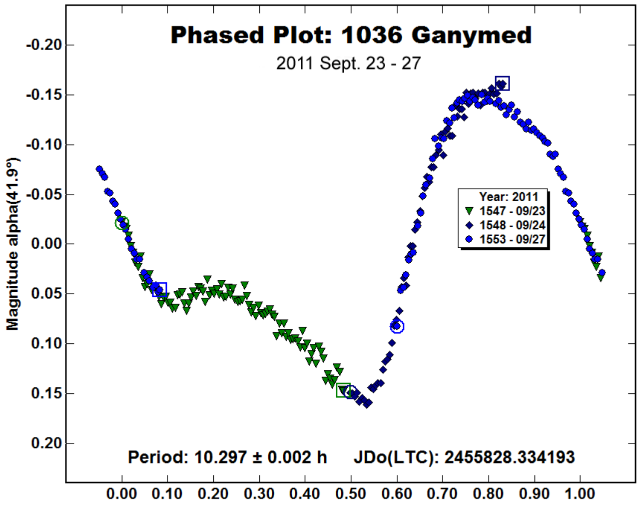

Figure 9. Lightcurve of 1036 Ganymed 2011 Sept. 23 - 27.

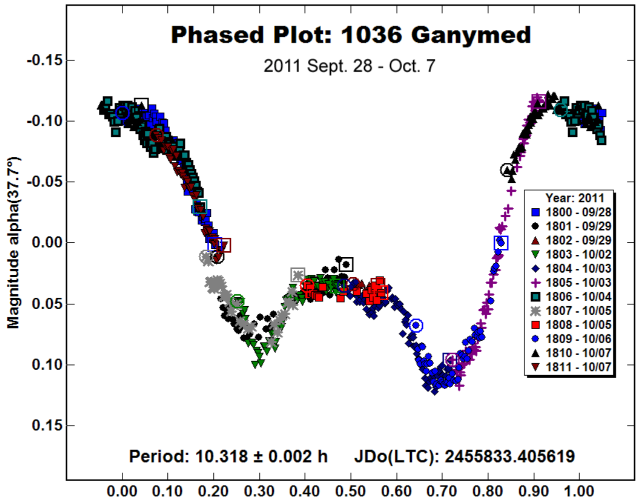

Figure 10. Lightcurve of 1036 Ganymed 2011 Sept. 28 - Oct. 7

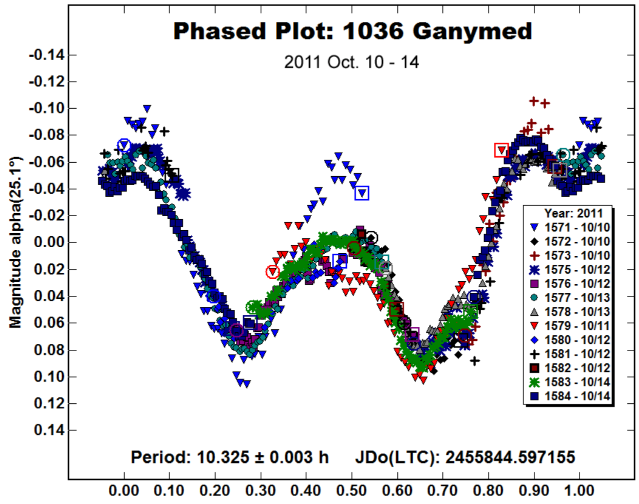

Figure 11. Lightcurve of 1036 Ganymed 2011 Oct. 10 - 14.

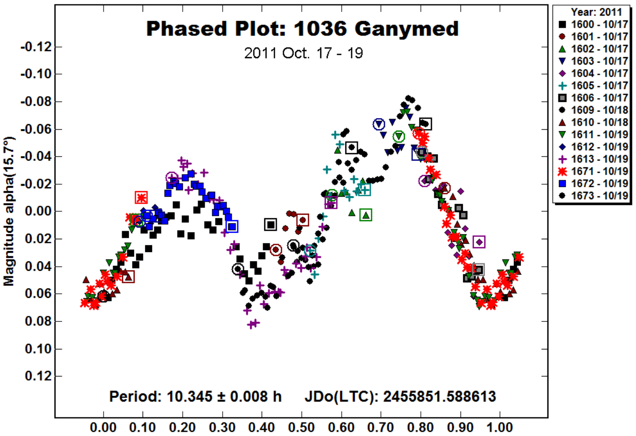

Figure 12. Lightcurve of 1036 Ganymed 2011 Oct. 17 - 19.

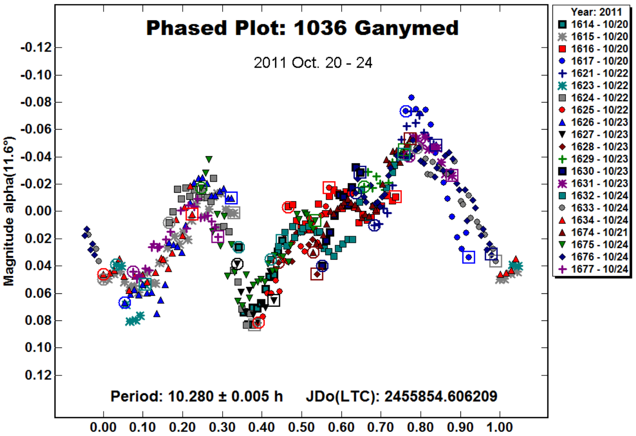

Figure 13. Lightcurve of 1036 Ganymed 2011 Oct. 20 - 24.

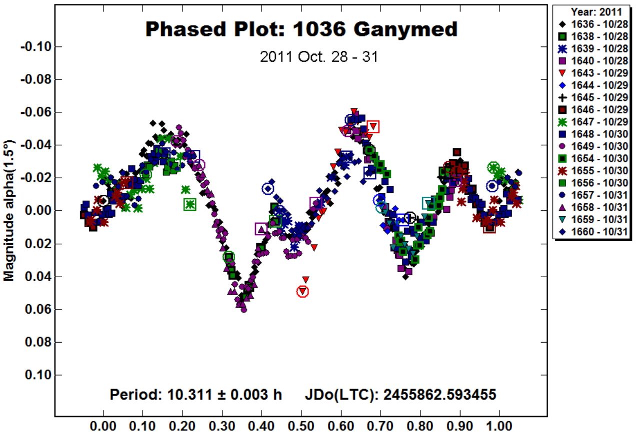

Figure 14. Lightcurve of 1036 Ganymed 2011 Oct. 28 - 31.

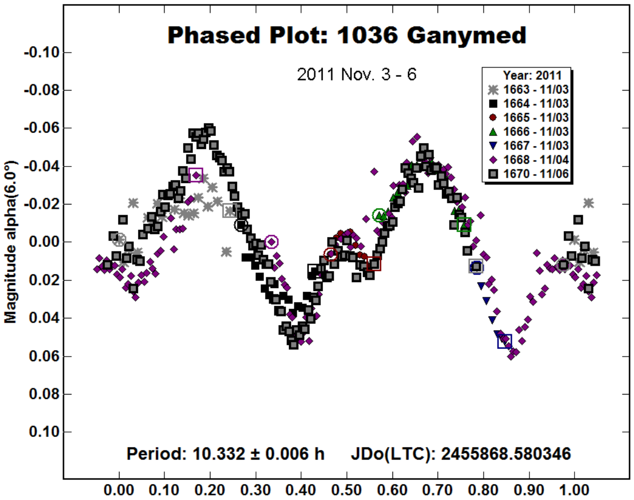

Figure 15. Lightcurve of 1036 Ganymed 2011 Nov. 3 - 6.

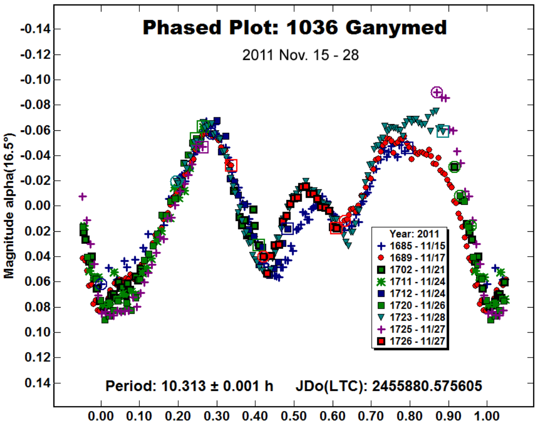

Figure 16. Lightcurve of 1036 Ganymed 2011 Nov. 15 - 28.

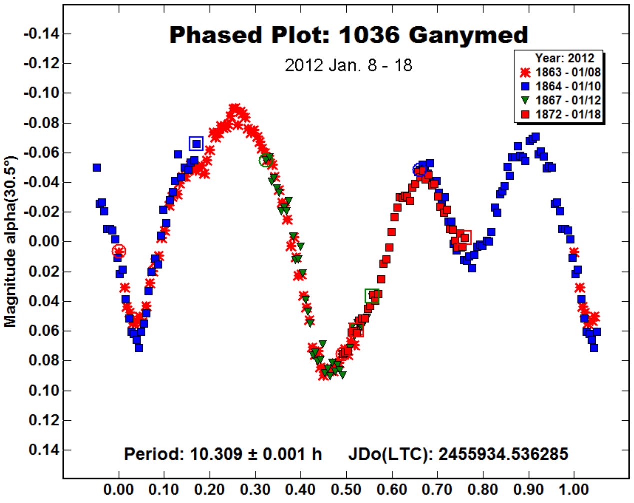

Figure 17. Lightcurve of 1036 Ganymed 2012 Jan. 8 - 18.

LIGHTCURVE ANALYSIS OF ASTEROIDS OBSERVED IN 2011 FROM LEURA AND KINGSGROVE OBSERVATORIES

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Photometric observations of the following asteroids were done from both Kingsgrove and Leura Observatories in 2011: 1263 Varsavia (7.1680 ± 0.0006 h); 1702 Kalahari (21.153 ± 0.005 h); 2015 Kachuevskaya (42.532 ± 0.004 h); 2130 Evdokiya (4.354 ± 0.002 h); 2731 Cucula (61.55 ± 0.02 h); 2870 Haupt (274.0 ± 1.0 h); 5701 Baltuck (4.8328 ± 0.0005 h); 5642 Bobbywilliams (4.8341 ± 0.0003 h); 7559 Kirstinemeyer (5.475 ± 0.003 h); and 12738 Satoshimiki (8.7081 ± 0.0006 h).

Kingsgrove Observatory uses a 0.25-m *f*/11 Schmidt-Cassegrain telescope with a self-guiding ST-9XE SBIG CCD camera operating at 1x1 binning for a scale of 1.45 arcsec/pixel. Exposures were 300 seconds and unfiltered to maximize SNR. Leura Observatory uses a 0.35-m Schmidt-Cassegrain telescope and SBIG CCD camera operating at 1x1 binning producing a 0.77 arcsec/pixel resolution. All images were taken unfiltered at 300 seconds integration. Further information about the instruments can be found at (Oey, 2011). *MPO Canopus* software was used for period analysis which incorporates the Fourier algorithm developed by Harris (Harris *et al.*, 1989).

All asteroids in this paper were main-belt asteroids. Target selection was based mainly on listings on the CALL website (Warner, 2010) with the selection criteria being an average magnitude during closest approach of V = 13–14 and a relatively southerly declination. All data were reduced using differential photometry with Comp Star Selector (CSS) method in *MPO Canopus*. v10. This finds up to five values for the target by using

$$M_{target} = (m_{target} - m_{comp}) + M_{comp} \qquad (1)$$

where m_{target} and m_{comp} are, respectively, the instrumental magnitudes of the target and comparison and M_{comp} is the catalog magnitude of the comparison. The final value for the target (M_{target}) is the mean of the intermediate results and the error is the standard deviation of the mean. The catalog values are taken from the MPOSC3 (Warner, 2007). See Stephens (2008) for additional details on this method.

Most of the linkages were accurate to 0.03-0.05 magnitudes. Standardizing data to an internal system is critical for work associated with large amplitude and very long period targets ($P >$ 100 h). In the latter case, the data from a single night would not reveal a recognizable shape of the curve but only an upward or downward trend, as was the case for 2870 Haupt.

This main belt asteroid had no known rotational period. It was selected for work under the Photometric Survey of Asynchronous Binary Asteroids (PSABA; Pravec, 2011). The period was 274.0 ± 1.0 h and amplitude 0.60 ± 0.10 mag. Due to the scarcity of data, it was not certain if the asteroid exhibited any non-principal axis rotation ("tumbling"). Further observations with multiple observers over large geographic locations will be needed to allow such detection (Oey *et al.*, 2012).

Those targets with a moderately long period, $P > 40$ h, but still showing one minimum or one maximum and a trend up or down each night benefited greatly with the CSS method. The 40-hour limit was calculated based on an average of 10 hours observing time per winter night. It will require 4 of those 10 hours to complete one bimodal light curve. The relatively large amplitude of 1.20 magnitudes for 2015 Kachuevskaya and 0.40 magnitudes for 2731 Cucula played a significant role in finding their solutions. As the period extended longer than the 40-hour limit and the length of the observing time shortened, the dependency for standardized magnitude or, in this case, the CSS method, became more critical.

However, in some cases, the default alignment of the sessions using the CSS lead to one or more sessions that were significantly above or below what appeared to be the correct location in the lightcurve. By adding an arbitrary adjustment of the nightly offset to each of those sessions, they were brought into line and a more definitive lightcurve was produced. This method was successfully used with the rest of the asteroids.

One exception was 7559 Kirstinemeyer, which had no previously-reported lightcurve and was about at the limit of either system's capabilities because of a low amplitude lightcurve and faintness. This asteroid required a large number of observing nights to identify the correct period. The CSS method clearly eliminated the possibility of a long period and large amplitude type asteroid. It was observed over a period of 8 nights and the amplitude obtained was a very low 0.05 ± 0.05 mag, indicating a pole on view or an object that was close to a spherical shape. The lightcurve is

Name	H	Date (2011) mm/dd	Obs	Period (h)	Amp (m)	PA	L_{PAB}	B_{PAB}
1263 Varsavia	10.5	01/30-02/25	K	7.1680 ± 0.0006	0.15 ± 0.03	11	130	-20,-15
1702 Kalahari	11.0	07/28-08/26	K	21.153 ± 0.005	0.12 ± 0.01	5,10	312	-7
2015 Kachuevskaya	12.4	06/20-08/26	K	42.532 ± 0.004	1.20 ± 0.03	19,7,16	302	-9
2130 Evdokiya	13.0	06/21-06/25	K	4.354 ± 0.002	0.50 ± 0.03	17	293	-8
2731 Cucula	10.7	08/01-09/20	K	61.55 ± 0.02	0.40 ± 0.05	3,17	309	7,3
2870 Haupt	12.7	10/09-12/02	L	274.0 ± 1.0	0.60 ± 0.10	7,23	23,32	6,-4
5701 Baltuck	12.7	09/22-03/10	K	4.8328 ± 0.0005	0.70 ± 0.05	4,9	354	-5
5642 Bobbywilliams	13.5	06/20-07/11	K	4.8341 ± 0.0003	0.50 ± 0.05	18,13	285	-21,-17
7559 Kirstinemeyer	13.0	09/26-10/20	K	5.475 ± 0.003	0.05 ± 0.05	10,18	356	-12
12738 Satoshimiki	13.4	11/18-01/02	K	8.7081 ± 0.0006	0.20 ± 0.02	18,13,18	72,78	-20,-16

Table 1. Observatory Code: K= Kingsgrove Observatory, L= Leura Observatory. *H* is taken from the MPCORB file. PA is the solar phase angle. If three values are given, the phase angle reached a minimum during the range of observations. L_{PAB} and B_{PAB} are, respectively, the phase angle bisector longitude and latitude.

presumed to be monomodal with a period of 5.475 ± 0.003 h.

Conclusion

A small range of different periodicity asteroid has been observed in 2011. Although the CSS method has its limitations, it has provided a very useful tool in determining the synodic period for some difficult long period targets.

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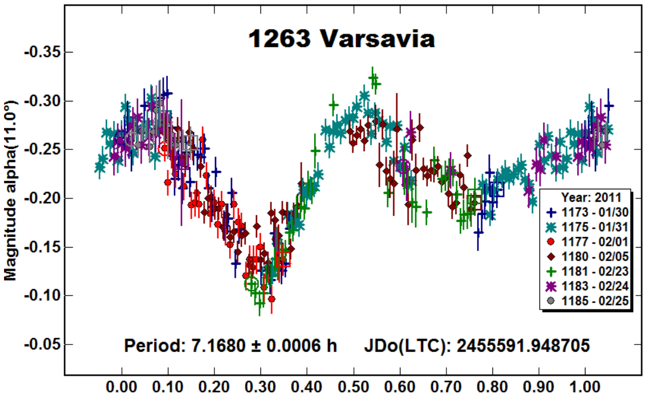

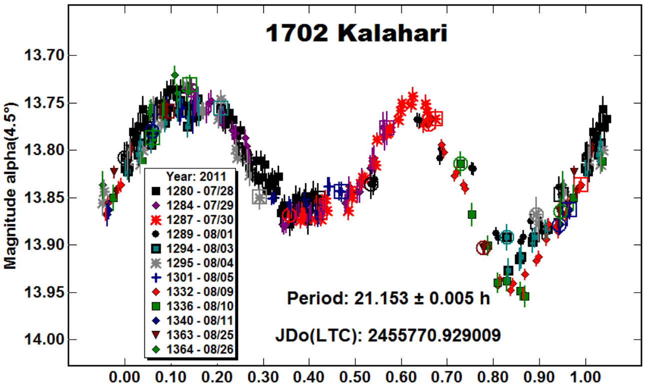

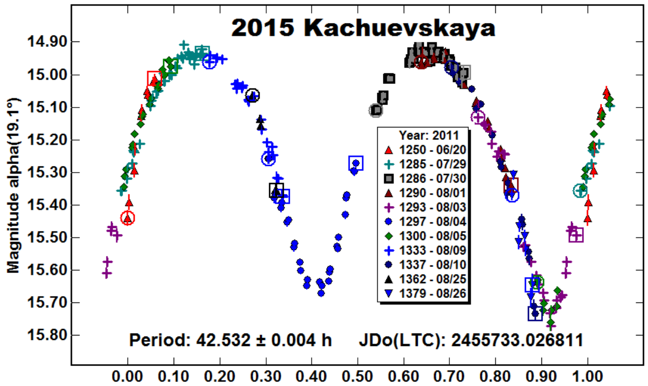

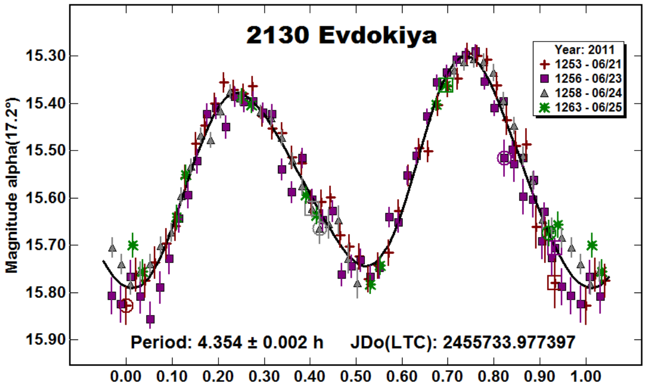

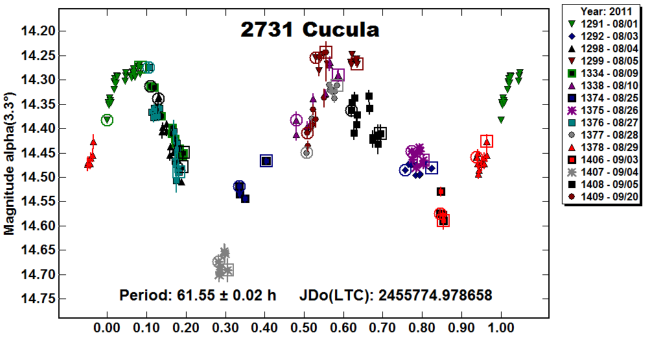

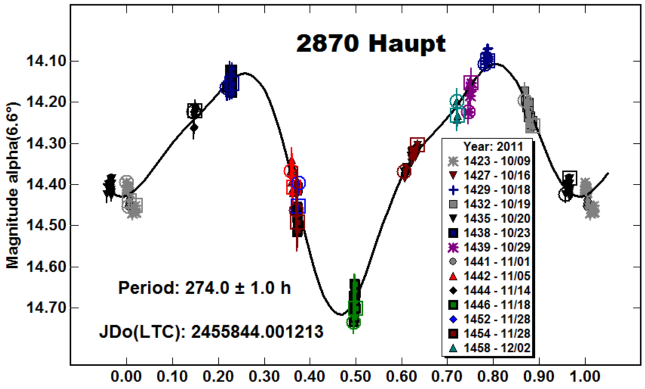

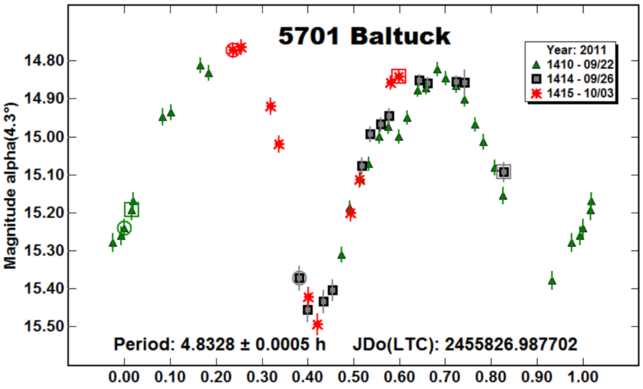

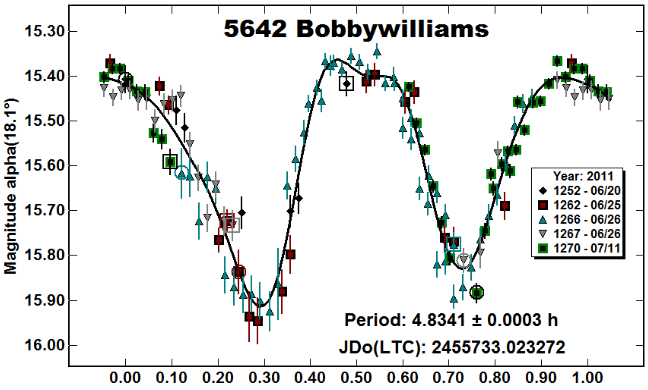

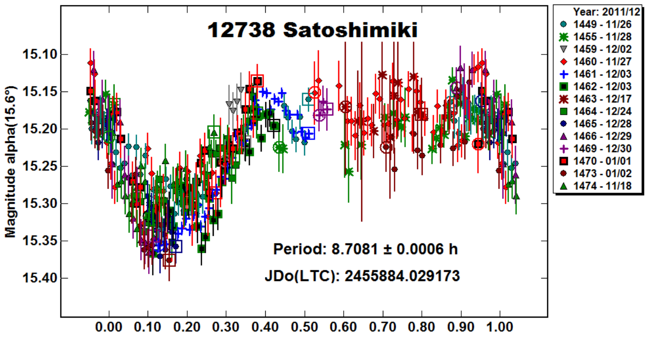

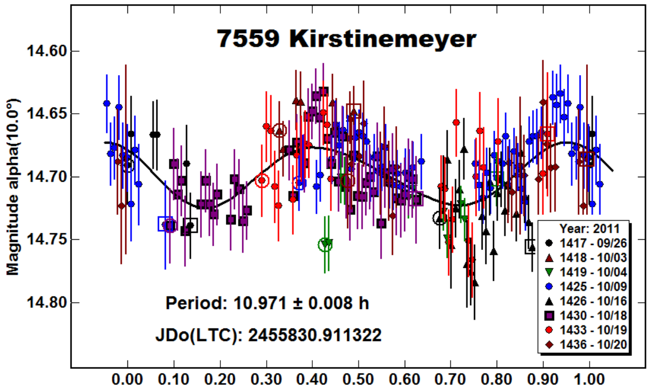

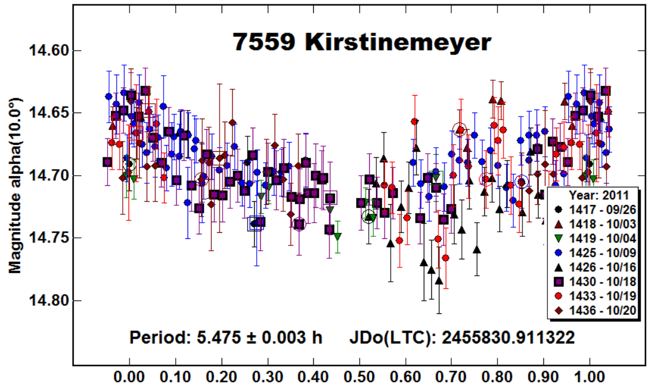

PERIOD DETERMINATION FOR 1660 WOOD

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Lightcurve analysis for asteroid 1660 Wood was performed in collaboration with observers in Australia and Uruguay from observations obtained during the asteroid's favorable opposition in 2012. The synodic rotation period was found to be 6.8090 ± 0.0002 h and the lightcurve amplitude was 0.14 ± 0.03 mag.

The main-belt asteroid 1660 Wood was named after the British/South African astronomer Harry Edwin Wood. With no previously reported lightcurve parameters, it was selected from the "Potential Lightcurve Targets" list on the Collaborative Asteroid Lightcurve Link (CALL) site (Warner, 2011) as a particularly favorable target for observation. Oey and Alvarez independently worked on this target from opposite sides of the world.

Unfiltered CCD photometric images of 1660 Wood were taken at Kingsgrove Observatory, Australia (MPC E19), and Observatorio Los Algarrobos, Salto, Uruguay (MPC I38), from 2012 January 02 to February 12. Oey used a 0.25-m *f*/11 Meade LX-3 with a self-guiding ST-9XE SBIG CCD camera resulting in an image scale of

1.45 arcsec/pix. Alvarez used a 0.30-m *f*/6.9 Meade LX-200R with a NABG QSI516wsg camera resulting in an image scale of 1.77 arcsec/pix, guided with a SX Lodestar. All images were dark and flat field corrected and then measured using *MPO Canopus* v10 (Bdw Publishing), applying a differential photometry technique. The data were light-time corrected. Period analysis was also done with *MPO Canopus*, which incorporates the Fourier analysis algorithm developed by Harris (Harris *et al*., 1989).

Due to the contamination from a large number of faint back ground stars, numerous data points had to be excluded from the analysis. However, this still left a very dense data set of 2170 data points obtained during the 15 observing sessions. All sessions were done with Comp Star Selector (CSS) method in *MPO Canopus* as described in Stephens (2008). With a reported error of 0.03-0.05 mag, the zero points still needed to be arbitrarily adjusted to fit into the bimodal shape of the light curve.

Over the span of observations, the phase angle varied from 26.5º to 24.6º. The phase angle bisector (PAB) longitude changed from 121.3º to 130.8º and the latitude from –31.3º to –31.9º. Analysis of the data found a synodic rotational period for 1660 Wood of P = 6.8090 ± 0.0002 h and an amplitude of A = 0.14 ± 0.03 mag.

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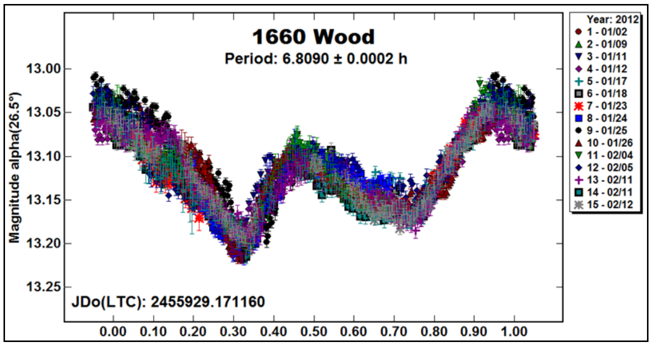

ROTATION PERIOD DETERMINATION FOR 5143 HERACLES

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The Earth crossing minor planet 5143 Heracles made in late 2011 its closest approach to Earth since discovery. A consortium of observers found a synodic rotation period near 2.706 hours and amplitude increasing from 0.08 ±0.02 magnitudes at phase angle 20 degrees to 0.18 ±0.03 magnitudes at phase angle 87 degrees, with 3 unequal maxima and minima per cycle. Magnitude parameters H = 14.10 ±0.04 and G = 0.08 ±0.02 are found, and the color index V-R = 0.42 ±0.07. For an asteroid of taxonomic class Q, a suggested albedo pv = 0.20 ±0.05 yields estimated diameter D = 4.5 ±0.7 km. Three possible binary events were recorded, but these are insufficient for binary detection to be secure. Retrograde rotation is suggested.

Minor planet 5143 Heracles is an Apollo type object that made in late 2011 its closest approach to Earth since discovery. To illustrate the circumstances of the approach we provide a diagram (Figure 1) showing the path in the sky, and another diagram (Figure 2) showing phase angle and Earth distance Delta, both through the interval of observation. Previous unpublished photometry was obtained by co-author Krugly in 1996 October which were made with a precision of 0.03 – 0.05 mag and showed an apparently random 0.1 magnitude scatter. These data have been reanalyzed and confirm a rotation period of 2.7 hours. Pravec et al. (1998) also obtained observations in 1996 with no detected periodicity and found H = 14.27 ±0.09. These are also referenced by Warner et al. (2011), which suggests only a possibly long period. Daniel Klinglesmith on 2011 Nov. 7 performed photometry with a 15 cm Takahashi. The resultant lightcurve was very noisy but suggested a short rotation period near 2.7 hours. He communicated this result to Frederick Pilcher, who used a 35 cm Meade LX200 GPS S-C with SBIG STL-1001E CCD for further observations. Klinglesmith also subsequently used a much larger telescope, a 35 cm f/11 Celestron with STL-1001E CCD. The use of 35 cm telescopes greatly improved the SN ratio. Independently Lorenzo Franco also found a period of 2.7 hours with a 20 cm f/5.5 SCT and SBIG ST7-XME CCD. John Briggs with a DFM Engineering 40 cm f/8 Ritchey-Chretien and Apogee Alta U47 CCD, also provided observations. The four observers agreed to exchange data via *MPO Canopus* export files, combine their data, and publish jointly.

Later Petr Pravec (personal communication) kindly informed the first author of two additional sets of observations. Joe Pollock used a DFM Engineering 40 cm f/8 Ritchey-Chretien and Apogee Alta U47 CCD, clear filter with IR blocker. Raguli Inasaridze, Yurij Krugly, and Igor Molotov used the 70 cm Maksutov telescope AC-32 with IMG6063-E (FLI) CCD unfiltered at Abastumani. These people kindly accepted the first author's invitation to contribute their observations and become co-authors of the paper. A total of 41 lightcurves were obtained in the interval 2011 Oct. 21 - Dec. 11, showing a synodic period 2.706 ±0.001 hours with three maxima and minima per cycle. During this interval as the phase angle increased from 20 degrees to 87 degrees the amplitude correspondingly increased from 0.08 ±0.02 magnitudes to 0.18 ±0.03 magnitudes, and the shape of the lightcurve also changed appreciably. Magnitude measurements were made with the MPO Canopus Comp Star Selector. These are based on the Sloan r' reference star magnitudes in the CMC14 catalog and J and K magnitudes in the 2MASS catalog. The conversion to V magnitudes was obtained from the standard formula (Dymock and Miles 2009):

$$V = 0.6278*(J-K) + 0.9947*r'$$

To illustrate these changes we provide seven lightcurves (Figures 3-9) each covering only a few closely spaced dates.

Small asteroids with short rotation periods less than 3 hours are especially likely to possess satellites derived from centrifugal disruption. Petr Pravec made a special search and found three dips in the lightcurve of the form characteristic of binary transit/occultation/shadow events. These events were centered 2011 Nov. 22 3.36h UT, Nov. 22 6.24h UT, and Nov 26 6.24h UT. They are shown on three additional diagrams (Figures 10-12). In these the 8th order Fourier series most closely approximating the lightcurve in the interval Nov. 22 - 26 is shown. A segment below this curve represents observations inferred to be the binary event. Below this with the same time axis the value of the Fourier averaged lightcurve for each phase is flattened to show the time variation of the additional dip caused by the binary event. With only three events observed the revolution period could not be found. The evidence for binary nature is strong but is insufficient to be considered secure. The appearance of binary events separated by only 2.88 hours (Nov. 22 3.36h and 6.24h UT, respectively) is remarkable. At phase angle 31 degrees these probably indicate transit followed by shadow, or vice versa.

Minor planet 5143 Heracles will have an even closer approach in 2016 November. A global campaign should be organized to maintain nearly continuous photometric coverage over an interval of several weeks. Binary events, if they occur, should be sufficiently sampled at this time to fully define the parameters of the system.

The large range of phase angles possible only for Earth approachers has enabled the construction of a phase plot with especially well defined parameters in V band. This study sampled phase angles from 23 to 87 degrees. Observations in 1996 by Pravec et al. (1998) extend the range of phase angles to 6 degrees. Combining current data with those from 1996 enables the construction of a very accurate H-G plot (Fig. 13) showing H = 14.10 ±0.04 and G = 0.08 ±0.02. This value of H is in fair agreement with 14.27 by Pravec et al. (1998). Heracles was observed in both the V and R bands at Balzaretto Observatory 2011 November 18. This allowed the finding of the color index V-R = 0.42 ±0.07. The taxonomic class of 5143 Heracles is unambiguously Q, (Binzel et al. 2010) and the geometric albedo of class Q is typically pv = 0.20 ±0.05 (Pravec et al. 2012). From these values of H and pv the diameter D may be calculated by the formula by Pravec and Harris (2007):

$$\log D(\mathrm{km}) = 3.1235 - 0.2\ H - 0.5 \log (pv)$$

This leads to an estimated diameter D = 4.5 ±0.7 km, a value which compares favorably with the WISE satellite infrared radiometry value of 4.8 ±0.4 km (Mainzer et al. 2011).

The daily motion was always retrograde and increased steadily throughout the apparition. A table and graph (Figure 14) of mean synodic period versus mean daily motion are presented, which shows an increase of synodic period with increasing retrograde daily motion with, however, a low determination coefficient of only 0.3542. Such increase is characteristic of retrograde rotation, which is suggested for 5143 Heracles.

Acknowledgement

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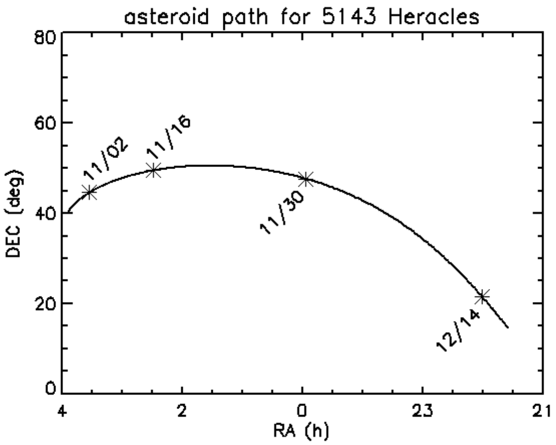

Figure 1. Sky path of 5143 Heracles

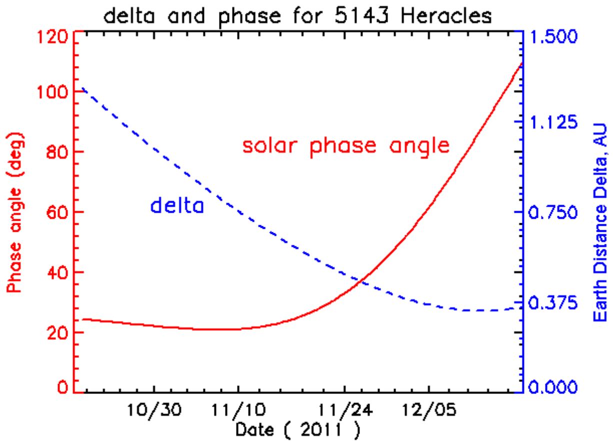

Figure 2. Phase angle and Earth Distance Delta of 5143 Heracles

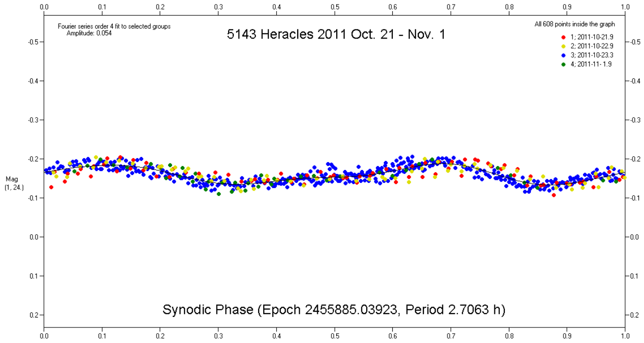

Figure 3. Lightcurve of 5143 Heracles 2011 Oct. 21 - Nov. 1

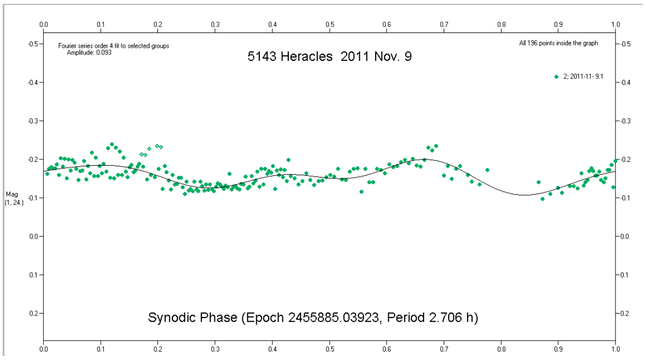

Figure 4. Lightcurve of 5143 Heracles 2011 Nov. 9

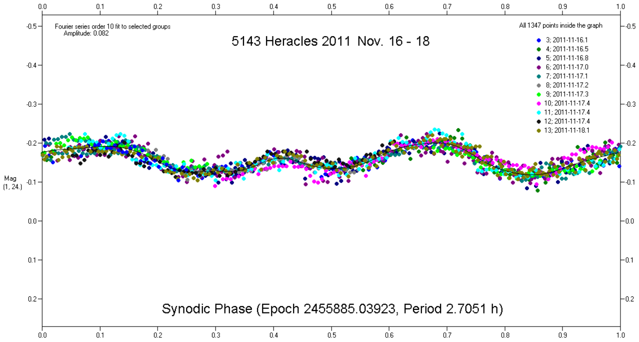

Figure 5. Lightcurve of 5143 Heracles 2011 Nov. 16 - 18

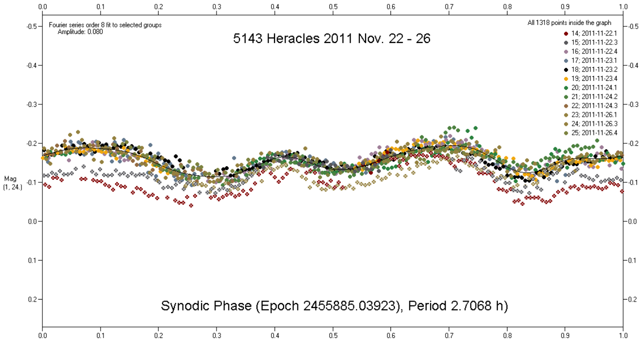

Figure 6. Lightcurve of 5143 Heracles 2011 Nov. 22 - 26

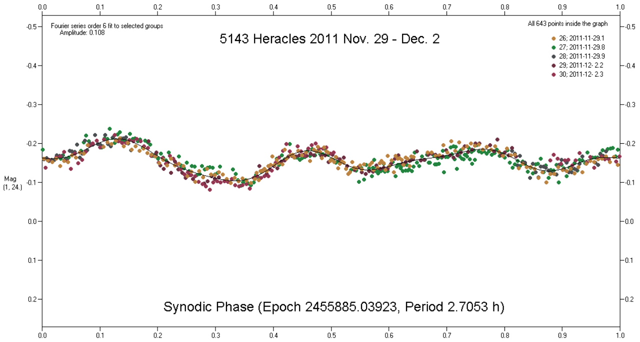

Figure 7. Lightcurve of 5143 Heracles 2011 Nov. 29 - Dec. 2

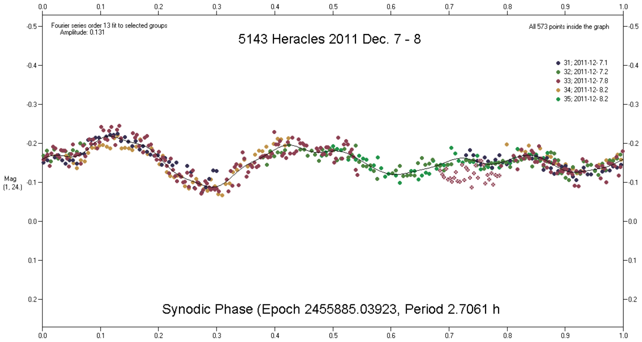

Figure 8. Lightcurve of 5143 Heracles 2011 Dec. 7 - 8

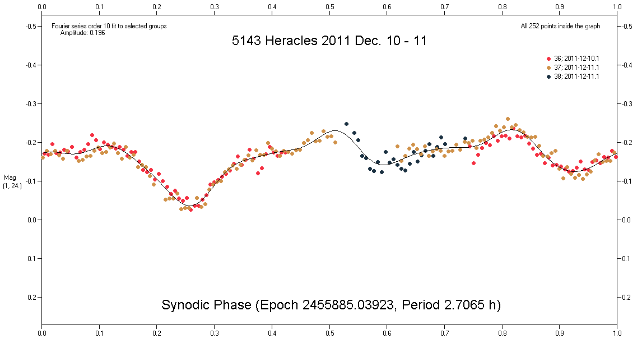

Figure 9. Lightcurve of 5143 Heracles 2011 Dec. 10 - 11

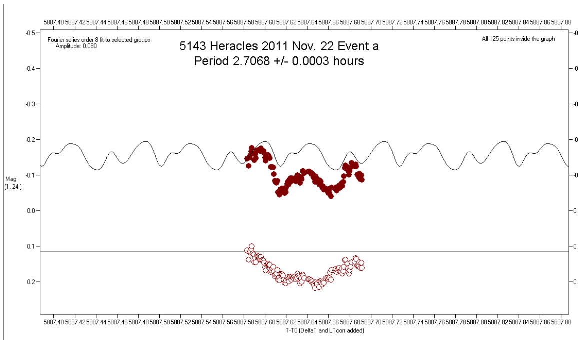

Figure 10. Dip in lightcurve of 5143 Heracles centered at 2011 Nov 22 3.36h UT

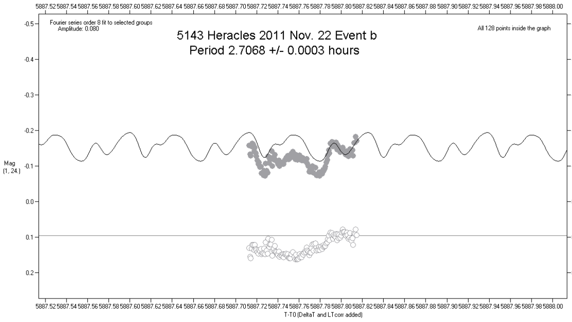

Figure 11. Dip in lightcurve of 5143 Heracles centered at 2011 Nov 22 6.24h UT

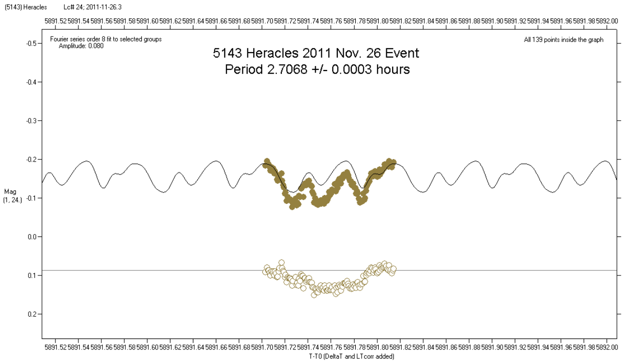

Figure 12. Dip in lightcurve of 5143 Heracles centered at 2011 Nov 26 6.24h UT

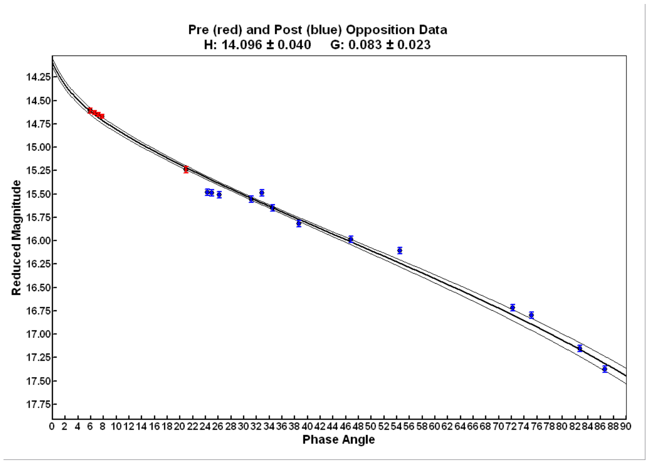

Figure 13. Phase curve of 5143 Heracles

Date (from-to)	PAB_L/day	Syn Period (h)	Period Err (h)
09-16 nov	-0.225	2.7061	0.0003
16-22 nov	-0.493	2.7055	0.0002
22-26 nov	-0.810	2.7072	0.0003
26-29 nov	-1.131	2.7067	0.0003
29-02 dec	-1.432	2.7055	0.0003
02-07 dec	-1.725	2.7074	0.0002
07-08 dec	-1.822	2.7071	0.0012
08-10 dec	-1.776	2.7074	0.0005
10-11 dec	-1.692	2.7072	0.0008

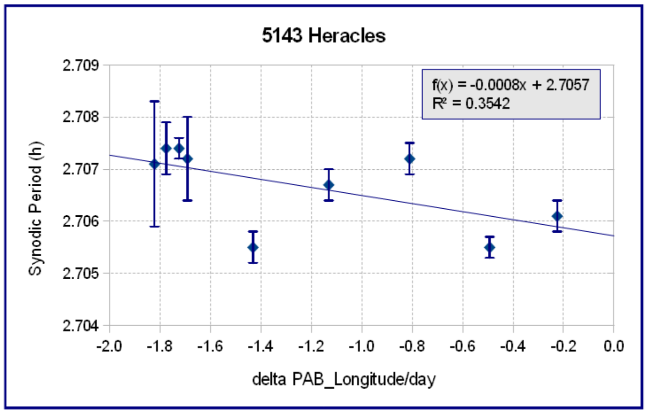

Figure 14. Table and plot of synodic period of 5143 Heracles versus daily motion of phase angle bisector

(25884) 2000 SQ4: A NEW HUNGARIA BINARY?

