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ADDITIONAL LIGHTCURVES OF 165 LORELEY

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Lightcurves of 165 Loreley obtained on three nights in early 2006 can be satisfied by several different rotation periods, one of which, 7.224 hours, is consistent with the tabulated value, with an amplitude of 0.17 mag.

Minor planet 165 Loreley was listed as a target for which additional lightcurves would be useful for shape modeling (Warner et al. 2006). A total of 501 data points were obtained on three nights, 2006 Jan. 15, 26, and Feb. 19. Equipment consisted of a 35 cm Meade LX200 SCT at longitude 89° 53' 48" W, latitude 39° 47' 09" N, altitude 190 meters, SBIG PixCel 237 CCD, unfiltered, differential photometry only. All exposures were 60 seconds in light only mode at CCD operating temperature –20° C. At the end of each night nine each of 60 second darks, 0.5 second dome flats, and 0.5 second flat darks were obtained and respectively median combined for dark and flat correction. The available observations were rather poorly distributed in time and do not yield a unique and unambiguous rotation period. The Jan. 26 sequence was interrupted by a focusing problem, and that of Feb. 19 by about 2 hours as the target passed very close to a somewhat brighter field star.

Image processing was performed with Canopus software by Brian Warner, bdw Publishing Company. On both Jan. 26 and Feb. 19 there was a shift in instrumental magnitude exceeding 0.1 between the data obtained before and after the interruption even although the same comparison stars were used. This we cannot explain, and we measured the image sets from each night as two separate sessions and arbitrarily adjusted the instrumental magnitudes up or down to obtain the best lightcurve fit.

The Canopus software permits a range of trial periods to be fitted by a Fourier series and the rms error for each period within this range to be tabulated and graphed. Local minima within a range of trial periods correspond to possible synodic rotation periods. In this analysis all periods between 6 and 15 hours, at intervals of 0.001 hour, had rms deviations computed. Lightcurves phased to each of a large number of periods with local rms minima were plotted and inspected visually for goodness of fit. Periods of 7.224 hours, 9.632 hours, 13.515 hours, and 14.448 hours, all ± 0.001 hours, provided nearly identical rms errors and comparably good fits on those parts of the lightcurve which overlapped on more than one night.

Hence this study by itself does not obtain a unique determination of the synodic rotation period. Harris (2006) stated that he considered a 7.223 hour period to have reliability 3 (secure). Our 7.224 hour period is consistent with this one, and the accompanying figure is phased to 7.224 hours.

The authors express their thanks to Brian D. Warner, Walt Cooney, Bob Koff, and Dan Klinglesmith for their instruction and continuing support which made this project possible.

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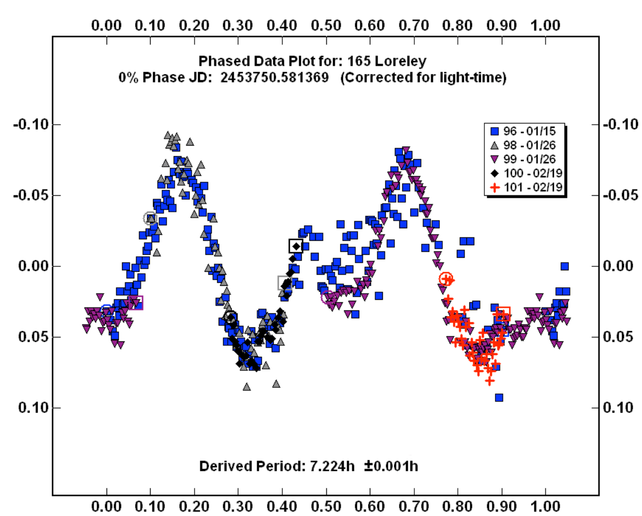

CCD PHOTOMETRY OF ASTEROIDS 276 ADELHEID, 1490 LIMPOPO, AND 2221 CHILTON FROM THE UNIVERSIDAD DE MONTERREY OBSERVATORY

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CCD photometry of asteroids 276 Adelheid, 1490 Limpopo, and 2221 Chilton obtained at the Universidad de Monterrey Observatory during August and September 2005 is reported. A synodic rotation period of 6.315±0.005 hours and an amplitude of 0.17±0.03 magnitudes is confirmed for Adelheid from five nights of observations. The resulting synodic rotation period and amplitude for Limpopo is 6.426±0.003 hours and 0.16±0.03 magnitudes from three nights of observations. Chilton was observed on four nights and exhibits a synodic rotation period of 7.445±0.015 hours and an amplitude of 0.20±0.05 magnitudes, though the period is uncertain due to the faintness of the asteroid in the images. Another possible solution for the rotation period of Chilton is 8.63±0.02 hours.

The observations of 276 Adelheid, 1490 Limpopo and 2221 Chilton reported here were made with the new Meade 36-cm LX200GPS telescope recently acquired for the Universidad de Monterrey Observatory (MPC 720). This telescope was permanently mounted inside a new 6-foot fiberglass dome and is operated from a nearby warm room. The CCD used to gather the data was an SBIG ST-9E with a 512x512x20 μm KAF-0261E chip yielding ~1.7 arc-seconds per pixel for a field of view of ~14.6'x14.6' with the aid of an f/6.3 focal reducer. The chip temperature was set between –9º C and –12º C depending on ambient conditions.

Two of the targets (Limpopo and Chilton) were selected from a list of asteroid photometry opportunities published by Brian Warner on his Collaborative Asteroid Lightcurve Link (CALL) website (Warner, 2005). The selection criteria used were not very stringent as this was basically a field test for the telescope. Adelheid was chosen because it was bright, it had a known relatively short rotation period, and also could be used for shape/spin modeling determination as suggested by Warner et al. (2005). Limpopo was fainter and there was no literature report on its rotation period, and Chilton was considered at the limit of the system also with no reported rotation period.

Usable data were collected on 2005 August 18, 19, 21, 22 and 26 for 276 Adelheid; August 29 & September 14 and 22 for 1490 Limpopo; and August 22, 24, 25 & September 01 for 2221 Chilton. All dates are UT. In total, 428 images were obtained and processed for Adelheid, 332 for Limpopo and 170 for Chilton. Of these, 360 (84%) were used in the final analysis for Adelheid, 308 (93%) for Limpopo and 170 (100%) for Chilton. The rest were discarded because of asteroid proximity to stars. The auto-guided exposure times were 90 seconds for Adelheid, 120 seconds for Limpopo and 240 seconds for Chilton. All images were unfiltered. Standard dark current and flat field corrections were applied. Eight stars were used in each image as magnitude comparison. No star fields with photometric standard stars were observed, so all magnitudes are relative to the field comparison stars.

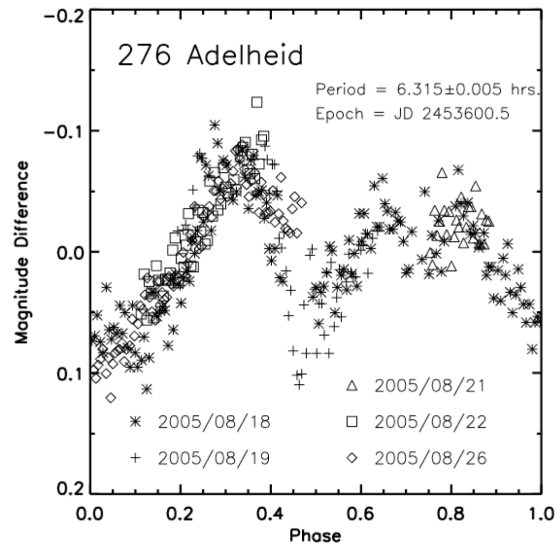
Times were corrected for light travel time from the asteroid to the Earth and were taken to be at the mid-times of the image exposures. Relative magnitudes from night-to-night were uncertain as different comparison star sets were used. This was dealt with by using arbitrary additive constants to bring all the data into the best agreement possible. These magnitude shifts also took into account intrinsic magnitude variation of the asteroids due to their change of distance from Earth, and their phase angle variations (8.5º-9.0º for 276 Adelheid, 13.2º-10.8º for 1490 Limpopo [through opposition], and 10.8º-11.9º for 2211 Chilton).

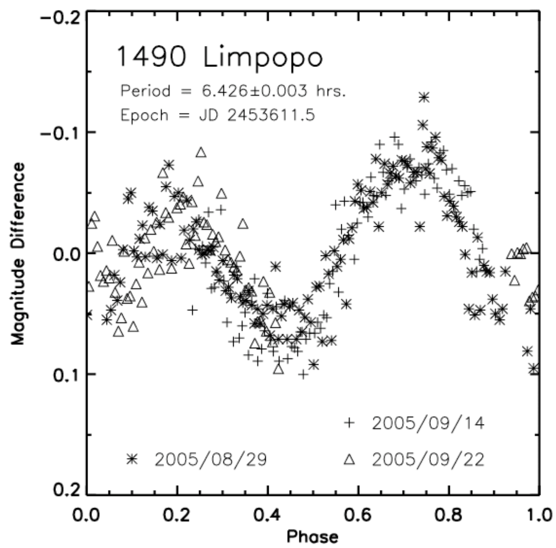
The best-fit rotational periods for the asteroids were obtained by computing the power spectrum of the time series of data (Scargle, 1982; Horne and Baliunas, 1986). For 276 Adelheid the resulting synodic rotational period was 6.315±0.005 hours with an amplitude of 0.17±0.03 magnitudes (Figure 1). The resulting synodic rotational period for 1490 Limpopo from the data presented here is 6.426±0.003 hours. The amplitude of the lightcurve is 0.16±0.03 magnitudes (Figure 2). For 2221 Chilton the resulting synodic rotational period was 7.445±0.015 hours with an amplitude of 0.20±0.05 magnitudes (Figure 3). However, Chilton was at the practical working magnitude limit of the system and the noise in the data was larger than desired. Another possible rotation period for this asteroid derived from the power spectrum could be 8.63±0.02 hours. Adelheid and Limpopo exhibited two slightly different maxima and minima per rotation, while the lightcurve for Chilton seems symmetric. The time scale is given in rotational phase with the zero corresponding to the epoch, in Julian Day, indicated in each figure.