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(Received: 1 April)

CCD photometry observations of the Hungaria asteroid (25884) 2000 SQ4 were made at the Palmer Divide and Via Capote Observatories in 2011 November. This asteroid is of particular interest since it is part of an "asteroid pair", one of two asteroids believed to have once been a single object. Such pairs are believed to have been created due to fission after YORP spin up followed by the prompt ejection of the smaller body instead of it becoming a satellite. The two asteroids now occupy almost identical heliocentric orbits but do not circle one another. Analysis of the observations gives strong indications that 2000 SQ4 is a binary. If true, this would be the second member of an asteroid pair to have been found to have its own satellite.

CCD photometry observations of the Hungaria asteroid (25884) 2000 SQ4 were made from 2011 November 3-26 at the Palmer Divide (PDO), Via Capote (VCO), and Ondřejov Observatories. The asteroid had been previously observed by Polishook (2011) and at Modra Observatory (unpublished), both in 2010. Neither of those two data sets found anything unusual in the lightcurves, i.e., the solutions were singly-periodic at about 4.917 h.

PDO observations by Warner were made with a 0.35-m Schmidt-Cassegrain (SCT) and SBIG STL-1001E CCD camera. Exposures were unfiltered and 300 s. All frames were dark and flat field corrected. VCO observations by Brinsfield used a 0.4-m SCT and Apogee U6 CCD camera. Exposures were unfiltered and 210 s. All frames were dark and flat field corrected. The entire data set was calibrated to a single internal system using J-K to BVRI conversions (Warner, 2007) on the comparison stars for each night to where merging the data from the two observatories required no zero point adjustment. *MPO Canopus* was used to measure all images and then do the period analysis for the plots presented here, which include only the PDO and VCO data. Pravec and Kušnirák used their custom software to analyze the data set that included a short session obtained by Kušnirák on Nov 22. Per advice from Pravec, corrections for changing phase angle were based on using $G = 0.50$ instead of the default value in the MPCORB file of $G = 0.15$. This is in keeping with high-albedo objects, e.g., type E, which comprise a large portion of the Hungaria members (Warner *et al.*, 2009).

Initial analysis using only the PDO data found signs of a potential occultation or eclipse (a "mutual event") on Nov. 3. Additional events were observed at PDO on Nov. 15, 23, and 26. These had a period of $P_2 \sim 36$ h with an amplitude of $A \sim 0.1$ mag. Pravec's analysis of the complete data set, which included the observations from Modra and Ondřejov, found a primary period of $P_1 = 4.91684 \pm 0.00007$ h with $A_1 = 0.36 \pm 0.02$ mag. This is well-determined.

The data show that on some nights, more than one station observed deviations from the mean curve on the order of 0.05 mag and, on other nights, deviations of 0.1 mag. The four sessions with 0.1 mag attenuations suggest a period of 36.75 h. If these are due to mutual events (occultations/eclipses) due to a satellite, this would lead to an orbital period of 73.5 h with two events being primary and two secondary. It should be noted that only a portion of each presumed event was observed, which could cast doubt on the 73 h solution. However, Pravec found no other period consistent with the data. The estimated size ratio of the putative satellite is $Ds/Dp = 0.28 \pm 0.02$.

The interpretation of the 0.05 mag events is not clear. These suggest a periodicity of 12.24 h, but since this is exactly the sixth harmonic of the longer 73.5 h period, it is somewhat suspect. At this point, the asteroid can be considered a *probable* binary candidate but *not a conclusive* one.

2000 SQ4 is the primary of an "asteroid pair" with (48527) 1993 LC1. An asteroid pair is two separate objects that are believed to have once been a single object (see Vokrouhlický and Nesvorný, 2008, Pravec and Vokrouhlický, 2009, and Pravec *et al.*, 2010). YORP spin up lead to fission of the single body, with the pair formed by the prompt ejection of the "cast off". So, instead of becoming gravitationally-bound to one another and forming a "binary asteroid", the two objects now occupy nearly identical heliocentric orbits but are separated by large distances. Should 2000 SQ4 be confirmed as a binary, it would be the second member of an asteroid pair to have a satellite, the first being 3749 Balam.

Acknowledgements

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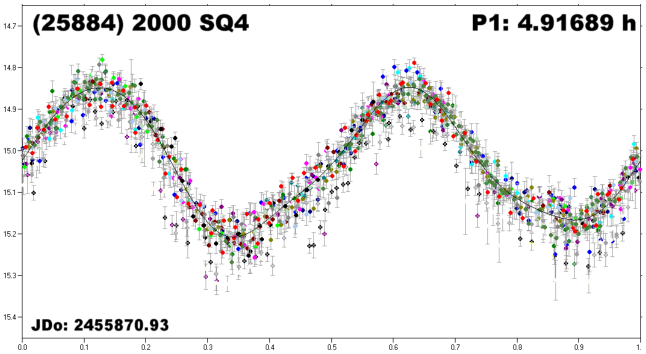

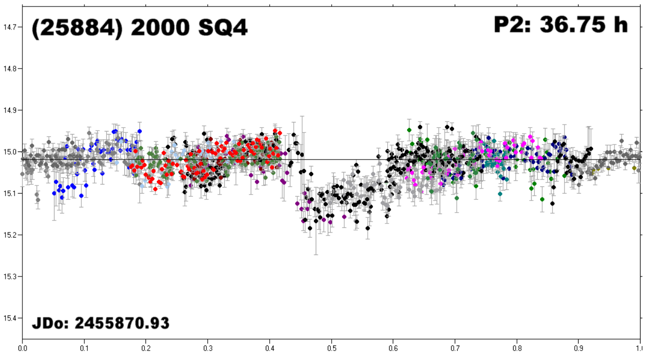

LIGHTCURVE PHOTOMETRY OF NEA 2012 EG5

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Photometric observations of near-Earth asteroid 2012 EG5 were made during the object’s close approach to Earth on 2012 March 30. Analysis of the resulting data found a synodic period P = 0.2924 ± 0.0002 h with an amplitude A = 0.42 ± 0.01 mag.

The Apollo near-Earth asteroid (NEA) 2012 EG5 was discovered by Pan-STARRS 1, Haleakala, on 2012 March 13. Due to its close approach, it was scheduled as a radar target from Goldstone on 2012 April 4. For this asteroid, the JPL Small-Body Database Browser reported an absolute magnitude *H* = 24.3, or an estimated diameter from 40 (medium albedo) to 80 meters (low albedo).

The asteroid was observed at San Marcello Pistoiese (MPC Code 104) the night of 2012 March 30, two days before its closest approach to Earth. A total of 479 unfiltered images were acquired over a time span of 2.5 hours, each of 15 seconds exposure. Data were collected with the 0.60-m *f*/4 reflector telescope and an Apogee Alta 1024x1024 CCD camera. This combination gave a field of view of 35x35 arcminutes and a pixel scale of 2 arcsec/pixel. All images were calibrated with dark and flat-field frames. Differential photometry and period analysis was done using *MPO Canopus* (Warner, 2010) at Balzaretto Observatory.

The derived synodic period was *P* = 0.2924 ± 0.0002 h (Fig.1, 2) with an amplitude of *A* = 0.42 ± 0.01 mag.

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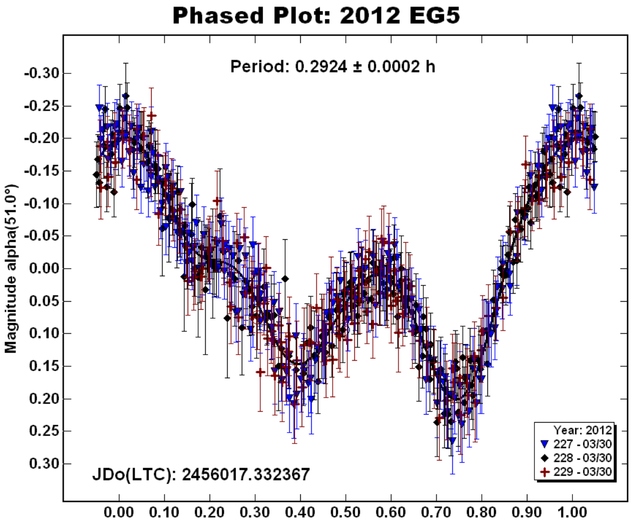

Figure 1. The light curve of NEA 2012 EG5 with a period of 0.2924 ± 0.0002 h and an amplitude of 0.42 ± 0.01 mag.

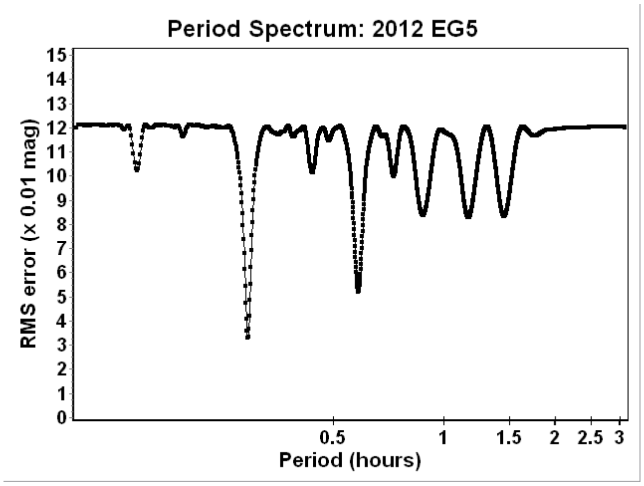

Figure 2. Period spectrum show the principal period P with low RMS value.

LIGHTCURVE ANALYSIS OF NEA (192642) 1999 RD32

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CCD photometry observations of the near-Earth asteroid (192642) 1999 RD32 were made in support of radar observations during a close approach in 2012 March. Analysis of the data indicates a period of 17.08 ± 0.03 with an amplitude of 0.28 mag. The possibility that the asteroid is in non-principal axis rotation (tumbling) cannot be formally excluded.

In 2012 March, the near-Earth asteroid (192642) 1999 RD32 made a fly-by of Earth at ~0.15 AU. Radar observers made a call for astrometric and photometric data to help with their observations. The authors collaborated to obtain photometric data a few days before closest approach.

Initial radar observations at Arecibo in Puerto Rico indicated a potentially long period, *P* > 100 h (Nolan, private communications). However, an extended run at the Goldstone facility in California revised this estimate (Benner, private communications), indicating that the viewing aspect was nearly pole-on. This lead to a period estimate in the range of 10-30 h, which made it it more likely that the photometric observations would be able to find a period despite having only a few days when the asteroid was both bright enough and far enough from the sun in the sky to get sufficient data.

Warner (PDO) used a 0.3-m Schmit-Cassegrain with ST-9XE CCD camera at the Palmer Divide Observatory. Megna used 0.35-m SCT and SBIG ST-9 camera at the Center for Solar System Studies. Both sets of data were unfiltered. However, they were placed approximately onto the Johnson V system by using a feature in *MPO Canopus* that uses version DR5 of the APASS catalog (Henden, private communications). In cases where the two observatories were observing at the same time, the data could be overlaid with no or only small adjustments (< 0.03 mag) to the internal zero points.

Warner did the period analysis of the combined data in *MPO Canopus*, find a period of 17.08 ± 0.03 h with an amplitude of 0.28 ± 0.03 mag. However, the data show some deviations from the solution that may indicate tumbling, i.e., non-principal axis rotation (see Pravec *et al.*, 2005). The asteroid makes a return appearance in 2012 November, when it will be brighter and have a slower sky motion. At which time it's hoped to refine the period and look for more outward signs of tumbling.

Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNX10AL35 and National Science Foundation grant AST-1032896. This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation.

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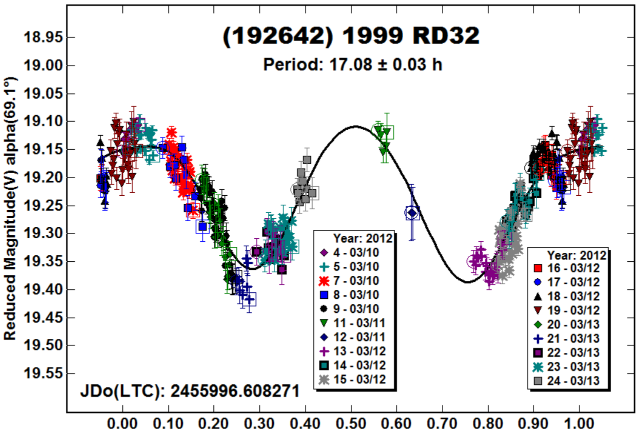

LIGHTCURVE ANALYSIS COLLABORATION FOR 561 INGWELDE AND 621 WERDANDI

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Lightcurves of 621 Werdandi and 561 Ingwelde were obtained by a collaboration between Bassano Bresciano Observatory and Organ Mesa Observatory. Thanks to this collaboration, it was possible to cover the full rotation cycle for both objects, both of which had periods close to half of an Earth day. For 561 Ingwelde we found P = 12.012 ± 0.001 h and for 621 Werdandi, P = 11.776 ± 0.001 h.

<u>561 Ingwelde</u> was started by Pilcher at Organ Mesa Observatory because the Asteroid Lightcurve Data file (Warner *et al.* 2011) showed no previous observations. Observations on 2012 Feb 25 and 26 suggested a period very near 12 hours, for which observations from a greatly different longitude would be required to get full lightcurve coverage. Strabla kindly responded to Pilcher's request and obtained lightcurves on Feb 29 and Mar 14. These, along with five nights by Pilcher from Feb 25 to Mar 21, enabled full lightcurve coverage. Our analysis found a period of 12.012 ± 0.001 h and an amplitude of 0.38 mag.

621 Werdandi was selected for observations by Bassano Bresciano Observatory (565) from “Lightcurve Photometry Opportunities: 2012 January-March” (Warner *et al.* 2012). The asteroid was reported a period 9.396 h and amplitude 0.58 mag with quality code U = 2 (see Almedia *et al.* 2004; Sauppe *et al.* 2007). The asteroid was observed at Bassano Bresciano Observatory for 5 nights covering an 8-day span. The observations were made with a 0.32-m *f*/3.1 Schmidt and Starlight HX-516 CCD camera at prime focus. The 120-second exposures, unfiltered and unguided, were at 2x2 binning and taken when the target’s altitude was more than 30°. *Polypus* software (Bassano Bresciano Observatory, 2010) was used for telescope and camera control. All raw images were processed with dark and flat field frames before being measured.

MPO Canopus (Bdw Publishing, 2010) was used to perform differential photometry on the reduced images. It incorporates the Fourier analysis algorithm developed by Harris (Harris *et al.*, 1989). Comparison stars were selected with the Comp Star Selector in *MPO Canopus* and restricted to near solar-color in order to match the approximate color of the asteroid. Preliminary analysis showed the same lightcurve phase every night. The longest session (8.5 hours) showed only one minimum and one maximum, suggesting a period longer than 9 hours with the most probable solution near 12 hours. A collaboration request was posted on CALL web site in order to have observations from a significantly different longitude.

Frederick Pilcher at Organ Mesa Observatory responded to this request with four more sessions, 2012 Feb. 14-19. He used a 0.35-m Meade LX-200 GPS Schmidt-Cassegrain with SBIG STL-1001E CCD camera. Exposures, also unfiltered and unguided, were 60 seconds. The large longitude span between observatories made it possible to obtain full coverage of the lightcurve. The individual observing sessions were adjusted to an internal zero point by adjusting the DeltaComp value in *MPO Canopus.* Based on a solution with the lowest RMS error, we found $P = 11.776 \pm 0.001$ h with an amplitude $A = 0.80$ mag.

Acknowledgements

Thanks to Brian Warner for his help with the *MPO Canopus* import/export session functions.

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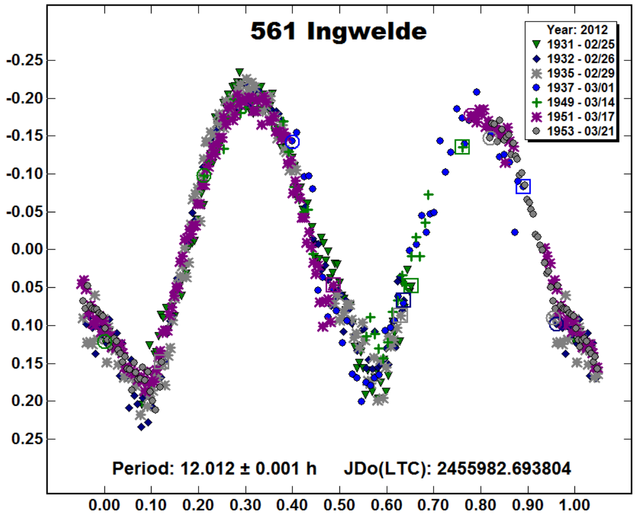
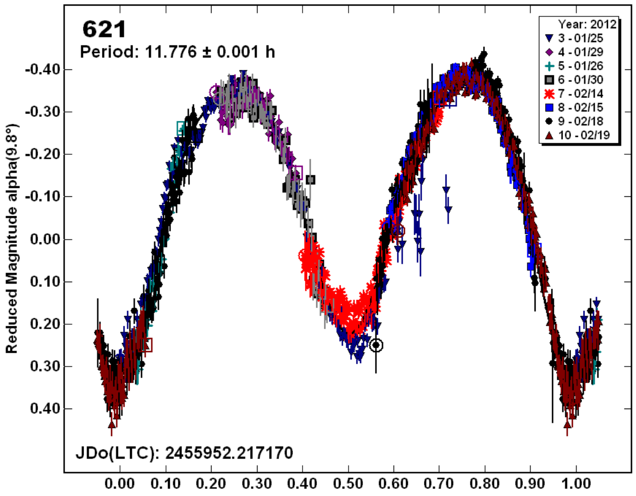
Observatory	Date	Phase Angle	Time h.	Num. Obs	Filter
561 Ingwelde					
Organ Mesa	2012-02-25	7.2	7.9	361	C
Organ Mesa	2012-02-26	6.8	8.1	338	C
Organ Mesa	2012-02-29	5.7	7.9	323	C
Bassano Br.	2012-02-29	5.5	6.0	140	C
Bassano Br.	2012-03-14	0.2	6.7	102	C
Organ Mesa	2012-03-17	1.1	8.5	395	C
Organ Mesa	2012-03-21	2.6	3.6	187	C
621 Werdandi					
Bassano Br.	2012-01-23	9.0	6.0	86	C
Bassano Br.	2012-01-25	7.1	8.5	194	C
Bassano Br.	2012-01-26	10.2	1.0	34	C
Bassano Br.	2012-01-29	11.3	2.0	55	C
Bassano Br.	2012-01-30	11.6	2.5	62	C
Organ Mesa	2012-02-14	15.9	3.5	158	C
Organ Mesa	2012-02-15	16.2	3.8	153	C
Organ Mesa	2012-02-18	16.9	7.1	270	C
Organ Mesa	2012-02-19	17.1	5.2	237	C

Table I. Observation circumstances.





THE LIGHTCURVE OF 29292 CONNIEWALKER

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(Received: 18 March)

Asteroid 29292 Conniewalker was observed for 22 sessions over a 46-day period in 2011 from two collaborating observatories. The asteroid is a tumbler exhibiting a principal lightcurve period of approximately 30.6 h and amplitude of approximately 0.62 mag during the 2011 apparition apparition.

CCD photometry observations made at Via Capote Observatory (VCO) were guided and obtained through a 0.4-m Schmidt-Cassegrain (SCT) working at *f*/10. The CCD imager was an Apogee Alta U6 featuring a 1024x1024 array of 24-micron pixels. All observations were made unfiltered at 1x binning yielding an image scale of 1.24 arcsec/pixel. All images were dark, flat field, and bias corrected. Observations made at Carbuncle Hill Observatory (CHO) were obtained through a 0.5-m *f*/4 reflector. The CCD imager was an unfiltered SBIG ST 10XME. With 3x3 binning, the image scale was 2.05” per pixel. Sessions 6, 9 and 13 in the lightcurve plot were obtained at CHO while the other 19 sessions were from VCO.

All images were measured using *MPO Canopus* (Bdw Publishing). Night-to-night zero point calibration for both observatories was accomplished by selecting up to five comp stars exhibiting 2MASS B-V color indexes similar to the Sun. See Warner (2007) and Stephens (2008) for a further discussion of this process. Using *MPO Canopus* and the linkage protocols it supports, session linkages were very close between the two observatories. In sessions 9 and 10 there were approximately 45 minutes of simultaneous observations from both sites and the zero point difference between the two sessions during this overlapping time was about 0.05 mag. This confirmation of internal linkage quality between the two observing stations was important since it added to the degree of confidence that the internal session-to-session linkages at VCO could be assumed to be of good quality. The reasonable linkage quality also tended to justify the consideration of a tumbler.

Prior to this campaign, no other references to photometric lightcurve analysis for 29292 were found in the literature. After selecting the target from the Collaborative Asteroid Lightcurve Link (*http://www.minorplanet.info/call.html*), VCO began the campaign on 2011 May 26. The first two sessions were on back-to-back nights and the data produced a nearly flat lightcurve with less than 0.08 mag upward trend. As the campaign progressed, more significant trending in magnitudes were observed. However, the data did not fit well to a typical bimodal sinusoidal curve.

29292 was also a target of interest for the Binary Asteroid Photometric Survey that is led by Petr Pravec (*http://www.asu.cas.cz/~asteroid/binastphotsurvey.htm*). VCO posted a notice of observations with supporting data obtained to date at the survey web site. On 2011 July 13, Pravec contacted VCO via private email to inquire about the night-to-night linkage quality of the data reported to his survey and to advise that CHO had also obtained lightcurve data on this target. VCO suspected that there may be an emerging tumbling component to the lightcurve. Pravec agreed to perform a tumbling analysis on the combined VCO/CHO dataset using the method of Pravec *et al.* (2005) fitting a 2-period Fourier series to the data. He found a main period of 30.5 h with several possible solutions for the second period. Figure 3 plots a composite lightcurve with the data folded with the main period and with the 2-period Fourier series fit for the candidate second period of 22.55 h. This solution is rated PAR = –2 on the scale of Pravec *et al*. (2005), i.e., non-principal axis rotation detected but the second period not resolved.

Determining a unique 2-period solution was problematic in that the data were taken from only two stations from the same continent (and mostly just from one station). Thus 2-period solutions with the harmonics for some frequencies ($m{*}f_1 + n{*}f_2$), where m and n are integers and $f_1 = 1/P_1$ and $f_2 = 1/P_2$, that were close to commensurability with an Earth day were poorly determined. A collaboration of stations over a wider range of longitudes is usually needed to get a unique 2-period solution for a slowly rotating tumbler. This problem can be reduced if long sessions are taken but, in this case, VCO session durations were relatively short, averaging only about 3 hours, which limited the ability to resolve the ambiguity.

Acknowledgements

Thanks go to Brian Warner for his guidance in helping to verify the linkage qualities obtained at VCO. Partial funding for work at the Carbuncle Hill Observatory is provided by a 2007 Gene Shoemaker NEO Grant from the Planetary Society.

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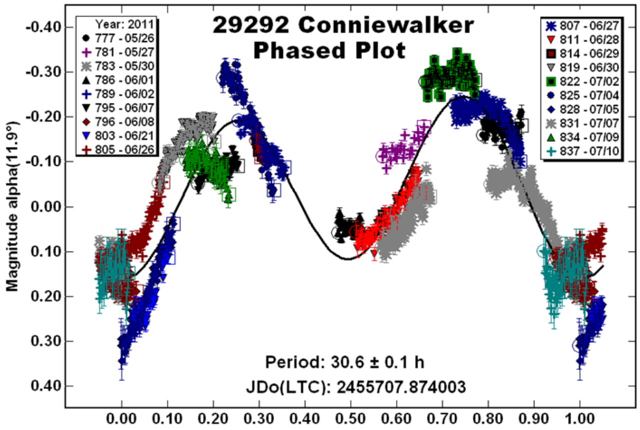
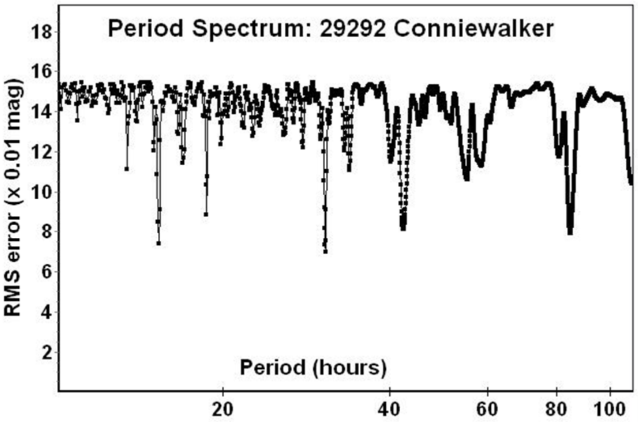
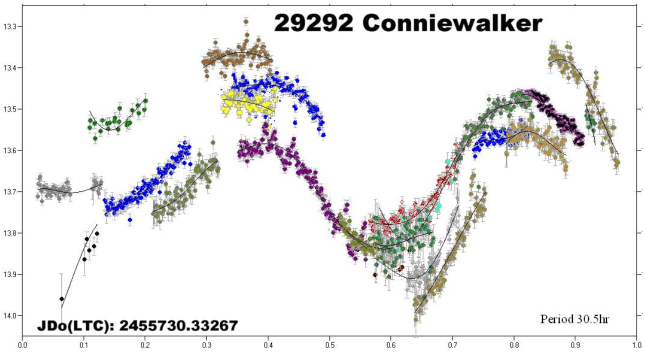
#	Name	Date (mm/dd) 2011	Data Points	Phase	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (m)	AE
29292	Conniewalker	05/26 - 07/10	1542	12,8,21	255	8	~30.6		0.62	0.05

Table I. Observation circumstances.







LIGHTCURVE ANALYSIS OF NEAR-EARTH ASTEROID 3352 MCAULIFFE

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(Received: 9 April)

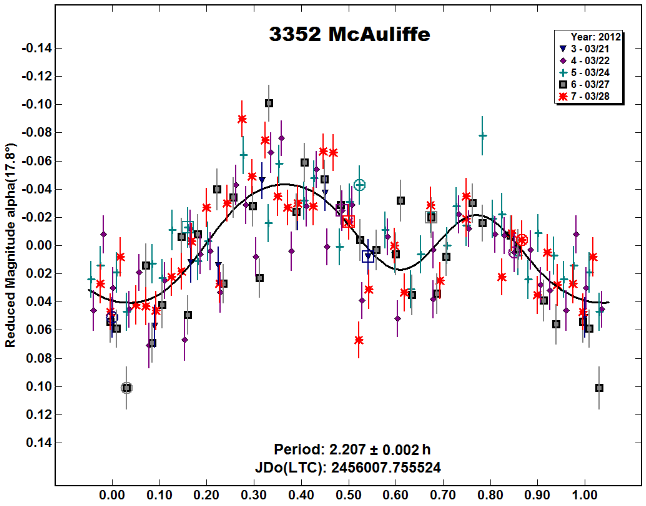
Analysis of photometric measurements of 3352 McAuliffe yielded a period of P = 2.207 ± 0.002 h and amplitude A = 0.09 ± 0.01 mag.

The near-Earth asteroid 3352 McAuliffe was observed on five nights during 2012 March 21-28 using the robotic 0.37-m *f*/14 Rigel telescope of Sierra Stars Observatory Network (SSON). According to the Collaborative Asteroid Lightcurve Link (CALL, *http://www.minorplanet.info/call.html*) web site, the 2012 March apparition of 3352 McAuliffe was one of the five brightest during 1995-2050. At the time of the data query (2012 March 15), the only reported results in the light curve database (LCDB; Warner *et al.*, 2009) were from Pravec *et al.* (1998) with a period of 6 hrs but uncertainty code U = 1 ("most likely wrong"). This suggested that the asteroid would be a worthwhile target for the author's initial venture into asteroid photometry.

The imager was an FLI ProLine camera with KAF-16803 CCD chip using 12-micron pixels binned 2x2, giving an image scale of 0.72 arc-seconds/pixel. The camera was operated at–36°C. Images were taken unfiltered with an exposure of 60 seconds, yielding S/N > 100 for the 15th magnitude object. Images were taken at a cadence of one every 10 minutes. Image calibration used master dark and flat frames generated at the Rigel telescope.

After downloading calibrated images from the SSON server, they were reduced using differential photometry with *MPO Canopus*. The comparison star selector in *MPO Canopus* was used to select 4-5 solar type stars each observing session. Period analysis was done using the Fourier analysis algorithm in *MPO Canopus*.

The five observing sessions yielded 146 data points. The best fit was a 4th order Fourier model with P = 2.207 ± 0.002h and A = 0.09 ± 0.01 mag.



Acknowledgements

The author greatly appreciates the tangible support and useful guidance from Brian D. Warner in getting started with asteroid photometry. The support of the 0.37-m Rigel telescope operated by the University of Iowa for the Sierra Stars Observatory Network (*http://www.sierrastars.com*) is gratefully acknowledged.

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ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: 2011 DECEMBER – 2012 MARCH

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(Received: 2 April)

Lightcurves for 41 asteroids were obtained at the Palmer Divide Observatory (PDO) from 2011 December to 2012 March: 77 Frigga, 2933 Amber, 3352 McAuliffe, 3483 Svetlov, 4031 Mueller, 5378 Ellyett, 5579 Uhlherr, 5771 Somerville, 6087 Lupo, 6602 Gilclark, (6618) 1936 SO, 6635 Zuber, (8404) 1995 AN, (9873) 1992 GH, (11058) 1991 PN10, (16421) 1988 BJ, (16426) 1988 EC, (16585) 1992 QR, 16589 Hastrup, 18368 Flandrau, (19537) 1999 JL8, (23974) 1999 CK12, (24465) 2000 SX155, (26383) 1999 MA2, (30856) 1991 XE, (39618) 1994 LT, (45898) 2000 XQ49, (47983) 2000 XX13, (49566) 1999 CM106, (49678) 1999 TQ7, (50991) 2000 GK94, (57739) 2001 UF162, (63260) 2001 CN, (69350) 1993 YP, 79316 Huangshan, (82066) 2000 XG15, (82078) 2001 AH46, (105155) 2000 NG26, (141018) 2001 WC47, (256700) 2008 AG3, (320125) 2007 EQ185. Two asteroids showed indications of being binary. Analysis of the data for near-Earth asteroid, 3352 McAuliffe showed a second period of 20.86 h but no obvious mutual events (occultations and/or eclipses). The Hungaria asteroid, (24465) 2000 SX15, displayed similar characteristics. Furthermore, the primary (or only) period of 3.256 h cannot be reconciled with analysis from previous apparitions. Three asteroids showed signs of being in non-principal axis rotation (NPAR, “tumbling”). New values for absolute magnitude (H) were found for several Hungaria asteroids using either derived or assumed values of G. These new values were compared against those used in the WISE mission to determine diameters and albedos. In all cases where the WISE results featured an unusually high albedo for the asteroid in question, the new value of H resulted in an albedo that was significantly lower and closer to the expected value for type E asteroids, which are the likely members of the Hungaria collisional family.

CCD photometric observations of 41 asteroids were made at the Palmer Divide Observatory (PDO) from 2011 December to 2012 March. See the introduction in Warner (2010a) for a discussion of equipment, analysis software and methods, and overview of the lightcurve plot scaling. The “Reduced Magnitude” in the plots is Johnson V or Cousins R (indicated in the Y-axis title) corrected to unity distance by applying $-5*\log(r\Delta)$ with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the phase angle given in parentheses, e.g., alpha(6.5°), using $G = 0.15$ unless otherwise stated.

For the sake of brevity in the following discussions on specific asteroids, only some of the previously reported results are referenced. For a more complete listing, the reader is referred to the asteroid lightcurve database (LCDB, Warner *et al.* 2009). The on-line version allows direct queries that can be filtered a number of ways and the results saved to a text file. A set of text files, including the references with Bibcodes, is also available for download at *http://www.minorplanet.info/lightcurvedatabase.html*. Readers are strongly encouraged to obtain, when possible, the original references listed in the LCDB for their work.

Also for brevity, references will be made to the NEOWISE (WISE for short) mission without giving the publication reference every time. The general description of the data analysis and calibration is in Mainzer *et al.* (2011). The diameters of Hungaria asteroids from WISE referenced in this paper appeared in Masiero *et al.* (2011). In conjunction with the methods and processes used to revise WISE diameters and albedos based on newly-determined values for *H* reported in this paper, see the detailed discussion in Warner (2012).

77 Frigga. This main-belt asteroid was worked in support of radar observations for Michael Shepard, who needed to know the rotation phase and shape of the lightcurve at the time of observations.

3352 McAuliffe. This near-Earth asteroid was worked as a “full moon project”, i.e., it was bright enough to work under bright sky conditions when other targets were not. There are three plots shown. The first assumes a single period solution. Periodic deviations appeared to be involved and so a dual period analysis was performed in *MPO Canopus*. This gave $P_1 = 2.2060 \pm 0.0003$ h, $A_1 = 0.09 \pm 0.01$ mag and $P_2 = 20.86 \pm 0.02$ h, $A_2 = 0.07 \pm 0.01$ mag (the second and third plots, respectively). No obvious mutual events (occultations/eclipses) were observed, although there appear to be hints of some in the plot for P_2 as well as an overall upward “bowing”, both of which are potential indicators for the existence of a satellite. Furthermore, there are other solutions possible for the secondary period. At this point, the asteroid can be considered a *possible* binary and so warrants high-precision observations in the future.

3483 Svetlov. This Hungaria asteroid was previously observed by Warner (2010c). The period from the recent observations agrees with the earlier results.

4031 Mueller. The period of 2.944 ± 0.001 h is similar to the one found by Warner (2009c).

5378 Ellyett. The period of 47.32 h is a best fit to the data. Given the complex and non-repeating lightcurve, the asteroid is likely tumbling (see Pravec *et al.*, 2005). The data set was insufficient to determine the periods of rotation and precession.

5579 Uhlherr. Warner (2009c) found a period of 4.754 h. At the time of those observations, 2008 December, the amplitude was 0.20 mag. In 2012, the amplitude was 0.06 mag. Analysis found no definitive solution across a range of periods. The plot was forced to the best-fit period within a small range about the earlier solution.

5771 Somerville. This outer main-belt asteroid was a “target of opportunity”, an asteroid in the same field as a planned target. A period of 7.7 h cannot be formally excluded. However, half-period analysis favors the longer period.

6087 Lupo. The period found from the 2012 data set agrees with that found before (Warner, 2011a). The WISE survey found a high albedo of $p_V = 0.9769$. The observations did not cover a sufficient range of phase angles to determine the phase slope parameter (G), so a value of 0.43 ± 0.08 was assumed (Warner *et al.*, 2009b). This gave $H_R = 15.20 \pm 0.05$. Using V-R = 0.41 (Dandy *et al.*, 2003),

#	Name	mm/dd 2012	Data Pts	α	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
77	Frigga	01/29-01/31	497	4.9,5.8	119	3	9.002	0.003	0.09	0.01
2933	Amber	03/09-03/12	179	4.3,5.4	161	6	13.11	0.03	0.32	0.02
3352	McAuliffe*	03/09-03/22	326	26.9,17.2	192	10	2.2060	0.0003	0.09	0.01
3483	Svetlov (H)	12/28*-01/04	162	6.4,6.8	100	9	6.811	0.005	0.21	0.02
4031	Mueller (H)	03/04-03/06	126	5.5,6.0	160	7	2.944	0.001	0.14	0.01
5378	Ellyett (H)*	11/27*-01/02	762	6.4,25.8	58	1	47.32	0.05	0.48	0.03
5579	Uhlherr (H)	01/26-02/15	223	15.7,15.3,16.4	136	27	4.777	0.002	0.06	0.01
5771	Somerville*	03/14-03/16	120	4.4,4.0	185	-9	9.20	0.05	0.80	0.03
6087	Lupo (H)	02/10-02/17	107	5.2,4.5	144	-6	4.717	0.001	0.55	0.02
6602	Gilclark (H)	03/04-03/06	94	2.0,2.1	165	-2	4.573	0.004	0.21	0.02
6618	1936 SO (H)	02/16-02/24	181	3.9,3.7	150	3	8.286	0.002	0.17	0.02
6635	Zuber (H)	03/16-03/22	152	7.1,4.1	182	-6	5.5355	0.0004	0.73	0.02
8404	1995 AN (H)	03/06-03/16	142	12.5,7.8	183	-7	3.200	0.004	0.06	0.02
9873	1992 GH (H)	02/10-02/15	72	9.8,8.2	148	12	2.9270	0.0004	0.33	0.02
11058	1991 PN10 (H)	02/17-02/24	96	7.7,8.7	146	-11	6.518	0.002	0.39	0.02
16421	1988 BJ (H)	01/03-01/25	310	13.9,20.7	94	16	173.	5.	1.25	0.10
16426	1988 EC (H)	01/04-01/18	323	16.2,12.9	117	20	33.30	0.02	0.27	0.02
16585	1992 QR (H)	01/23-01/28	88	20.7,21.9	101	-23	5.255	0.003	0.44	0.02
16589	Hastrup (H)*	12/17*-01/02	566	19.8,21.8	82	29	128	5	0.62	0.05
18368	Flandrau (H)	01/04-01/06	126	19.9,19.9	88	26	5.777	0.003	0.89	0.02
19537	1999 JL8 (H)	01/01-01/18	313	9.7,12.3	103	15	50.1/25.2	0.2/0.1	0.10	0.01
23974	1999 CK12 (H)	01/13-01/18	188	6.8,5.7	116	8	5.485	0.002	0.80	0.02
24465	2000 SX155 (H)	01/14-02/15	407	21.0,20.1,21.7	125	32	3.256	0.001	0.08	0.01
26383	1999 MA2 (H)	03/22-03/24	158	23.3,23.2	195	33	4.918	0.002	0.32	0.02
30856	1991 XE (H)	01/23-01/26	138	19.2,19.0	133	30	5.361	0.001	0.77	0.02
39618	1994 LT (H)	12/17*-01/03	378	7.9,4.5	96	6	140	15	0.85	0.05
45898	2000 XQ49 (H)	02/25-03/05	221	0.7,5.8	156	0	5.4170	0.0002	0.96	0.02
47983	2000 XX13 (H)	03/17-03/23	77	4.6,4.0	179	5	2.902	0.002	0.09	0.01
49566	1999 CM106	02/24	21	6.6	145	-12	long		>0.2	
49678	1999 TQ7 (H)	03/13-03/15	98	6.2,4.9	182	0	3.954	0.004	0.35	0.05
50991	2000 GK94	02/24-02/26	116	7.6,8.5	141	-3	7.010	0.005	0.86	0.03
57739	2001 UF162	02/24	37	6.3	141	9	5.9	0.5	0.52	0.05
63260	2001 CN (H)	01/28-01/31	137	2.7,4.5	125	4	8.76	0.01	0.79	0.02
69350	1993 YP (H)	02/10-03/04	236	4.2,14.7	141	-3	99.5	0.5	0.91	0.03
79316	Huangshan (H)	01/01-01/06	169	19.6,20.1	96	29	11.7	0.1	0.10	0.02
82066	2000 XG15 (H)	03/10-03/14	143	23.6,24.3	152	33	19.07	0.06	0.19	0.02
82078	2001 AH46 (H)	03/04-03/12	232	12.7,15.8	152	12	19.57	0.02	0.41	0.02
105155	2000 NG26 (H)	02/17-02/26	164	5.3,11.0	143	7	5.08	0.01	0.12	0.02
141018	2001 WC47	02/17-03/09	221	20.3,40.2	142	12	16.747	0.006	0.23	0.02
256700	2008 AG3	03/23-03/24	41	3.6,3.9	179	5	5.1	0.1	0.45	0.03
320125	2007 EQ185	03/23-03/24	41	2.6,2.9	179	5	9.0/11.1	0.3	0.48	0.05

* November/December dates are 2011
* (3352) Possible binary; secondary period of 20.86 ± 0.02 h, A = 0.07 mag.
* (5378) Probably tumbling
* (5571) Period of 7.7 h cannot be formally excluded
* (16589) Probably tumbling
* (24465) Possible binary; secondary period of 21.42 ± 0.01 h.
* (39618) Possibly tumbling.