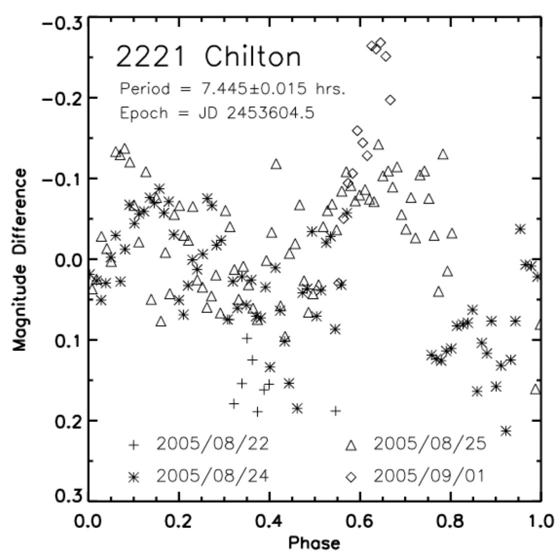
This is probably the first reported rotational period for 2221 Chilton since it is not listed in A. Harris and B. Warner's 'Minor Planet Lightcurve Parameters' list (Harris and Warner, 2006). 1490 Limpopo was also observed in 2005 by L. Bernasconi on five nights between August 26 and September 01, and a rotation period of 6.647±0.004 hours is reported in Behrend's "Asteroids and Comets Rotation curves" webpage (2006). When applied to our data this rotation period also yields a reasonable lightcurve. We note that in our analysis two other periods that flanked our chosen result also yielded good lightcurves, though they had slightly less power. These were 6.217±0.003 and 6.650±0.003 hours. The second one coincides with Behrend's reported period, but we choose to report our initial result since it has slightly higher power than the neighboring periods and our data spans a larger time period.

Asteroid 276 Adelheid has been previously observed. Carlsson and Lagerkvist (1983) first report photoelectric observations, though they could not derive a rotation period from their three nights of observations. Piironen et al. (1994) observed the asteroid over 8 nights in October and November of 1984 and derived a rotation period of about 6.32 hours that they consider in good agreement with a 6.328 hour period previously reported, according to them, by Dotto et al. (1992a). That reference does not contain photometry for 276 Adelheid and they probably meant to reference Dotto et al. (1992b). This same last group (Di Martino et al. 1995) report observations in 1992 February and March that confirm their initial 6.328-hour period with an uncertainty of ± 0.012 hours and an amplitude of 0.10±0.02 magnitudes. Wang and

Shi (2002) report a less-precise rotation period of 6.29±0.01 hours. The last published observation of 276 Adelheid is by Pray (2005) and he reports a rotational period of 6.315±0.002 hours and an amplitude of 0.17±0.02 magnitudes from observations performed between June 13 and 22, 2004. The rotation period and amplitude presented here for 276 Adelheid matches remarkably well the ones reported by Pray.







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BRIGHTNESS VARIATION OF THE ASTEROID (35690) 1999 CT21

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The asteroid (35690) 1999 CT21 was incidentally recorded on 29 and 30 July 2000 UT during the observations of the globular cluster M22. These data have allowed determination of the synodic rotation period to be 9.06 ± 0.02 hours. On 29 July 2000 the reduced V magnitude, the amplitude of the light variation and color index B-V were 14.82 ± 0.01, 0.60 ± 0.02 and 0.7 ± 0.1 mag, respectively. Dimensions and the biaxial ellipsoid models of this asteroid have been obtained for two assumed taxonomic classes (C and S).

Galactic globular clusters are target objects for the Cluster AgeS Experiment (CASE). One of the aims of the project is the search for possible "outbursting" stars (Kaluzny et al. 2005, Pietrukowicz et al. 2005a). The cluster M22 was monitored in the seasons 2000 and 2001 at Las Campanas using the 1.0-m Swope telescope equipped with a 2048 × 3150 pixel SITE3 CCD camera. The photometry was extracted with the *Difference Image Analysis Package* written by Wozniak (2000) and recently modified by W. Pych. This package is an implementation of the method developed by Alard and Lupton (1998).

The asteroid 1999 CT21 was incidentally detected as a straight sequence of residuals on subtracted images representing two consecutive nights 28/29 and 29/30 July 2000 UT. The total number of frames on which the asteroid was present amounts to 64 and 21 in the V and B bands, respectively. The SkyCat tool and USNO-A2.0 catalog were used to obtain an astrometric solution. The obtained positions were sent to the Minor Planet Center where the asteroid was identified (Pietrukowicz et al. 2005b).

Period of Rotation

The observations from 29 July 2000 did not cover the whole rotational cycle but displayed two maxima and one minimum of a large amplitude of 0.60 ± 0.02 mag. The maximum brightness reduced to the unit distances asteroid-Sun and asteroid-Earth was V = 14.82 ± 0.01 mag. The run from 30 July covered only part of the cycle with one visible maximum.

These observational data allow us to determine the synodic rotation period that can take two possible values: 11.44 and 9.06 hours. We have been able to construct the composite lightcurve with these two values. The lightcurve obtained with the longer period covered about 70% rotational cycle. The maximum from 30 July coincided with the second maximum from 29 July. The difference between two maxima was about 0.4 rotational phase. Moreover, the shape of the composite lightcurve suggested the existence of the third pair of extrema not recorded in our observations. We can conclude that the lightcurve with three pairs of extrema is not likely for a such small body (see below).

The synodic period of 9.06 ± 0.02 hours suggests a more classical quasi-sinusoidal lightcurve. The maximum from the second night coincided with the first maximum from 29 July. The data covered about 80% of the cycle and the maxima are in 0.5 rotational phase apart. We have assumed that this period is more probable and the composite lightcurve is presented on the top panel of Fig.1.

The B, V observations indicate that the mean color index B-V is 0.7 ± 0.1 mag. The B-V showed small changes with the rotational cycle. The asteroid seemed to be a little bluer in the first minimum of light as shown in the bottom panel of Fig.1. The lack of data did not allow us to check this behavior for the second minimum.

Dimension and shape model of the asteroid

The photometric data presented above do not allow a determination of the dimension and shape of this asteroid. However, if we assume some parameters, we can obtain provisional values. The maximum brightness (V = 14.82 mag) and the amplitude observed (0.60 mag) are related to the size and shape of the asteroid. However, these values should be corrected to the zero phase angle: brightness by using the so-called HG-magnitude system (Bowell et al. 1989) and the amplitude by the method developed by Zappala et al. (1990). Such reductions are important as the phase angle was $\alpha = 11.9$ deg on 29 July.

Unfortunately, the observations from two consecutive nights did not allow us to make correction for the zero solar phase angle. It can be approximately performed assuming typical values obtained for asteroids. Most of them belong to one of the two taxonomic classes: C and S (Tholen 1989). We can calculate physical parameters of the asteroid 1999 CT21 assuming that it belongs to one of these two classes. The mean values of slope parameter G and geometric albedo p_v for these taxonomic classes have been taken from Harris (1989) while m parameters for reducing the amplitude from Zappala et al. (1990). These assumed values are shown in Table I. They allow us to obtain the absolute magnitude (H) and reduced amplitude (A(0)) for C and S classes and also shown in the same table.

The asteroid showed the large amplitude which indicated an elongated shape of the body or/and the aspect angle close to 90º. If we assume such an aspect angle and the triaxial ellipsoid model (see e.g. Michalowski 1993), we can easily estimate the a/b axes ratio from the formula: $A(0) = 2.5 \log(a/b)$.

We have obtained a/b equal to 1.60 or 1.50 for the assumed C, S parameters, respectively (see Table I). If the aspect angle was lower than 90º, the a/b ratio would be greater than the above mentioned values.

The absolute H magnitude is connected with the diameter D of a spherical body via the relation (e.g. Harris and Harris 1997):

$$\log D = 3.1236 - 0.5 \log p_v - 0.2 H$$

where p_v is the geometric albedo and D diameter in kilometers. The albedo is also unknown for 1999 CT21 and we have assumed the mean values for a given taxonomic class (Table I). These assumptions yield the diameter of 8.4 or 4.6 km for C or S classes, respectively. These values of the diameter have been calculated for spherical body but we know that asteroid is elongated. With the assumptions of the aspect angle equals to 90° and biaxial ellipsoid model (b = c) we can write the relation:

$$\pi (D/2)^2 = \pi ab,$$

and using a/b ratios from Table I we have obtained the dimensions 2a and 2b in kilometers (last two columns in Table I).

All calculated values shown in Table I are only the first approximation of the real parameters describing the asteroid. However, from the orbital semi-major axis (2.55 AU) and low inclination and eccentricity, we would like to pointed out that this asteroid is more likely S-like than C-like.

Planned future observations are expected to verify calculated parameters (Table I) when one is able to determine the G, *m* values, estimate the geometric albedo and check if the assumptions about the 90° aspect angle in the 2000 apparition and the biaxial ellipsoid model are valid for this asteroid. Anyway, at present we have only some preliminary results shown in the present paper.

Acknowledgments

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Table I. Assumed and calculated parameters of the asteroid (35690) 1999 CT21 for C and S taxonomic classes (G and p_v are taken from Harris (1989), while *m* from Zappala et al. (1990)).

Class	G	p_v	m	H [mag]	A(0) [mag]	D [km]	a/b	2a [km]	2b [km]
C	0.09	0.06	0.015	14.04	0.51	8.4	1.60	10.7	6.7
S	0.23	0.18	0.030	14.16	0.44	4.6	1.50	5.6	3.8

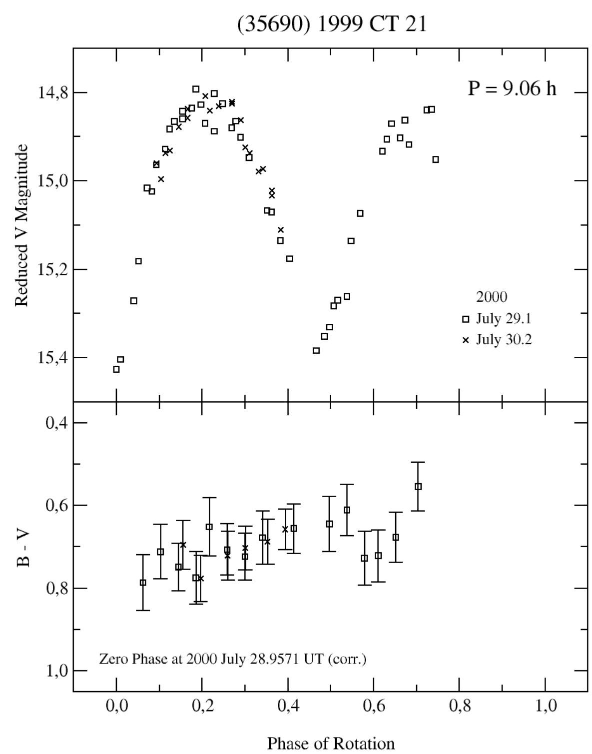

Fig. 1. Composite lightcurve of the asteroid (35690) 1999 CT21 in V band (top panel) and B-V color index (bottom panel).

ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY – FEBRUARY-MARCH 2006

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Lightcurves for 15 asteroids were obtained at the Palmer Divide Observatory from February through mid-March 2006: 353 Ruperto-Carola, 486 Cremona, 535 Montague, 1319 Disa, 1326 Losaka, 1396 Outeniqua, 1653 Yakhontovia, 1854 Skvortsov, 1889 Pakhmutova, 2288 Karolinum, 2725 David Bender, 4490 Bambery, (6159) 1991 YH, (6393) 1990 HM1, and 6859 Datemasamune.

Observations of 15 asteroids were made at the Palmer Divide Observatory in February to mid-March 2006. One of three telescopes/camera combinations was used: 0.5m Ritchey-Chretien/FLI IMG-1001E, 0.35m SCT/FLI IMG-1001E, or 0.35m SCT/ST-9E. The scale for each was about 2.5 arcseconds/pixel. Exposure times were 120–240s, all unguided. The operating temperature for the FLI cameras was –30°C while the ST-9E was run between –15° to –30°C, depending on ambient conditions.

When selecting targets, first priority was given to members of the Hungaria group, those being part of an ongoing study at the Palmer Divide Observatory. When no suitable Hungarias were available, other targets were chosen by comparing the list of known lightcurve periods maintained by Harris and Warner (Harris 2006) against a list of well placed asteroids. Asteroids were often selected with the intent of removing the observational biases against faint objects (due to size and/or distance) as well as those with lightcurves of small amplitudes, long periods, or a complex nature. All images were measured using MPO Canopus, which employs differential aperture photometry to determine the values used for analysis. The period analysis was also done within Canopus using the Fourier analysis algorithm developed by Harris (1989).

The results are summarized in the table below. The individual plots are presented afterwards. The data and curves are presented without comment except when additional details are warranted. Column 3 gives the full range of dates of observations while column 4 gives the number of data points used in the analysis. Column 5 is the range of phase angles over the full date range. If there are three values in the column, this means the phase angle reached a minimum with the middle value being the minimum. Columns 6 and 7 give the range of values (or average if the range was relatively small) for the Phase Angle Bisector (PAB) longitude and latitude respectively. Columns 8 and 10 give the period and amplitude of the curve while columns 9 and 11 give the respective errors in hour and magnitudes.

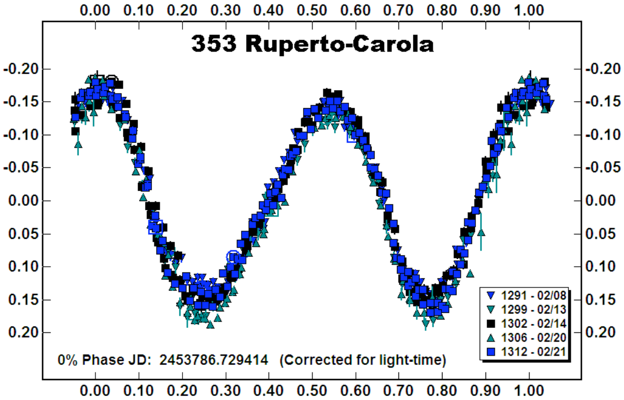
486 Cremona. Wisniewski (1997) reported an amplitude of 0.02 mag but no period.

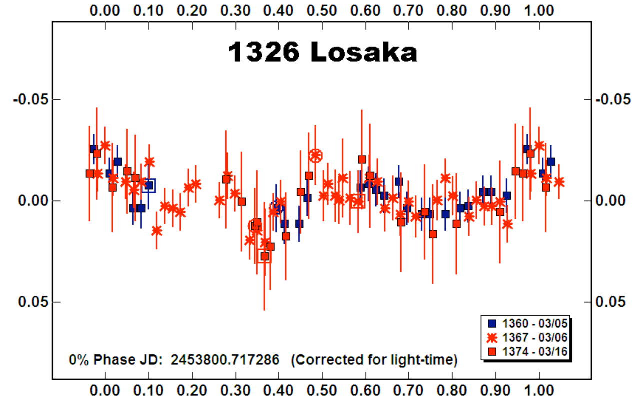
535 Montague. Koff (2001) previously reported a period of 10.28h and an amplitude of 0.20mag.

1326 Losaka. The low amplitude of the lightcurve, only 0.03 mag, makes the solution somewhat uncertain. No other solution seemed to fit well enough to consider.

1653 Yakhontovia. The low amplitude again makes the solution uncertain, especially since the period of 15.41h assumes a monomodal curve. This might indicate the asteroid was viewed pole-on during this apparition. Assuming a bimodal curve, a period search was made between 29 and 32 hours. The resulting plots for the periods of 29.3 or 30.6h were not sufficiently convincing to adopt either solution as being an acceptable alternative. However, they do remain a possibility.