Table I. Observing circumstances. Asteroids with (H) after the name are members of the Hungaria group/family. The phase angle (α) is given at the start and end of each date range, unless it reached a minimum, which is then the second of three values. If a single value is given, the phase angle did not change significantly and the average value is given. L_{PAB} and B_{PAB} are each the average phase angle bisector longitude and latitude, unless two values are given (first/last date in range).

this results in H = 15.61. The WISE observations assumed H = 14.7. Applying the corrections discussed in Warner (2012), the estimated diameter D = 1.44 km and p_V = 0.4893 ± 0.0971. This revised albedo is more inline with expectations for type E asteroids (Warner *et al.*, 2009b), the main constituents of the Hungaria family.

6602 Gilclark. Warner (2009a) found a period of 4.574 h from data obtained in 2008. The results from 2012 are identical within 1-sigma.

(6618) 1936 SO. The period from 2012 agrees within 1-sigma of that found in 2008 by Warner (2009a).

6635 Zuber. This was follow-up to observations in 2010 (Warner, 2010c) to help with shape and spin axis modeling. The two results agree to within 0.01 h while the amplitudes differed by 0.1 mag.

(8404) 1995 AN. A period of 4.612 h was previously reported by Warner (2009c). However, the data from 2012 could not be fit to that period, a best fit being 3.200 ± 0.004 h. The amplitude in 2009 was 0.16 mag whereas in 2012 it was 0.06, giving some support for the 4.6 h period. A check of the 2009 data found that it could be fit to a period of 3.204 ± 0.002 h, A = 0.09 mag. This revised period is statistically the same as the 2012 result. Observations at future apparitions are strongly encouraged.

(9873) 1992 GH. A period of P ~ 2.92 h was previously reported by Warner (2007c, 2009a) and Sauppe (2007). The results from PDO in 2012 are in close agreement.

(11058) 1991 PN10. Period analysis results are identical to those from Warner (2011a). WISE reported an albedo of p_V = 1.0. Assuming a value of G = 0.43 ± 0.08 (Warner *et al.*, 2009a) and V-

R = 0.41 (Dandy *et al.*, 2003) found H = 15.13. The corrected diameters are then 1.67 km and p_V = 0.5616 ± 0.0477.

(16421) 1988 BJ. There were no outwards signs of this long-period (173 h) object being a tumbler. However, the period is well in-excess of the one for a damping time equal to the age of the Solar System (see Pravec *et al.*, 2005 and references therein). A coordinated campaign generating calibrate high-precision data may be required to detect tumbling should the precession amplitude be small, e.g., the asteroid is just starting or ending tumbling state.

(16426) 1988 EC. The period found by Warner (2009c) and the new period agree within 0.1%. The earlier data set was of slightly lesser quality and showed a significantly lower amplitude. WISE reported an albedo p_V = 0.5080 ± 0.1054 using H = 14.1. The PDO data give H = 14.62 using G = 0.43 and V-R = 0.41. This gives revised diameters of D = 2.72 km and p_V = 0.3384 ± 0.0645.

(16585) 1992 QR. Warner (2007c) found a period of 5.273 h. The new result of P = 5.255 h similar. The 2012 data set had a much larger amplitude and was of higher quality. All observations were at solar phase angle, $\alpha > 20°$, so it was not possible to determine an accurate value for G. WISE reported p_V = 1.00 ± 0.07 with H = 14.0. Using the assumed values of before, a value of H = 15.24 ± 0.15 was found, giving revised values of D = 1.69 km and p_V = 0.4970 ± 0.1554.

16589 Hastrup. The previous result by Warner (2009c) of 27.62 h was not supported by the 2012 data, which lead to a period of P = 128 h and strong indications of tumbling. This is supported by a damping time exceeding the age of the Solar System, though this is only a broad guideline. WISE found pV = 0.5797 ± 0.1463 using H = 14.5. The complex curve and all observations being at $\alpha > 20°$ made finding a revised value for H difficult, even when assuming G = 0.43. The results were H = 14.96 ± 0.15, giving corrected values of D = 2.19 km and p_V = 0.3816 ± 0.1268, or within about 1-sigma of the WISE result.

(24465) 2000 SX1155. Warner (2009c) previously found a period of 9.156 h. Analysis of the 2012 data cannot be reconciled to this value. The results are, instead, highly-ambiguous. A primary period of 3.256 h seems likely. However, there is a solution at 21.42 h. If that period is subtracted from the data set, a better-defined result of P = 3.2562 ± 0.0005 h presents itself. This secondary period could be the period of the body itself or due to the rotation of an undetected satellite. There were no occultations or eclipses observed to confirm the latter. Observations at future apparitions are strongly encouraged.

(26383) 1999 MA2. The period of P = 4.918 h is in close agreement to the one of 4.889 h found previously (Warner, 2009d). WISE reported p_V = 1.00 ± 0.17 with H = 14.2. Using G = 0.43, the PDO data (already in V magnitudes) give H = 15.58 ± 0.15, D = 1.52 km, and p_V = 0.4475 ± 0.1448.

(30856) 1991 XE. The 2012 results are in good agreement with those found earlier (Warner, 2007c; 2010c).

(39618) 1994 LT. While analysis of the data set is not conclusive, this Hungaria is likely in non-principal axis rotation. The plot shows the data phased to a best-fit single period solution.

(45898) 2000 XQ49. The period of 5.4174 h is in good agreement with the one found earlier by Warner (2009d). WISE reported p_V = 0.6449 ± 0.2436 with H = 14.0. PDO data (V magnitudes) gave H = 14.90 ± 0.13 assuming G = 0.43. This results in corrected values of D = 2.50 km and p_V = 0.3089 ± 0.1304.

(49566) 1999 CM106. This Eunomia group member was a target of opportunity. Given that it showed signs of being a long period (assuming the last 4-5 data points did not include systematic errors or affected by a faint star), no observations were made after the first night.

(49678) 1999 TQ7. Warner (2011a) found a period of 3.957 h. The latest results are essentially identical. WISE reported p_V = 0.8888 ± 0.0942 with H = 15.5 (G = 0.15). Using G = 0.43, the PDO V magnitudes data give H = 16.61 ± 0.10 and corrected D = 1.03 km and p_V = 0.3814 ± 0.1023.

(69350) 1993 YP. The results are similar to those found by Warner (2007c), but not exactly. Both data sets show signs of tumbling. The 2012 data also fit a period of 99.5 h, which is close to a 3:1 ratio with the adopted period. The longer period may be a harmonic fit of the shorter one or the two periods are members of just one of a number of solution sets that fit the data for a tumbling object.

(82066) 2000 XG15. Despite the asymmetric lightcurve, the data could not be fit reasonably to another period.

(105155) 2000 NG26. The data were phased to a period of 5.08 h. However the period spectrum shows numerous solutions of almost equal probability.

(141018) 2001 WC47. This NEA was listed as a potential target for a robotic mission, which – along with manned missions – would require that the asteroid not be spinning so fast that the robot (or an astronaut) go flying into space. In this context, the period of 16.7 h makes this a good candidate for a robotic or manned mission. Assuming G = 0.15 and V-R = 0.45, gave H = 19.09. Assuming p_V = 0.2 gave an estimated diameter of D = 450 meters.

(256700) 2000 AG3, (320125) 2007 EQ185. These were targets of opportunity. What makes them stand out is that they were both V ~ 19.5 and yet somewhat reasonable results were obtained using a 0.35-m telescope and 5-minute unfiltered, guided exposures because the somewhat large amplitudes overcame the low SNR to allow finding a solution. For 320125, a period of 11.1 h cannot be formally excluded. However, a half-period search strongly favors the 9.0 h solution.

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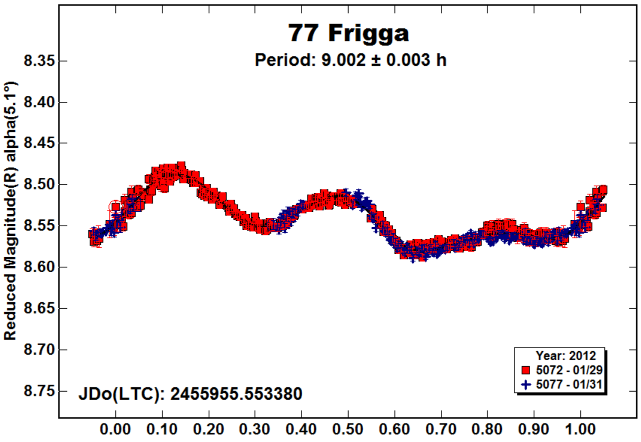

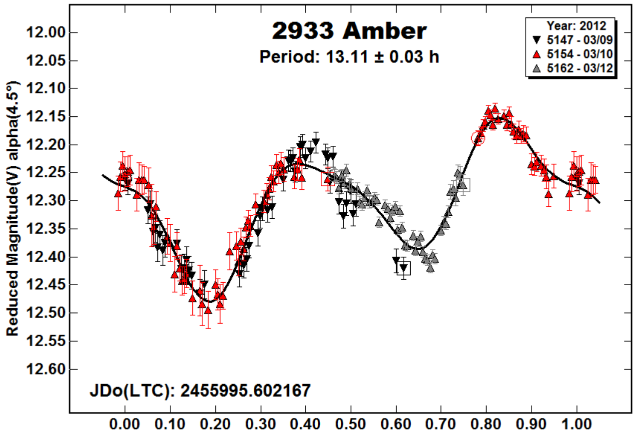

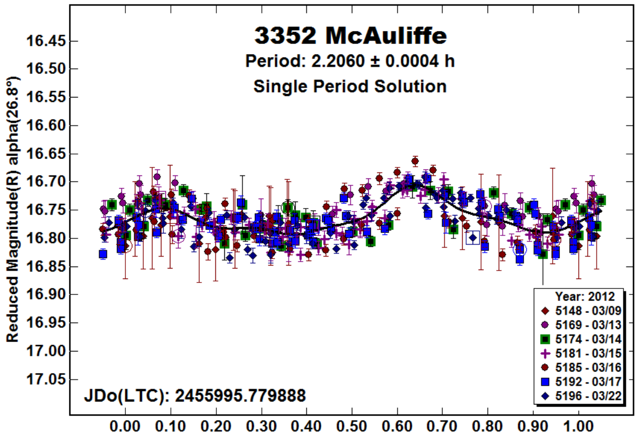

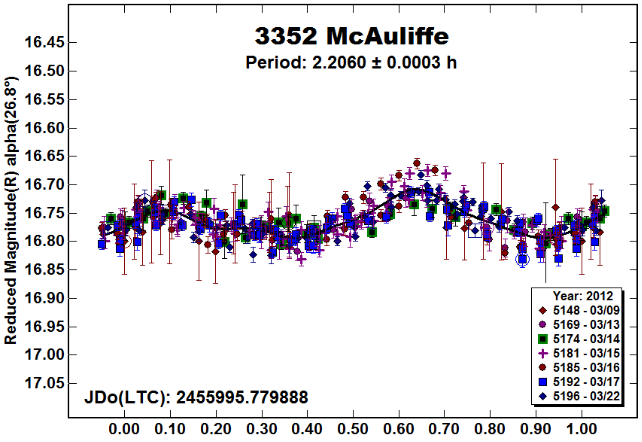

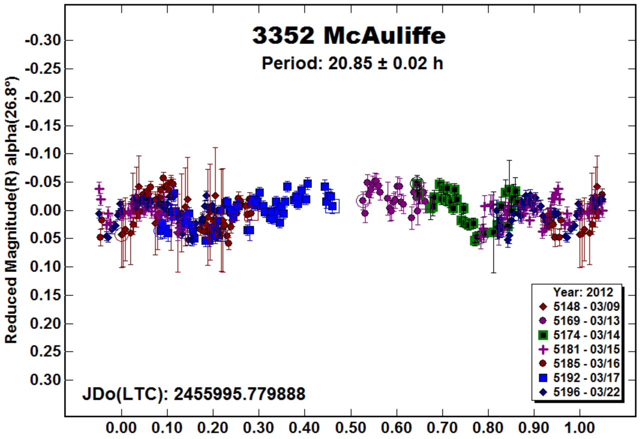
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Year: 2012
5148 - 03/09
5169 - 03/13
5174 - 03/14
5181 - 03/15
5185 - 03/16
5192 - 03/17
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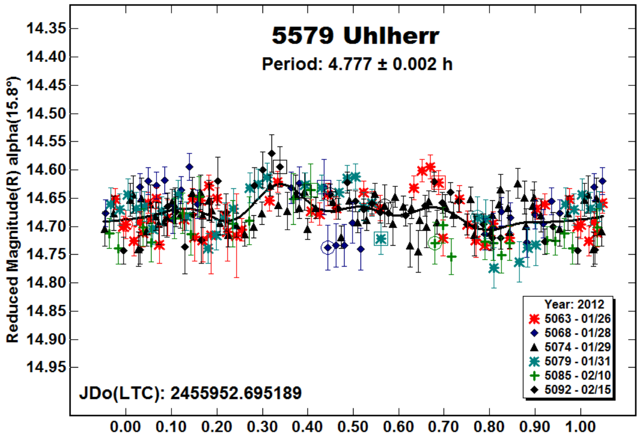
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Year: 2012
5063 - 01/26
5068 - 01/28
5074 - 01/29
5079 - 01/31
5085 - 02/10
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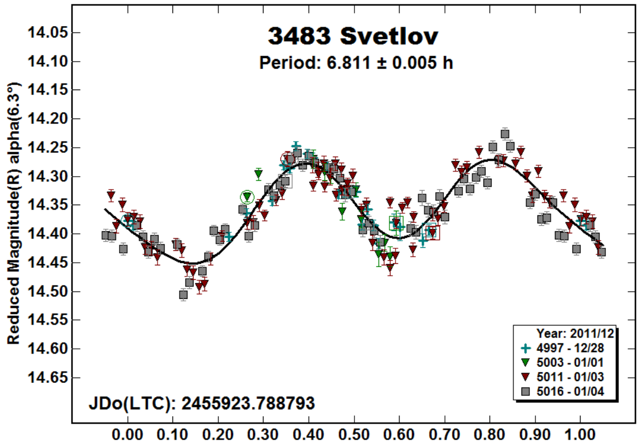
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Year: 2011/12
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5003 - 01/01
5011 - 01/03
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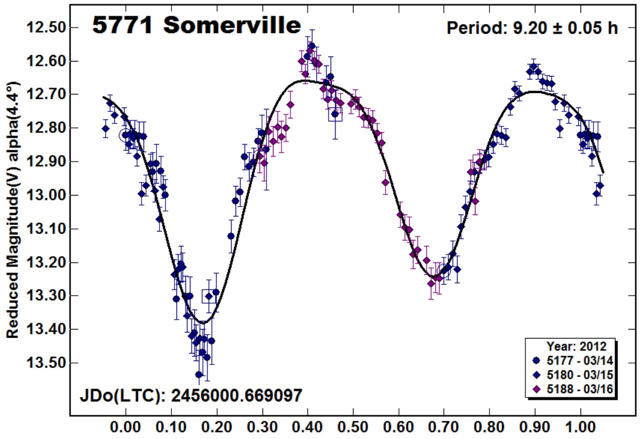
5771 Somerville
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Reduced Magnitude(V) alpha(4.4°)
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Year: 2012
5177 - 03/14
5180 - 03/15
5188 - 03/16
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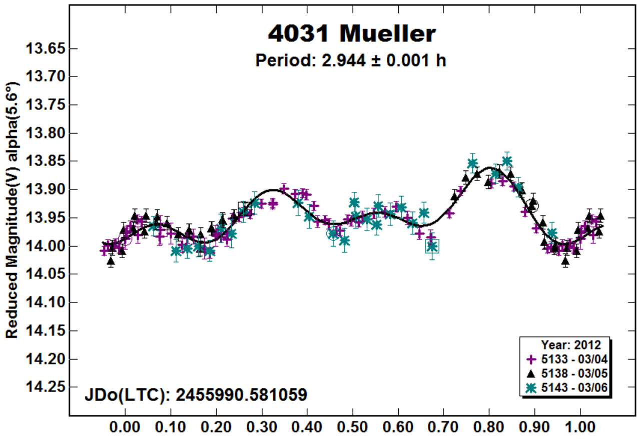
4031 Mueller
Period: 2.944 ± 0.001 h
Reduced Magnitude(V) alpha(5.6°)
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Year: 2012
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5138 - 03/05
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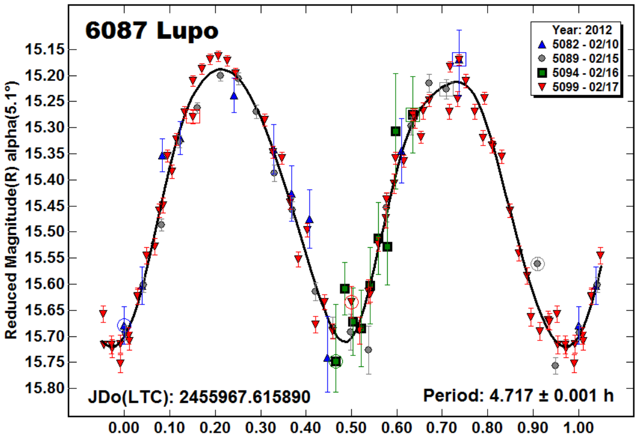
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5089 - 02/15
5094 - 02/16
5099 - 02/17
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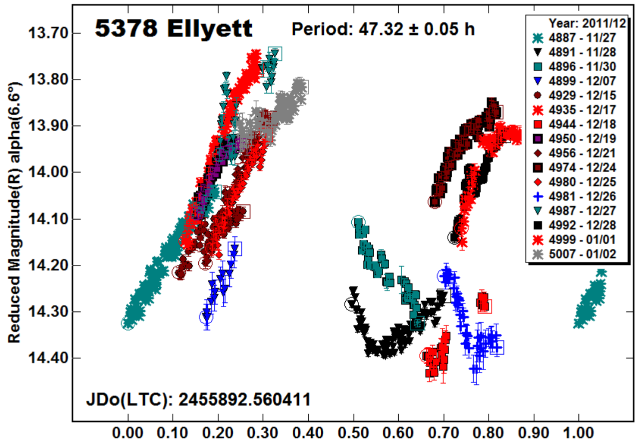
5378 Ellyett
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Year: 2011/12
4887 - 11/27
4891 - 11/28
4896 - 11/30
4899 - 12/07
4929 - 12/15
4935 - 12/17
4944 - 12/18
4950 - 12/19
4956 - 12/21
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4981 - 12/26
4987 - 12/27
4992 - 12/28
4999 - 01/01
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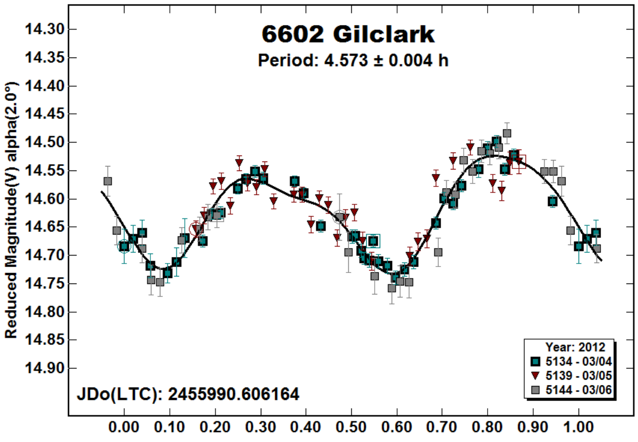
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5139 - 03/05
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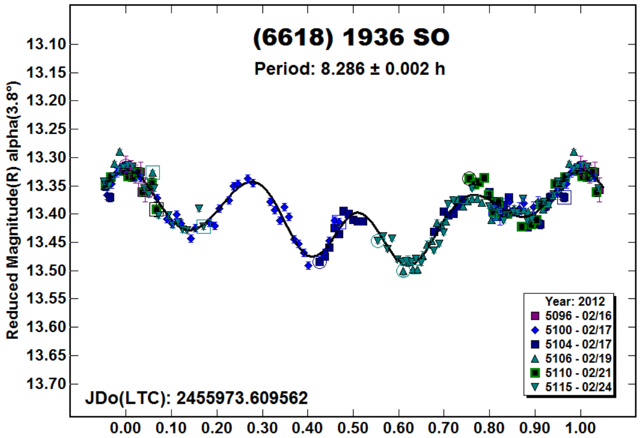
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13.20
13.25
13.30
13.35
13.40
13.45
13.50
13.55
13.60
13.65
13.70
Year: 2012
5096 - 02/16
5100 - 02/17
5104 - 02/17
5106 - 02/19
5110 - 02/21
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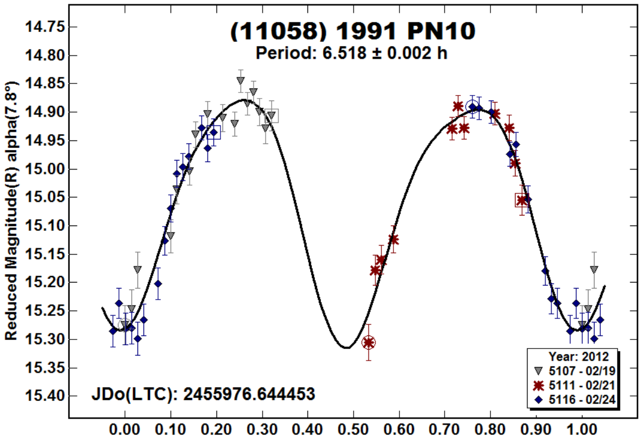
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14.90
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
Year: 2012
5107 - 02/19
5111 - 02/21
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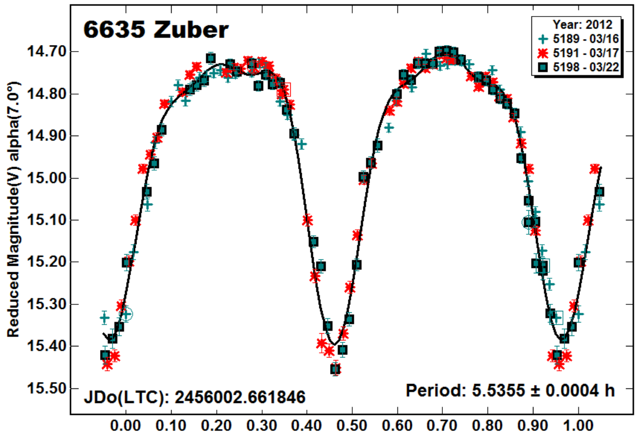
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5189 - 03/16
5191 - 03/17
5198 - 03/22
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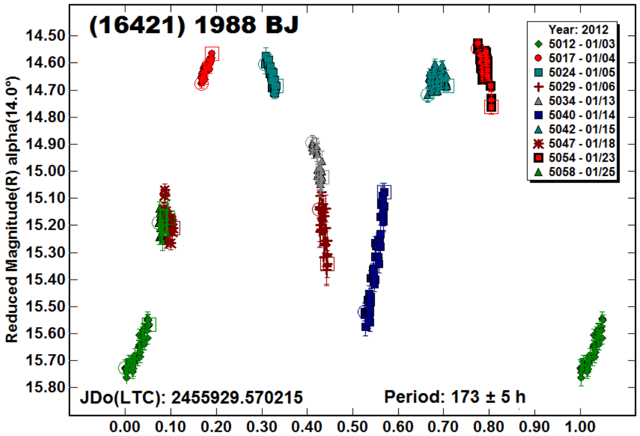
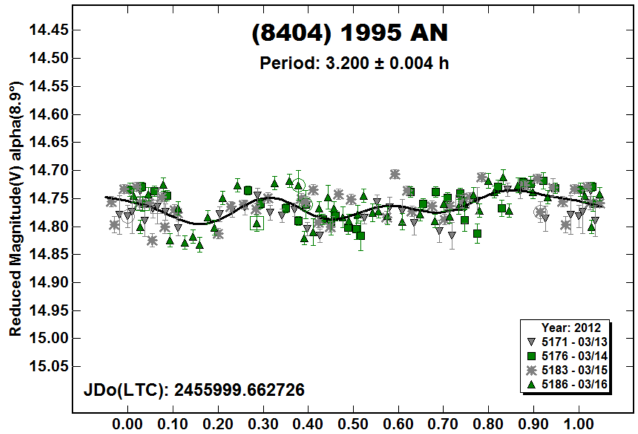
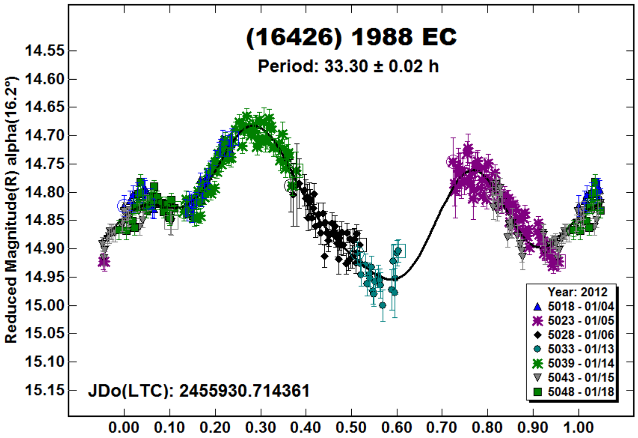
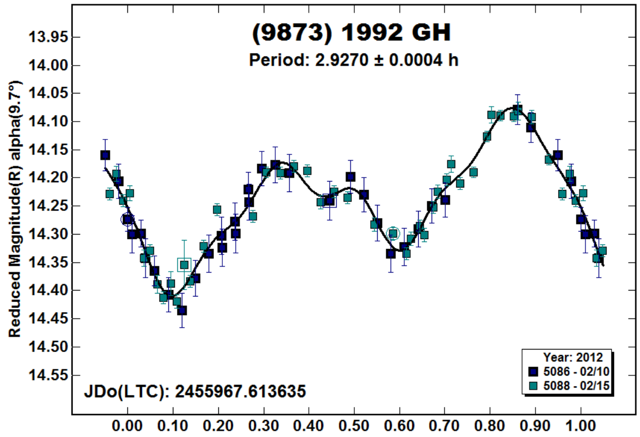
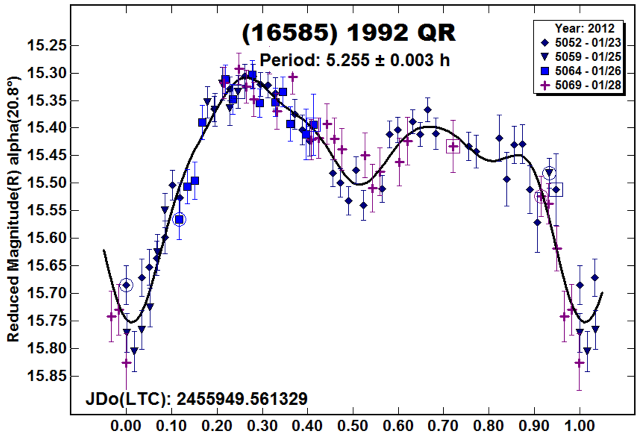
14.90
15.00
15.10
15.20
15.30
15.40
15.50
JDo(LTC): 2456002.661846
Period: 5.5355 ± 0.0004 h
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

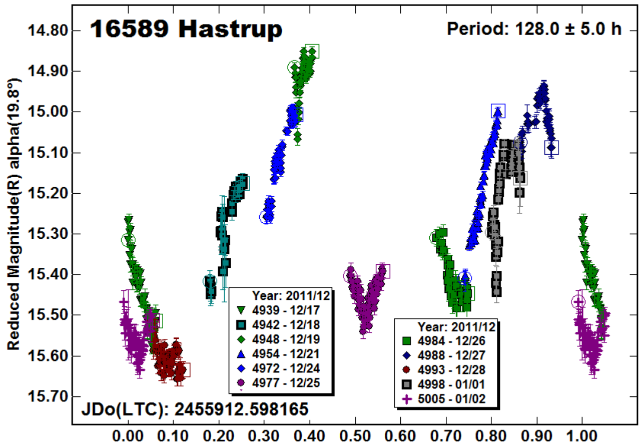

(16421) 1988 BJ
Year: 2012
5012 - 01/03
5017 - 01/04
5024 - 01/05
5029 - 01/06
5034 - 01/13
5040 - 01/14
5042 - 01/15
5047 - 01/18
5054 - 01/23
5058 - 01/25
Reduced Magnitude(R) alpha(14.0°)
14.50
14.60
14.70
14.80
14.90
15.00
15.10
15.20
15.30
15.40
15.50
15.60
15.70
15.80
JDo(LTC): 2455929.570215
Period: 173 ± 5 h
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

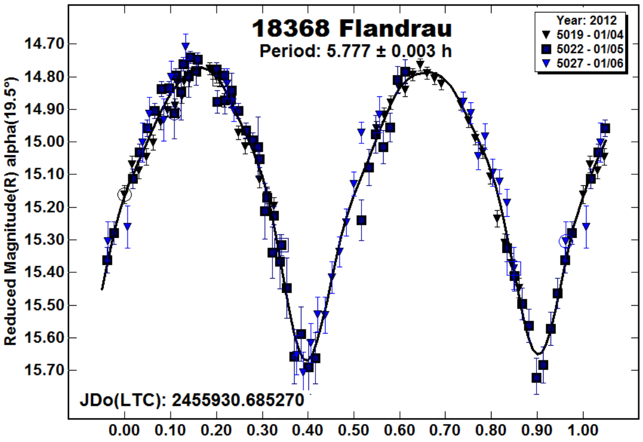

(8404) 1995 AN
Period: 3.200 ± 0.004 h
Reduced Magnitude(V) alpha(8.9°)
14.45
14.50
14.55
14.60
14.65
14.70
14.75
14.80
14.85
14.90
14.95
15.00
15.05
Year: 2012
5171 - 03/13
5176 - 03/14
5183 - 03/15
5186 - 03/16
JDo(LTC): 2455999.662726
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

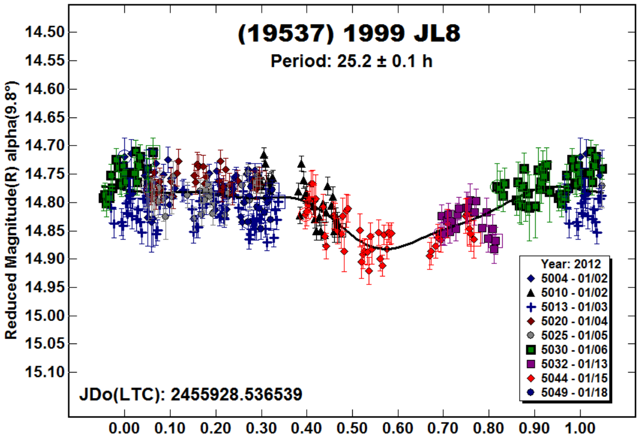

(16426) 1988 EC
Period: 33.30 ± 0.02 h
Reduced Magnitude(R) alpha(16.2°)
14.55
14.60
14.65
14.70
14.75
14.80
14.85
14.90
14.95
15.00
15.05
15.10
15.15
Year: 2012
5018 - 01/04
5023 - 01/05
5028 - 01/06
5033 - 01/13
5039 - 01/14
5043 - 01/15
5048 - 01/18
JDo(LTC): 2455930.714361
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

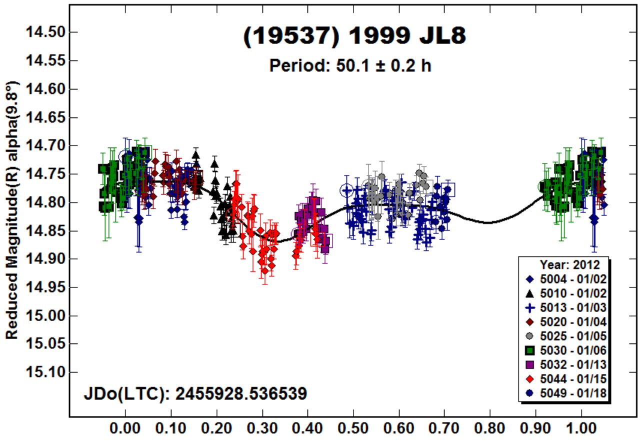

(9873) 1992 GH
Period: 2.9270 ± 0.0004 h
Reduced Magnitude(R) alpha(9.7°)
13.95
14.00
14.05
14.10
14.15
14.20
14.25
14.30
14.35
14.40
14.45
14.50
14.55
Year: 2012
5086 - 02/10
5088 - 02/15
JDo(LTC): 2455967.613635
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

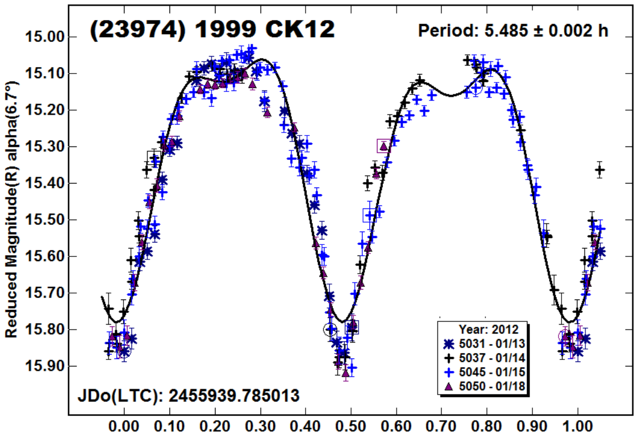

(16585) 1992 QR
Year: 2012
5052 - 01/23
5059 - 01/25
5064 - 01/26
5069 - 01/28
Period: 5.255 ± 0.003 h
Reduced Magnitude(R) alpha(20.8°)
15.25
15.30
15.35
15.40
15.45
15.50
15.55
15.60
15.65
15.70
15.75
15.80
15.85
JDo(LTC): 2455949.561329
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

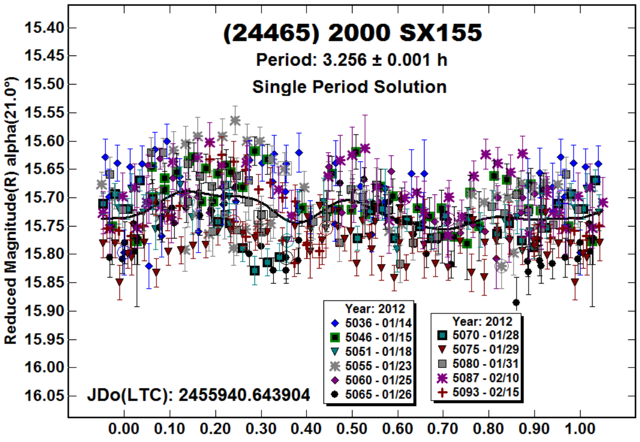

16589 Hastrup
Period: 128.0 ± 5.0 h
Reduced Magnitude(R) alpha(19.8°)
14.80
14.90
15.00
15.10
15.20
15.30
15.40
15.50
15.60
15.70
Year: 2011/12
4939 - 12/17
4942 - 12/18
4948 - 12/19
4954 - 12/21
4972 - 12/24
4977 - 12/25
Year: 2011/12
4984 - 12/26
4988 - 12/27
4993 - 12/28
4998 - 01/01
5005 - 01/02
JDo(LTC): 2455912.598165
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

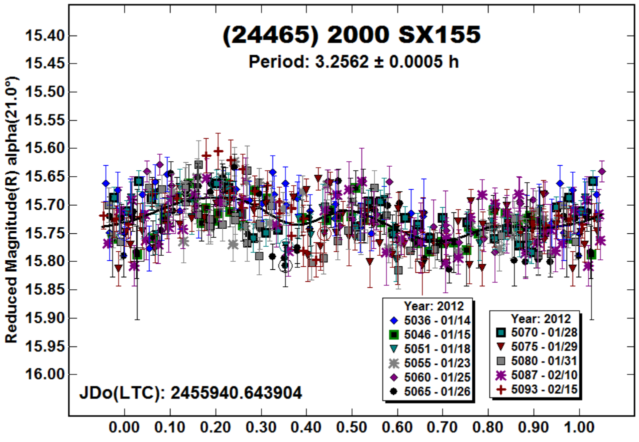

18368 Flandrau
Period: 5.777 ± 0.003 h
Year: 2012
5019 - 01/04
5022 - 01/05
5027 - 01/06
Reduced Magnitude(R) alpha(19.5°)
14.70
14.80
14.90
15.00
15.10
15.20
15.30
15.40
15.50
15.60
15.70
JDo(LTC): 2455930.685270
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

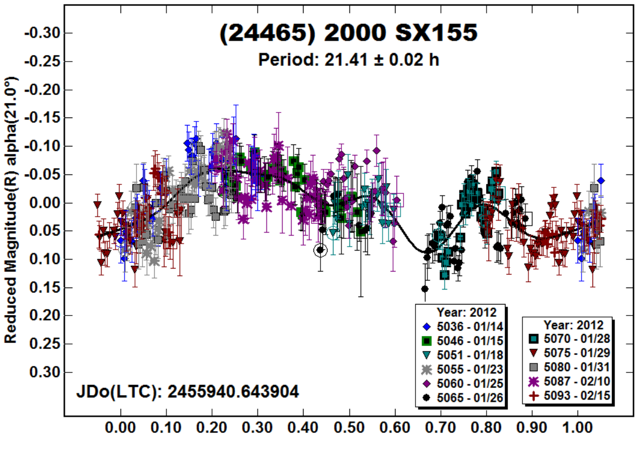

(19537) 1999 JL8
Period: 25.2 ± 0.1 h
Reduced Magnitude(R) alpha(9.8°)
14.50
14.55
14.60
14.65
14.70
14.75
14.80
14.85
14.90
14.95
15.00
15.05
15.10
Year: 2012
5004 - 01/02
5010 - 01/02
5013 - 01/03
5020 - 01/04
5025 - 01/05
5030 - 01/06
5032 - 01/13
5044 - 01/15
5049 - 01/18
JDo(LTC): 2455928.536539
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

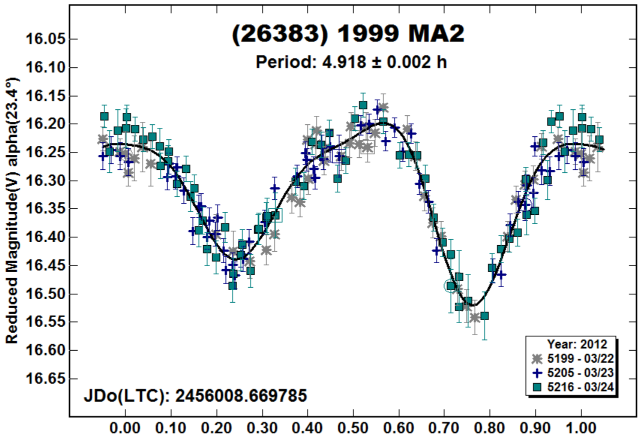

(19537) 1999 JL8
Period: 50.1 ± 0.2 h
Reduced Magnitude(R) alpha(9.8°)
14.50
14.55
14.60
14.65
14.70
14.75
14.80
14.85
14.90
14.95
15.00
15.05
15.10
Year: 2012
5004 - 01/02
5010 - 01/02
5013 - 01/03
5020 - 01/04
5025 - 01/05
5030 - 01/06
5032 - 01/13
5044 - 01/15
5049 - 01/18
JDo(LTC): 2455928.536539
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

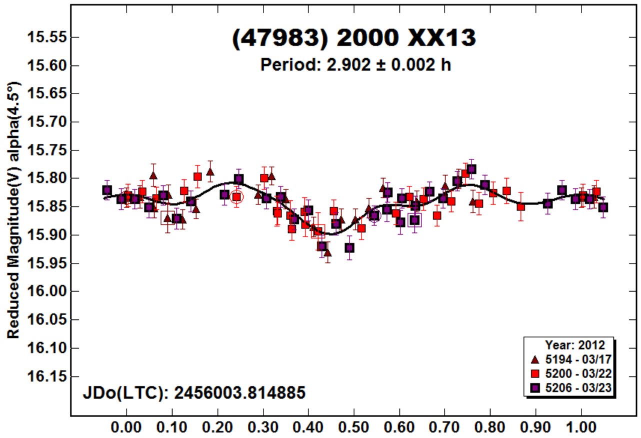

(23974) 1999 CK12
Period: 5.485 ± 0.002 h
Reduced Magnitude(R) alpha(6.7°)
15.00
15.10
15.20
15.30
15.40
15.50
15.60
15.70
15.80
15.90
Year: 2012
5031 - 01/13
5037 - 01/14
5045 - 01/15
5050 - 01/18
JDo(LTC): 2455939.785013
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

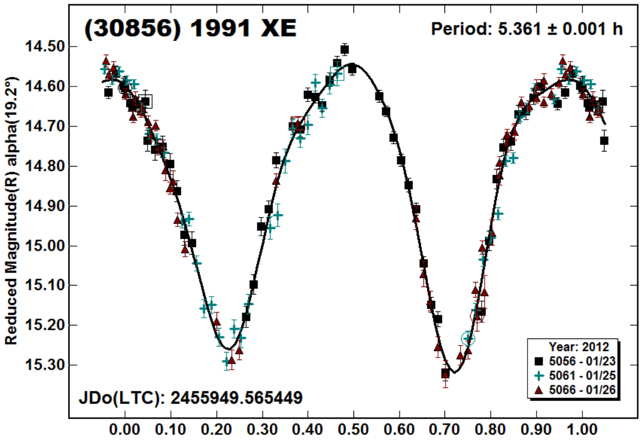

(24465) 2000 SX155
Period: 3.256 ± 0.001 h
Single Period Solution
Reduced Magnitude(R) alpha(21.0°)
15.40
15.45
15.50
15.55
15.60
15.65
15.70
15.75
15.80
15.85
15.90
15.95
16.00
16.05
Year: 2012
5036 - 01/14
5046 - 01/15
5051 - 01/18
5055 - 01/23
5060 - 01/25
5065 - 01/26
Year: 2012
5070 - 01/28
5075 - 01/29
5080 - 01/31
5087 - 02/10
5093 - 02/15
JDo(LTC): 2455940.643904
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

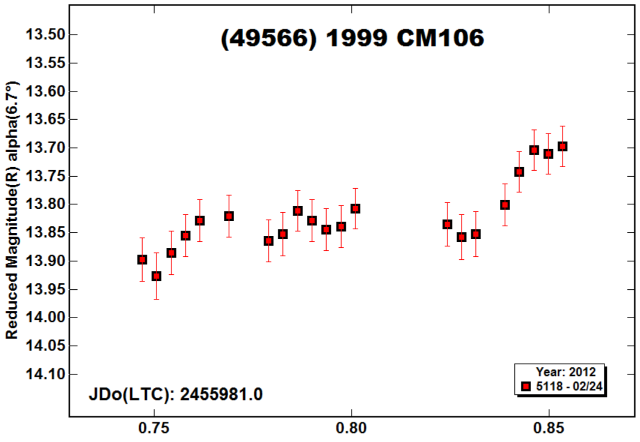

(24465) 2000 SX155
Period: 3.2562 ± 0.0005 h
Reduced Magnitude(R) alpha(21.0°)
15.40
15.45
15.50
15.55
15.60
15.65
15.70
15.75
15.80
15.85
15.90
15.95
16.00
Year: 2012
5036 - 01/14
5046 - 01/15
5051 - 01/18
5055 - 01/23
5060 - 01/25
5065 - 01/26
Year: 2012
5070 - 01/28
5075 - 01/29
5080 - 01/31
5087 - 02/10
5093 - 02/15
JDo(LTC): 2455940.643904
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

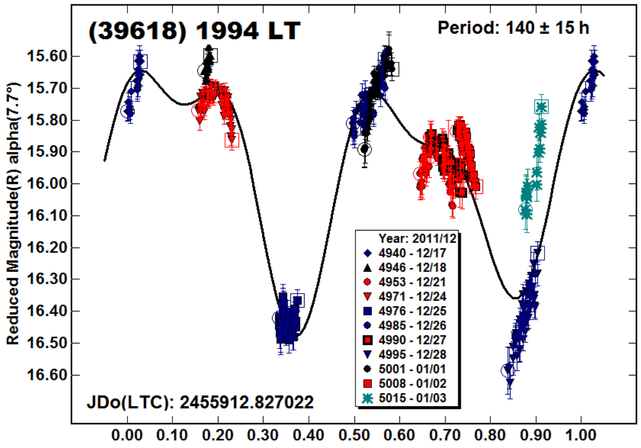

(24465) 2000 SX155
Period: 21.41 ± 0.02 h
Reduced Magnitude(R) alpha(21.0°)
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Year: 2012
5036 - 01/14
5046 - 01/15
5051 - 01/18
5055 - 01/23
5060 - 01/25
5065 - 01/26
Year: 2012
5070 - 01/28
5075 - 01/29
5080 - 01/31
5087 - 02/10
5093 - 02/15
JDo(LTC): 2455940.643904
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

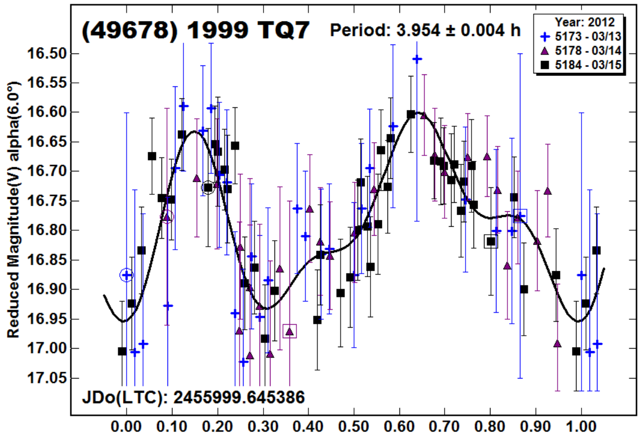

(26383) 1999 MA2
Period: 4.918 ± 0.002 h
Reduced Magnitude(V) alpha(23.4°)
16.05
16.10
16.15
16.20
16.25
16.30
16.35
16.40
16.45
16.50
16.55
16.60
16.65
Year: 2012
5199 - 03/22
5205 - 03/23
5216 - 03/24
JDo(LTC): 2456008.669785
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

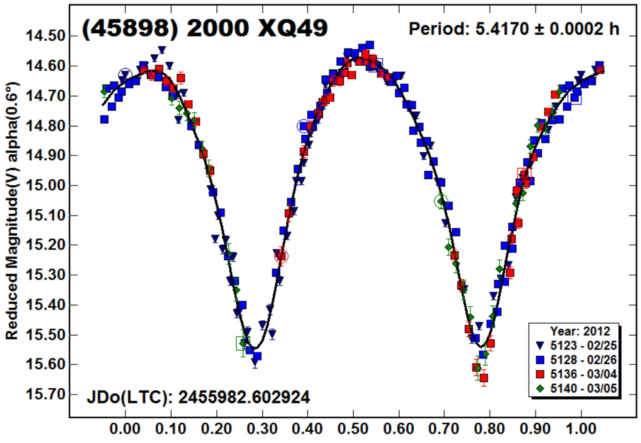

(47983) 2000 XX13
Period: 2.902 ± 0.002 h
Reduced Magnitude(V) alpha(4.5°)
15.55
15.60
15.65
15.70
15.75
15.80
15.85
15.90
15.95
16.00
16.05
16.10
16.15
Year: 2012
5194 - 03/17
5200 - 03/22
5206 - 03/23
JDo(LTC): 2456003.814885
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

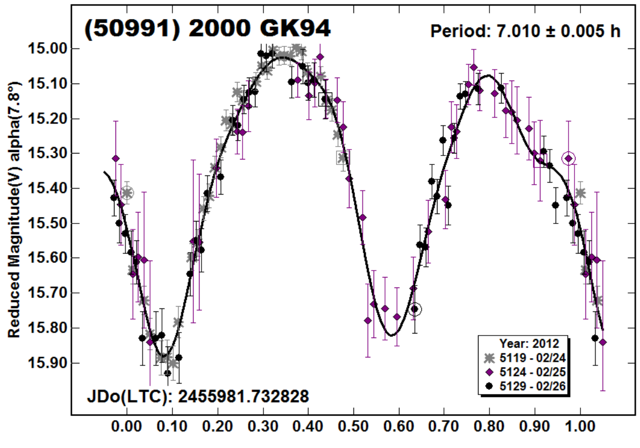

(30856) 1991 XE
Period: 5.361 ± 0.001 h
Reduced Magnitude(R) alpha(19.2°)
14.50
14.60
14.70
14.80
14.90
15.00
15.10
15.20
15.30
Year: 2012
5056 - 01/23
5061 - 01/25
5066 - 01/26
JDo(LTC): 2455949.565449
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

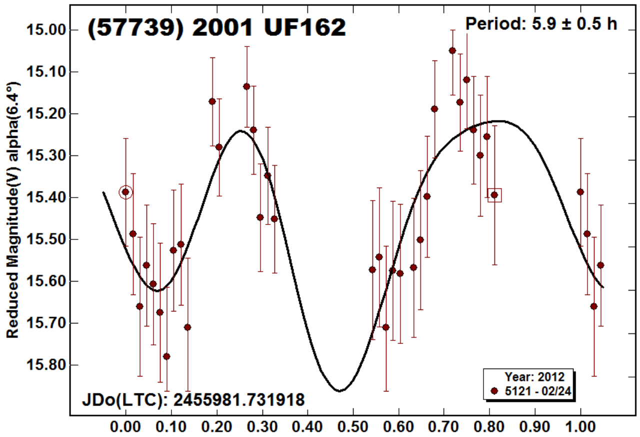

(49566) 1999 CM106
Reduced Magnitude(R) alpha(6.7°)
13.50
13.55
13.60
13.65
13.70
13.75
13.80
13.85
13.90
13.95
14.00
14.05
14.10
Year: 2012
5118 - 02/24
JDo(LTC): 2455981.0
0.75
0.80
0.85

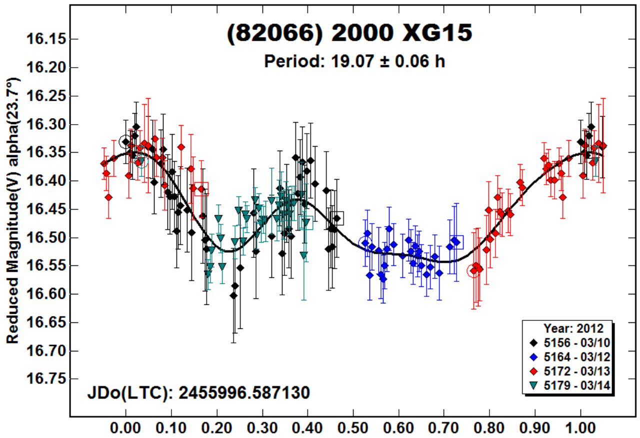

(39618) 1994 LT
Period: 140 ± 15 h
Reduced Magnitude(R) alpha(7.7°)
15.60
15.70
15.80
15.90
16.00
16.10
16.20
16.30
16.40
16.50
16.60
Year: 2011/12
4940 - 12/17
4946 - 12/18
4953 - 12/21
4971 - 12/24
4976 - 12/25
4985 - 12/26
4990 - 12/27
4995 - 12/28
5001 - 01/01
5008 - 01/02
5015 - 01/03
JDo(LTC): 2455912.827022
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

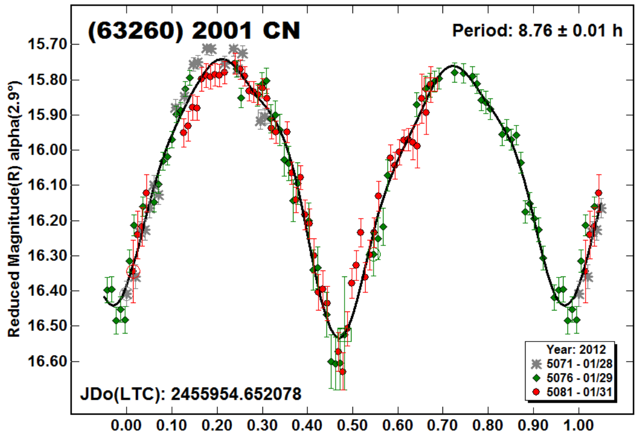

(49678) 1999 TQ7
Period: 3.954 ± 0.004 h
Year: 2012
5173 - 03/13
5178 - 03/14
5184 - 03/15
Reduced Magnitude(V) alpha(6.0°)
16.50
16.55
16.60
16.65
16.70
16.75
16.80
16.85
16.90
16.95
17.00
17.05
JDo(LTC): 2455999.645386
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

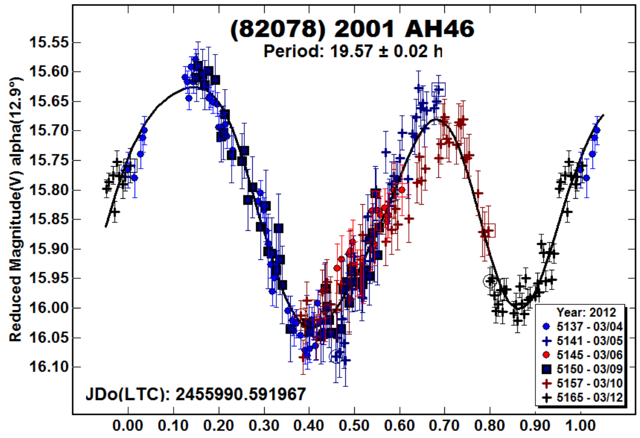

(45898) 2000 XQ49
Period: 5.4170 ± 0.0002 h
Reduced Magnitude(V) alpha(0.6°)
14.50
14.60
14.70
14.80
14.90
15.00
15.10
15.20
15.30
15.40
15.50
15.60
15.70
Year: 2012
5123 - 02/25
5128 - 02/26
5136 - 03/04
5140 - 03/05
JDo(LTC): 2455982.602924
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

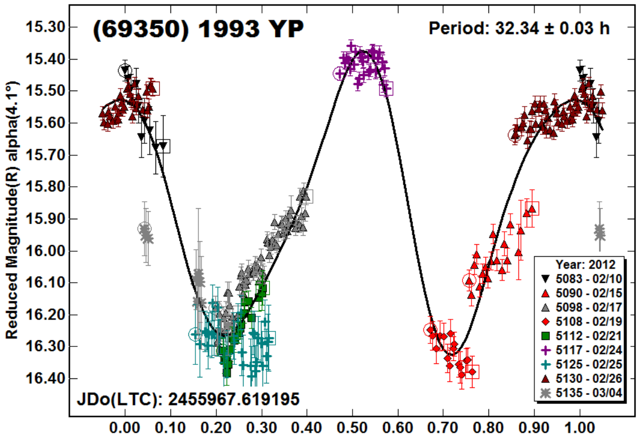

(50991) 2000 GK94
Period: 7.010 ± 0.005 h
Reduced Magnitude(V) alpha(7.8°)
15.00
15.10
15.20
15.30
15.40
15.50
15.60
15.70
15.80
15.90
Year: 2012
5119 - 02/24
5124 - 02/25
5129 - 02/26
JDo(LTC): 2455981.732828
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

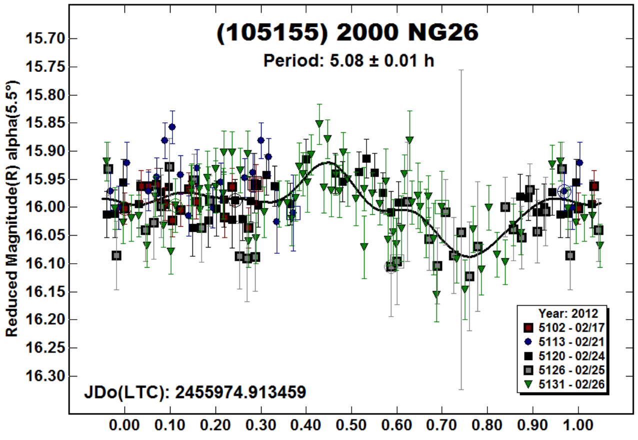

(57739) 2001 UF162
Period: 5.9 ± 0.5 h
Reduced Magnitude(V) alpha(6.4°)
15.00
15.10
15.20
15.30
15.40
15.50
15.60
15.70
15.80
JDo(LTC): 2455981.731918
Year: 2012
● 5121 - 02/24
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

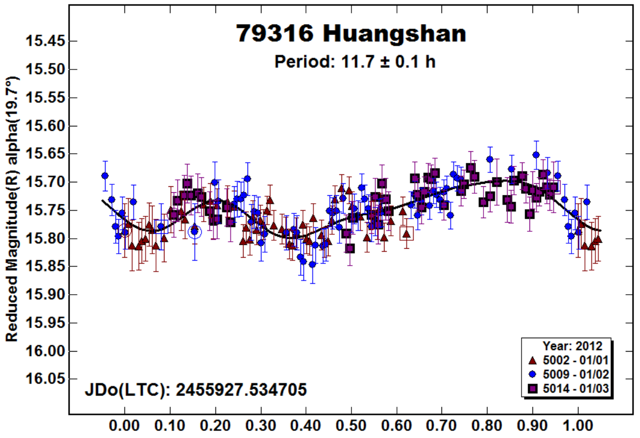

(82066) 2000 XG15
Period: 19.07 ± 0.06 h
Reduced Magnitude(V) alpha(23.7°)
16.15
16.20
16.25
16.30
16.35
16.40
16.45
16.50
16.55
16.60
16.65
16.70
16.75
JDo(LTC): 2455996.587130
Year: 2012
◆ 5156 - 03/10
◆ 5164 - 03/12
◆ 5172 - 03/13
▼ 5179 - 03/14
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


(63260) 2001 CN
Period: 8.76 ± 0.01 h
Reduced Magnitude(R) alpha(2.9°)
15.70
15.80
15.90
16.00
16.10
16.20
16.30
16.40
16.50
16.60
JDo(LTC): 2455954.652078
Year: 2012
✳ 5071 - 01/28
◆ 5076 - 01/29
● 5081 - 01/31
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


(82078) 2001 AH46
Period: 19.57 ± 0.02 h
Reduced Magnitude(V) alpha(12.9°)
15.55
15.60
15.65
15.70
15.75
15.80
15.85
15.90
15.95
16.00
16.05
16.10
JDo(LTC): 2455990.591967
Year: 2012
● 5137 - 03/04
+ 5141 - 03/05
● 5145 - 03/06
■ 5150 - 03/09
+ 5157 - 03/10
+ 5165 - 03/12
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


(69350) 1993 YP
Period: 32.34 ± 0.03 h
Reduced Magnitude(R) alpha(4.1°)
15.30
15.40
15.50
15.60
15.70
15.80
15.90
16.00
16.10
16.20
16.30
16.40
JDo(LTC): 2455967.619195
Year: 2012
▼ 5083 - 02/10
▲ 5090 - 02/15
▲ 5098 - 02/17
◆ 5108 - 02/19
■ 5112 - 02/21
+ 5117 - 02/24
+ 5125 - 02/25
▲ 5130 - 02/26
✳ 5135 - 03/04
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


(105155) 2000 NG26
Period: 5.08 ± 0.01 h
Reduced Magnitude(R) alpha(5.5°)
15.70
15.75
15.80
15.85
15.90
15.95
16.00
16.05
16.10
16.15
16.20
16.25
16.30
JDo(LTC): 2455974.913459
Year: 2012
■ 5102 - 02/17
● 5113 - 02/21
■ 5120 - 02/24
■ 5126 - 02/25
▼ 5131 - 02/26
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


79316 Huangshan
Period: 11.7 ± 0.1 h
Reduced Magnitude(R) alpha(19.7°)
15.45
15.50
15.55
15.60
15.65
15.70
15.75
15.80
15.85
15.90
15.95
16.00
16.05
JDo(LTC): 2455927.534705
Year: 2012
▲ 5002 - 01/01
● 5009 - 01/02
■ 5014 - 01/03
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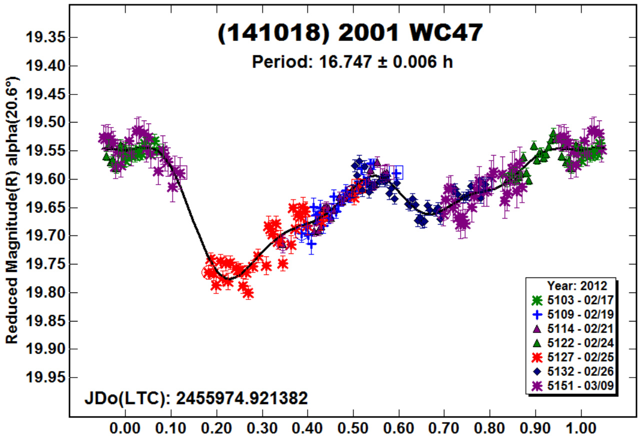
(141018) 2001 WC47
Period: 16.747 ± 0.006 h
Reduced Magnitude(R) alpha(20.6°)
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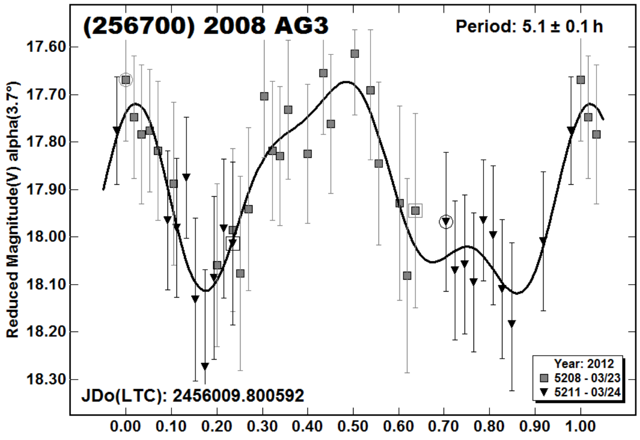
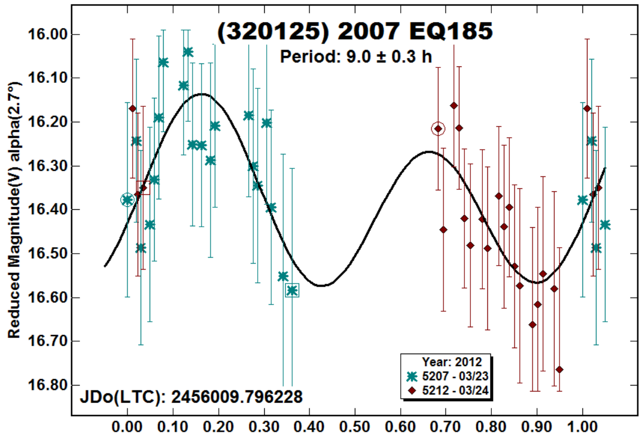
19.40
19.45
19.50
19.55
19.60
19.65
19.70
19.75
19.80
19.85
19.90
19.95
JDo(LTC): 2455974.921382
Year: 2012
✳ 5103 - 02/17
+ 5109 - 02/19
▲ 5114 - 02/21
▲ 5122 - 02/24
✳ 5127 - 02/25
◆ 5132 - 02/26
✳ 5151 - 03/09
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00





GENERAL REPORT OF POSITION OBSERVATIONS BY THE ALPO MINOR PLANETS SECTION FOR THE YEAR 2011

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Observations of positions of minor planets by members of the Minor Planets Section in calendar year 2011 are summarized.

During the year 2011 a total of 718 positions of 219 different minor planets were reported by members of the Minor Planets Section. Of these 30 are CCD images (denoted C), and all the rest are approximate visual positions.

The summary lists minor planets in numerical order, the observer and telescope aperture (in cm), UT dates of the observations, and the total number of observations in that period. The year is 2011 in each case.

Positional observations were contributed by the following observers:

Observer, Instrument	Location	Planets	Positions
Faure, Gerard 20 cm Celestron, 40 cm Meade LX20, 7x5cm binoculars	Col de l'Arzelier, France and environs	11	28
Harvey, G. Roger 74 cm Newtonian	Concord, North Carolina, USA	118	405
Hubbell, Jerry 20 cm RC+CCD 81 cm RC+CCD at Mt. Lemmon	Locust Grove, Virginia, USA and Mt. Lemmon Sky Center, Arizona, USA	8	30C
Hudgens, Ben 41 cm f/4.5 Dobsonian	Stephenville, Texas, USA	83	199
Pryal, Jim 20 cm f/10 SCT 12 cm f/8.33 refractor 15 cm f/5 Newtonan	Federal Way, WA USA and environs	7	17
Watson, William W. 20 cm Celestron	Tonawanda, NY USA and vicinity.	5	39

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2011)	NO. OBS.
4 Vesta	Faure, 5 Pryal, 20	Aug 4-7 Aug 26-27	3 2
44 Nysa	Pryal, 15	Feb 23-26	2
75 Eurydike	Harvey, 73	Dec 18	6
90 Antiope	Pryal, 20	Aug 28	2
192 Nausikaa	Pryal, 20	Aug 26-27	2
196 Philomela	Harvey, 73	Apr 3	3
220 Stephania	Pryal, 20	Aug 26-27	2
299 Thora	Harvey, 73	Jul 30	3
433 Eros	Watson, 20	Nov 24	2
444 Gyptis	Pryal, 20	Aug 26-27	2
449 Hamburga	Watson, 20	Feb 23-24	2
496 Gryphia	Faure, 40	Feb 9-10	2
503 Evelyn	Watson, 20	Feb 5-9	2
531 Zerlina	Hudgens, 41	Apr 28	2
577 Rhea	Hubbell, 20	Nov 25	3C
841 Arabella	Hudgens, 41	Oct 20-21	2
895 Helio	Hubbell, 20	Jul 2	5C
935 Clivia	Faure, 40	Feb 6	2
993 Moultona	Hudgens, 41	Apr 2	2
1025 Riema	Hudgens, 41	Jan 27	2
1026 Ingrid	Faure, 20 Hudgens, 41	Aug 27-28 Aug 27-Sep 1	3 3
1036 Ganymed	Hudgens, 41 Pryal, 20, 12 Watson, 20	Oct 19-21 Jul 30-Nov 6 Jun 2-Nov 24	4 5 30
1077 Campanula	Hudgens, 41	Sep 29-Oct 1	2
1124 Stroobantia	Hudgens, 41	Mar 10	2
1151 Ithaka	Hudgens, 41	Aug 27-Sep 1	3
1173 Anchises	Hudgens, 41	Jul 27	2
1176 Lucidor	Faure, 40	Feb 9-10	2
1192 Prisma	Hudgens, 41	Mar 9-10	2
1201 Strenua	Hudgens, 41	Oct 21	2
1238 Predappia	Hudgens, 41	May 6	2
1265 Schweikarda	Hudgens, 41	Oct 20-21	2
1286 Banachiewicza	Hudgens, 41	Jun 23-24	2
1288 Santa	Hudgens, 41	Jul 27	2

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2011)	NO. OBS.
1335 Demoulina	Hudgens, 41	Aug 27-Sep 1	3
1339 Desagneauxa	Hudgens, 41	Jun 30-Jul 1	2
1347 Patria	Hudgens, 41	Feb 25	2
1359 Prieska	Hudgens, 41	May 6-28	4
1361 Leuschneria	Hudgens, 41	Sep 29-Oct 1	2
1406 Komppa	Faure, 20	Aug 28	2
1413 Roucarie	Hudgens, 41	Mar 24	2
1430 Somalia	Hudgens, 41	Sep 6-24	3
1448 Lindbladia	Hudgens, 41	Jan 8-27	4
1455 Mitchella	Hudgens, 41	May 27-28	2
1517 Beograd	Faure, 20	Aug 28	2
1532 Inari	Hudgens, 41	Sep 29-Oct 1	2
1534 Nasi	Hudgens, 41	Jan 8-27	4
1536 Pielinen	Hudgens, 41	Oct 20-21	2
1568 Aisleen	Hudgens, 41	Sep 29-Oct 1	2
1573 Väisälä	Hudgens, 41	Oct 20-21	2
1574 Meyer	Faure, 20	Aug 27	2
1577 Reiss	Hudgens, 41	Oct 21	2
1592 Mathieu	Hudgens, 41	Jun 30-Jul 1	2
1593 Fagnes	Hudgens, 41	Sep 29-Oct 1	2
1614 Goldschmidt	Hudgens, 41	Sep 29-Oct 1	2
1618 Dawn	Hudgens, 41	Jun 24-25	2
1637 Swings	Hudgens, 41	Sep 6-24	3
1688 Wilkens	Hudgens, 41	Jun 25-26	2
1718 Namibia	Harvey, 73	Jul 27	3
	Hudgens, 41	Jul 27	2
1721 Wells	Hudgens, 41	Feb 25	2
1758 Naantali	Hudgens, 41	Jun 24-25	2
1759 Kienle	Hudgens, 41	Sep 6-24	3
1764 Cogshall	Hudgens, 41	Jun 24-25	2
1768 Appenzella	Hudgens, 41	Sep 29-Oct 1	2
1769 Carlostorres	Hudgens, 41	Sep 26-Oct 1	3
1779 Paraná	Hudgens, 41	Jun 30-Jul 1	2
1786 Raahe	Hudgens, 41	Oct 20-21	2
1816 Liberia	Hudgens, 41	Jan 8-27	4
1820 Lohmann	Hudgens, 41	Sep 6-24	3
1844 Susilva	Hudgens, 41	Feb 25	2
1855 Korolev	Hudgens, 41	Jan 8	2
1896 Beer	Hudgens, 41	Oct 20-21	2
1938 Lausanna	Hudgens, 41	Jun 23-24	3
1959 Karbyshev	Hudgens, 41	Sep 29-Oct 1	2
1965 van de Kamp	Hudgens, 41	Jan 8-28	4
1977 Shura	Hudgens, 41	Jun 30-Jul 1	2
1986 Plaut	Hudgens, 41	Sep 24	2
1991 Darwin	Hudgens, 41	Jun 30-Jul 1	2
2008 Konstitutsiya	Hudgens, 41	Apr 28	2
2017 Wesson	Hudgens, 41	Jul 27	2
2041 Lancelot	Harvey, 73	Dec 19	3
2143 Jimarnold	Harvey, 73	Nov 6	3
2214 Carol	Harvey, 73	Sep 29	3
2410 Morrison	Hudgens, 41	Apr 28	2
2438 Oleshko	Hudgens, 41	Apr 28	2
2709 Sagan	Hudgens, 41	Feb 8	2
2746 Hissao	Harvey, 73	Jan 29	3
2802 Weisell	Hudgens, 41	Mar 24	2
2844 Hess	Hudgens, 41	Jul 6-7	2
2975 Spahr	Hudgens, 41	May 6	2
3080 Moisseiev	Hudgens, 41	Oct 21	2
3084 Kondratyuk	Harvey, 73	Jul 2	3
3122 Florence	Harvey, 73	Jan 8	3
3127 Bagration	Hubbell, 20	Nov 25	3C
3151 Talbot	Harvey, 73	Jun 5	3
3185 Clintford	Harvey, 73	Oct 3	3
3384 Daliya	Harvey, 73	Oct 30	3
3385 Bronnia	Hudgens, 41	Apr 28	2
3434 Hurless	Harvey, 73	Oct 30	3
3470 Yaronika	Harvey, 73	Feb 26	3
3509 Sanshui	Faure, 20	Aug 27	2
	Harvey, 73	Aug 24	3
3541 Graham	Harvey, 73	Apr 3	3
3554 Amun	Hudgens, 41	Mar 9-10	2
3636 Pajdušáková	Harvey, 73	Feb 26	3
3759 Piironen	Harvey, 73	Jan 8	3
4023 Jarník	Harvey, 73	Oct 30	3
4072 Yayoi	Harvey, 73	Mar 25	3
4090 Říšehvězd	Hudgens, 41	Jun 24-25	2
4175 Billbaum	Hudgens, 41	Mar 9-10	2
4213 Njord	Harvey, 73	Jan 9	3
4278 Harvey	Faure, 40	Feb 10	2
4284 Kaho	Hudgens, 41	Jun 30-Jul 1	2
4317 Garibaldi	Harvey, 73	Jan 9	3
4439 Muroto	Harvey, 73	Nov 25	3
4597 Consolmagno	Harvey, 73	Apr 30	3
4615 Zinner	Harvey, 73	Sep 29-Oct 1	2
4681 Ermak	Harvey, 73	Oct 30	3
4798 Mercator	Harvey, 73	Apr 30	3
4817 1984 DC1	Harvey, 73	Oct 2	3
5008 Miyazawakenji	Harvey, 73	Apr 3	3
5064 Tanchozuru	Harvey, 73	Jul 30	3
5069 Tokeidai	Harvey, 73	Jun 26	3
5168 Jenner	Harvey, 73	Feb 6	3
	Hudgens, 41	Feb 25	2
5181 SURF	Harvey, 73	Jan 30	3
5245 Maslyakov	Harvey, 73	Apr 25	3
5287 Heishu	Harvey, 73	Nov 19	3
5357 1992 EL	Hubbell, 20	Nov 25	3C
5364 1980 RC1	Harvey, 73	Sep 19	3
5438 Lorre	Hudgens, 41	Jan 27	2
5506 1987 SV11	Harvey, 73	Jan 29	3

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2011)	NO. OBS.
5510 1988 RF7	Harvey, 73	Nov 25	3
5553 Chodas	Harvey, 73	Feb 12	3
5666 Rabelais	Harvey, 73	Jan 29	3
5682 Beresford	Hudgens, 41	Oct 21	2
5802 1984 HL1	Harvey, 73	Jan 8	3
6172 Prokofeana	Harvey, 73	Nov 24	6
6528 Boden	Harvey, 73	Sep 29	3
6613 Williamcarl	Hubbell, 20	Jul 2	3C
6701 Warhol	Harvey, 73	Aug 23	3
6787 1991 PF15	Harvey, 73	Aug 23	3
6827 Wombat	Harvey, 73	Oct 30	3
6858 1990 ST10	Harvey, 73	Oct 22	3
6921 Janejacobs	Harvey, 73	Oct 2	3
7143 Haramura	Harvey, 73	Oct 2	3
7197 Pieroangela	Harvey, 73	Feb 12	3
7579 1990 TN1	Harvey, 73	Jan 9	3
7750 McEwen	Harvey, 73	Aug 23	3
7779 Susanring	Harvey, 73	Apr 3	3
7865 Françoisgros	Harvey, 73	Nov 19-25	3
8073 Johnharmon	Harvey, 73	Jan 9	3
8348 Bhattacharyya	Harvey, 73	Jan 9	3
8402 1994 GH9	Harvey, 73	Apr 3	3
8487 1989 SQ	Harvey, 73	Oct 30	3
8513 1991 PK11	Harvey, 73	Jan 9	3
8609 Shuvalov	Harvey, 73	Dec 18	3
8813 Leviathan	Harvey, 73	Oct 30	3
9033 Kawane	Harvey, 73	Nov 25	3
9417 1995 WU	Harvey, 73	Feb 26	3
9851 Sakamoto	Harvey, 73	Nov 19	6
10303 Fréret	Harvey, 73	Aug 23	3
10317 1990 SA15	Harvey, 73	Nov 25	3
10400 Hakkaisan	Harvey, 73	Oct 2	3
10586 Jansteen	Harvey, 73	Oct 2	3
10911 1997 YC1	Harvey, 73	Oct 5	3
10940 1990 CE52	Harvey, 73	Nov 19	3
11885 Summanus	Harvey, 73	Mar 25	6
12693 1989 EZ	Harvey, 73	Oct 3	3
12853 1998 FZ97	Harvey, 73	Jul 2	3
12877 1998 QF11	Harvey, 73	Jan 30	3
13519 1990 VM3	Harvey, 73	Nov 26	3
14335 Alexosipov	Harvey, 73	Sep 19	3
14510 1996 ES2	Harvey, 73	Aug 23	3
14912 1993 RP3	Harvey, 73	Dec 18	3
15040 1998 XC	Harvey, 73	Sep 29	3
15071 Hallerstein	Harvey, 73	Jan 8	3
15243 1989 TU1	Harvey, 73	Dec 18	3
15318 Innsbruck	Harvey, 73	Jun 5	3
15562 2000 GF48	Harvey, 73	Apr 3	3
16182 2000 AH137	Hudgens, 41	Aug 27-Sep 1	3
16666 Liroma	Harvey, 73	Oct 30	3
18595 1998 BR1	Harvey, 73	Oct 2	3
18813 1999 KA15	Harvey, 73	Apr 25	3
19763 Klimesh	Harvey, 73	Aug 23	3
20391 1998 KT55	Harvey, 73	Jun 5	3
20607 Vernazza	Harvey, 73	Jan 29	3
20932 2258 T-1	Harvey, 73	Sep 30	3
	Hudgens, 41	Oct 20-21	2
22128 2000 SH242	Harvey, 73	Mar 25	3
23143 2000 AZ177	Hudgens, 41	Jul 27	2
23200 2000 SH3	Harvey, 73	Oct 22	3
	Hudgens, 41	Oct 21	2
24260 Kriváň	Harvey, 73	Nov 25	3
24475 2000 VN2	Harvey, 73	Nov 24	6
24683 1990 DV3	Harvey, 73	Feb 27	6
24694 1990 SZ2	Harvey, 73	Oct 2	3
24808 1994 FN1	Harvey, 73	Oct 23	3
26206 1997 PJ4	Harvey, 73	Nov 25	3
27708 1987 WP	Hudgens, 41	May 6-28	4
29292 Conniewalker	Harvey, 73	Jun 5	3
29515 1997 YL7	Harvey, 73	Jan 8	3
44262 1998 QR51	Harvey, 73	Feb 6	3
44892 1999 VJ8	Harvey, 73	Sep 29	3
52266 Van Flandern	Harvey, 73	Jan 29	3
55927 1998 FN60	Hubbell, 81	Nov 23	3C
59402 1999 FR32	Harvey, 73	Oct 2	3
62128 2000 SO1	Harvey, 73	Oct 1-2	3
68134 2001 AT18	Harvey, 73	Jan 8	3
68348 2001 LO7	Harvey, 73	Jun 26	6
	Hubbell, 20	Jul 2	7C
85953 1999 FK21	Harvey, 73	Mar 25	6
96487 1998 JU1	Harvey, 73	Nov 6	6
99913 1997 CZ5	Harvey, 73	Jan 9	6
	Hudgens, 41	Jan 27	2
105106 2000 LS14	Harvey, 73	Aug 23	3
134340 Pluto	Hudgens, 41	Jun 24-25	2
136472 Makemake	Faure, 40	Feb 6	2
138524 2000 OJ8	Harvey, 73	Sep 19	6
188349 2003 ST9	Harvey, 73	Nov 24	3
215738 2004 DN49	Hubbell, 81	Nov 23	3C
253841 2003 YG118	Harvey, 73	Feb 11	6
267494 2002 JB9	Harvey, 73	May 29-30	12
276741 2004 EM66	Harvey, 73	Apr 30	3
308635 2005 YU55	Hudgens, 41	Nov 9	10
	Watson, 20	Nov 9	3
2011 EZ78	Harvey, 73	Jun 26	6
2011 GP59	Harvey, 73	Apr 15	6

PERIOD DETERMINATION FOR NEA (162421) 2000 ET70

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Lightcurve analysis for (162421) 2000 ET70 was performed in collaboration with observers in Uruguay, Australia, and the United States from observations obtained during the asteroid's favorable opposition in 2012. The synodic rotation period was found to be 8.947 ± 0.001 h and the lightcurve amplitude was 0.60 ± 0.07 mag.

The Aten type near-Earth asteroid, (162421) 2000 ET70, with no previously reported lightcurve parameters, was selected from the potential lightcurve opportunities listed in the *Minor Planet Bulletin* (Warner *et al*. 2012) as a particularly favorable target for observation. At widely spaced locations, Alvarez, Oey and Han worked on this target independently from each other.

Unfiltered CCD photometric images of (162421) 2000 ET70 were taken by Alvarez at Observatorio Los Algarrobos, Salto, Uruguay (MPC I38), Oey at Kingsgrove Observatory, Australia (MPC E19) and Han and collaborators at Kitt Peak, USA (MPC 695) from 2012 February 19 to 24. Observing dates are summarized in Table I while technical specifications are described in Table II. Additional information about the instruments can be found on previous reports from Alvarez (2012) and Oey (2011).

All images were dark and flat field corrected and then measured using *MPO Canopus* v10 (Bdw Publishing), applying a differential photometry technique. The data were light-time corrected. Period analysis was also done with *MPO Canopus*, which incorporates the Fourier analysis algorithm developed by Harris (Harris *et al.* 1989).

Due to the asteroid's fast motion, all observations had to be broken into several "sessions", where a session was defined to be those data referenced against a given set of comparison stars in the same field as the asteroid. About 4,800 data points were obtained during 7 observing runs, resulting in a total of 65 sessions. Each observing run was longer than 5 hours, giving a total of more than 42 hours of observations. Over the span of observations, the phase angle varied from 40.7º to 45.4º. Analysis of the data found a rotation period for (162421) 2000 ET70 of P = 8.947 ± 0.001 h along with a peak-to-peak amplitude of A = 0.60 ± 0.07 mag.

References

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Oey, J. (2011). "Lightcurve Analysis of Asteroids from Leura and Kingsgrove Observatory for the Second Half of 2009 and 2010." *Minor Planet Bulletin* **38**, 221-223.

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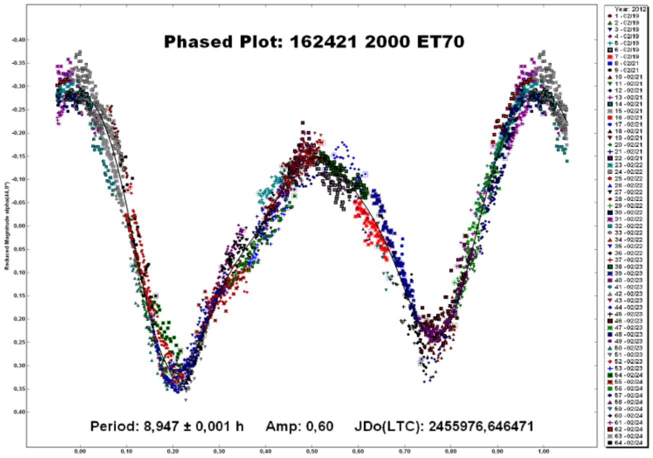

Obs	Date Obs 2012	Sess	Session numbers
Alvarez	02/19, 22, 23	19	1-7, 8-13, 22-27
Oey	02/22, 23, 24	31	14-21, 28-39, 40-50
Han	02/24	15	51-65

Table I. Corresponding observing sessions by authors

Observer	Observatory (MPC)	Telescope	Image scale
	Location	Camera	Exposure
Alvarez	OLASU (I38)	0.30 m SCT	1.77 "/px
	Salto, Uruguay	QSI 516wsg	30 sec
Oey	Kingsgrove (E19)	0.25 m SCT	1.45 "/px
	NSW, Australia	SBIG ST-9XE	30 sec
Han	Kitt Peak (695)	0.90 m R-C	0.77 "/px
	Arizona, USA	Apogee Alta U6	20 sec

Table II. Equipment specifications

ROTATION PERIOD DETERMINATIONS FOR 46 HESTIA, 223 ROSA, 225 HENRIETTA, 266 ALINE, 750 OSKAR, AND 765 MATTIACA

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Synodic rotation periods and amplitudes have been found for 46 Hestia, 21.040 ± 0.001 h, 0.12 ± 0.01 mag; 223 Rosa, 20.283 ± 0.002 h, 0.13 ± 0.02 mag; 225 Henrietta, 7.3556 ± 0.0001 h, 0.20 ± 0.02 mag; 266 Aline, 13.018 ± 0.001 h, 0.10 ± 0.01 mag; 750 Oskar, 6.2584 ± 0.0002 h, 0.21 ± 0.02 mag; and 765 Mattiaca, 3.4640 ± 0.0001 h, 0.09 ± 0.01 mag with an irregular lightcurve.

All observations published here were made at the Organ Mesa Observatory. Equipment consists of a Meade 0.35-m LX-200 GPS Schmidt-Cassegrain and SBIG STL-1001-E CCD. Exposures used a clear filter and were unguided. Differential photometry was used to find the instrumental values for the target, i.e., they were not put onto a standard system. Image measurement and lightcurve analysis were done with *MPO Canopus*. Because of the large number of data points, the data for the lightcurves presented here have been binned in sets of three points with a maximum time interval between any two points no greater than 5 minutes. In all cases, full or at least nearly-full phase coverage was obtained for the double period. When phased to the double period the two halves of the lightcurve looked the same within variations to be expected from observational error or changing phase angle. The probability of the double period being the correct one is extremely small and I rejected all double period solutions.

46 Hestia. This was the lowest numbered minor planet for which only one set of lightcurve observations is shown in the Asteroid Lightcurve Data Base (Warner *et. al.* 2011). These were from Scaltriti *et. al.* (1981), who observed from 1978 Oct 24 to Nov 12 (ecliptic longitude 63 degrees and latitude –4 degrees) and found a period of 21.04 hours for a bimodal lightcurve with unequal minima of depths 0.06 and 0.12 magnitudes. Although this period is considered secure, it seemed productive to obtain the first photometric data set for more than 30 years on this object. Analysis of the new data from ten nights, 2012 Jan 27 – Apr 13, near ecliptic longitude 154 degrees, latitude –2 degrees, is in excellent agreement. It shows a rotation period of 21.040 ± 0.001 h with unequal minima of depths 0.05 and 0.12 magnitudes, both ± 0.01 mag. That the two lightcurves are nearly identical suggests that they were obtained at nearly equal *viewing aspects* (the direction of the asteroid spin axis versus line-of-sight). The rotational pole therefore may lie within a few degrees of the great circle with longitude/latitude points of (0°,+90°), (109°,0°), (0°,–90°), and (289°,0°).

223 Rosa. The only previous period determination is by Warner (2007) who plotted a lightcurve with period 9.91 h and one maximum and minimum per cycle. He also noted the possibility of a solution at 19.83 h when assuming a bimodal lightcurve. Analysis of new observations on eight nights, 2011 Dec 31 – 2012 Feb 11, shows a period of 20.283 ± 0.002 h, amplitude 0.13 ± 0.02 mag with two asymmetric maxima and minima per cycle. The period near 9.91 hours is ruled out.

225 Henrietta. Previous period determinations were made by Zappala *et al.* (1989; 8.04 h), Weidenschillling *et al.* (1990; 8.75 h), Michalowski *et al.* (2000; 7.356 h), and Chiorny *et al.* (2007; 7.360 h). Analysis of new observations on eight nights, 2012 Feb 15 – Mar 25, shows a period of 7.3556 ± 0.0001 h, amplitude 0.20 ± 0.02 mag. This is in agreement with Michalowski *et al.* (2000) and Chiorny *et al.* (2007) and rules out the other two determinations.