#	Name	Date Range (mm/dd) 2006	Data Pts	Phase	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (m)	AE
353	Ruperto-Carola	02/08-21	581	10.4-16.1	121.6-123.1	3.4	2.73898	0.00004	0.32	0.02
486	Cremona	02/09-22	678	10.5-16.2	121.9	8.2	65.90	0.05	1.0	0.02
535	Montague	02/12-21	561	14.3-17.2	112.6	4.7	10.2482	0.0008	0.25	0.02
1319	Disa	03/04-06	127	7.2-8.1	147.7	-3.4	7.080	0.003	0.26	0.02
1326	Losaka	03/05-16	91	8.4-11.4	147.9	15.2	6.90	0.01	0.03	0.01
1396	Outeniqua	03/15-16	103	12.7-13.2	149.5	2.3	3.081	0.002	0.44	0.03
1653	Yakhontovia	02/02-07	112	4.9-7.3	123.4	-0.1	15.41	0.05	0.03	0.01
1854	Skvortsov	02/26-03/06	276	5.6-9.4	147.8	-4.0	78.5	0.2	0.56	0.02
1889	Pakhmutova	02/03-07	196	8.6-9.7	119.7	15.3	17.490	0.004	0.50	0.02
2288	Karolinum	02/26-03/04	401	10.1-11.6	146.3	18.3	42.16	0.04	0.40	0.02
2725	David Bender	02/26-28	196	10.1-10.5	142.5	19.5	9.956	0.005	0.37	0.02
4490	Bambery	02/22-23	192	13.5-13.2	165.4	18.0	5.815	0.003	0.90	0.03
6159	1991 YH	03/04-06	206	8.6-9.5	149.9	7.8	10.639	0.005	0.78	0.03
6393	1990 HM1	02/03-09	232	6.2-8.1	123.4	10.4	32.70	0.06	0.24	0.02
6859	Datemasamune	02/22-26	201	9.2-7.0	165.2	4.4-5.4	12.95	0.03	0.12	0.03


353 Ruperto-Carola
1291 - 02/08
1299 - 02/13
1302 - 02/14
1306 - 02/20
1312 - 02/21
0% Phase JD: 2453786.729414 (Corrected for light-time)


1326 Losaka
1360 - 03/05
1367 - 03/06
1374 - 03/16
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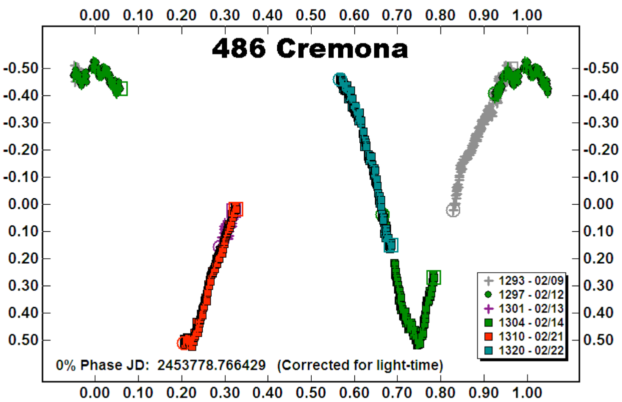
486 Cremona
1293 - 02/09
1297 - 02/12
1301 - 02/13
1304 - 02/14
1310 - 02/21
1320 - 02/22
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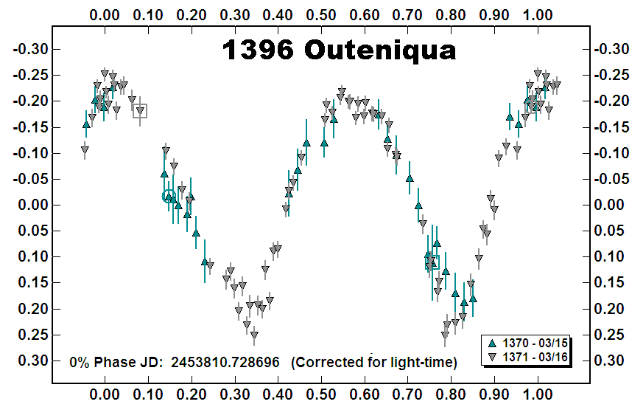
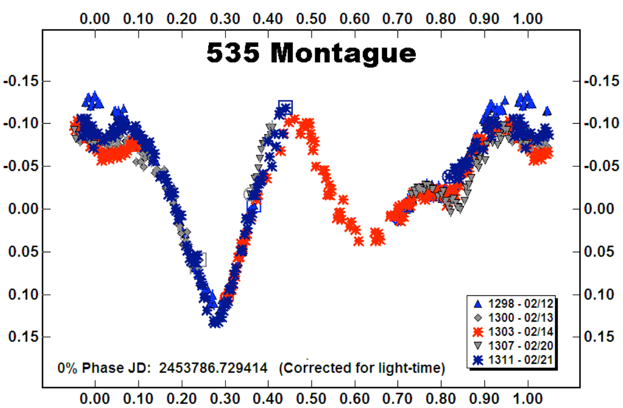