266 Aline. Denchev *et al.* (1998) obtained a sparse lightcurve from which they interpreted a 12.3-hour period. Pilcher and Benishek (2011) obtained a dense, nearly sinusoidal lightcurve. They plotted their data both with one maximum and minimum per cycle with a period of 13.011 h and with two symmetric maxima and minima per cycle with a period 26.023 h, amplitude 0.07 mag, and preferred the 13.011-hour period. Analysis of new observations on eight nights, 2011 Dec 18 – 2012 Jan 19, showed that the shorter period is the correct one, finding a period of 13.018 ± 0.001 h, amplitude 0.10 ± 0.01 mag with two asymmetric maxima and minima per cycle.

750 Oskar. Previous period determinations are by Behrend (2012, 6.247 h, based on observations in 2003) and Durkee (2011; 6.47 h). Analysis of new observations on five nights, 2012 Feb 21 – Mar 23, shows a period of 6.2584 ± 0.0002 h, amplitude 0.21 ± 0.02 mag. This is consistent with, and improves upon, the previous determinations.

765 Mattiaca. The Asteroid Lightcurve Data Base (Warner *et al.* 2011) shows no previous observations. Analysis of new observations on five nights, 2011 Dec 25 – 2012 Jan 30, shows an irregular lightcurve with rotation period 3.4640 ± 0.0001 h, amplitude 0.09 ± 0.01 mag.

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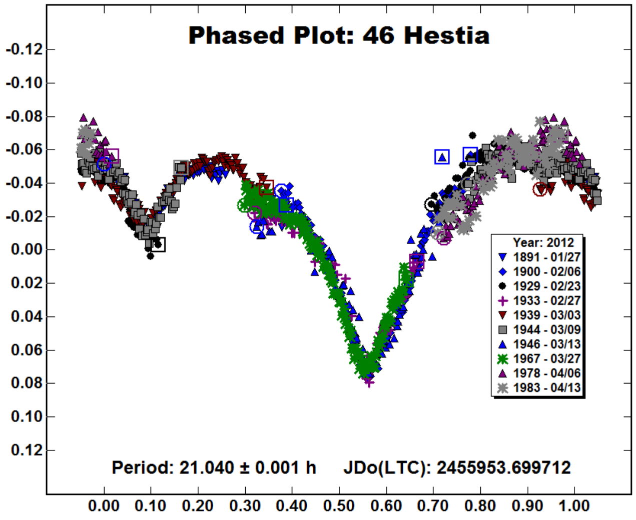

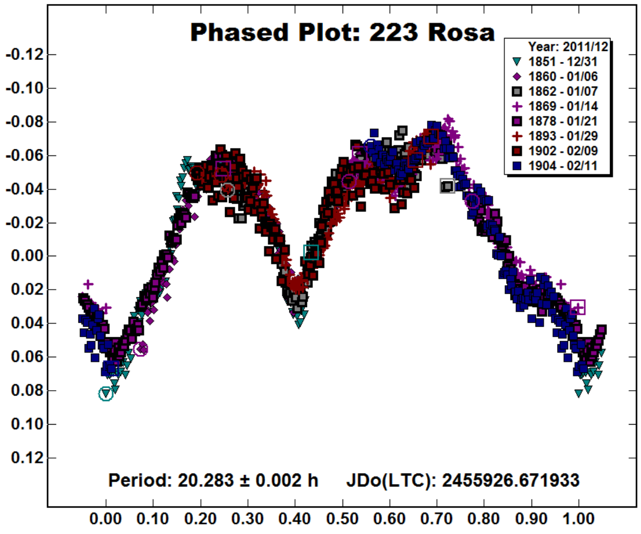

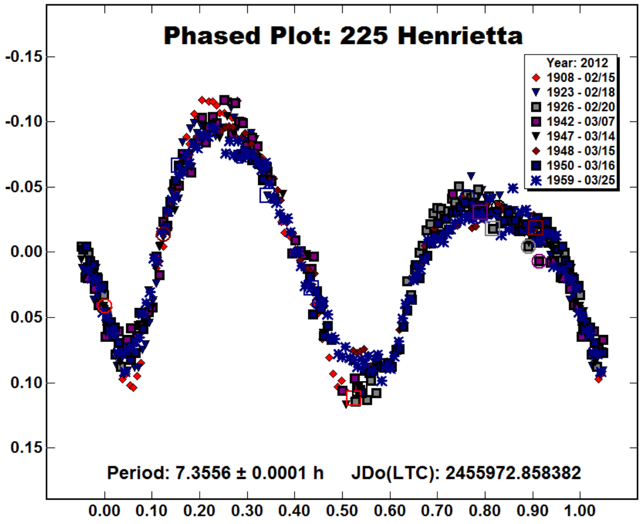

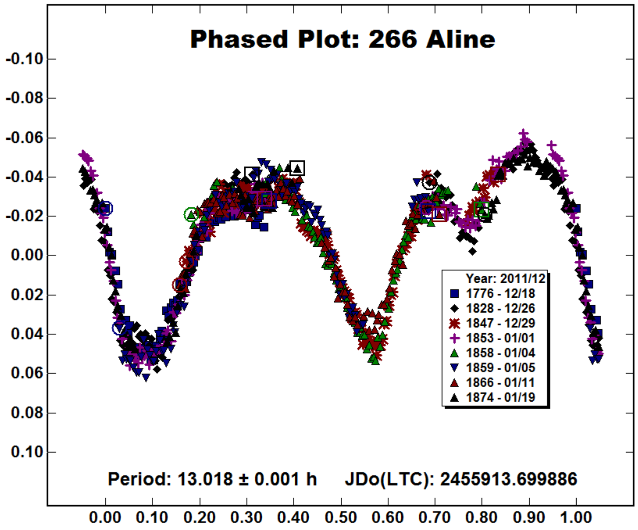

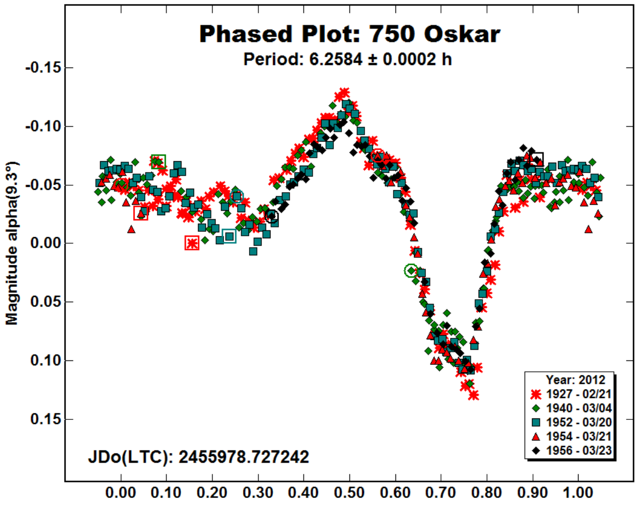

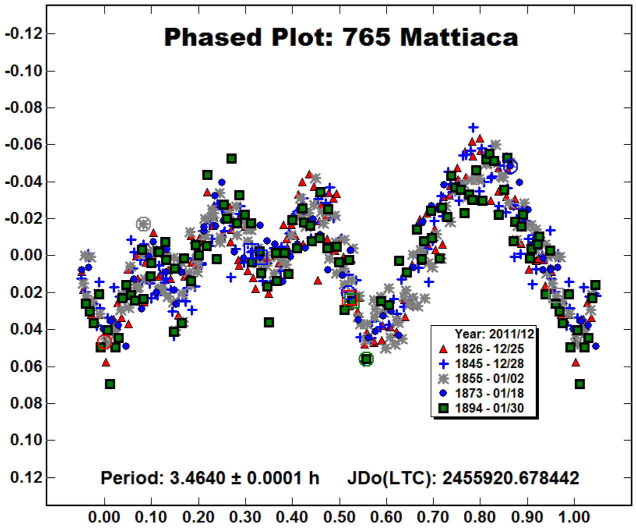

A SHAPE MODEL OF THE TAXONOMIC A-CLASS ASTEROID 446 AETERNITAS

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We acquired dense rotational lightcurves for the taxonomic A-class asteroid 446 Aeternitas during three apparitions in 2006, 2007-2008, and 2009. Our results show that 446 Aeternitas is a prograde rotator, has a distinct angular shape, and is moderately elongated. Several planar areas in the convex shape model suggest concavities, possibly large craters or saddles. These features suggest that 446 Aeternitas is likely to be a collisional fragment. We found a pole solution of β = +52º, λ = 356º with no mirror solution apparent. However, low chi-square pole solutions centered on ecliptic longitude λ = 210º cannot be ruled out, leaving the ecliptic longitude of 446 Aeternitas unconstrained. Lightcurves measured over three asteroid apparitions were used during the inversion process to determine a refined rotational period of 15.73743 ± 0.00005 h. Typical errors for ecliptic latitude and longitude values are ± 10 degrees.

The taxonomic A-class asteroids are thought to represent olivine-rich mantle remnants (Reddy et al., 2005), or possibly core-mantle boundary fragments of shattered protoplanetary bodies from the early solar system (Cruikshank and Hartmann, 1984; Gaffey et al., 2002). If so, it is reasonable to expect they should be relatively abundant among the asteroid population. However, A-class objects are extremely rare. Overall, the A-class asteroids represent <1% of the total number of individual spectrally surveyed asteroids (17 out of ~2150) from the four major asteroid taxonomic surveys conducted during the last three decades. The apparent scarcity of these objects poses a significant paradox for our understanding of asteroid evolution (Xu et al., 1995) and for studies of the dynamical evolution of the early solar system (Bottke et al., 2006).

The main-belt asteroid 446 Aeternitas was discovered on 1899 October 27 by M.F. Wolf and A. Schwassmann at Heidelberg. Chruikshank and Hartmann (1984) were the first to suggest a meteorite/parent-body connection for the A-class asteroids, linking near-infrared (NIR) spectra of two A-type objects with the pure olivine assemblage of the brachinite meteorites or the olivine/iron-alloy pallasite meteorite group. Lucey and Keil (1998) compared NIR spectra of 446 Aeternitas and three other A-types to olivine samples from the U.S. Geological Survey spectral library, and concluded that the olivine silicate assemblage for A-class objects is solely represented in the meteorite collections by pallasite meteorites. Sunshine et al. (2007) analyzed nine olivine-rich asteroid NIR spectra (including Aeternitas) and concluded that the majority (7 out of 9) are forsteritic olivine and therefore sample differentiated mantle sources from melted ordinary chondritic material (e.g. pallasites).

In order for mantle material to be exposed, the parent body must be fragmented or its deep interior exposed by large impacts (Reddy et al., 2005). Therefore, we are interested in resolving the shapes of the known A-class asteroids in order to determine if their morphology is consistent with collisionally-derived fragments.

The Lightcurves: 446 Aeternitas has previously reported rotational periods of 15.85 ± 0.01 h (Florczak et al., 1997), 15.736 ± 0.001 h (Fauerbach et al., 2008 – Figure 1), 15.740 ± 0.003 h (Lucas et al., 2011 – Figure 2), and 15.7413 ± 0.0004 h (Behrend, 2011). The three most recently derived periods are in excellent agreement and compare well with our previously unpublished lightcurve of 446 Aeternitas from the 2007-2008 apparition (Figure 3), which yielded a period of 15.7405 ± 0.0005 h.

The Model: Dense photometric observations of 446 Aeternitas were acquired over three apparitions in 2006, 2007-2008, and 2009 (Table I) at the Evelyn L. Egan Observatory (MPC code H72) on the campus of Florida Gulf Coast University, Fort Myers, Florida. Lightcurve analyses were performed using MPO Canopus v.10.3 to produce 28 individual lightcurve data sets, these data were then inverted using the Kaasalainen code (Kaasalainen et al., 2001a; 2001b) in the LCInvert v.2.3 processing software. A period search function was performed in LCInvert, starting with the synodic periods derived from the 2006–2009 lightcurves, to yield a sidereal rotational period for the asteroid. This period was input as a “free” parameter in the “Medium” (50 iterations each of 264 test orientations in 15º increments of β and λ) pole-search function using discrete, fixed longitude-latitude pairs, which generated an initial ecliptic latitude β and longitude λ best-fit pole solution (Figure 4).

The results of this initial pole search are shown in Figure 4. Dark blue indicates the lowest values of log(chi-square) in the range of possible pole solutions. Colors progress toward bright red with increasing log(chi-square) with the highest value indicated by maroon (dark red). An initial pole solution centered near ecliptic latitude β = +45˚ and longitude λ = 0º is apparent, however low log(chi-square) values centered near β = +60˚ and λ = 210º cannot be ruled out as a possible pole solution (Figure 4).

The most probable solution centered near β = +45˚ and λ = 0˚ was then refined by running the pole search function again, allowing the preliminary pole solution as well as the sidereal rotational period to be free parameters in 50 more iterations. The iteration that produces the lowest relative standard deviation and chi-square value is the most probable solution of the pole orientation and convex hull shape model of the asteroid. Figure 5 shows the phase angle bisector (PAB) longitude plot for the dense lightcurve data used in the modeling. The PAB longitude coverage could be improved with more data, as such we inverted two separate shape models that included a sparse set of USNO Flagstaff data (173 photometric data points). These iterations greatly improved the PAB longitude coverage, however, the chi-square values (~4.2) for both models yielded unacceptable results, and therefore only the dense lightcurve data was used in the final model.

Our results show that the A-class asteroid 446 Aeternitas is a prograde rotator, has a distinct angular shape, and is moderately elongated (Figures 6 and 7). Several planar areas in the convex shape model suggest concavities, possibly large craters or saddles. These features suggest that 446 Aeternitas is more likely to be a collisional fragment than an intact object. The solution for the pole orientation of β = +52º, λ = 356º (Figure 7 and Table II) stood out from 264 trial solutions with no mirror pole solution apparent. However, low chi-square pole solutions centered on ecliptic longitude λ = 210º cannot be ruled out, leaving the ecliptic longitude of 446 Aeternitas unconstrained (Figure 4). Twenty-eight input lightcurves measured over three asteroid apparitions were used during the inversion process to determine a refined rotational period of 15.73743 ± 0.00005 h (Table II).

As a test of the robustness of the convex shape obtained for the asteroid, actual lightcurve sets were compared to the synthetic model lightcurve (based on a reference time and geometry). The lightcurve fits obtained matched the synthetic lightcurves very closely (Figure 8). Typical errors for ecliptic latitude and longitude values using robust photometric data are ± 10º for this method; this error estimate is based on comparisons with in situ spacecraft exploration of asteroids and from laboratory experimental data (Kaasalainen et al., 2005).

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Table I. Observational circumstances for 446 Aeternitas over three apparitions, a total of 1787 data points were used in the lightcurve inversion technique to produce the shape model of the asteroid; λ_{pab} = ecliptic longitude phase angle bisector, β_{pab} = ecliptic latitude phase angle bisector.

Asteroid	**Date Range**	**Data Points**	**Phase**	λ_{pab}	β_{pab}	**V (mag)**
446 Aeternitas	2009 04 23 to 2009 04 29	397	10.3 to 12.1	186.4 to 186.5	6.6 to 6.3	13.5 to 13.7
446 Aeternitas	2007 12 13 to 2008 05 03	988	11.6 to 17.6	111.5 to 121.5	11.4 to 10.4	13.8 to 14.9
446 Aeternitas	2006 10 26 to 2006 11 19	402	6.8 to 15.3	18.6 to 19.9	-4.8 to -3.3	12.5 to 13.1

Table II. Parameters for the derived shape model of 446 Aeternitas.

Asteroid	**β**	**λ**	**Per. (h)**	**Obs. Years**	**Phase Range**	N_{lc}	χ^2	**rms Δ (mag)**
446 Aeternitas	+52º	356º	15.73743	2006-09	6.8º-17.6º	28	0.3126	0.0134

β and **λ** are the ecliptic latitude and longitude of the pole
Obs. Years - the length of time the observations span
N_{lc} denotes the number of lightcurves used
χ^2 denotes the chi-square value of the model fit
rms Δ - the rms deviation of the model fit

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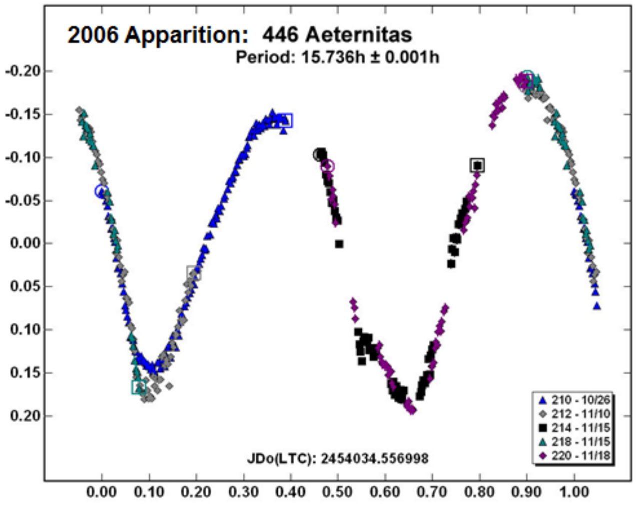

Figure 1. Lightcurve of 446 Aeternitas from the 2006 apparition (Fauerbach et al., 2008).

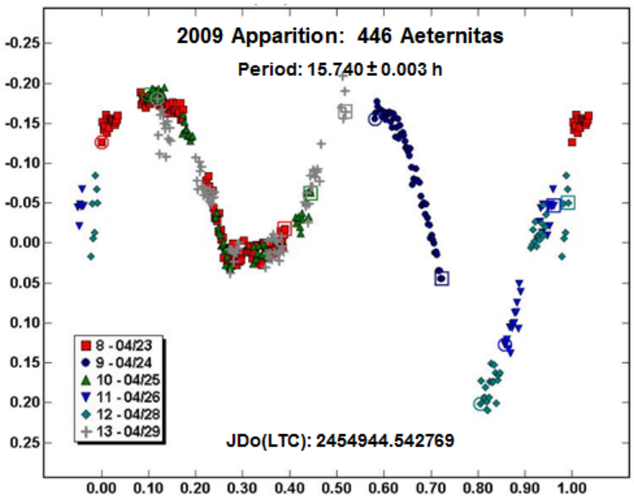

Figure 2. Lightcurve of 446 Aeternitas from the 2009 apparition (Lucas et al., 2011).

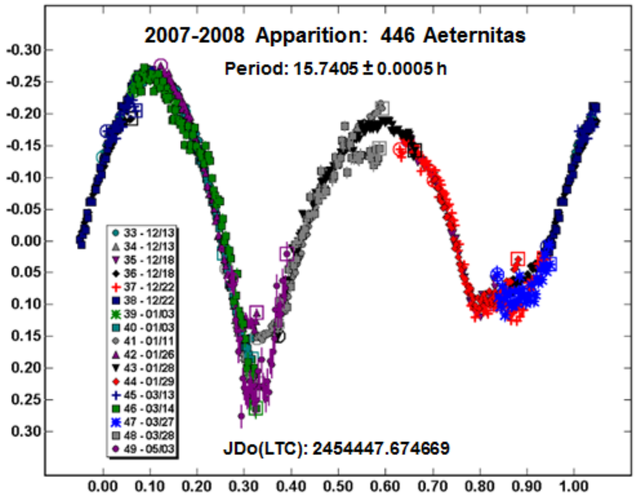

Figure 3. Previously unpublished lightcurve of 446 Aeternitas from the 2007-2008 apparition.

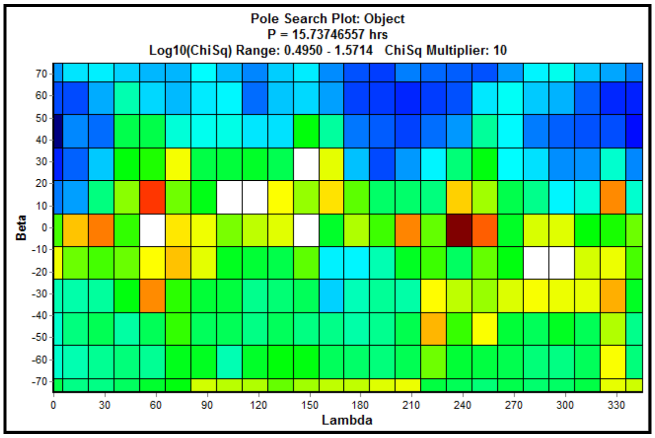

Figure 4. Plot of the log chi-square values obtained from the initial pole-search function. Dark blue represents the lowest chi-square value.

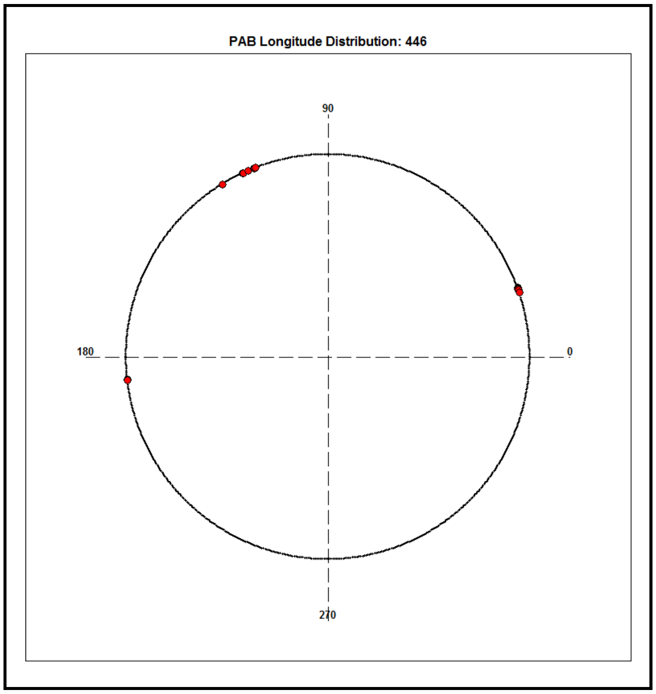

Figure 5. PAB longitude distribution of the dense lightcurve data (red circles) used in the model.

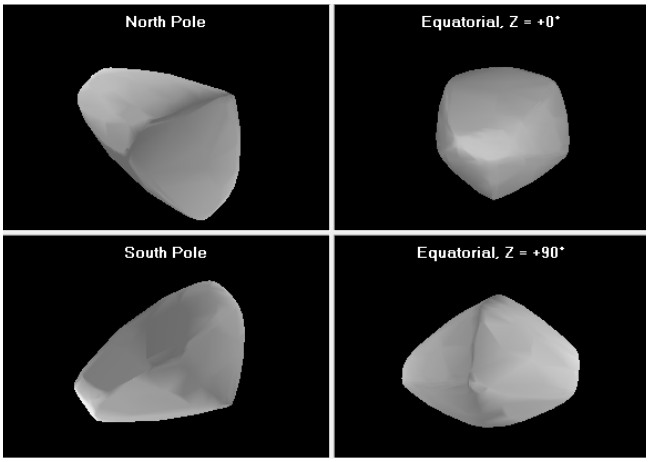

Figure 6. The shape model of 446 Aeternitas with the lowest chi-square value, the IRAS determined diameter of Aeternitas is 45.4 km for scale.

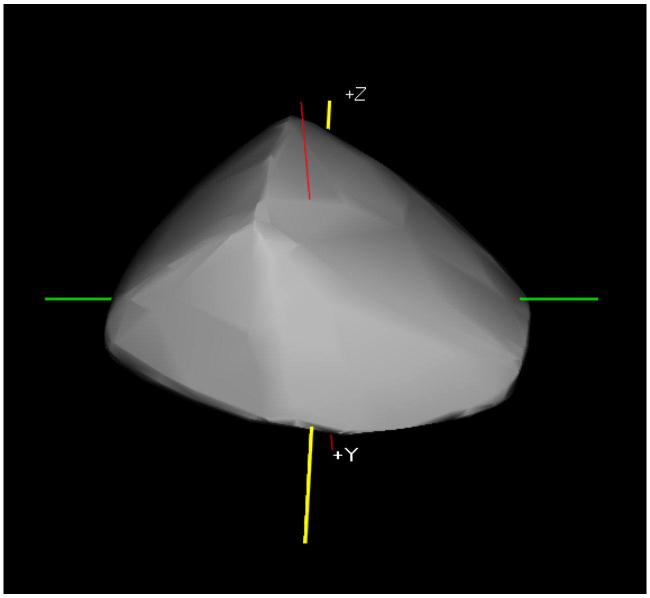

Figure 7. Shape model of 446 Aeternitas shown in ecliptic view with pole solution (z-axis) of β = +52°, λ = 356° indicated. In this view the observer and asteroid are on the ecliptic plane (asteroid on ascending or descending node of orbit) with phase angle of 0°. The IRAS determined diameter of Aeternitas is 45.4 km for scale.

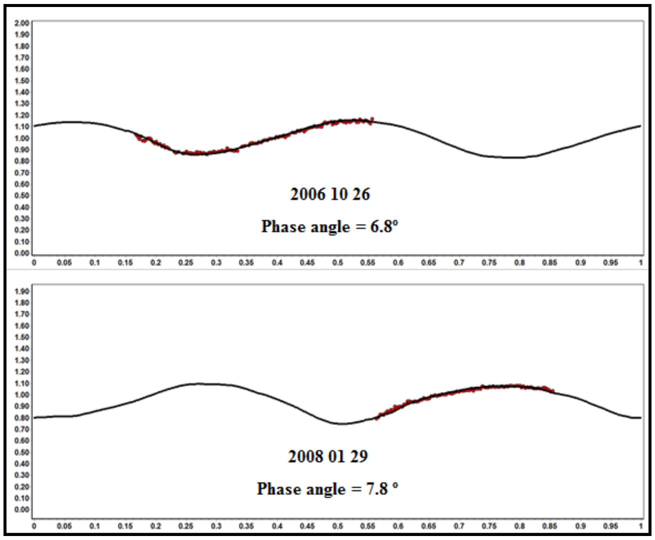

Figure 8. Lightcurve fits for measured photometric lightcurves (red dots) compared to the synthetic model lightcurve (black curves) for two observation dates, 2006 10 26 and 2008 01 29.

LIGHTCURVE ANALYSIS FOR EIGHT MINOR PLANETS AT BASSANO BRESCIANO OBSERVATORY

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Lightcurves for eight minor planets were obtained at Bassano Bresciano Observatory from 2011 September to 2012 March: 1028 Lydina, 1430 Somalia, 3397 Leyla, 4350 Shibecha, 8345 Ulmerspatz, (16959) 1998 QE17, (27111) 1998 VV34, and (28913) 2000 OT.

Photometric measurements of eight minor planets were obtained at Bassano Bresciano Observatory (565) using the 0.32-m *f*/3.1 Schmidt and Starlight HX-516 CCD camera at prime focus. The camera was binned 2x2, giving a scale of 3.05 arcsec/pixel. Exposure times for the unfiltered, unguided images were 120 s. All exposures were taken when the target's altitude was more than 30°. *Polypus* software (Bassano Bresciano Observatory, 2010) was used to control the robotic observations. All raw images were processed with flat field and dark frames. *MPO Canopus* (Bdw Publishing, 2010) was used to perform differential photometry on the reduced images. Only solar-coloured comparison stars were used in order to minimize colour difference errors by using the Comp Star Selector in *MPO Canopus*. Data were light-time corrected but not reduced to standard magnitudes. The periods reported here were based on those having the lowest RMS error. Night-to-night calibration was done by adjusting the DeltaComp value in MPO *Canopus*. All data have been sent to the ALCDEF database (*http://minorplanetcenter.net/light_curve*)

1028 Lydina. This asteroid was selected from Warner *et al.* (2011b) where it was listed as having a period of 15.59 h, amplitude 0.70 mag, and quality code U = 2. We observed for 5 nights covering an 11-day span. All sessions showed one minimum and one maximum. Our analysis found a bimodal lightcurve with a period *P* = 11.674 ± 0.002 h and amplitude *A* = 0.30 ± 0.02 mag. Despite the small gap in the lightcurve at around 0.9 phase in the plot, we are confident in the reported period.

1430 Somalia. Somalia was selected from Warner *et al.* (2011a). No previous period was reported. We observed it for 6 nights covering a 10-day span. The longest session covered more than half of the derived period of *P* = 6.913 ± 0.001 h. The lightcurve has an amplitude *A* = 0.45 ± 0.02 mag.

3397 Leyla. We selected this asteroid from Warner *et al.* (2012). No previous period was reported. Observations were made on 2 nights over a 2-day span. The raw data from the longest session showed 6 minimums and 5 maximums, which made a 3- hour period very likely. Our analysis found *P* = 3.099 ± 0.002 h for a bimodal lightcurve with amplitude *A* = 0.38 ± 0.02 mag.

4350 Shibecha. This asteroid was selected from Warner *et al.* (2012). No previous period was reported. Observations on 4 nights covered a 5-day span. All sessions appeared to show fast changes with little overall amplitude. We found a period of *P* = 2.89 ± 0.01 h and amplitude *A* = 0.16 ± 0.03 mag.

8345 Ulmerspatz. We selected this target from Warner *et al.* (2011b). No previous period was reported. We observed it for 8 nights over a 22-day span. The period for the bimodal lightcurve is *P* = 17.416 ± 0.002 h with an amplitude *A* = 0.80 ± 0.03 mag.

Asteroid	Date	Phase Angle	Time h.	Num. Obs
1028 Lydina	2011-12-19	6.6	5.9	127
1028 Lydina	2011-12-20	7.1	5.5	115
1028 Lydina	2011-12-22	7.8	6.4	160
1028 Lydina	2011-12-27	9.5	6.2	153
1028 Lydina	2011-12-30	10.4	6.3	130
1430 Somalia	2011-09-19	6.1	1.7	30
1430 Somalia	2011-09-20	6.6	3.8	80
1430 Somalia	2011-09-21	7.1	2.8	69
1430 Somalia	2011-09-26	9.7	5.5	135
1430 Somalia	2011-09-27	10.2	3.5	58
1430 Somalia	2011-09-29	11.2	5.5	128
3398 Leyla	2012-02-14	23.1	1.0	27
3398 Leyla	2012-02-15	22.9	9.0	177
3398 Leyla	2012-02-16	22.8	3.3	51
4350 Shibecha	2012-03-20	17.5	2.5	61
4350 Shibecha	2012-03-21	17.8	2.8	61
4350 Shibecha	2012-03-22	18.1	4.8	121
4350 Shibecha	2012-03-25	19.1	4.5	98
8345 Ulmerspatz	2011-12-21	5.3	1.5	39
8345 Ulmerspatz	2011-12-23	4.5	1.5	59
8345 Ulmerspatz	2011-12-24	3.8	0.2	6
8345 Ulmerspatz	2011-12-26	2.3	2.3	60
8345 Ulmerspatz	2011-12-27	1.6	4.1	75
8345 Ulmerspatz	2011-12-29	0.3	1.7	45
8345 Ulmerspatz	2012-01-12	10.4	6.5	122
8345 Ulmerspatz	2012-01-13	11.1	7.0	94
16959 1998 QE17	2011-10-17	11.3	6.5	159
16959 1998 QE17	2011-10-22	13.8	2.2	50
27111 1998 VV34	2011-09-22	5.6	1.5	36
27111 1998 VV34	2011-09-30	10.5	5.0	107
27111 1998 VV34	2011-10-01	11.0	5.5	118
27111 1998 VV34	2011-10-03	12.2	5.5	126
28913 2000 OT	2012-02-17	9.2	5.4	63
28913 2000 OT	2012-02-21	11.5	5.8	39
28913 2000 OT	2012-02-22	12.1	6.5	161
28913 2000 OT	2012-02-24	13.2	4.0	83
28913 2000 OT	2012-02-25	13.8	6.7	164
28913 2000 OT	2012-02-26	14.3	4.8	122
28913 2000 OT	2012-02-29	15.8	3.2	69
28913 2000 OT	2012-03-11	20.8	4.8	121

Table I. Observation circumstances.

(16959) 1998 QE17. This asteroid was selected from Warner *et al.* (2011b), which gave a period of 6.31 h and amplitude of 0.30 mag with quality code U = 1+. We obtained observations on 2 nights over a 5-day span. In the first session it was possible see a very regular sine wave with 4 minimum and 4 maximum, or a period of about 3 hours assuming a bimodal lightcurve. Another session fives days later was enough to find the period. Given the amplitude of 0.30 ± 0.03 mag, the lightcurve is almost certainly bimodal. This lead to a period solution *P* = 3.226 ± 0.001 h.

(27111) 1998 VV34. We selected 1998 VV34 from Warner *et al.* (2011a). No previous period was reported. Observations on 4 nights were obtained over an 11-day span. In the longest session it was possible to see 4 minimum and 3 maximum, which indicated a period of about 3 hours. The final analysis found a bimodal lightcurve with *P* = 3.323 ± 0.001 h and amplitude *A* = 0.15 ± 0.03 mag.

(28913) 2000 OT. 2000 OT was was selected from Warner *et al.* (2012) where the asteroid was reported to have a period of 15.30 hours and amplitude 0.35 mag with quality code U = 2. We observed it on 8 nights over a 23-day span. The best solution we found was for a bimodal lightcurve with a period of P = 13.754 ± 0.002 h and amplitude A = 0.32 ± 0.02 mag.

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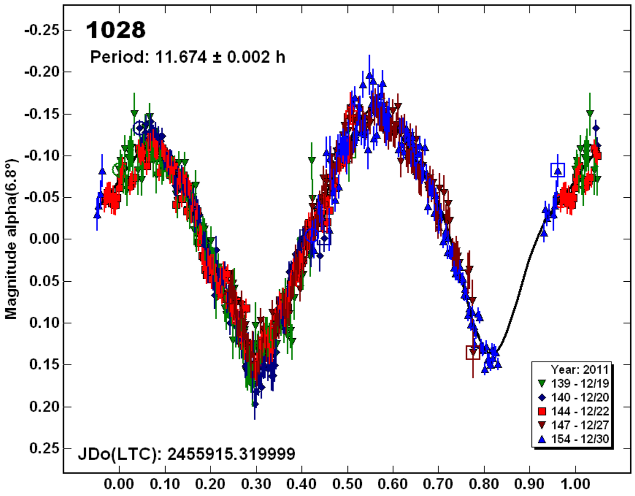

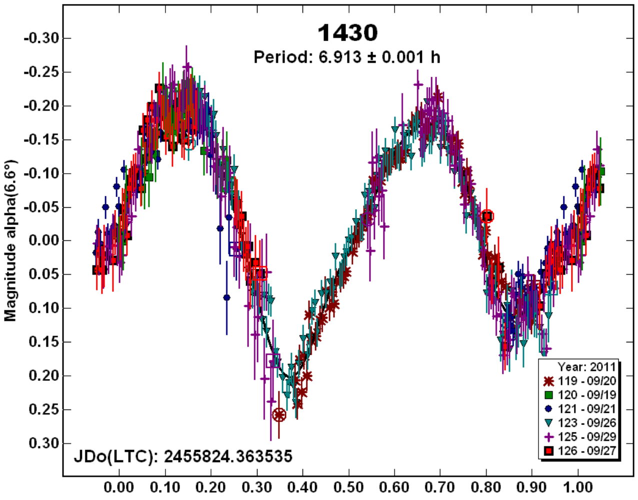

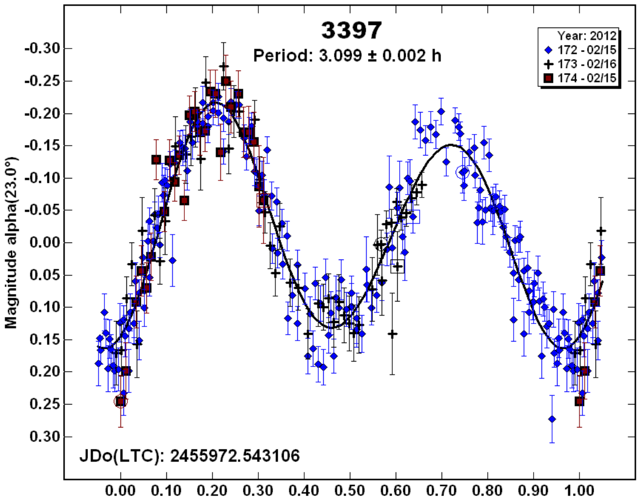

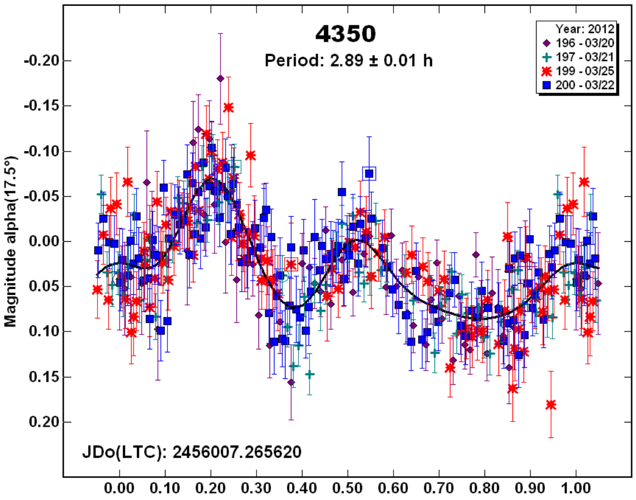

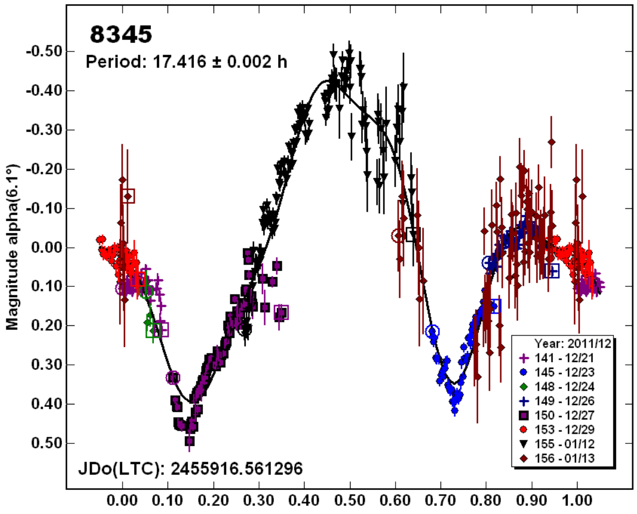

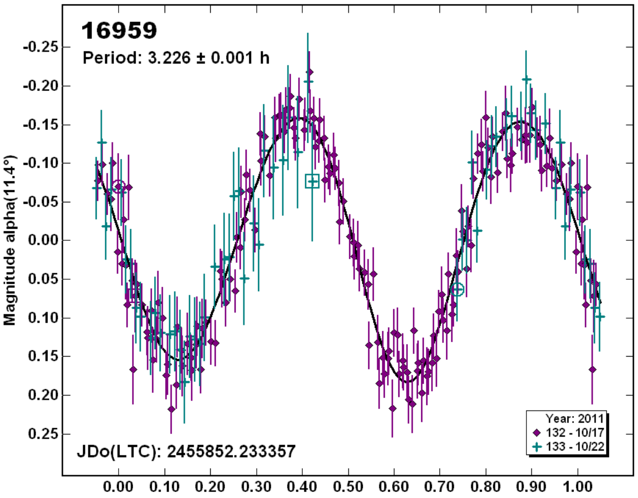

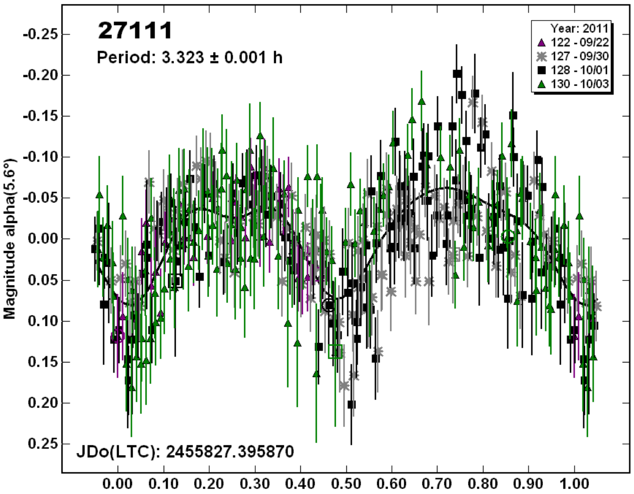

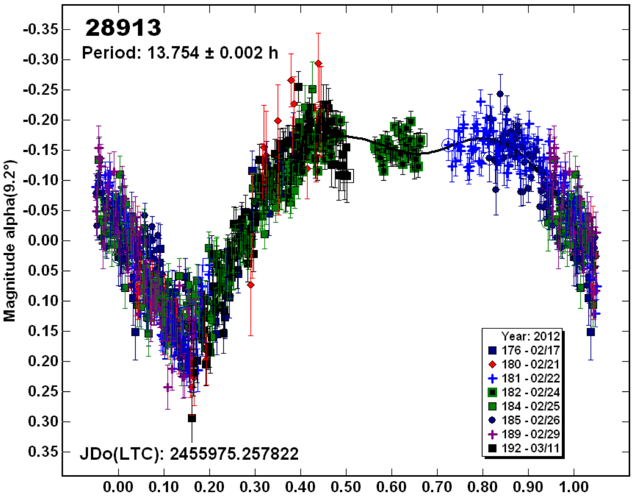

CCD PHOTOMETRY AND LIGHTCURVE ANALYSIS OF MAIN-BELT ASTEROIDS 14 IRENE, 4874 BURKE, 1985 HOPMANN, 3017 PETROVIC, AND 3070 AITKEN FROM OBSERVATORI CARMELITA IN TIANA

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Observations carried out from 2011 December to late 2012 March allowed us to determine the synodic periods of 14 Irene, 1985 Hopmann, 3017 Petrovic, 3040 Aitken, and 4874 Burke. For 14 Irene, a period of 15.038 ± 0.002 h was found with an amplitude A = 0.10 mag, well in accordance with other published estimates. 1985 Hopmann exhibited a rotational period of 17.476 ± 0.003 h, A = 0.44 mag. 3017 Petrovic exhibited a rotational period of 4.080 ± 0.001 h, A = 0.62 mag. 3070 Aitken showed a period of 6.390 ± 0.005 h, A = 0.59 mag. For 4874 Burke we found a short rotational period of 3.657 ± 0.001 h with A = 0.31 mag.

The Carmelita Observatory (MPC B20) is situated in Tiana, in the southernmost part of the Serra de Marina, a moderately light-polluted suburban park 15 km north of Barcelona, Spain. The observatory is equipped with an Astro-Physics AP900 German equatorial mount on top of a fixed pier, a 25-cm Schmidt-Cassegrain telescope with a focal reducer, and a dual-chip SBIG ST8-XME CCD camera with filter wheel. However, for this particular imaging run, a 13-cm triplet refractor with a field flattener yielding an effective resolution of 2.08 arcsec/pix was used.

14 Irene (1952 TM) is a main-belt asteroid (e = 0.16569, a = 2.5874) of very respectable size (about 150 km) that was discovered by J. R. Hind in 1851. It is known that the asteroid lightcurve is very shallow, and several rotational periods have been estimated over the years. The most recent data sets published are those from Hanus *et al.* (2011) and Pilcher (2009). They determined synodic periods of 15.02991 h and 15.028 h, respectively. The 2011-2012 apparition presented an excellent opportunity for the small refractor, with the asteroid at V ~ 10.8. We collected more than 3,000 60-s images from 2011 December 18 to 2012 January 10 through a C filter with Maxim DL acquisition software. The CCD camera operated at –15° C and all images were calibrated with master bias, dark, and flat frames. We performed real-time differential photometry of the asteroid with *Fotodif* as the images were being downloaded. With *MPO Canopus* we derived a lightcurve showing a period of 15.038 ± 0.002 h and amplitude A = 0.10 mag. This agrees well with the most recent results.

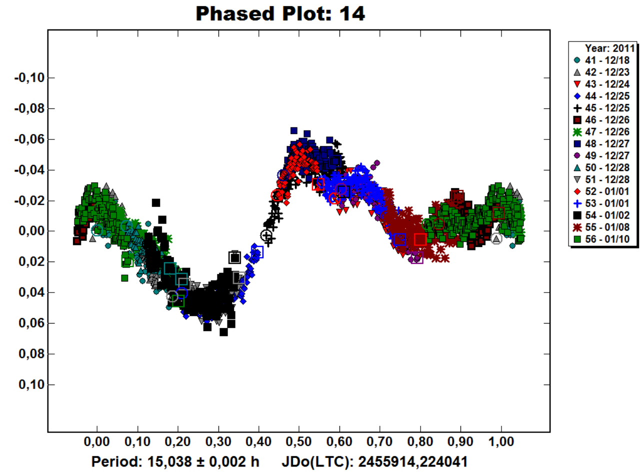

Figure 1. Lightcurve for 14 Irene.

1985 Hopmann (1929 AE) is a main-belt asteroid (e = 0.15267, a = 3.1223) that was also listed as being in need of photometric measurements the Lightcurve Photometry Opportunities list by Warner *et al.* (2011). This asteroid was discovered by K. Reinmuth Heidelberg in 1929. We could find no previously-published rotational data. We obtained 1320 150-s images of the asteroid through a clear filter on 15 nights in 2012 February with the CCD operating at –15º C. The asteroid brightness reached 14.3-14.4 as estimated by *Astrometrica*. Analysis of the data allowed us to determine a synodic period of 17.476 ± 0.003 h, A = 0.44 mag. Figure 2 shows the composite lightcurve.

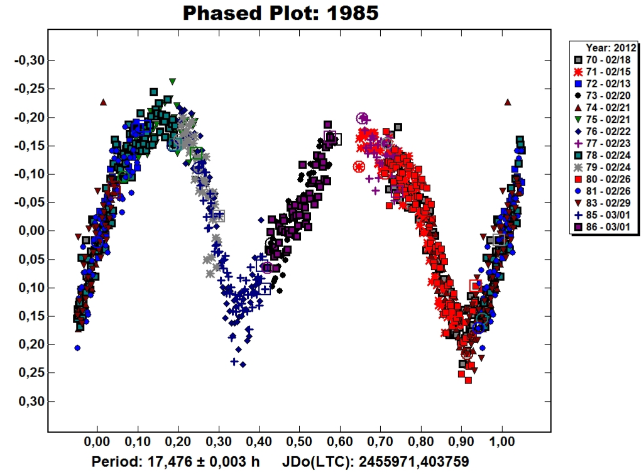

Figure 2. Composite lightcurve for 1985 Hopmann.

3017 Petrovic was another main-belt asteroid listed as an asteroid in the Lightcurve Opportunity list by Warner *et al.* (2011). Angeli and Barucci (1996) estimated a period of 4.069 h, although their observations lacked full coverage. We observed this asteroid on several nights, but it was only possible to reduce data of four of them due to the asteroid moving through the dense star fields of Canis Minor. 350 150-s images through a clear filter were obtained in unbinned mode and the CCD camera working at –15º C. According to our measurements with *Astrometrica* against CMC-14 stars in R-band, the asteroid brightness was 14.2-14.5 mag. We derived a lightcurve that shows a fast rotational period of 4.080 ± 0.001 h and an amplitude of 0.62 mag. Figure 3 shows the composite lightcurve.

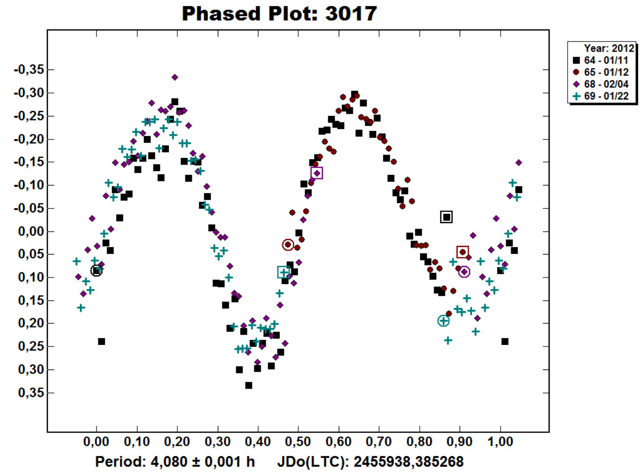

Figure 3. Composite lightcurve for 3017 Petrovic.

3070 Aitken (1949 GK) is one of the many main-belt asteroids (e = 0.19825, a = 2.3056) discovered in 1949 from the Goethe Link Observatory during the Indiana Asteroid Program. It was also mentioned in the Lightcurve Photometry Opportunities list by Warner *et al.* (2012) as most others appearing in this article. We followed the asteroid at the end of 2012 March when its brightness was R = 14.7-15.2, according to the CMC-14 star catalogue. 460 images of 150 s were obtained with the CCD working at –12º C and were calibrated with dark, flat and bias frames. Our analysis with *MPO Canopus* suggests a rotational period of 6.390 ± 0.005 h and A = 0.59 mag.

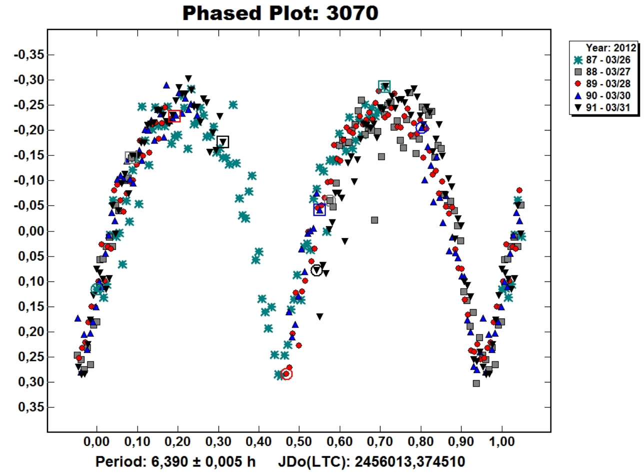

Figure 4. Composite lightcurve for 3070 Aitken.

4874 Burke (1991 AW, e = 0.12250, a = 2.6022) is a main-belt asteroid discovered by Eleanor Helin at Palomar Observatory in 1991. No published data were available for this asteroid, which had been included in the Lightcurve Photometry Opportunities list by Warner *et al.* (2011). 753 calibrated images of 150 s through a clear filter were collected with *Maxim DL* during nine nights from 2011 December 28 to 2012 January 22 with the CCD working at –15º C. The asteroid brightness was measured against the CMC-14 catalogue in R band at mag 15.0-15.3. Real-time images processed with *Fotodif* soon revealed a fast rotating body. Figure 5 shows part of the lightcurve of December 31.

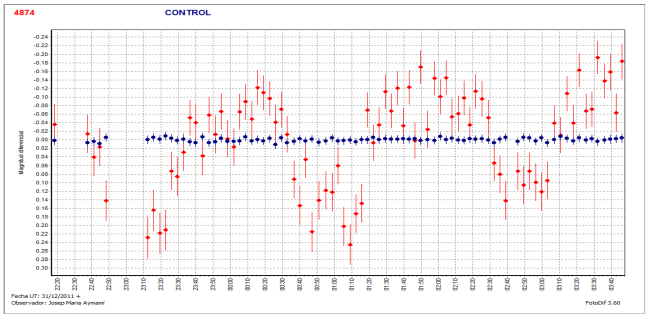

Figure 5. Lightcurve for 4874 Burke on 2011 December 31.

The lightcurves obtained were relatively noisy due to the modest telescope aperture, even though the lower resolution provided by the refractor allowed us to carry out longer exposures than would have been possible with the 25-cm reflector. With *MPO Canopus* we produced a lightcurve of two maxima showing a synodic period of 3.657 ± 0.001 h and A = 0.31 mag. Figure 6 shows the composite lightcurve.

Acknowledgements

Special thanks are due to Ramón Bosque, a member of the Grup d'Astronomia de Tiana (G.A.T.) for revising this paper, and to Julio Castellano for constantly improving *Fotodif* with new features. The Grup d'Astronomia de Tiana (G.A.T.) granted access to *MPO Canopus* so that we could derive the lightcurves appearing in this paper.

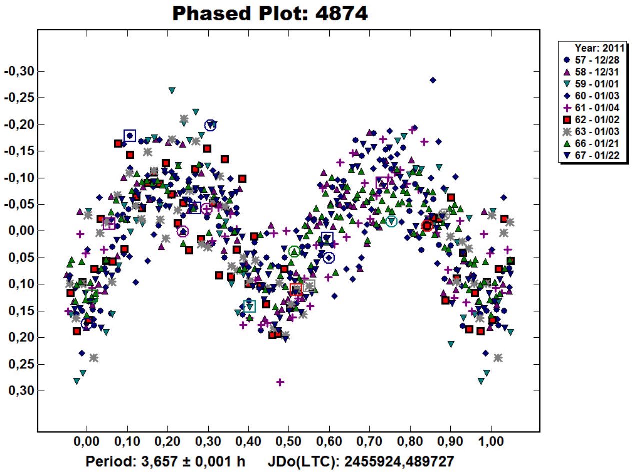

Figure 6. Composite lightcurve for 4874 Burke.

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ASTEROIDS OBSERVED FROM GMARS AND SANTANA OBSERVATORIES: 2012 JANUARY - MARCH

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Lightcurves of five asteroids were obtained from Santana Observatory and Goat Mountain Astronomical Research Station (GMARS): 369 Aeria, 1985 Hopmann, 4106 Nada, 2842 Unsold, and (35886) 1999 JG80.

With the exception of (35886) 1999 JG80, all observations were made at Santana Observatory (MPC Code 646) using a 0.30-m Schmidt-Cassegrain (SCT) with a SBIG STL-1001E CCD camera. All images were unguided and unbinned with no filter. (35886) 1999 JG80 was observed at GMARS (MPC Code G79) using a 0.35-m Schmidt-Cassegrain (SCT) with a SBIG STL-1001E. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *MPO Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.*, 1989). Except for (35886) 1999 JG80, the asteroids were selected from the list of asteroid photometry opportunities published on the Collaborative Asteroid Lightcurve Link (CALL) website (Warner, 2012).

The results are summarized in Table I. Night-to-night calibration of the data (generally < ±0.05 mag) was done using field stars converted to approximate Cousins R magnitudes based on 2MASS J-K colors (Warner, 2007; Stephens, 2008).

369 Aeria. All images were acquired at Santana Observatory. Schober (1986) reported a flat lightcurve suggesting a rotational period of 14 hours. Dotto (1992) observed Aeria in 1984 August and reported a period of 4.787 h. Higgins (2011) reported a result with either low amplitude monomodal curve with a period of 4.7776 h or a bimodal curve with a 9.555 h. This result agrees with the Dotto period and is similar to Higgins' monomodal result.

1985 Hopmann. This asteroid does not have a previously reported period in the LCDB (Warner et al., 2012).

4106 Nada. This asteroid does not have a previously reported period in the LCDB (Warner *et al.*, 2012).

2842 Unsold. This asteroid does not have a previously reported period in the LCDB (Warner *et al.*, 2012).

(35886) 1999 JG80. This asteroid does not have a previously reported period in the LCDB (Warner *et al.*, 2012). It was a dim target found in the field of view of the primary target, 12714 Alkimos, and could be followed for only two nights.

The data for each of these asteroids were uploaded to the ALCDEF database on the Minor Planet Center's web site (MPC, 2012).

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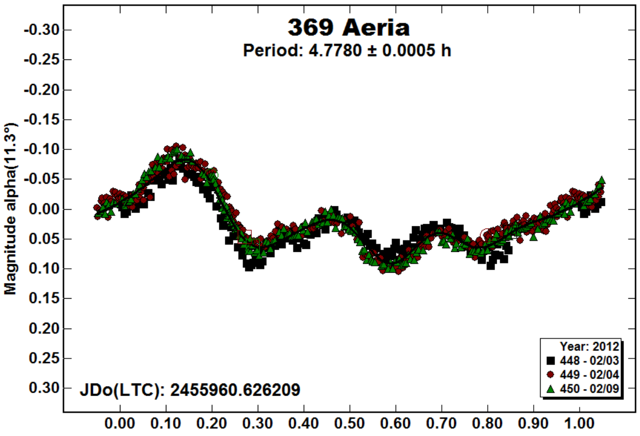
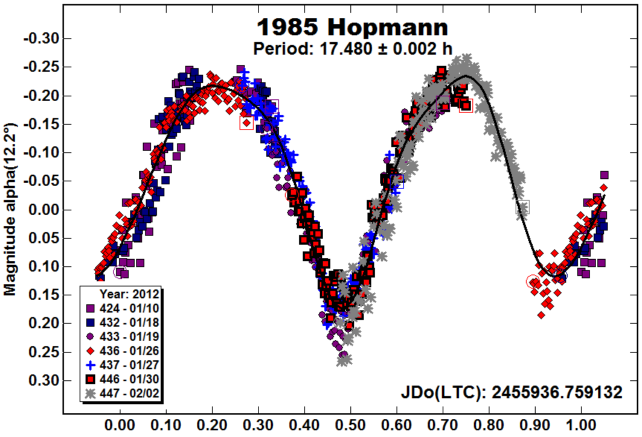
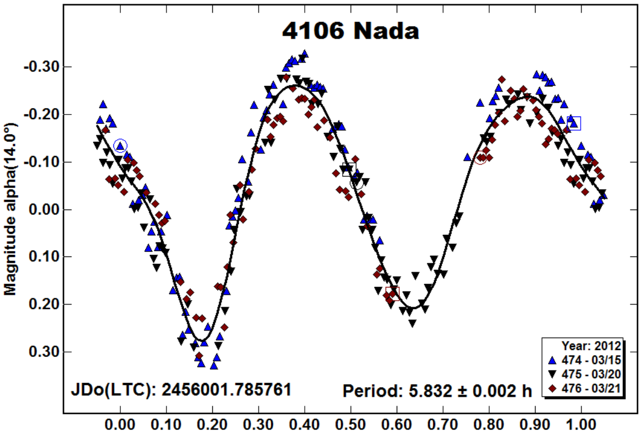
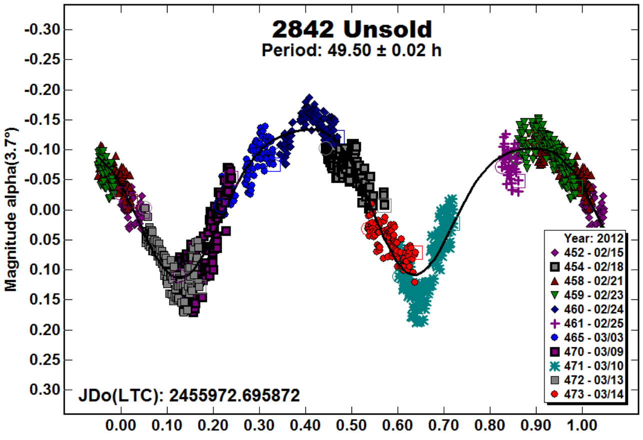


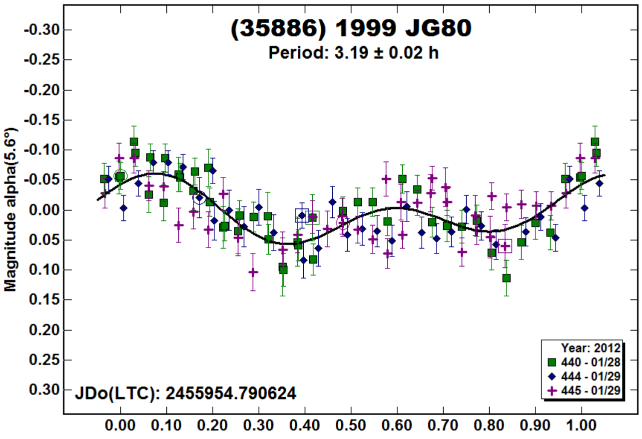




#	Name	mm/dd/2012	Data Pts	α	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
369	Aeria	02/03 – 02/09	656	11.2, 13.2	107	5	4.7880	0.0005	0.17	0.02
1985	Hopmann	01/10 – 02/02	906	12.3, 3.9	140	-4	17.480	0.002	0.54	0.03
4106	Nada	03/15 – 03/21	265	14.1, 11.7	202	6	5.832	0.002	0.54	0.03
2842	Unsold	02/15 – 03/14	1071	3.8, 11.9	151	-7	49.50	0.02	0.25	0.03
35886	1999 JG80	01/28 – 01/29	103	5.4, 5.8	116	0	3.19	0.02	0.12	0.02

Table I. Observation circumstances.





PHOTOMETRY OF 17 JOVIAN TROJAN ASTEROIDS

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Lightcurves for 17 Jupiter Trojan asteroids were obtained from Cerro Tololo Interamerican Observatory, Lowell Observatory, and GMARS Observatory from 2010 August to 2012 March.

The Jovian Trojan asteroids are found in orbits near the stable L4 and L5 Lagrange points of Jupiter's orbit. As of 2012 15 April, 3402 had been found in the L4 (preceding) region and 1758 in the L5 region. As yet, the rotation properties of Trojan asteroids are poorly known relative to those of main-belt asteroids, due to the low albedo and greater distance of the Trojans. Here we report lightcurve data for 17 Trojans. Most are in the 50-100 km diameter range.

Observations at GMARS (Goat Mountain Astronomical Research Station, MPC G79) were made by Stephens, Coley, and Megna with four telescopes, one 0.4-m and three 0.35-m SCTs, two using an SBIG STL-1001E CCD cameras and the others using an SBIG ST-9e CCD cameras. All images were unbinned with no filter. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *MPO Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.*, 1989).

Observations at CTIO (Cerro Tololo Interamerican Observatory, MPC 807) were made with the CTIO 0.9-m telescope. The NOAO CFCCD camera has a field of view of 13.5 arcmin/side. At 0.401 arcsec/pixel, a quarter-chip configuration was used to yield 1024 x1024-pixel images with a read noise of 3.5 and a gain of 1.5. All images taken at CTIO were unbinned. V and R filters were used. Data analysis was carried out using *IRAF* and *MPO Canopus*.

Observations at Lowell Observatory (MPC 688) were made by French, Stephens, and Wasserman with the Perkins 1.8-m telescope. The PRISM camera has a field of view 13.3 arcmin/side. The 2048x2068-pixel images had a read noise of 13 and a gain of 3.3. All images were unbinned using V and R filters. Data analysis was carried out with *MPO Canopus*.

The results are summarized in Table 1. Night-to-night calibration of the data (generally < ±0.05 mag) was done using field stars converted to approximate Cousins R magnitudes based on 2MASS J-K colors (Warner, 2007; Stephens, 2008).

911 Agamemnon. Earlier work was done by Dunlap and Gehrels (1969) and Taylor (1971). The period obtained by Stephens (2009) is 6.592 h, consistent with periods of 6.5819 h obtained by Mottola *et al.* (2011) and the 6.59 h we report here. Dunham (private communication) indicated that the International Occultation Timing Association (IOTA) might have detected a possible satellite with a size of 4 to 5 km in their observations of the 2012 January 19 occultation. While the possible satellite is too small to detect in lightcurves obtained with small ground based telescopes, we decided to observe Agamemnon as a follow-up to the 2009 observations to provide data for an eventual pole solution. Observations were made at GMARS by Megna using a 0.35-m SCT with an SBIG ST-9e CCD camera.

1867 Deiphobus. French (1987) found no evidence for a period of less than 24 hours, while Mottola *et al.* (2011) reported a period of 58.66 h. Our new period of 15.72 hours gives the best fit to the current observations, but the amplitude is low. Further observations are encouraged.

4709 Ennomos. Mottola *et al.* (2011) reported a period of 12.275 h, which is not consistent with our derived period of 11.12 h.

(11397) 1998 XX93. Duffard *et al.* (2008) obtained a period of 14.24 h, which is not consistent with our period of 12.70 h.

(23135) 2000 AN146. Duffard *et al.* (2008) obtained a period of 6.86 h, which is not consistent with our period of 8.69 h.

We can find no previous studies reported in the literature of 4138 Kalchas, 4708 Polydoros, 9023 Mnesthus, 9694 Lycomedes, 10247 Amphiaraos, 12444 Prothoon, 12714 Alkimos, (13694) 1997 WW7, (16070) 1999 RB101, (16956) 1998 MQ11, (22180) 2000 YZ, or (24470) 2000 SJ310.

Acknowledgements

French and Stephens were visiting astronomers at Lowell Observatory and at Cerro Tololo Interamerican Observatory, National Optical Astronomy Observatory, operated by the Association of Universities for Research in Astronomy, under contract with the National Science Foundation. The Cerro Tololo 0.9-m telescope is operated by the SMARTS Consortium. This research was supported by an American Astronomical Society Small Research Grant and by an Artistic and Scholarly Development Grant from Illinois Wesleyan University.

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Name	Dates (2011)	Observers	Obs.	Data Pts.	Phase	Avg. L_{PAB}	Avg. B_{PAB}	Period	P.E.	Amp.	AE
911 Agamemnon	02/24 03/04/12	Megna	GMARS	379	7.4-8.6	119	115	6.59	0.01	0.04	0.02
1867 Deiphobus	06/05 08/08/10	Stephens	GMARS	779	7.8,0.9,5.6	290	4	15.72	0.01	0.10	0.02
4138 Kalchas	11/06 01/29/12	Stephens	GMARS	537	10.5,0.4,3.8	110	-2	29.17	0.01	0.40	0.03
4708 Polydoros	07/30 08/04	French, Stephens	CTIO	219	0.9,1.8	303	3	20.03	0.04	0.25	0.05
4709 Ennomos	09/04 09/24	Stephens	GMARS	348	6.0, 5.8,6.0	348	28	11.12	0.01	0.45	0.05
9023 Mnesthus	07/23 08/28	Stephens Coley	GMARS	260	4.1,6.8	311	13	30.60	0.01	0.23	0.03
9694 Lycomedes	11/26 11/27	Coley	GMARS	109	3.0,2.8	76	5	18.2	0.1	0.55	0.05
10247 Amphiaraos	02/26 03/25/12	Stephens	GMARS	198	2.1,7.3	146	-1	34.26	0.01	0.55	0.05
(11397) 1998 XX93	01/29 02/06	Stephens	GMARS	221	5.0,6.4	107	-11	12.7	.01	0.25	0.03
12444 Prothoon	08/27 09/03	Stephens	GMARS	142	6.5,6.7	219	31	15.99	0.07	0.20	0.03
12714 Alkimos	12/23 02/20/12	Stephens	GMARS	388	5.1,0.2,7.2	115	1	28.48	0.01	0.27	0.03
(13694) 1997 WW7	01/29 03/06	Stephens	GMARS	158	3.4,9.4	147	-6	30.64	0.01	0.39	0.03
(16070) 1999 RB101	09/03 11/06	Stephens Coley	GMARS	450	2.8,11.3	340	12	31.74	0.01	0.10	0.03
(16956) 1998 MQ11	06/25 07/24	Stephens	GMARS	211	7.2,2.3	304	11	8.84	0.01	0.28	0.03
(22180) 2000 YZ	5/10 7/10	Stephens French Wasserman	Lowell GMARS	185	11,6.4	185	27	19.40	0.01	0.50	0.05
(23135) 2000 AN146	11/20 11/27	Stephens	GMARS	186	10.4,9.8	119	-11	8.69	0.01	0.27	0.03
(24470) 2000 SJ310	09/24 11/06	Stephens	GMARS	176	6.4,10.5	350	27	11.60	0.01	0.30	0.05

Table 1. Observation circumstances and results

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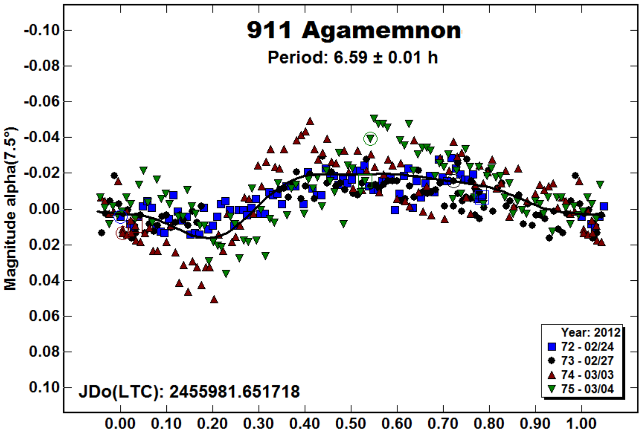
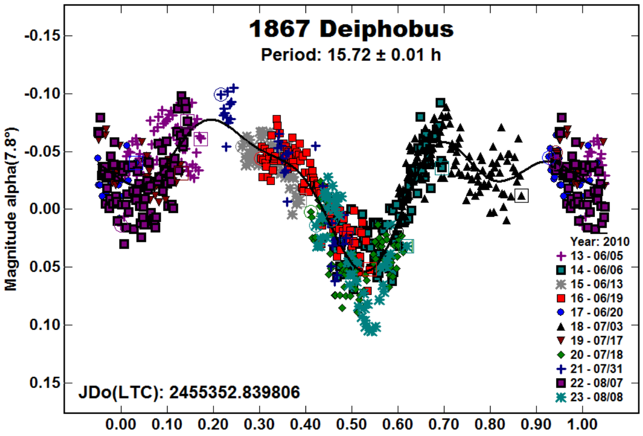
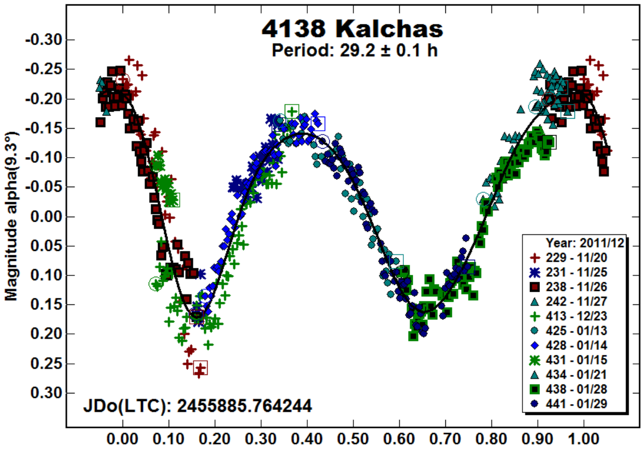
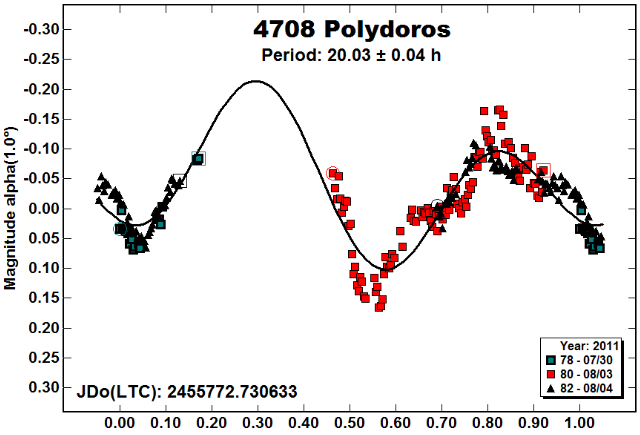
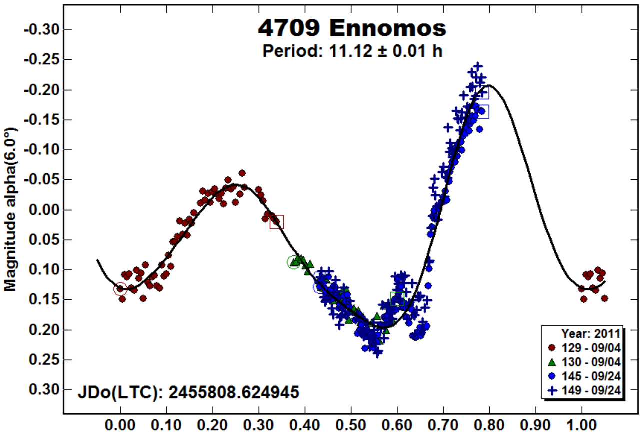
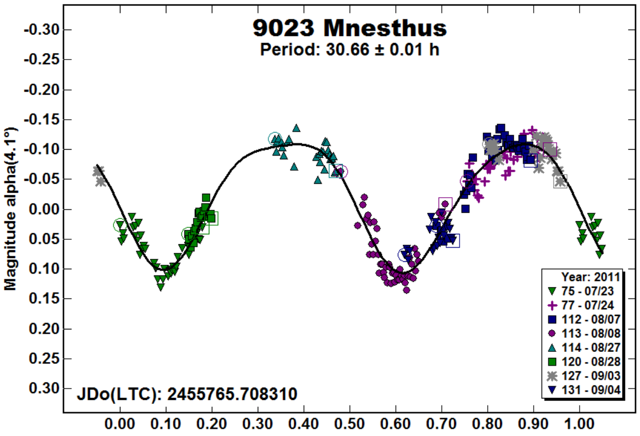


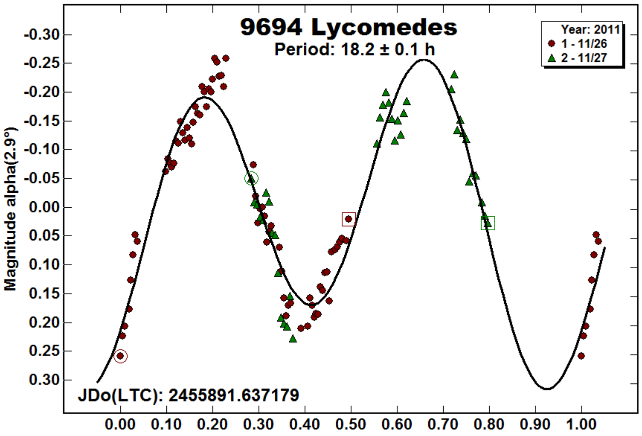


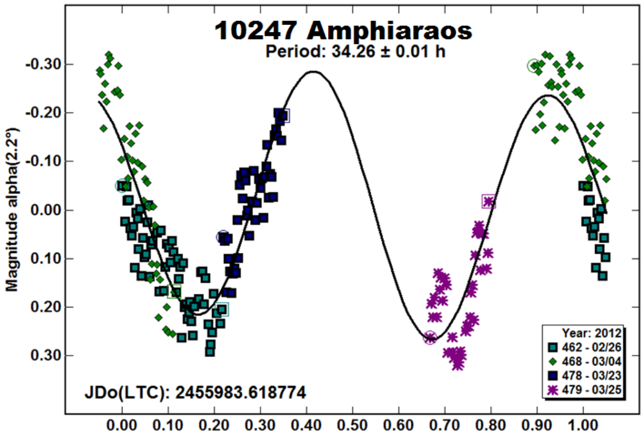


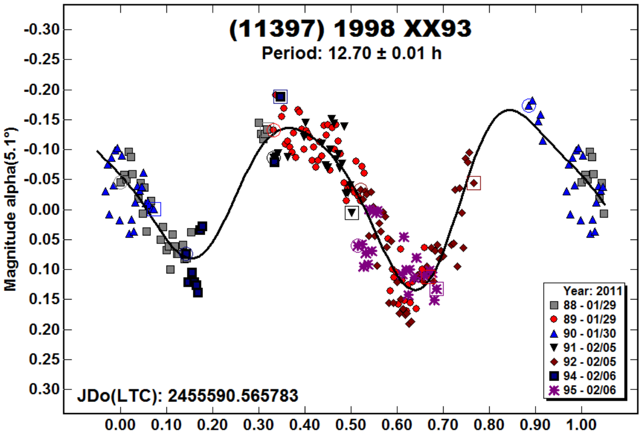


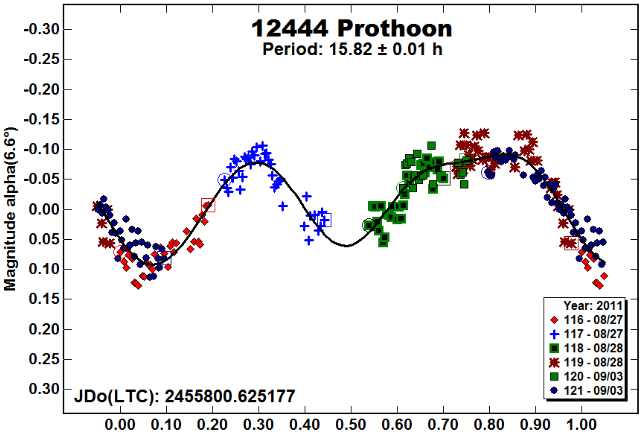


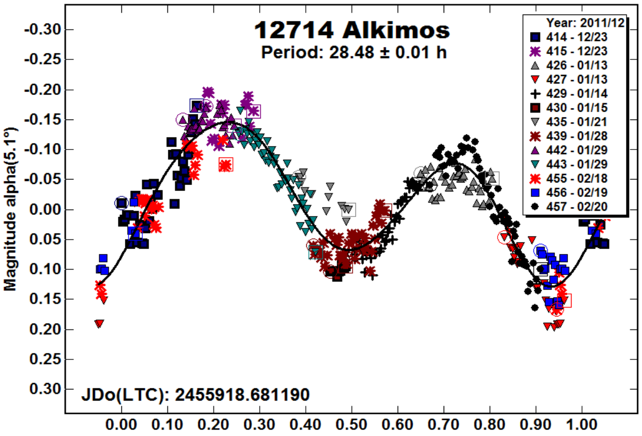





10247 Amphiaraos
Period: 34.26 ± 0.01 h
Magnitude alpha(2.2°)
-0.30 -0.20 -0.10 0.00 0.10 0.20 0.30
Year: 2012
462 - 02/26
468 - 03/04
478 - 03/23
479 - 03/25
JDo(LTC): 2455983.618774
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


(11397) 1998 XX93
Period: 12.70 ± 0.01 h
Magnitude alpha(5.1°)
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
Year: 2011
88 - 01/29
89 - 01/29
90 - 01/30
91 - 02/05
92 - 02/05
94 - 02/06
95 - 02/06
JDo(LTC): 2455590.565783
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


12444 Prothoon
Period: 15.82 ± 0.01 h
Magnitude alpha(6.6°)
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
Year: 2011
116 - 08/27
117 - 08/27
118 - 08/28
119 - 08/28
120 - 09/03
121 - 09/03
JDo(LTC): 2455800.625177
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


12714 Alkimos
Period: 28.48 ± 0.01 h
Magnitude alpha(5.1°)
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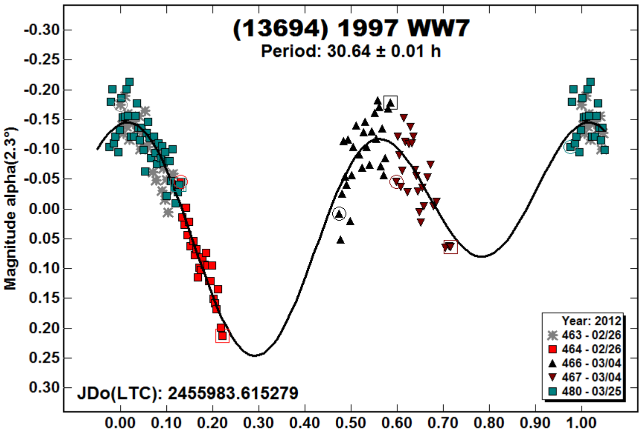
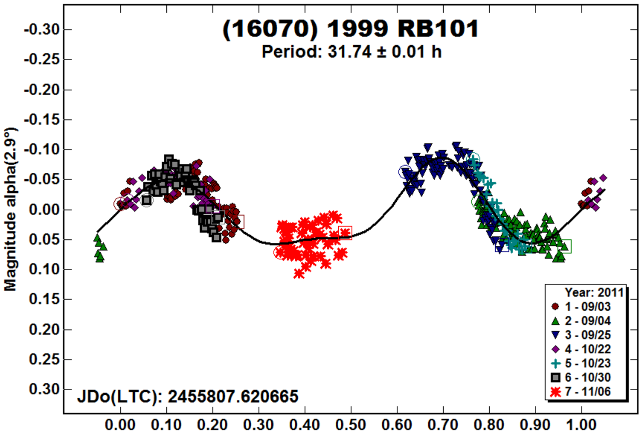
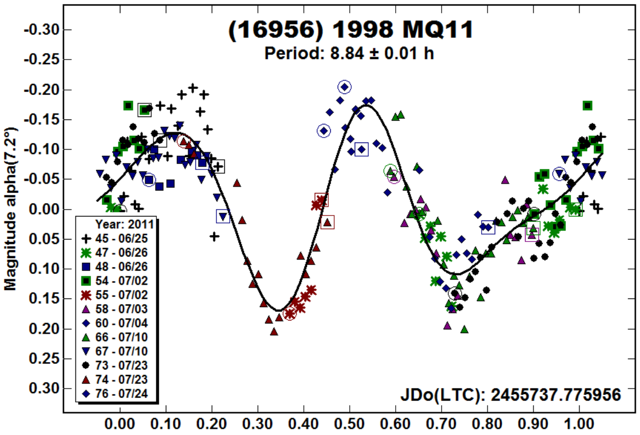
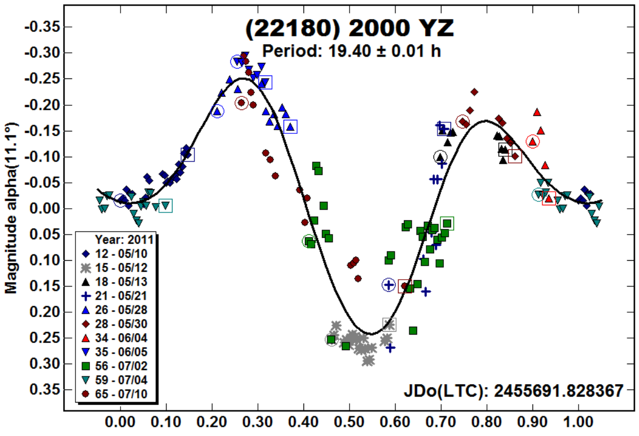
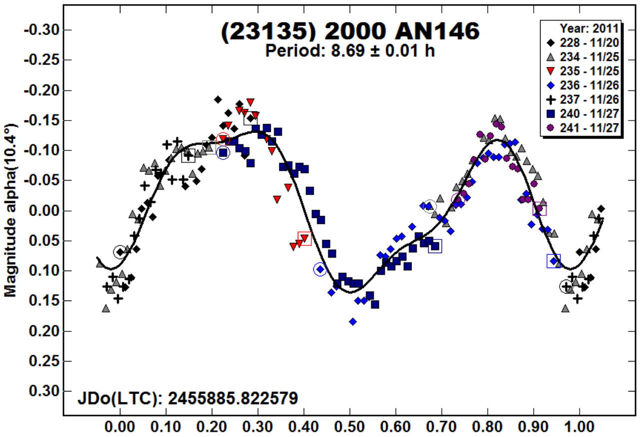
Year: 2011/12
414 - 12/23
415 - 12/23
426 - 01/13
427 - 01/13
429 - 01/14
430 - 01/15
435 - 01/21
439 - 01/28
442 - 01/29
443 - 01/29
455 - 02/18
456 - 02/19
457 - 02/20
JDo(LTC): 2455918.681190
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

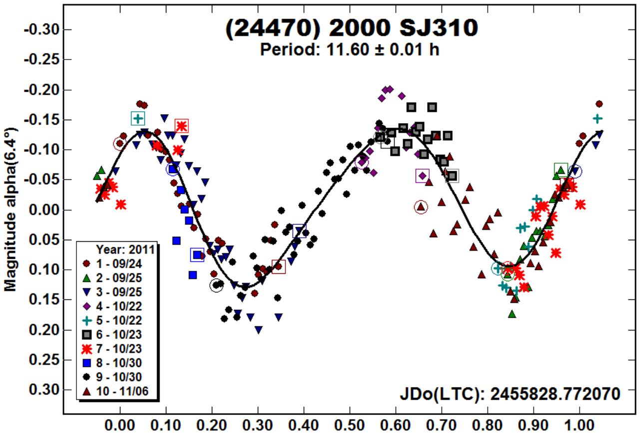

(13694) 1997 WW7
Period: 30.64 ± 0.01 h
Magnitude alpha(2.3°)
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
Year: 2012
463 - 02/26
464 - 02/26
466 - 03/04
467 - 03/04
480 - 03/25
JDo(LTC): 2455983.615279
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


(16070) 1999 RB101
Period: 31.74 ± 0.01 h
Magnitude alpha(2.9°)
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
Year: 2011
1 - 09/03
2 - 09/04
3 - 09/25
4 - 10/22
5 - 10/23
6 - 10/30
7 - 11/06
JDo(LTC): 2455807.620665
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


(16956) 1998 MQ11
Period: 8.84 ± 0.01 h
Magnitude alpha(7.2°)
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
Year: 2011
45 - 06/25
47 - 06/26
48 - 06/26
54 - 07/02
55 - 07/02
58 - 07/03
60 - 07/04
66 - 07/10
67 - 07/10
73 - 07/23
74 - 07/23
76 - 07/24
JDo(LTC): 2455737.775956
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


(22180) 2000 YZ
Period: 19.40 ± 0.01 h
Magnitude alpha(11.1°)
-0.35 -0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35
Year: 2011
12 - 05/10
15 - 05/12
18 - 05/13
21 - 05/21
26 - 05/28
28 - 05/30
34 - 06/04
35 - 06/05
56 - 07/02
59 - 07/04
65 - 07/10
JDo(LTC): 2455691.828367
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00





LIGHTCURVES AND SPIN PERIODS OF NEAR-EARTH ASTEROIDS, THE WISE OBSERVATORY, 2005 - 2010

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The lightcurves and period analysis of 16 near-Earth asteroids that were observed at the Wise Observatory in Israel between 2005 and 2010 are reported.

Photometry of near-Earth asteroids (NEAs) has been done at the Wise Observatory since 2004 in order to increase the statistics of their spin parameters and constrain their shape models. I report here the observations of 16 NEAs observed between 2005 and 2010 at the Wise Observatory in Israel. The measurements can be obtained from the author by request.

Observations were performed using the two telescopes of the Wise Observatory (code: 097, E 34:45:47, N 30:35:46): a 1-m Ritchey-Chrétien and a 0.46-m Centurion (Brosch *et al.*, 2008). During the time these observations took place, the 1-m telescope was equipped with two cryogenically-cooled CCDs at the *f*/7 focus of the telescope: a wide-field SITe CCD (field of view [FOV] of 34'x17', 4096x2048 pixels, 0.872" per pixel, binned 2x2) and a Princeton Instruments (PI) CCD (FOV of 13'x13', 1340x1300 pixels, 0.58" per pixel, unbinned). The 0.46-m telescope was used with two CCDs at the *f*/2.8 prime focus: an SBIG ST-10XME (FOV of 40.5'x27.3', 2184x1472 pixels, 1.1" per pixel, unbinned) and an SBIG STL-6303E (FOV of 75'x55', 3072x2048 pixels, 1.47" per pixel, unbinned). While a filter wheel was mounted on the 1-m telescope, the 0.46-m was used in white light with no filters (Clear). Exposure times were 60–300s, determined by the brightness and angular velocity of the asteroids. All images were guided. The observational circumstances are given in Table I.