1396 Outeniqua
1370 - 03/15
1371 - 03/16
0% Phase JD: 2453810.728696 (Corrected for light-time)


535 Montague
1298 - 02/12
1300 - 02/13
1303 - 02/14
1307 - 02/20
1311 - 02/21
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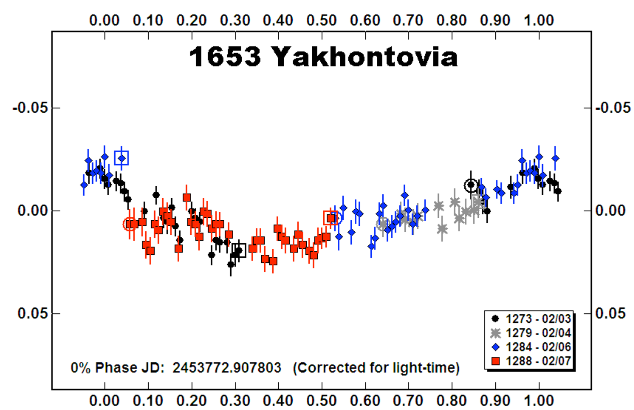
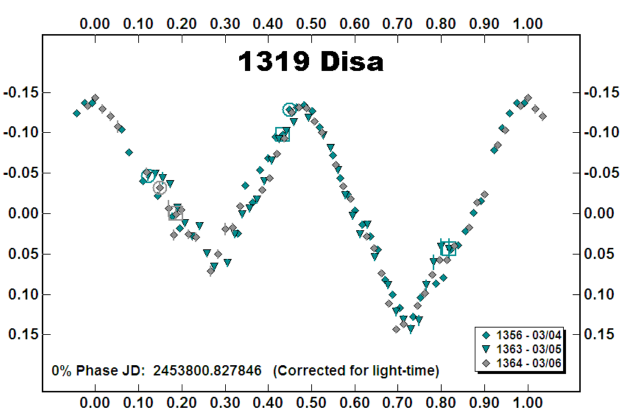
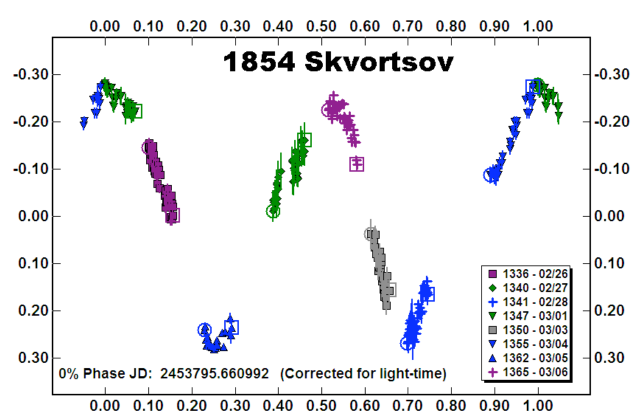
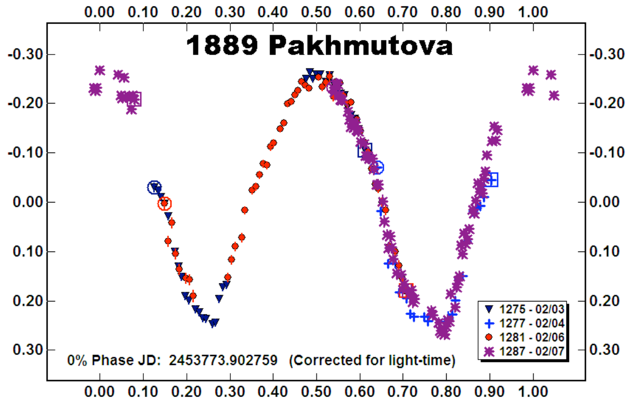
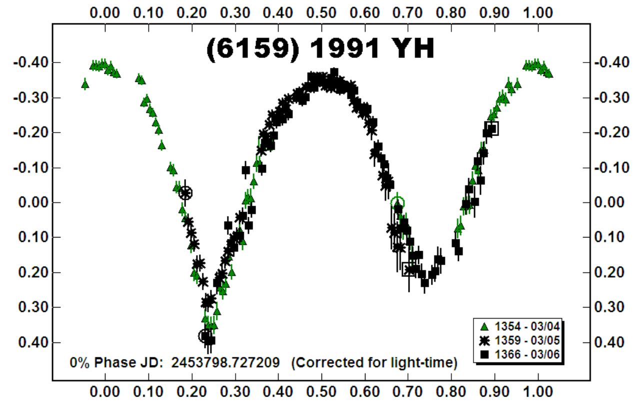
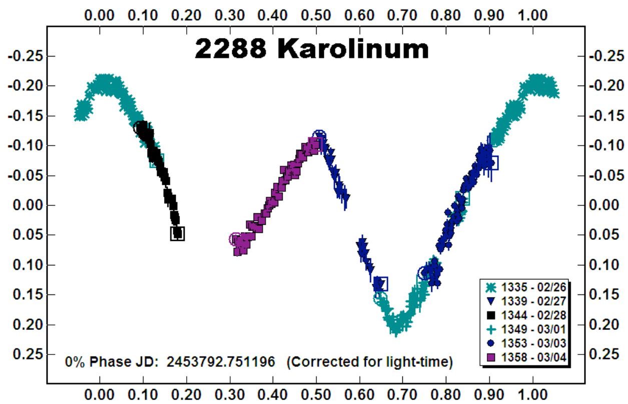