The images were reduced in a standard way. IRAF *phot* function was used for the photometric measurements with an aperture of four pixels. After measuring, the photometric values were calibrated to a differential magnitude level using local comparison stars. The brightness of these stars remained constant to ±0.02 mag.. Some of the observed fields were also calibrated to a standard magnitude system by observing Landolt's equatorial standards (Landolt 1992). This usually adds an error of ~0.03 mag. and allows fitting the data to *H-G* system (Bowell et al. 1989). Astrometric solutions were obtained using *PinPoint* (www.dc3.com) and the asteroids were identified in the MPC web database. Analysis for the lightcurve period and amplitude was done by the Fourier series analysis (Harris and Lupishko 1989). See Polishook and Brosch (2009) for a complete description about reduction, measurements, calibration and analysis.

Results

Lightcurves and spin periods of 16 asteroids are reported. The reliability code (U) is determined by the definitions that appeared in Warner *et al.* (2009). Twelve of the NEAs belong to the Apollo sub-group, three are Atens, and one is an Amor. Excluding two objects (138893 and 152931), all asteroids were measured photometrically by other observers in the past. For three of them (5143, 105140 and 141495), a period with better accuracy is given. The period of 5143 is short (2.7060 ± 0.0002 h), which is in contrast to the previous published period that suggested a long rotation (Pravec *et al.*, 1998), and in agreement with an unpublished period by Pilcher (*http://aslc-nm.org/5143Heracles.jpg*). The same goes for 141432, which was reported to have a rotation period of >8 h (Polishook *et al.*, 2005) based on data with low S/N. New measurements of higher S/N indicate a rotation period of 2.6 ± 0.1 h, in agreement with a period posted by Skiff on the CALL website (*http://www.minorplanet.info/call.html*). In two cases (10115 and 2009 UN$_3$), the rotation period was estimated based on fragmentary data and the error is accordingly high. Two objects (5143 and 141495) were observed during a period long enough that allow deriving a phase curve and to find a fit to the *H-G* system. In the other cases, where the measurements were calibrated to the standard magnitude scale, a fixed $G = 0.15$ was assumed to derive the absolute magnitude *H*. All results are listed in Table II, which includes the asteroid name, sub-group, rotation period, reliability code (U), photometric amplitude, absolute magnitude *H* and slope parameter *G*. Folded lightcurves that were not calibrated by Landolt's standard stars are presented on a relative magnitude scale.

References

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Asteroid	Scope	CCD	Fil	Date mm/dd/yy	Time span [hours]	N	r [AU]	Δ [AU]	α [Deg]	L_{PAB} [Deg]	B_{PAB} [Deg]	Mean M [Mag]
(1862) Apollo	1m	PI	R	03/28/07	3.36	35	1.39	0.49	31.31	210.7	2.2	16.22
	1m	PI	R	03/29/07	4.09	34	1.38	0.48	31.17	211	2.1	16.15
(3361) Orpheus	1m	PI	V	11/06/05	4.48	29	1.13	0.24	49.32	25.9	-1.9	18.31
	1m	PI	V	11/07/05	4.15	24	1.12	0.24	50.64	26.5	-2	18.47
(5143) Heracles	C18	ST-10	C	10/21/06	5.37	233	1.74	0.81	17.35	43.4	13	15.9
	C18	ST-10	C	10/22/06	3.64	130	1.73	0.8	17.06	43.4	13	15.82
	C18	ST-10	C	10/23/06	4.31	131	1.72	0.78	16.68	43.5	13	15.74
	C18	ST-10	C	11/26/06	4.11	183	1.33	0.45	34.14	45.2	14	14.42
(5693) 1993 EA	C18	ST-10	C	01/26/07	4.23	83	1.45	0.48	12.53	134.7	4.4	-
	C18	ST-10	C	01/27/07	8.97	208	1.45	0.48	11.49	134.8	4.4	-
(10115) 1992 SK	C18	ST-10	C	03/05/06	3.39	128	1.02	0.13	74.99	175.7	9.5	15.61
	C18	ST-10	C	03/06/06	1.47	52	1.01	0.13	77.09	176.7	9.1	15.65
(40267) 1999 GJ$_4$	C18	ST-10	C	04/29/06	2.44	35	1.68	1.58	35.86	135.4	3.3	18.98
	C18	ST-10	C	04/30/06	1.66	27	1.69	1.6	35.56	135.7	3.4	19.05
	C18	ST-10	C	05/01/06	2.77	38	1.7	1.62	35.28	135.9	3.6	19.02
(66251) 1999 GJ$_2$	C18	ST-10	C	12/09/07	5.29	77	1.52	0.58	17.01	77.2	-15	17.45
	C18	ST-10	C	12/16/07	2	36	1.54	0.6	17.8	79.2	-15	17.74
(68216) 2001 CV$_{26}$	1m	PI	C	03/20/10	5.6	206	1.38	0.41	15.23	186.8	6.9	-
	1m	PI	C	03/21/10	5.53	207	1.39	0.41	14.07	187	6.7	-
(86829) 2000 GR$_{146}$	C18	ST-10	C	06/17/06	2.36	42	1.59	0.78	32.02	232	5.7	-
	C18	ST-10	C	06/22/06	1.85	30	1.63	0.86	32.54	233.1	5	-
(105140) 2000 NL$_{10}$	1m	SITe	V	08/17/06	7.15	42	1.51	0.86	39.54	328.3	47	17.94
	1m	SITe	V	08/18/06	7.66	41	1.52	0.86	39.3	328.2	47	18.06
	1m	SITe	V	09/15/06	5.62	28	1.63	1.02	36.24	324.4	44	18.29
	1m	SITe	V	09/16/06	5.09	35	1.63	1.02	36.24	324.3	44	18.35
(138893) 2000 YH$_{66}$	C18	ST-10	C	11/04/07	5.26	77	1.39	0.51	31.99	30.9	22	18.82
	C18	ST-10	C	11/05/07	7.34	138	1.4	0.52	31.67	30.9	22	18.81
(141432) 2002 CQ$_{11}$	C18	ST-10	C	02/24/07	4.6	65	1.36	0.37	8.42	159.3	3.8	-
(141495) 2002 EZ11	C18	ST-10	C	04/30/06	3.8	91	1.31	0.3	3.39	218.9	0.8	16.72
	C18	ST-10	C	05/01/06	3.08	81	1.3	0.29	5.39	218.9	0.8	16.75
	C18	ST-10	C	05/02/06	5.77	154	1.28	0.28	7.46	218.9	0.8	16.72
	C18	ST-10	C	05/03/06	5.02	144	1.27	0.27	9.82	218.9	0.8	16.79
	C18	ST-10	C	05/21/06	2.61	115	1.05	0.21	74.12	218.4	0.3	17.85
	C18	ST-10	C	05/22/06	2.3	81	1.04	0.22	77.9	218.4	0.2	18.06
	C18	ST-10	C	05/27/06	1.65	55	0.96	0.24	94.88	218.2	0	18.63
	C18	ST-10	C	05/28/06	1.54	62	0.95	0.25	97.97	218.2	-0.1	18.84
	C18	ST-10	C	05/29/06	1.2	39	0.93	0.25	101.01	218.1	-0.1	19.06
(152931) 2000 EA107	C18	STL	C	03/07/10	0.79	15	1.28	0.58	48.46	182.4	38	-
	C18	STL	C	03/10/10	5.18	72	1.27	0.56	48.98	183.2	38	-
	C18	STL	C	03/11/10	4.59	76	1.26	0.55	49.16	183.5	38	-
	C18	STL	C	03/12/10	4.64	82	1.26	0.55	49.36	183.7	38	-
	C18	STL	C	03/13/10	5.83	95	1.26	0.54	49.56	184	38	-
(185851) 2000 DP107	C18	ST-10	C	11/02/08	7.97	67	1.31	0.36	23.12	30.4	8.1	17.54
	C18	ST-10	C	11/03/08	3.07	48	1.32	0.37	23.63	30.9	8.2	17.49
2009 UN3	C18	STL	C	02/18/10	2.68	110	1.04	0.12	60.5	149.9	12	-

Table I: Observational circumstances. Legend: asteroid name, telescope, CCD, filter, observation date, nightly time span of the specific observation, the number of images obtained (N), the object's heliocentric (r) and geocentric distances (Δ), the phase angle (α), the Phase Angle Bisector (PAB) ecliptic coordinates (L_{PAB}, B_{PAB}), and the *mean observed V* or *R* (in case of measurements taken in *R* or "clear" filters) after standard calibration.

Name	Group	Period [hours]	U	Amp [mag]	H_R [mag]	G
(1862) Apollo	Apollo	3.075 ± 0.008	2	0.20 ± 0.05	15.7 ± 0.2	(0.15)
(3361) Orpheus	Apollo	3.51 ± 0.02	3	0.25 ± 0.05	19.4 ± 0.3[V]	(0.15)
(5143) Heracles	Apollo	2.7060 ± 0.0002	3	0.05 ± 0.02	14.52 ± 0.02	0.45 ± 0.01
(5693) 1993 EA	Apollo	2.497 ± 0.009	2	0.10 ± 0.05	17.0	
(10115) 1992 SK[1]	Apollo	7.31 ± 0.02	1	0.70 ± 0.05	17.4 ± 0.3	(0.15)
(40267) 1999 GJ_4	Apollo	4.97 ± 0.01	3	1.1 ± 0.1	15.4	
(66251) 1999 GJ_2	Amor	2.50 ± 0.08	2	0.10 ± 0.05	16.9 ± 0.1	(0.15)
(68216) 2001 CV_{26}	Apollo	2.427 ± 0.004	3	0.12 ± 0.05	16.3	
(86829) 2000 GR_{146}	Apollo	3.5 ± 0.4	2	0.12 ± 0.05	15.9	
(105140) 2000 NL_{10}	Aten	6.9269 ± 0.0009	3	0.55 ± 0.05	15.8 ± 0.2[V]	(0.15)
(138893) 2000 YH_{66}	Apollo	5.30 ± 0.02	3	0.7 ± 0.1	18.3 ± 0.2	(0.15)
(141432) 2002 CQ_{11}	Aten	2.6 ± 0.1	2	0.2 ± 0.1	19.9	
(141495) 2002 EZ_{11}	Apollo	2.3270 ± 0.0006	3	0.06 ± 0.02	18.39 ± 0.02	0.09 ± 0.01
(152931) 2000 EA_{107}	Aten	4.137 ± 0.005	3	0.28 ± 0.05	16.2	
(185851) 2000 DP_{107}	Apollo	2.769 ± 0.005	3	0.15 ± 0.05	18.0 ± 0.2	(0.15)
2009 UN_3[1]	Apollo	4.0 ± 0.5	1	0.45 ± 0.05	18.5	

Table II: Analysis results. Legend: asteroid name, group, rotation period, reliability code, amplitude, absolute magnitude HR and the G slope. H values are presented for asteroid magnitudes that were calibrated to a standard level. For these objects G slopes of 0.15 was estimated (marked in brackets) excluding cases when a wide range of phase angles was available. An H value with no error was derived from the MPC website.

[V] - Absolute magnitude H_V (V band).

[1] - Lightcurves 1992 SK and 2009 UN3 were only partially covered therefore the period values presented here are only an estimate.

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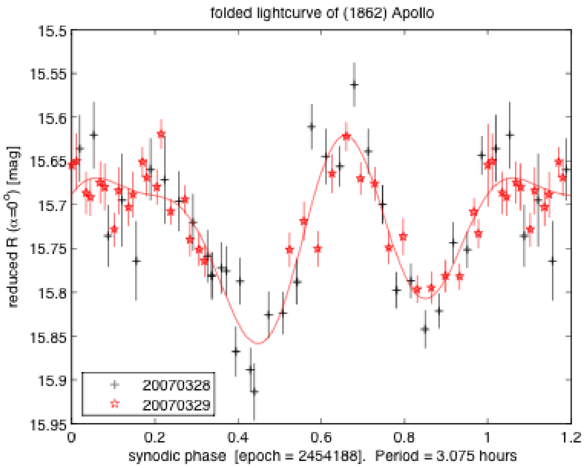
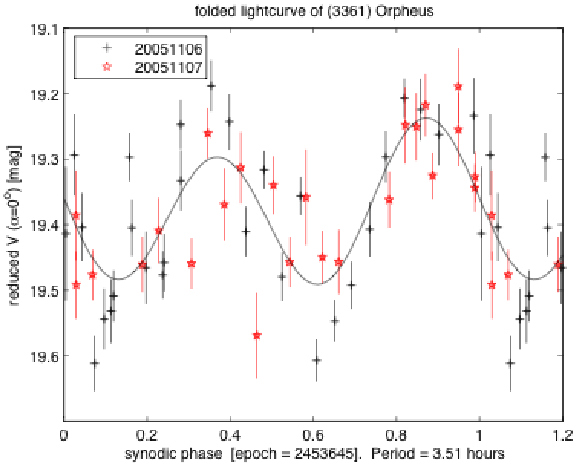
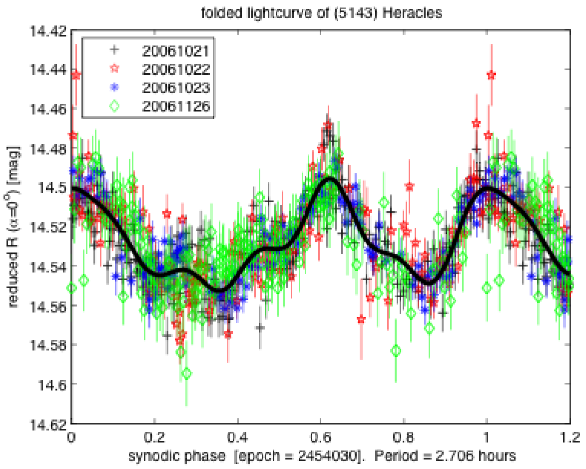
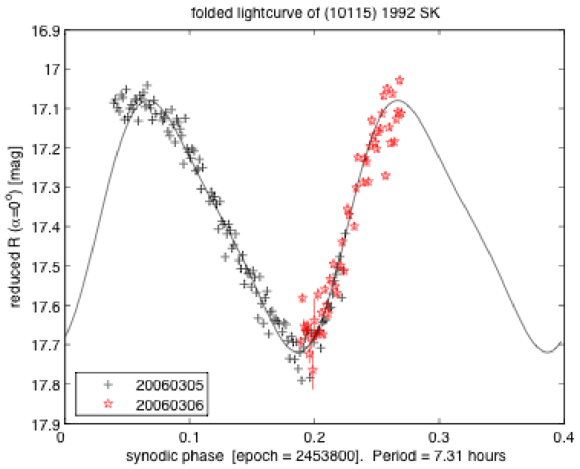
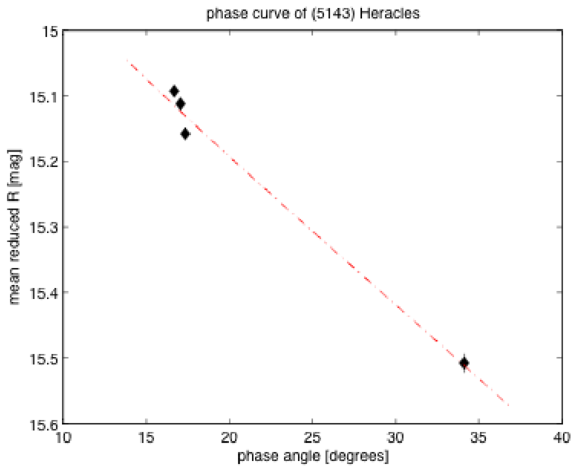
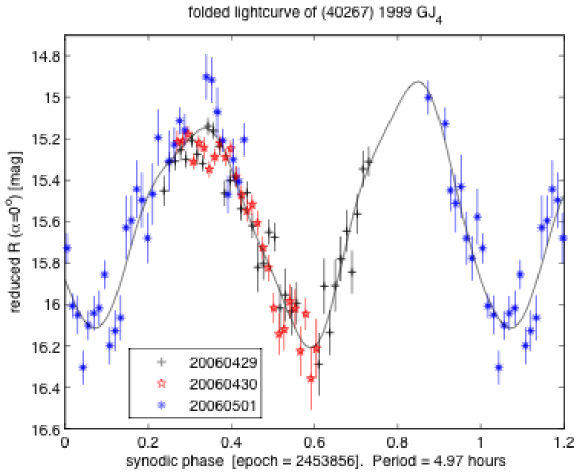


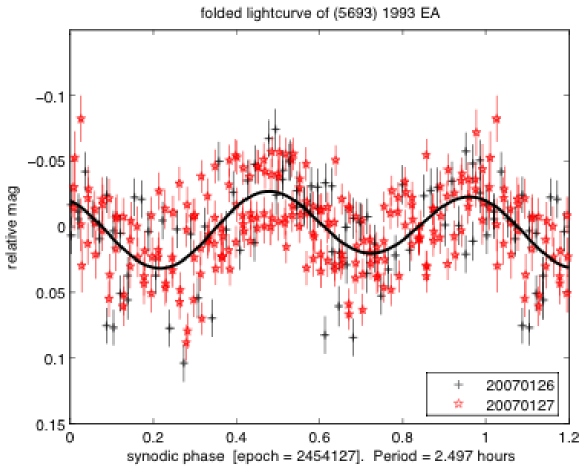


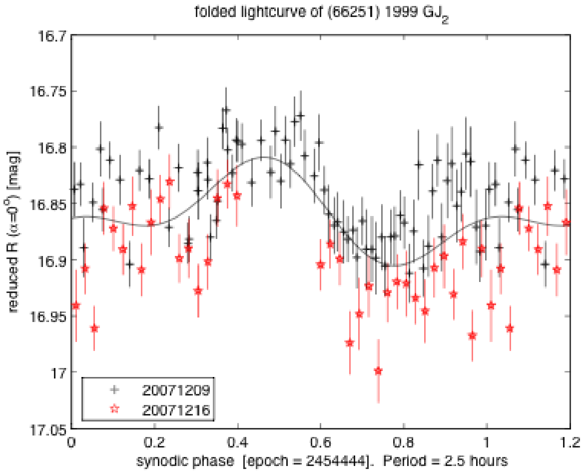

folded lightcurve of (5143) Heracles
20061021
20061022
20061023
20061126
reduced R ($\alpha=0^0$) [mag]
14.42
14.44
14.46
14.48
14.5
14.52
14.54
14.56
14.58
14.6
14.62
0
0.2
0.4
0.6
0.8
1
1.2
synodic phase [epoch = 2454030]. Period = 2.706 hours

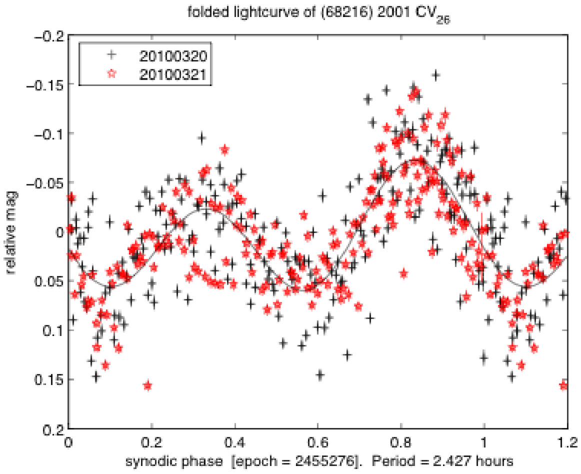

folded lightcurve of (10115) 1992 SK
20060305
20060306
reduced R ($\alpha=0^0$) [mag]
16.9
17
17.1
17.2
17.3
17.4
17.5
17.6
17.7
17.8
17.9
0
0.1
0.2
0.3
0.4
synodic phase [epoch = 2453800]. Period = 7.31 hours


phase curve of (5143) Heracles
mean reduced R [mag]
15
15.1
15.2
15.3
15.4
15.5
15.6
10
15
20
25
30
35
40
phase angle [degrees]


folded lightcurve of (40267) 1999 GJ_4
20060429
20060430
20060501
reduced R ($\alpha=0^0$) [mag]
14.8
15
15.2
15.4
15.6
15.8
16
16.2
16.4
16.6
0
0.2
0.4
0.6
0.8
1
1.2
synodic phase [epoch = 2453856]. Period = 4.97 hours


folded lightcurve of (5693) 1993 EA
20070126
20070127
relative mag
−0.1
−0.05
0
0.05
0.1
0.15
0
0.2
0.4
0.6
0.8
1
1.2
synodic phase [epoch = 2454127]. Period = 2.497 hours


folded lightcurve of (66251) 1999 GJ_2
20071209
20071216
reduced R ($\alpha=0^0$) [mag]
16.7
16.75
16.8
16.85
16.9
16.95
17
17.05
0
0.2
0.4
0.6
0.8
1
1.2
synodic phase [epoch = 2454444]. Period = 2.5 hours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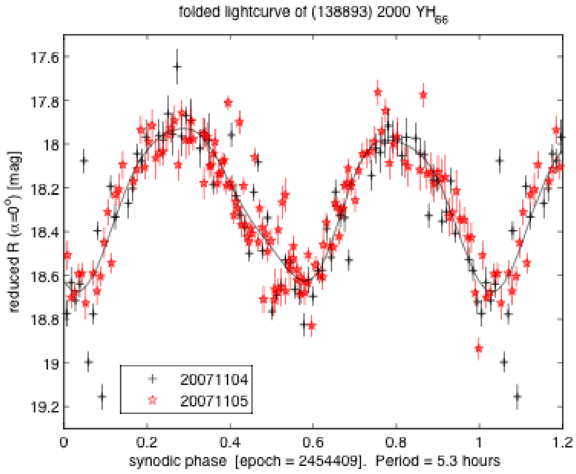
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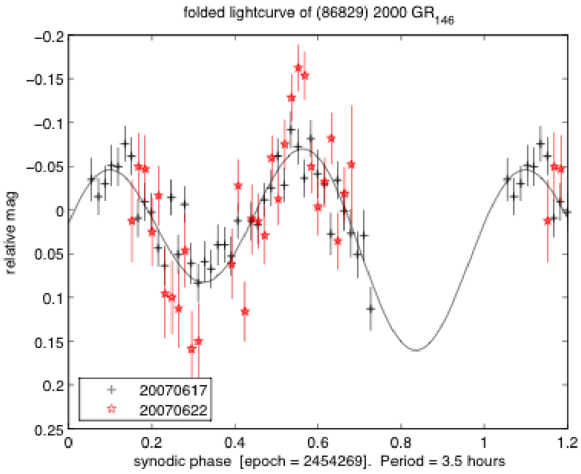
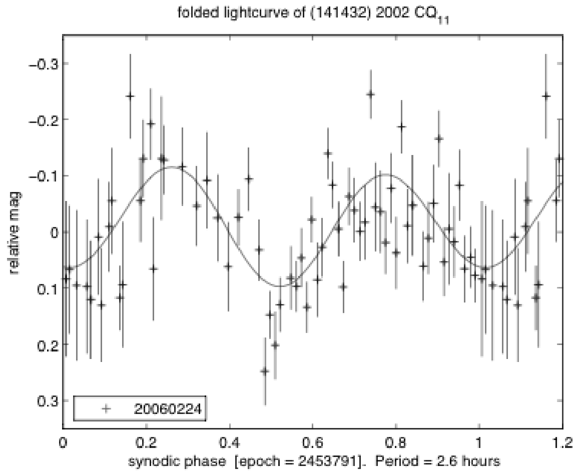
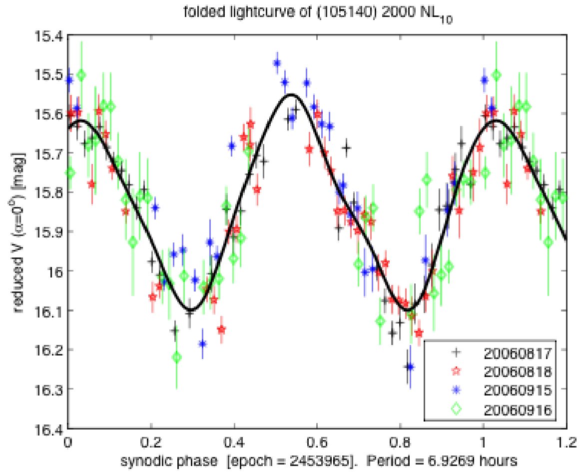

folded lightcurve of (86829) 2000 GR_{146}


folded lightcurve of (141432) 2002 CQ_{11}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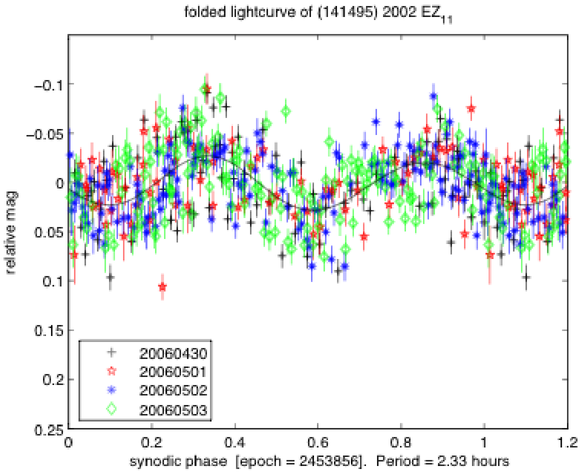
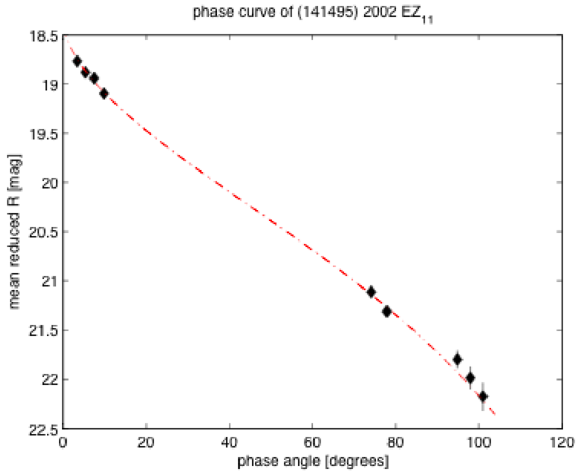
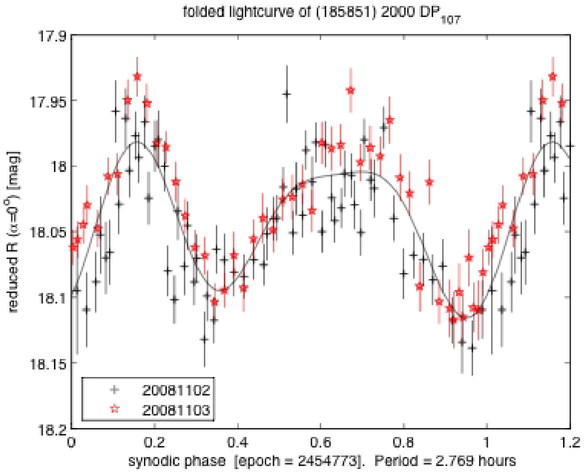
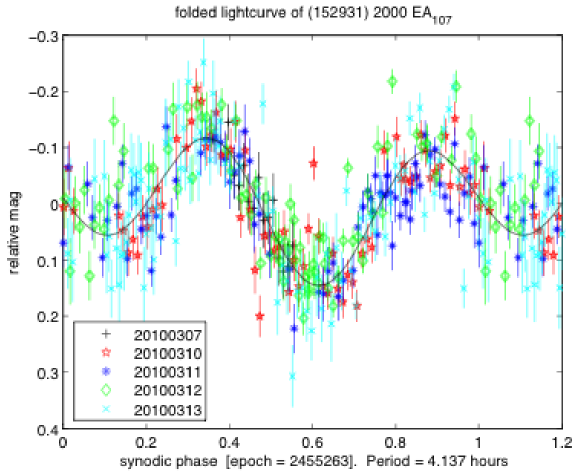
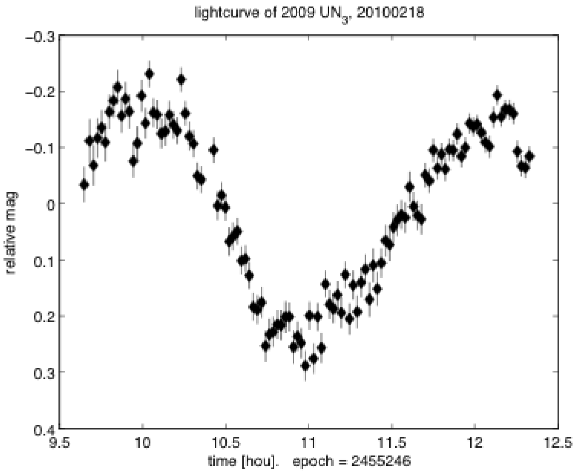

folded lightcurve of (141495) 2002 EZ_{11}









THE VERY LONG PERIOD OF 1479 INKERI

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After two months of consecutive observations, the asteroid 1479 Inkeri reveals a period of 659.9 ± 0.7 h .

On 2011 November 24 the Bigmuskie Observatory started to work on the main-belt asteroid 1479 Inkeri because no previous secure result was reported on the CALL web site (Warner, 2012a). After some sessions on the target, a very early lightcurve seemed to suggest a period close to 48 h. If true, it would have been impossible for only one observer to record the whole lightcurve. This led to the decision to ask for help from Frederick Pilcher of western North America, who was well-spaced in longitude to be able to work portions of the lightcurve of 1479 Inkeri impossible to record at the Bigmuskie Observatory. Both observatories produced additional sessions, and it soon became evident that the early period of about 48 h was completely wrong and that a very long period beyond 500 h with an amplitude of about 1 mag started to appear. With such a long period, both observers agreed that it was useless to record long sessions every night, but it was better to work short sessions of one or two hours each every useful night.

Observations by Pilcher were obtained with a Meade 35 cm LX 200 GPS S-C, SBIG STL-1001-E CCD, R filter, unguided exposures. Those by Ferrero were with a 30-cm *f*/8 Ritchey-Chretien and SBIG ST9 CCD, R filter and unguided exposure. Image measurement and lightcurve analysis were done with *MPO Canopus* software V 10.4.0.20. To calibrate the data to an internal system, every session worked by Pilcher was coupled with a set of 10 calibrated images chosen among the best ones in the same session. Every image was then remeasured at the Bigmuskie Observatory as if it was an entire session. The results were used to put the data onto the internal system.

Working in the described manner for two months, a clear bimodal lightcurve with a period of about 660 h slowly appeared. From the period spectrum it can be seen that two other periods fit the data equally well, one at about 1000 h and the other at about 1300 h. These two periods produce lightcurves with three maxima and minima, and four maxima and minima, respectively, per cycle. We reject these periods because a bimodal solution is the only realistic one for an amplitude as large as 0.9 magnitudes.

During the work on this target, after it completed the first rotation, discordances in the sparse data between phase 0.10 and 0.20, appeared which could be the evidence that 1479 Inkeri is a tumbler. However, with the addition of more sessions, those sessions that were out of track were too few to give consistency to the theory. The final result on 1479 Inkeri is a period of 659.9 ± 0.7 h and an amplitude of 0.94 mag.

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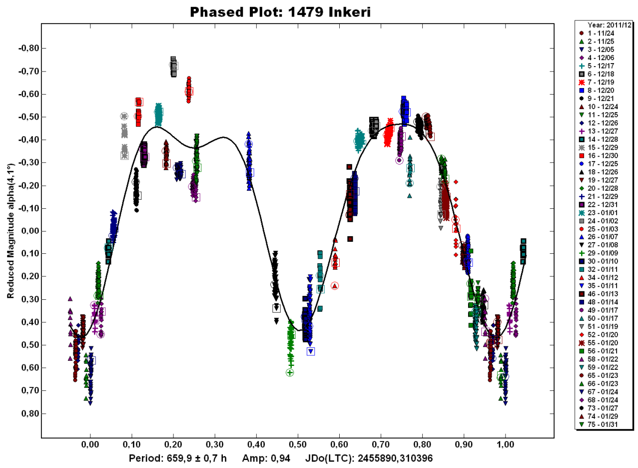

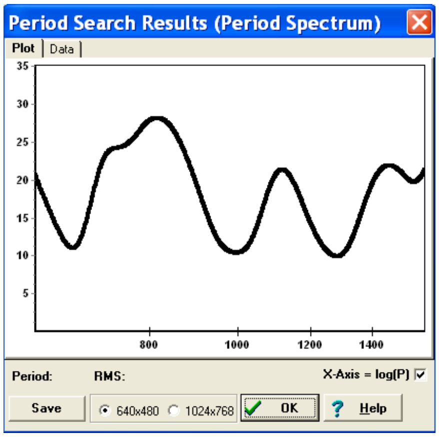

A DEEP MAIN-BELT ASTEROID SURVEY

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As a byproduct of a Trojan asteroid study, seven main-belt asteroids were observed using the 4-m Blanco telescope at Cerro Tololo Inter-American Observatory. Since each asteroid was observed on a single night, periods could only be determined on three of the asteroids.

In August 2011, the authors commenced a study of Jovian Trojan asteroids using the 4-m Blanco telescope at Cerro Tololo Inter-American Observatory (MPC 807). Observations were made with the MOSAIC II CCD imager shortly before it was retired. Observations were planned over 4 nights, but the first two nights were lost to weather.

The MOSAIC II CCD imager consisted of an array of eight 2048 x 4096 CITe CCDs creating an overall image size of 8192 x 8192 pixels. The center of each night's field of view was carefully chosen to place the targeted Trojan asteroids so that they drift towards the center of each of the individual CCDs. Since Main-belt asteroids are a byproduct of this study, they were randomly placed across the array. Because of the approximately 50 pixel gap between the individual CCDs, sometimes the Main-belt asteroids did not 'mind the gap' resulting in a shortened observing run. Observations with the MOSAIC II camera were 180 second exposures through a Cousins R filter. Wasserman did a search of the Lowell asteroid database for all known asteroids in the field of view, and blinked the observations to confirm their presence. On the two nights, 34 Main-belt asteroids were identified. Of the 34, seven Main-belt asteroids with a SNR exceeding 10 were measured. All measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data and incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris et al., 1989).

None of the seven asteroids has previously had results published in the Lightcurve Database (Warner 2011). The data for each of

#	Name	mm/dd 2011	Data Pts	α	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
55514	2001 VJ6	08/21	60	2.4	336	0	7.1	0.2	0.40	0.05
75538	1999 XV230	08/20	30	3.6	328	-10	> 24		> 0.1	
84415	2002 TL195	08/21	40	3.3	335	0	> 24		> 0.05	
141240	2001 XQ252	08/21	59	2.9	335	0	> 24		> 0.15	
194473	2001 WQ21	08/20	52	5.3	328	-8	6.5	0.5	0.10	0.02
232438	2003 FH71	08/21	48	4.2	335	0	> 24		> 0.25	
	2001 BC73	08/20	73	4.2	328	-9	8.4	0.2	0.65	0.04

these asteroids was uploaded to The Minor Planet Center's Lightcurve database MPC (2012).

Acknowledgements

This research was supported by Cottrell College Science Award grants from the Research Corporation and support from the Faculty Development Fund of Illinois Wesleyan University.

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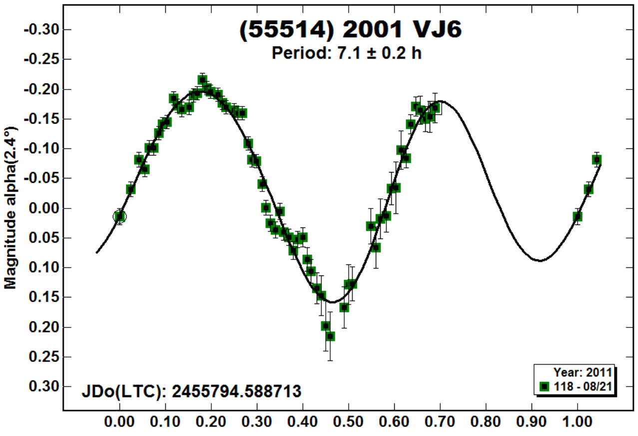

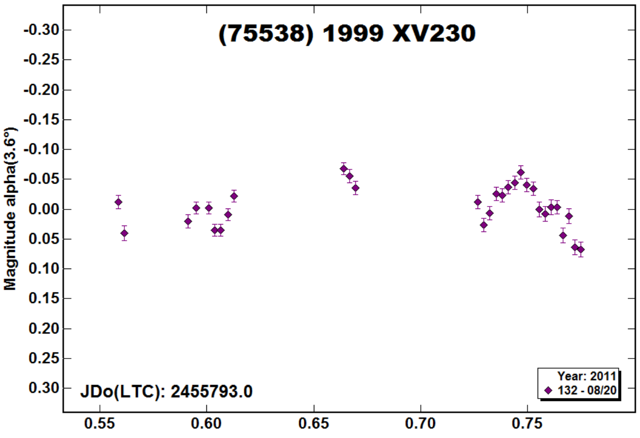

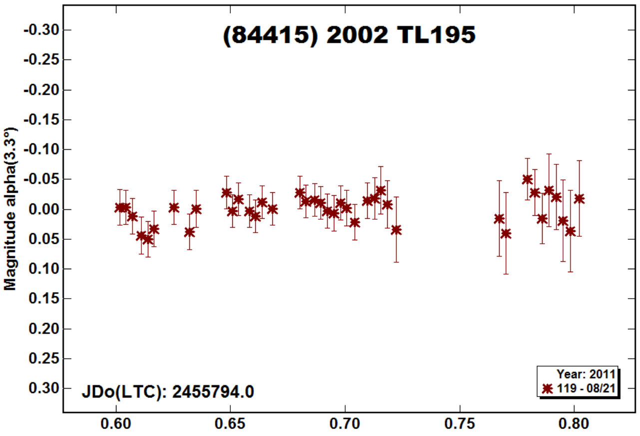

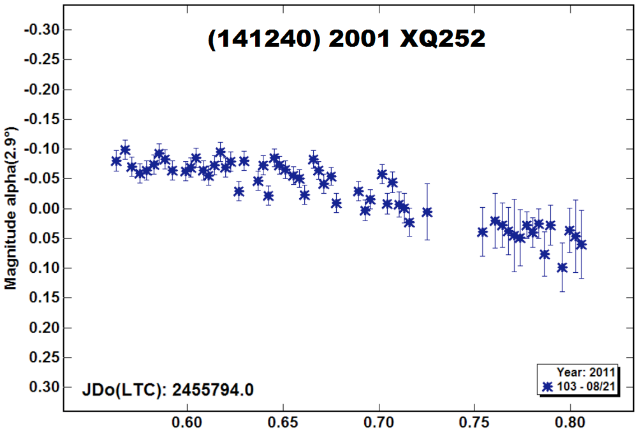

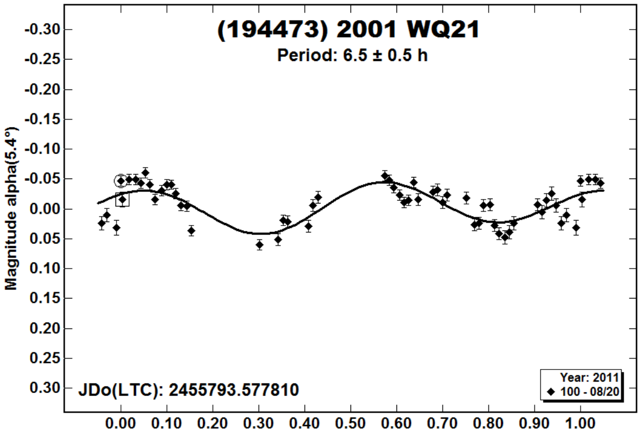

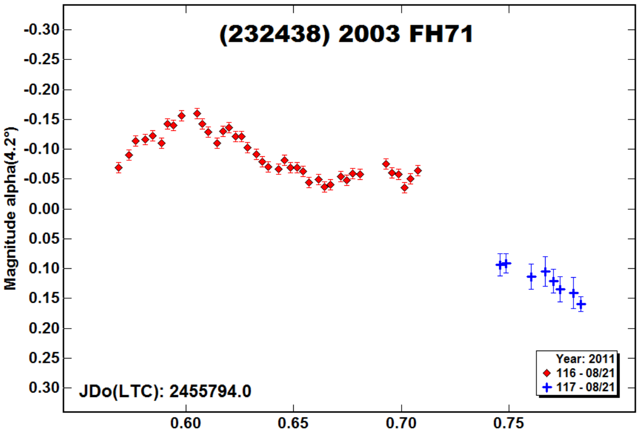

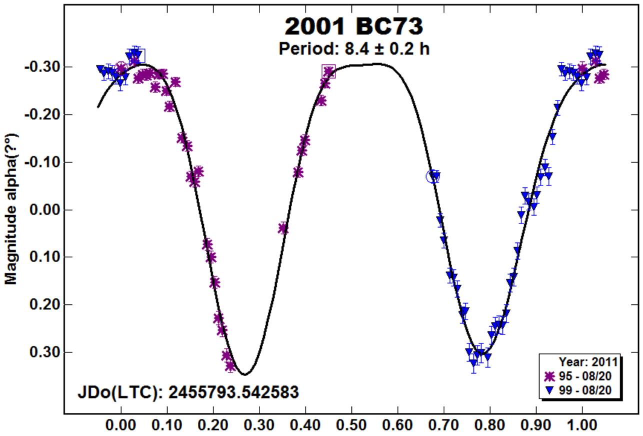

LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2012 JULY-SEPTEMBER

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We present lists of asteroid photometry opportunities for objects reaching a favorable apparition and have no or poorly-defined lightcurve parameters. Additional data on these objects will help with shape and spin axis modeling via lightcurve inversion. We also include lists of objects that will be the target of radar observations. Lightcurves for these objects can help constrain pole solutions and/or remove rotation period ambiguities that might not come from using radar data alone.

We present four lists of “targets of opportunity” for the period 2012 July-September. For background on the program details for each of the opportunity lists, refer to previous issues, e.g., *Minor Planet Bulletin* **36**, 188. In the first three sets of tables, “Dec” is the declination, “U” is the quality code of the lightcurve, and “α” is the solar phase angle. See the asteroid lightcurve data base (LCDB) documentation for an explanation of the U code:

http://www.minorplanet.info/lightcurvedatabase.html

Objects with U = 1 should be given higher priority over those rated U =2 or 3 but not necessarily over those with no period. On the other hand, d*o not overlook asteroids with* U = 2 *on the assumption that the period is sufficiently established.* Regardless, do not let the existing period influence your analysis since even high quality ratings have been proven wrong at times. Note that the lightcurve amplitude in the tables could be more or less than what’s given. Use the listing only as a guide.

The first list is an *abbreviated list* of those asteroids reaching V < 15.0 at brightest during the period and have either no or poorly-constrained lightcurve parameters. A ‘(F)’ after the name indicates that the asteroid is reaching one of its five brightest apparitions between the years 1995-2050.

The goal for these asteroids is to find a well-determined rotation rate. The target list generator on the CALL web site allows you to create custom lists for objects reaching V ≤ 17.0 during any month in the current year, e.g., limiting the results by magnitude and declination.

http://www.minorplanet.info/PHP/call_OppLCDBQuery.php

The Low Phase Angle list includes asteroids that reach very low phase angles. Getting accurate, calibrated measurements (usually V band) at or very near the day of opposition can provide important information for those studying the “opposition effect.” You will have the best chance of success working objects with low amplitude and periods that allow covering, e.g., a maximum, every night. Objects with large amplitudes and/or long periods are much more difficult for phase angle studies since, for proper analysis, the data have to be reduced to the average magnitude of the asteroid for each night. Without knowing the period and/or the amplitude at the time, that reduction becomes highly uncertain. As an aside, some use the maximum light to find the phase slope parameter (G). However, this can produce a significantly different value for both H and G versus using average light, which is the method used for values listed by the Minor Planet Center.

The third list is of those asteroids needing only a small number of lightcurves to allow spin axis and/or shape modeling. Those doing work for modeling should contact Josef Ďurech at the email address above and/or visit the Database of Asteroid Models from Inversion Techniques (DAMIT) web site for existing data and models:

http://astro.troja.mff.cuni.cz/projects/asteroids3D

The fourth list gives a brief ephemeris for planned radar targets. Supporting optical observations to determine the lightcurve period, amplitude, and shape are needed to supplement the radar data. *High-precision work, 0.01-0.02 mag, is preferred, especially if the object is a known or potential binary*. Those obtaining lightcurves in support of radar observations should contact Dr. Benner directly at the email given above.

Future radar targets:
http://echo.jpl.nasa.gov/~lance/future.radar.nea.periods.html

Past radar targets:
http://echo.jpl.nasa.gov/~lance/radar.nea.periods.html

Arecibo targets:
http://www.naic.edu/~pradar/sched.shtml

Goldstone targets:
http://echo.jpl.nasa.gov/asteroids/goldstone_asteroid_schedule.html

As always, we encourage observations of asteroids even if they have well-established lightcurve parameters and especially if they are lacking good spin axis and/or shape model solutions. Every lightcurve of sufficient quality supports efforts to resolve a number of questions about the evolution of individual asteroids and the general population. For example, pole directions are known for only about 30 NEAs out of a population of 8000. This is hardly sufficient to make even the most general of statements about NEA pole alignments, including whether or not the thermal YORP effect is forcing pole orientations into a limited number of preferred directions (see La Spina *et al.*, 2004, *Nature* **428**, 400-401). Data from many apparitions can help determine if an asteroid's rotation rate is being affected by YORP, which can also cause the rotation rate of a smaller, irregularly-shaped asteroid to increase or decrease. See Lowry *et al.* (2007) *Science* **316**, 272-274 and Kaasalainen *et al.* (2007) *Nature* **446**, 420-422.

The ephemeris listings for the optical-radar listings include lunar elongation and phase. Phase values range from 0.0 (new) to 1.0 (full). If the value is positive, the moon is waxing – between new and full. If the value is negative, the moon is waning – between full and new. The listing also includes the galactic latitude. When this value is near 0°, the asteroid is likely in rich star fields and so may be difficult to work. It is important to emphasize that the ephemerides that we provide are only guides for when you might observe a given asteroid. Obviously, you should use your discretion and experience to make your observing program as effective as possible.

Once you've analyzed your data, it's important to publish your results. Papers appearing in the *Minor Planet Bulletin* are indexed in the Astrophysical Data System (ADS) and so can be referenced by others in subsequent papers. It's also important to make the data available at least on a personal website or upon request.

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Lightcurve Opportunities

		Brightest			LCDB Data		
#	Name	Date	Mag	Dec	Period	Amp	U
2412	Wil	07 02.2	14.2	-28			
1426	Riviera	07 03.7	13.4	-36	4.404	0.30	3
1063	Aquilegia	07 03.9	13.8	-24	5.791	0.73-0.93	3
267	Tirza	07 05.0	13.5	-28	7.648	0.18- 0.4	3
1436	Salonta	07 05.6	14.3	-14	8.87	0.33	3
431	Nephele	07 13.2	12.0	-21	18.821	0.02-0.30	2
2858	Carlosporter	07 13.3	14.5	-17			
628	Christine	07 13.8	12.1	-22	16.1783	0.18- 0.4	3
4263	Abashiri	07 13.9	14.1	-23	4.8821	0.15	3
1233	Kobresia	07 16.8	14.2	-21	27.83	0.34	2
17711	1997 WA7	07 18.2	14.4	-31			
1131	Porzia	07 18.4	13.6	-23	4.6584	0.15-0.23	3
153958	2002 AM31	07 18.7	13.7	+49			
4937	Lintott	07 20.0	14.5	-8	3.123	0.24	3
174	Phaedra	07 20.9	11.7	-30	5.744	0.38-0.58	3
67	Asia	07 21.7	10.1	-8	15.89	0.15-0.26	3-
1130	Skuld	07 22.1	13.1	-16	4.81	0.50	3
7102	Neilbone	07 22.3	14.4	-19			
1180	Rita	07 22.6	13.8	-25	14.902	0.29	3
2443	Tomeileen	07 23.0	14.2	-21	3.974	0.1	2
3948	Bohr	07 23.3	14.4	-14			
1490	Limpopo	07 25.7	14.2	-5	6.647	0.15	3
2730	Barks	07 29.1	14.5	-28			
224	Oceana	07 29.3	11.8	-25	9.401	0.09-0.14	3
544	Jetta	08 02.7	12.3	-14	7.745	0.44-0.52	3
2271	Kiso	08 03.9	14.0	-17		0.12	
2599	Veseli	08 04.9	14.0	-37	18.54	0.33	2
1096	Reunerta	08 05.7	13.0	-30	13.036	0.26-0.39	3

Lightcurve Opportunities (cont'd)

		Brightest			LCDB Data		
#	Name	Date	Mag	Dec	Period	Amp	U
20899	2000 XB3	08 07.6	14.2	-7			
11705	1998 GN7	08 08.7	14.3	-18	3.8	0.32	2
1060	Magnolia	08 09.5	14.0	-3	2.9107	0.09-0.14	3
2467	Kollontai	08 10.0	13.5	-14			
6092	Johnmason	08 10.0	14.3	-17			
1360	Tarka	08 11.2	14.0	-24	8.87	0.82	3
234	Barbara	08 12.6	10.0	-12	26.468	0.19	3-
1789	Dobrovolsky	08 13.4	13.1	-17	4.812	0.13- 0.7	3
1198	Atlantis	08 13.7	14.5	-8			
4869	Piotrovsky	08 14.7	14.5	-19			
3009	Coventry	08 15.1	14.5	-22			
2090	Mizuho	08 15.8	14.4	-19	5.47	0.30	2+
317	Roxane	08 16.2	11.8	-13	8.169	0.61-0.75	3
4769	Castalia	08 16.5	14.0	-27	4.095	0.64- 1.0	3
141	Lumen	08 17.3	10.5	-11	19.87	0.12- 0.2	3
1167	Dubiago	08 18.2	14.3	-5	14.3	0.23	2
1928	Summa	08 20.4	14.3	-8	9.66	0.14	1
5369	Virgiugum	08 20.5	14.4	-9			
7534	1995 UA7	08 20.5	14.4	-21			
9963	Sandage	08 20.8	14.3	-38			
3813	Fortov	08 22.9	14.3	-10	12.3	0.76	3-
639	Latona	08 24.0	11.9	-1	6.22	0.07-0.35	3
620	Drakonia	08 24.5	13.4	-18	5.487	0.52-0.62	3
2393	Suzuki	08 24.7	14.2	+4	9.31	0.40	2+
930	Westphalia	08 25.0	13.4	-15		0.10	
1240	Centenaria	08 25.8	12.7	-8	11.2907	0.08-0.20	3
602	Marianna	08 30.8	11.2	-6	30.	0.3	1
625	Xenia	08 30.9	12.1	-19	21.101	0.37-0.50	2
1049	Gotho	08 31.5	14.0	-10	8.47	0.17	3-
767	Bondia	09 01.0	13.3	-12			
4332	Milton	09 02.3	13.0	-3	3.2978	0.30	2+
11	Parthenope	09 03.1	8.9	-12	13.7204	0.05-0.12	3
3920	Aubignan	09 03.4	13.6	-22			
2815	Soma	09 03.9	14.0	-15	2.7332	0.07	3
2141	Simferopol	09 04.5	14.5	+2	14.956	0.48	3
339	Dorothea	09 05.3	12.7	-4	5.974	0.10	3
1346	Gotha	09 06.2	14.0	-5	2.6407	0.10-0.16	3-
72	Feronia	09 07.6	10.8	+1	8.097	0.11-0.15	3
2964	Jaschek	09 08.2	14.5	+1	12.53	0.46	3-
277	Elvira	09 08.3	13.1	-4	29.69	0.34-0.59	3
1632	Siebohme	09 08.5	14.3	+0			
601	Nerthus	09 09.6	13.3	-4	13.59	0.29	3
7530	Mizusawa	09 09.8	14.5	-9			
1111	Reinmuthia	09 10.7	14.1	-8	4.02	0.72	3
1560	Strattonia	09 12.1	13.9	+5			
1332	Marconia	09 15.7	13.8	-4			
2298	Cindijon	09 16.3	14.4	+2			
612	Veronika	09 16.7	13.9	+14			
1474	Beira	09 16.9	13.8	+32	4.184	0.18	3
787	Moskva	09 17.5	12.2	+2	6.056	0.32-0.68	3
5951	Alicemonet	09 17.7	14.1	-14			
3879	Machar	09 18.7	14.0	+10			
236	Honoria	09 20.8	10.6	+1	12.333	0.05-0.18	3
923	Herluga	09 24.9	13.8	+7	19.746	0.16	2
79	Eurynome	09 26.0	9.8	+4	5.978	0.05-0.25	3
1527	Malmquista	09 26.9	13.4	-1	14.077	0.54	3
5275	Zdislava	09 27.2	14.3	+13			
522	Helga	09 29.1	13.6	-3	8.129	0.13-0.30	3
4608	Wodehouse	09 29.9	14.2	+7	13.944	0.10	3
59	Elpis	09 30.7	10.7	-1	13.69	0.10-0.23	3

Low Phase Angle Opportunities

#	Name	Date	α	V	Dec	Period	Amp	U
1063	Aquilegia	07 03.9	0.57	13.8	-24	5.791	0.73-0.93	3
847	Agnia	07 05.9	0.31	14.0	-22	14.827	0.45	3
20	Massalia	07 06.7	0.42	10.0	-22	8.098	0.15-0.27	3
445	Edna	07 09.6	0.97	13.4	-25	19.97	0.21	2
38	Leda	07 11.5	0.38	12.6	-23	12.838	0.05-0.16	3
431	Nephele	07 13.2	0.15	12.0	-21	18.821	0.02-0.30	2
628	Christine	07 13.8	0.16	12.1	-22	16.135	0.18-0.4	2
1233	Kobresia	07 16.8	0.24	14.0	-21	27.83	0.34	2
1457	Ankara	07 22.6	0.31	13.5	-20	31.8	0.21	2
133	Cyrene	08 01.7	0.68	11.6	-20	12.708	0.26	3
2271	Kiso	08 03.9	0.19	14.0	-17			
17	Thetis	08 05.8	0.65	10.1	-18	12.27048	0.13-0.40	3
111	Ate	08 07.1	0.44	11.7	-15	22.2	0.1	2
317	Roxane	08 16.2	0.26	11.9	-13	8.169	0.65	3
354	Eleonora	08 18.3	0.85	10.6	-15	4.277	0.12-0.52	3
163	Erigone	08 23.6	0.53	12.6	-10	16.136	0.37	3
64	Angelina	08 26.5	0.30	11.6	-10	8.752	0.04-0.42	3
1049	Gotho	08 31.4	0.75	14.0	-10	8.470	0.17	3-
35	Leukothea	09 04.0	0.72	13.1	-09	31.900	0.07-0.43	3

Low Phase Angle Opportunities (cont'd)

#	Name	Date	α	V	Dec	Period	Amp	U
1346	Gotha	09 06.1	0.44	14.0	-05	11.19	0.12	2
76	Freia	09 06.4	0.55	12.8	-04	9.969	0.10-0.33	3
277	Elvira	09 08.3	0.65	13.1	-04	29.69	0.34-0.59	3
601	Nerthus	09 09.6	0.44	13.3	-04	13.59	0.29	3
	2010 GT12	09 10.8	0.20	7.0	-04			
1332	Marconia	09 15.7	0.53	13.6	-04			
658	Asteria	09 20.5	0.19	14.0	-01	21.034	0.22-0.32	3
236	Honoria	09 20.8	0.86	10.7	+01	12.333	0.05-0.18	3
313	Chaldaea	09 22.0	0.32	12.1	-01	8.392	0.08-0.24	3

Shape/Spin Modeling Opportunities

There are two lists here. The first is for objects for which good occultation profiles are available. These are used to constrain the models obtained from lightcurve inversion, eliminating ambiguous solutions and fixing the size of asteroid. Lightcurves are needed for modeling and/or to establish the rotation phase angle at the time the profile was obtained. The second list is of those objects for which another set of lightcurves from one more apparitions will allow either an initial or a refined solution.

Occultation Profiles Available

		Brightest			LCDB DATA		
#	Name	Date	Mag	Dec	Period	Amp	U
404	Arsinoe	07 04.9	11.7	-28	8.887	0.27-0.38	3
94	Aurora	07 11.4	12.3	-33	7.22	0.12	3
139	Juewa	07 12.8	12.0	-37	20.991	0.20	3
431	Nephele	07 13.2	12.0	-21	18.821	0.02-0.30	2
828	Lindemannia	07 15.4	14.4	-23			
99	Dike	07 19.9	12.6	-42	18.127	0.08-0.22	3
134	Sophrosyne	07 21.3	12.5	-34	17.196	0.19	3
566	Stereoskopia	08 07.4	12.3	-22	12.103	0.08-0.25	3
234	Barbara	08 12.6	10.0	-12	26.468	0.19	3-
141	Lumen	08 17.3	10.5	-11	19.87	0.12-0.2	3
345	Tercidina	08 17.8	11.8	+01	12.371	0.12-0.23	3
350	Ornamenta	08 20.2	13.1	-41	9.178	0.10-0.20	3
51	Nemausa	09 02.2	10.4	-04	7.783	0.10-0.25	3
76	Freia	09 06.5	12.7	-04	9.969	0.10-0.33	3
638	Moira	09 17.0	14.0	-12	9.875	0.31	3
366	Vincentina	09 20.7	12.6	+02	15.5	0.08	1
522	Helga	09 29.1	13.6	-03	8.129	0.17-0.30	3

Inversion Modeling Candidates

		Brightest			LCDB Data		
#	Name	Date	Mag	Dec	Period	Amp	U
408	Fama	07 02.9	14.1	-27	202.10	0.05-0.58	3
1219	Britta	07 05.3	14.7	-29	5.575	0.56-0.70	3
20	Massalia	07 06.7	9.9	-22	8.098	0.15-0.27	3
899	Jokaste	07 17.7	13.9	-08	6.245	0.28	3
1742	Schaifers	07 19.9	14.7	-19	8.56	1.46	3
174	Phaedra	07 20.9	11.7	-30	5.744	0.38-0.53	3
1130	Skuld	07 22.1	13.2	-16	4.810	0.50	3
390	Alma	07 24.1	14.3	-21	3.74	0.42	3
355	Gabriella	07 28.5	13.7	-24	4.830	0.42	3
544	Jetta	08 02.7	12.3	-14	7.745	0.44-0.52	3
1419	Danzig	08 13.8	14.3	-06	8.1202	0.81-0.92	3
317	Roxane	08 16.2	11.8	-13	8.169	0.65	3
163	Erigone	08 23.7	12.6	-10	16.136	0.37	3
590	Tomyris	08 24.0	14.3	-22	5.562	0.21-0.93	3
620	Drakonia	08 24.5	13.4	-18	5.487	0.58	3
770	Bali	09 04.5	13.1	-14	5.9513	0.40-0.55	3
484	Pittsburghia	09 05.2	13.2	-18	10.63	0.37	3
277	Elvira	09 08.3	13.1	-04	29.69	0.34-0.59	3
601	Nerthus	09 09.6	13.3	-04	13.59	0.29	3
1368	Numidia	09 11.8	14.1	-16	3.64	0.35	3
787	Moskva	09 17.5	12.4	+02	6.056	0.47-0.60	3
313	Chaldaea	09 22.0	12.1	-01	8.392	0.08-0.24	3
733	Mocia	09 28.6	14.2	+14	11.374	0.29	3
567	Eleutheria	09 28.7	14.0	-07	7.71	0.26-0.50	3

Radar-Optical Opportunities

Use the ephemerides below to judge your best chances for observing. Some of the targets may be too faint to do accurate photometry with backyard telescopes. However, accurate astrometry using techniques such as "stack and track" is still possible and can be helpful for those asteroids where the position uncertainties are significant. Note that the intervals in the ephemerides are not always the same and that *geocentric* positions are given. Use these web sites to generate updated and *topocentric* positions:

MPC: *http://www.minorplanetcenter.org/iau/MPEph/MPEph.html*
JPL: *http://ssd.jpl.nasa.gov/?horizons*

In the ephemerides below, ED and SD are, respectively, the Earth and Sun distances (AU), V is the estimated Johnson V magnitude, and α is the phase angle. SE and ME are the great circles distances (in degrees) of the Sun and Moon from the asteroid. MP is the lunar phase and GB is the galactic latitude. "PHA" in the header indicates that the object is a "potentially hazardous asteroid", meaning that at some (long distant) time, its orbit might take it very close to Earth.

The first three objects are repeats from the previous issue of the *Minor Planet Bulletin* since they are still observable in the early part of the third quarter of 2012.

(153958) 2002 AM31 (2012 Jun-Jul, H = 18.1)
There are no lightcurve parameters in the LCDB for 2002 AM31, an NEA with estimated size of 0.7 km. It will miss planet Earth by 0.035 AU on July 22. The ephemeris does not extend that far because, by the time of closest approach, the solar elongation will be only 90°, making photometry difficult. However, astrometric observations before the approach may be beneficial to the radar teams for pointing at the object.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
06/25	18 13.1	+03 03	0.16	1.17	15.7	22.9	154	116	+0.27	+10
06/30	18 15.0	+06 19	0.13	1.13	15.3	26.6	150	55	+0.81	+11
07/05	18 18.3	+10 51	0.11	1.11	14.9	31.8	145	37	-0.98	+12
07/10	18 24.9	+17 50	0.08	1.08	14.4	39.3	138	86	-0.60	+14
07/15	18 40.0	+30 18	0.06	1.05	14.0	51.2	126	118	-0.16	+16

1685 Toro (2012 Jun-Jul, H = 14.2)
This Apollo member is sometimes called "Earth's second satellite." It has resonances with both Earth and Venus that cause it to have close approaches to Earth twice every eight years, this being one of those years. The solar elongation is never very large, meaning that photometry runs are kept short. The period is about 10.1 h, so a single station will have to obtain a number of sessions to get good coverage of the full lightcurve.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
06/25	22 47.4	+01 35	0.48	1.26	15.0	49.2	110	172	+0.27	-49
06/30	23 04.8	+05 38	0.44	1.23	14.8	51.6	109	123	+0.81	-48
07/05	23 24.6	+10 18	0.40	1.19	14.6	54.6	107	56	-0.98	-47
07/10	23 47.8	+15 38	0.37	1.16	14.5	58.3	104	11	-0.60	-45
07/15	00 15.5	+21 36	0.34	1.12	14.4	63.0	100	55	-0.16	-40

2201 Oljato (2012 Jun-Aug, H = 16.8)
This NEA of about 1.8 km size is thought to have a period on the order of 24 h or more. This makes it a prime candidate for a coordinated photometry campaign, providing enough observers can be found in the Southern Hemisphere.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
06/25	21 29.6	-18 19	0.78	1.66	16.8	25.8	135	160	+0.27	-43
07/05	21 08.7	-20 15	0.81	1.76	16.8	17.1	149	16	-0.98	-39
07/15	20 46.0	-21 59	0.86	1.86	16.7	8.5	164	118	-0.16	-34
07/25	20 24.2	-23 19	0.94	1.95	16.7	2.0	176	108	+0.35	-30
08/04	20 05.8	-24 11	1.04	2.04	17.2	6.8	166	38	-0.96	-26
08/14	19 52.1	-24 38	1.17	2.13	17.8	12.2	154	161	-0.14	-24
08/24	19 43.4	-24 48	1.32	2.21	18.3	16.3	142	60	+0.44	-22

2003 KU2 (2012 Jul, H = 17.7, PHA)

There are no rotation statistics in the LCDB for this NEA. The estimated size is 900 meters. 2003 KU2 has a "EMOID" (Earth Minimum Orbit Intersect Distance) of about 2.6 M miles. Even a MOID that is less than the radius of the Earth does not assure an impact. The asteroid and Earth have to be at the same place at the same time. A small MOID indicates the possibility, *no matter how remote*, of this happening. The Minor Planet Center's list of close approaches through 2178 does not include this asteroid.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/01	21 07.4	-15 56	0.18	1.17	15.6	30.1	145	73	+0.89	-37
07/03	21 25.6	-15 45	0.16	1.15	15.4	32.6	143	48	+0.99	-41
07/05	21 47.4	-15 26	0.15	1.13	15.3	35.8	139	25	-0.98	-46
07/07	22 13.4	-14 53	0.13	1.11	15.1	40.1	135	9	-0.87	-51
07/09	22 44.4	-14 01	0.12	1.10	15.1	45.6	130	19	-0.70	-58
07/11	23 20.4	-12 43	0.11	1.08	15.0	52.3	123	34	-0.51	-64
07/13	00 00.7	-10 54	0.11	1.07	15.1	60.1	115	48	-0.32	-70
07/15	00 43.4	-08 35	0.10	1.05	15.3	68.7	106	60	-0.16	-71

1566 Icarus (2012 Jul, H = 16.9, PHA)

Despite it being so famous, there are only three lightcurve determinations in the LCDB, *P* = 2.273 h. The estimated diameter is 1.2 km. This time around, it is a target for those in the Southern Hemisphere with large telescopes, probably at 1east 1-meter. Additional lightcurves can be used for modeling the YORP effect. The next close approach to Earth is 2137 June at 0.04 AU.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/10	21 00.1	-40 28	1.01	1.97	19.2	14.2	152	65	-0.60	-41
07/12	20 54.1	-41 12	1.01	1.97	19.2	13.4	153	88	-0.41	-40
07/14	20 47.7	-41 54	1.00	1.97	19.1	12.8	155	110	-0.24	-39
07/16	20 41.1	-42 35	1.00	1.97	19.1	12.4	155	131	-0.10	-38
07/18	20 34.3	-43 12	1.00	1.97	19.1	12.1	156	148	-0.01	-36
07/20	20 27.2	-43 47	1.00	1.97	19.1	12.1	156	150	+0.01	-35
07/22	20 19.9	-44 20	1.00	1.97	19.1	12.2	156	134	+0.09	-34
07/24	20 12.6	-44 48	1.00	1.97	19.1	12.6	155	110	+0.25	-33

4179 Toutatis (2012 Jul-Sep, H = 15.3, PHA, NPA)

This 2.6 km NEA is one of the prime examples of a "tumbler", an asteroid in non-principal axis rotation (see Pravec *et al.*, 2005). The lightcurve will be anything from regular and so don't expect it to repeat itself. The two periods (rotation and precession) are 178 and 130 h. The amplitude has ranged from 0.15 to 1.0 mag or more. Since the asteroid is reasonably bright for several months, it will be good to get lightcurves at regular intervals, e.g,. every few days to a week, with well-calibrated data. This will allow finding good *H-G* values, though dealing with the complex lightcurve of a tumbler will make this a challenge.

The next close approach is 2012 December (0.046 AU) when it will be as bright as V ~ 10.4. As can happen with NEAs, this asteroid reaches opposition more than once this year. The one in December is more favorable in terms of brightness and will be within 20° of the celestial equator all month. Comparisons between the lightcurves in July/August versus those in December will be very interesting.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/01	20 53.3	-17 21	0.96	1.90	17.5	16.2	148	70	+0.89	-35
07/11	20 47.9	-17 45	0.83	1.82	17.0	11.4	159	69	-0.51	-33
07/21	20 38.1	-18 27	0.72	1.74	16.2	5.1	171	166	+0.04	-32
07/31	20 23.8	-19 23	0.64	1.65	15.7	2.7	176	24	+0.94	-29
08/10	20 05.9	-20 26	0.57	1.56	15.8	11.8	162	111	-0.48	-25
08/20	19 46.7	-21 27	0.52	1.47	15.8	21.6	147	117	+0.07	-21
08/30	19 29.2	-22 15	0.48	1.39	15.9	31.8	134	27	+0.97	-18
09/09	19 15.9	-22 50	0.46	1.30	15.9	41.6	121	154	-0.46	-15

(277475) 2005 WK4 (2012 Aug-Sep, H = 20.2, PHA)

The diameter for 2005 WK4 is about 300 meters. There are no entries in the LCDB. The MOID is only 0.00386 AU, or about 1.5 Earth-moon distances. However, the next closest approach is many times more (0.0128 AU, 2078 August). This is another object featured this month that favors those with large telescopes and in the Southern Hemisphere.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
08/10	02 24.4	+05 04	0.13	1.05	18.2	71.1	102	18	-0.48	-51
08/15	02 13.3	-02 29	0.13	1.07	18.0	62.1	111	80	-0.08	-59
08/20	02 00.8	-09 53	0.13	1.09	17.9	53.5	120	143	+0.07	-66
08/25	01 46.6	-16 48	0.14	1.10	17.8	45.7	129	126	+0.55	-74
08/30	01 30.7	-22 58	0.15	1.12	17.7	39.1	136	62	+0.97	-80
09/04	01 13.5	-28 10	0.16	1.14	17.8	34.3	141	40	-0.88	-85
09/09	00 55.5	-32 17	0.17	1.15	17.9	31.3	144	83	-0.46	-85
09/14	00 37.6	-35 19	0.19	1.16	18.1	30.2	144	132	-0.06	-81

2008 AF4 (2012 Jul-Aug, H = 19.7, PHA)

This NEAs MOID is just less than the Earth-moon distance. As with 2005 WK4, the next close approach is much farther out, 0.025 AU in 2021 January. There are no lightcurve parameters in the LCDB for 2008 AF4, which has an estimated diameter of 340 meters. As with all small asteroids that come relatively close to the sun, a collection of lightcurves (rotation periods) over several apparitions can help detect YORP (spin up/down) and Yarkovsky (orbit size change) changes and so help understand the exact nature of these critical thermal effects to help improve the threat assessment for a PHA.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/25	00 43.2	-13 42	0.25	1.15	18.9	52.3	117	157	+0.35	-76
07/27	00 59.2	-13 55	0.23	1.13	18.8	54.4	115	140	+0.57	-77
07/29	01 16.4	-14 06	0.22	1.12	18.8	56.8	113	119	+0.79	-76
07/31	01 34.9	-14 13	0.22	1.11	18.7	59.4	110	97	+0.94	-74
08/02	01 54.5	-14 16	0.21	1.09	18.7	62.4	107	76	+1.00	-70
08/04	02 15.2	-14 14	0.20	1.08	18.7	65.5	104	58	-0.96	-67
08/06	02 36.8	-14 05	0.20	1.07	18.7	68.9	101	43	-0.84	-62
08/08	02 58.9	-13 49	0.20	1.06	18.8	72.4	97	34	-0.67	-57

4581 Asclepius (2012 Aug, H = 19.6, PHA)

There are no lightcurve parameters for Asclepius, a 360 meter NEA. The MOID is 0.0034 AU (a little more than the Earth-moon distance) with the next close approach in 2105 March at 0.033 AU. This will be a difficult target because of the somewhat low solar elongation and magnitude, especially the first part of the month because of the nearly full moon.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
08/01	00 12.7	+28 01	0.16	1.08	17.9	60.2	112	80	+0.98	-34
08/03	00 28.5	+30 34	0.15	1.07	17.8	63.1	109	58	-0.99	-32
08/05	00 47.5	+33 18	0.14	1.06	17.8	66.6	106	40	-0.90	-30
08/07	01 10.4	+36 11	0.13	1.05	17.7	70.6	102	28	-0.76	-27
08/09	01 38.2	+39 03	0.12	1.04	17.7	75.4	98	25	-0.57	-23
08/11	02 11.6	+41 44	0.12	1.03	17.8	80.8	93	31	-0.39	-19
08/13	02 51.0	+43 54	0.11	1.01	17.9	86.7	87	42	-0.21	-14
08/15	03 35.5	+45 13	0.11	1.00	18.1	93.1	81	55	-0.08	-9

4769 Castalia (2012 Jul-Sep, H = 16.9)

The MPC includes Castalia on its list of PHAs, but with a MOID of 0.02 AU, it would seem much less a threat that some of the others covered this quarter. The next close approach is 2046 Aug at 0.025 AU. The LCDB gives a period of 4.095 h with amplitude range of 0.64-1.0 mag (depending on viewing aspect). This should be a good project for Southern Hemisphere observers with even modest backyard telescopes.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/01	22 22.9	-22 52	0.53	1.42	17.7	33.8	129	88	+0.89	-56
07/11	22 22.8	-23 16	0.43	1.37	17.0	29.5	138	52	-0.51	-56
07/21	22 14.2	-24 09	0.33	1.32	16.2	23.2	149	162	+0.04	-55
07/31	21 51.2	-25 32	0.25	1.26	15.2	14.2	162	44	+0.94	-50
08/10	21 01.1	-26 55	0.18	1.19	14.2	10.4	168	100	-0.48	-39
08/20	19 23.3	-25 31	0.13	1.12	14.1	34.4	141	111	+0.07	-18
08/30	17 07.0	-15 38	0.11	1.04	14.8	73.6	100	60	+0.97	+15
09/09	15 16.1	-02 15	0.14	0.95	16.7	110.9	62	144	-0.46	+44

2063 Bacchus (2012 Jul-Aug, H = 17.1)

Pravec et al. (1998) found a rotation period of 14.904 h for Bacchus. However, using radar observations, Benner *et al.* found a sidereal period of 15.0 ± 0.2 h. using single and two-lobbed models (the two-lobbed representing a bifurcated body). Additional lightcurves will help refine the existing models.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/15	01 00.7	-18 44	0.51	1.25	18.0	51.6	105	62	-0.16	-81
07/20	01 17.9	-18 16	0.47	1.23	17.9	52.8	105	112	+0.01	-79
07/25	01 36.5	-17 44	0.43	1.21	17.7	54.3	105	150	+0.35	-76
07/30	01 56.9	-17 04	0.40	1.18	17.5	56.2	105	113	+0.87	-72
08/04	02 19.4	-16 13	0.36	1.16	17.3	58.6	104	59	-0.96	-67
08/09	02 44.6	-15 07	0.33	1.13	17.2	61.7	102	32	-0.57	-61
08/14	03 13.0	-13 41	0.30	1.10	17.0	65.5	99	60	-0.14	-54
08/19	03 45.1	-11 47	0.28	1.07	16.9	70.2	95	107	+0.02	-47

(144411) 2004 EW9 (2012 Sep-Nov, H = 16.6)

Pravec *et al.* (2004) found a period of 49.94 h for this asteroid along with an amplitude at least 0.9 magnitude. The estimated size is for this NEA is 1.4 km. Finding the period is helped by the near-circumpolar position (north) that will allow for extended individual runs over several weeks.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
09/01	03 48.6	+50 26	0.29	1.06	16.6	71.9	92	81	-1.00	-3
09/11	03 28.1	+50 12	0.33	1.13	16.6	60.1	103	53	-0.27	-5
09/21	03 04.2	+49 13	0.36	1.20	16.6	48.9	116	148	+0.30	-8
10/01	02 37.6	+47 07	0.39	1.28	16.6	38.0	128	42	-0.99	-12
10/11	02 11.5	+43 50	0.43	1.36	16.7	27.9	140	95	-0.24	-17
10/21	01 49.7	+39 41	0.48	1.43	16.8	19.7	151	112	+0.38	-22
10/31	01 34.5	+35 16	0.55	1.51	17.0	15.3	156	28	-0.99	-27
11/10	01 26.0	+31 13	0.64	1.59	17.5	15.8	154	140	-0.20	-31

1999 RM45 (2012 Sep-Oct, H = 19.3, PHA)

There are no LCDB entries for this 400 meter NEA. The MOID is 0.0025 AU but the next closest approach is at about 0.02 AU (2021 March). Despite being faint (1-meter scope or larger), we've included this to encourage astrometry to improve the orbit and, if possible, photometry to start building a collection of lightcurves for modeling and YORP studies.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
09/01	13 38.2	-00 03	0.33	0.81	21.3	118.3	45	139	-1.00	+61
09/06	14 19.4	-05 19	0.28	0.86	20.7	114.2	51	165	-0.73	+51
09/11	15 15.2	-12 12	0.24	0.92	20.0	105.4	61	124	-0.27	+37
09/16	16 28.2	-19 47	0.22	0.97	19.3	92.3	75	76	+0.00	+20
09/21	17 51.1	-25 36	0.23	1.03	18.9	77.5	90	24	+0.30	+1
09/26	19 07.5	-28 06	0.26	1.08	18.9	64.9	102	31	+0.83	-16
10/01	20 06.9	-28 08	0.30	1.14	19.1	55.9	110	81	-0.99	-28
10/06	20 50.1	-27 05	0.36	1.19	19.4	49.8	114	129	-0.71	-37

(66146) 1998 TU3 (2012 Sep-Oct, H = 14.6, PHA)

There is no lack of previous work on this NEA. The period is well established at 2.377 h. Here is a case where additional lightcurves are most beneficial for YORP and shape/spin axis modeling. There have been no reported indications of the asteroid being binary. However, its rotation rate and size make it good candidate. Unfortunately, the high-precision photometry required for reliably detecting a satellite will be difficult because of the asteroid's faint showing.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
09/01	13 38.2	-00 03	0.33	0.81	21.3	118.3	45	139	-1.00	+61
09/06	14 19.4	-05 19	0.28	0.86	20.7	114.2	51	165	-0.73	+51
09/11	15 15.2	-12 12	0.24	0.92	20.0	105.4	61	124	-0.27	+37
09/16	16 28.2	-19 47	0.22	0.97	19.3	92.3	75	76	+0.00	+20
09/21	17 51.1	-25 36	0.23	1.03	18.9	77.5	90	24	+0.30	+1
09/26	19 07.5	-28 06	0.26	1.08	18.9	64.9	102	31	+0.83	-16
10/01	20 06.9	-28 08	0.30	1.14	19.1	55.9	110	81	-0.99	-28
10/06	20 50.1	-27 05	0.36	1.19	19.4	49.8	114	129	-0.71	-37

EDITORS' NOTE: CITE AND RECITE

As the quality (and quantity) of papers submitted to the *Minor Planet Bulletin* continues to increase, the *MPB* increases as the principal source for original published asteroid lightcurve results. As we move forward, the Editors remind authors that the highest quality research papers are those that include proper journal review and citation of previous works. It's understood that many *MPB* readers do not have full library access to the literature. However, there are some resources that allow the opportunity to enhance analysis of results and raise the level of the final work.

When reporting results (e.g., rotation period or spin axis), a good faith effort should be made to see if there are previously-reported results. If so, those results should be mentioned and cited. If the list is extensive, it's sufficient to give some relevant examples and mention that there are others. If the new results differ from the earlier ones, it is good practice to compare and contrast and mention why the new result is considered to be the right one. How extensively this is done depends on the number of similar cases in the paper, the significance of the difference, and other factors.

A good starting point to find previous results is the Asteroid Lightcurve Database (LCDB; Warner et al., 2009). The LCDB contains not only the "adopted" rotation periods, but those previously reported in the literature. Also in the files are reported spin axes, color indices, binary status, etc., as well as an extensive references list.

There is a set of text files available at
http://www.minorplanet.info/lightcurvedatabase.html
that are periodically updated. Maybe more convenient is the on-line version, updated about once a month, at
http://www.minorplanet.info/lcdbquery.html

While the LCDB can be used as a starting point, if at all possible, get a copy of the original work and confirm that what's in the LCDB agrees with that original. If the new and old results are significantly different, you might be able to determine why. If you can't get a copy, it's preferred that you cite the original work, not the LCDB, so that those who do have access to the journal can go to it directly.

Finally, please take note of the Author's Guide for how to include citations within the text (see example above) and carefully follow the requested formatting for references, e.g., include the title of the paper and full list of authors. If you participated in a project, you'd like to be known as something other than "et al."

References

Warner, B.D., Harris, A.W., Pravec, P. (2012). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146.

IN THIS ISSUE

This list gives those asteroids in this issue for which physical observations (excluding astrometric only) were made. This includes lightcurves, color index, and H-G determinations, etc. In some cases, no specific results are reported due to a lack of or poor quality data. The page number is for the first page of the paper mentioning the asteroid. EP is the “go to page” value in the electronic version.

Number	Name	Page	EP
14	Irene	81	179
33	Polyhymnia	40	138
46	Hestia	73	171
77	Frigga	60	158
132	Aethra	7	105
140	Siwa	36	134
198	Ampella	39	137
201	Penelope	9	107
203	Pompeja	1	99
223	Rosa	73	171
225	Henrietta	73	171
266	Aline	5	103
266	Aline	73	171
328	Gudrun	11	109
360	Carlova	9	107
369	Aeria	83	181
446	Aeternitas	75	173
467	Laura	40	138
561	Ingwelde	56	154
617	Patroclus	8	106
621	Werdandi	56	154
664	Judith	5	103
664	Judith	33	131
696	Leonora	2	100
739	Mandeville	33	131
750	Oskar	73	171
765	Mattiaca	73	171
781	Kartvelia	33	131
825	Tanina	40	138
871	Amneris	33	131
911	Agamemnon	85	183
971	Alsatia	33	131
1028	Lydina	79	177
1036	Ganymed	13	111
1036	Ganymed	43	141
1263	Varsavia	47	145
1421	Esperanto	40	138
1430	Somalia	79	177
1479	Inkeri	94	192
1577	Reiss	33	131
1620	Geographos	13	111
1627	Ivar	13	111
1660	Wood	49	147
1702	Kalahari	47	145
1862	Apollo	89	187
1865	Cerberus	13	111
1867	Deiphobus	85	183
1980	Tezcatlipoca	13	111
1985	Hopmann	81	179
1985	Hopmann	83	181
2015	Kachuevskaya	47	145
2026	Cottrell	11	109
2068	Dangreen	33	131
2130	Evdokiya	47	145
2363	Cebriones	13	111
2731	Cucula	47	145
2745	San Martin	33	131
2842	Unsold	83	181
2870	Haupt	33	131
2870	Haupt	47	145
2909	Hoshi-no-ie	33	131
2933	Amber	60	158
3017	Petrovic	6	104
3017	Petrovic	81	179
3041	Webb	33	131
3070	Aitken	81	179
3122	Florence	3	101
3352	McAuliffe	59	157
3352	McAuliffe	60	158
3361	Orpheus	89	187
3397	Leyla	11	109
3397	Leyla	79	177
3481	Xianglupeak	40	138
3483	Svetlov	60	158
4031	Mueller	60	158
4106	Nada	83	181
4138	Kalchas	85	183
4179	Toutatis	13	111
4257	Ubasti	13	111
4350	Shibecha	40	138
4350	Shibecha	79	177
4359	Berlage	33	131
4363	Sergej	33	131
4708	Polydoros	85	183
4709	Ennomos	85	183
4801	Ohre	11	109
4804	Pasteur	33	131
4874	Burke	81	179
5143	Heracles	50	148
5143	Heracles	89	187
5332	Davidaguilar	13	111
5378	Ellyett	60	158
5579	Uhlherr	60	158
5642	Bobbywilliams	47	145
5693	1993 EA	89	187
5701	Baltuck	47	145
5771	Somerville	60	158
5870	Baltimore	33	131
5874	1989 XB	33	131
6087	Lupo	60	158
6121	Plachinda	33	131
6172	Prokofeana	33	131
6402	Holstein	33	131
6602	Gilclark	60	158
6618	1936 SO	60	158
6635	Zuber	60	158
7358	Oze	13	111
7559	Kirstinemeyer	47	145
8345	Ulmerspatz	79	177
8404	1995 AN	60	158
8567	1996 HW1	13	111
9023	Mnesthus	85	183
9694	Lycomedes	85	183
9873	1992 GH	60	158
9983	Rickfienberg	37	135
10115	1992 SK	89	187
10247	Amphiaraos	85	183
10765	1990 UZ	33	131
11058	1991 PN10	60	158
11397	1998 XX93	85	183
12444	Prothoon	85	183
12714	Alkimos	85	183
12738	Satoshimiki	33	131
12738	Satoshimiki	47	145
13694	1997 WW7	85	183
16070	1999 RB101	85	183
16358	Plesetsk	33	131
16421	1988 BJ	60	158
16426	1988 EC	60	158
16585	1992 QR	60	158
16589	Hastrup	60	158
16956	1998 MQ11	85	183
16959	1998 QE17	5	103
16959	1998 QE17	79	177
16960	1998 QS52	13	111
18368	Flandrau	60	158
19537	1999 JL8	60	158
22180	2000 YZ	85	183
23135	2000 AN146	85	183
23276	2000 YT101	33	131
23974	1999 CK12	60	158
24465	2000 SX155	60	158
24470	2000 SJ310	85	183
24475	2000 VN2	33	131
25884	2000 SQ4	54	152
25916	2001 CP44	3	101
26383	1999 MA2	60	158
27111	1998 VV34	79	177
28913	2000 OT	79	177
29292	Conniewalker	58	156
30856	1991 XE	60	158
32910	1994 TE15	5	103
35886	1999 JG80	83	181
39572	1993 DQ1	13	111
39618	1994 LT	60	158
40267	1999 GJ4	89	187
45898	2000 XQ49	60	158
47035	1998 WS	3	101
47983	2000 XX13	60	158
49566	1999 CM106	60	158
49678	1999 TQ7	60	158
50991	2000 GK94	60	158
53430	1999 TY16	13	111
55514	2001 VJ6	95	193
57739	2001 UF162	60	158
63260	2001 CN	60	158
66146	1998 TU3	13	111
66251	1999 GJ2	89	187
68216	2001 CV26	89	187
69350	1993 YP	60	158
75538	1999 XV230	95	193
79316	Huangshan	60	158
82066	2000 XG15	60	158
82078	2001 AH46	60	158
84415	2002 TL195	95	193
85774	1998 UT18	13	111
86829	2000 GR146	89	187
87684	2000 SY2	13	111
96487	1998 JU1	33	131
98129	2000 SD25	33	131
105140	2000 NL10	89	187
105155	2000 NG26	60	158
136849	1998 CS1	13	111
137032	1998 UO1	13	111
137170	1999 HF1	3	101
137805	1999 YK5	13	111
138852	2000 WN10	13	111
138893	2000 YH66	89	187
141018	2001 WC47	60	158
141240	2001 XQ252	95	193
141432	2002 CQ11	89	187
141495	2002 EZ11	89	187
142348	2002 RX211	13	111
144901	2004 WG1	13	111
152931	2000 EA107	89	187
162421	2000 ET70	72	170
162900	2001 HG31	13	111
163000	2001 SW169	13	111
164400	2005 GN59	13	111
171576	1999 VP11	13	111
185851	2000 DP107	13	111
185851	2000 DP107	89	187
185854	2000 EU106	13	111
189700	2001 TA45	13	111
190135	2005 QE30	13	111
190491	2000 FJ10	13	111
192642	1999 RD32	56	154
194473	2001 WQ21	95	193
231134	2005 TU45	13	111
232438	2003 FH71	95	193
248818	2006 SZ217	13	111
256700	2008 AG3	60	158
257744	2000 AD205	13	111
305090	2007 VQ4	13	111
320125	2007 EQ185	60	158
	1998 SJ70	13	111
	2001 BC73	95	193
	2004 XK3	13	111
	2006 VB14	13	111
	2008 EV5	13	111
	2008 QS11	13	111
	2008 SA	13	111
	2008 SE	13	111
	2008 SQ1	13	111
	2008 SR1	13	111
	2008 US4	13	111
	2009 UN3	89	187
	2011 YH40	42	140

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