1653 Yakhontovia
1273 - 02/03
1279 - 02/04
1284 - 02/06
1288 - 02/07
0% Phase JD: 2453772.907803 (Corrected for light-time)

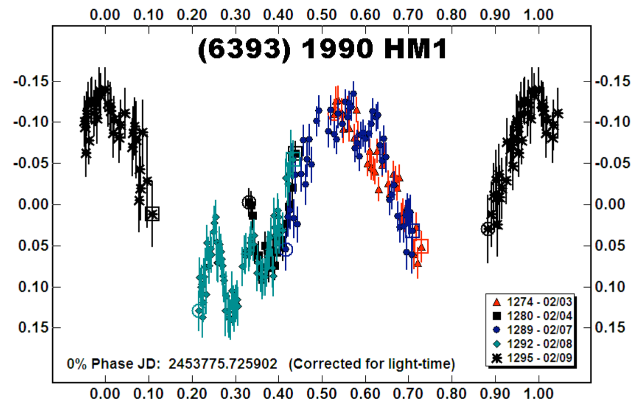

1319 Disa
1356 - 03/04
1363 - 03/05
1364 - 03/06
0% Phase JD: 2453800.827846 (Corrected for light-time)

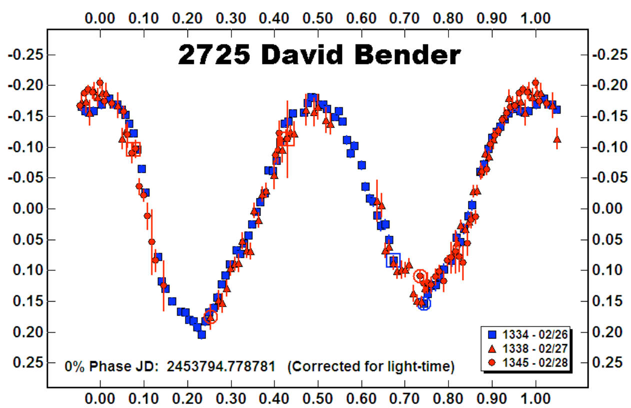

1854 Skvortsov
1336 - 02/26
1340 - 02/27
1341 - 02/28
1347 - 03/01
1350 - 03/03
1355 - 03/04
1362 - 03/05
1365 - 03/06
0% Phase JD: 2453795.660992 (Corrected for light-time)

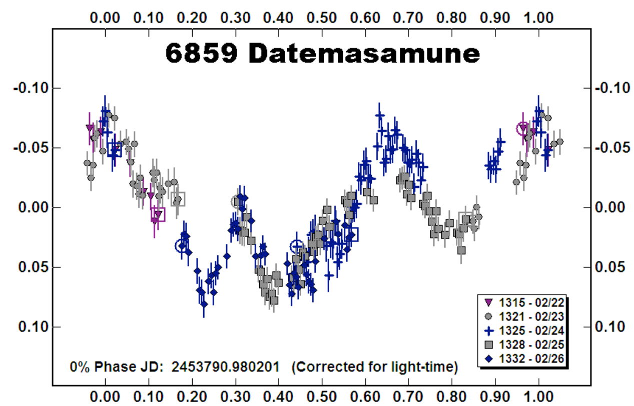


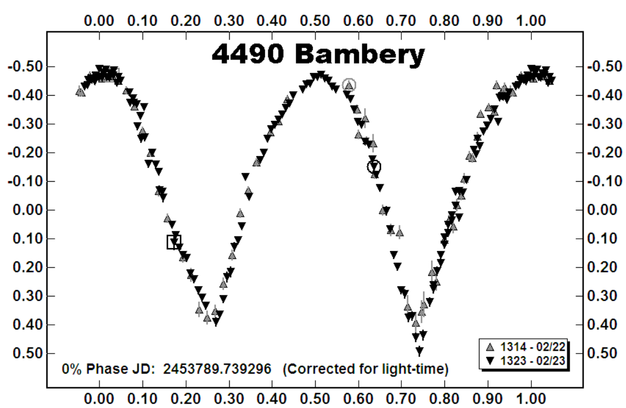












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ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY – MARCH-JUNE 2006

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Lightcurves for 22 asteroids were obtained at the Palmer Divide Observatory from early March through early June 2006: 216 Kleopatra, 314 Rosalia, 618 Elfriede, 633 Zelima, 1064 Aethusa, 1115 Sabauda, 1320 Impala, 1384 Kniertje, 1546 Izsak, 1592 Mathieu, 2047 Smetana, 3318 Blixen, 3642 Frieden, 4077 Asuka, 4985 Weir, 4091 Lowe, 5222 Ioffe, 6296 Cleveland, 5430 Luu, (7563) 1988 BC, 21022 Ike, and (68950) 2002 QF15.

Observations of 22 asteroids were made at the Palmer Divide Observatory from early March to early June 2006. One of three telescopes/camera combinations was used: 0.5m Ritchey-Chretien/FLI IMG-1001E, 0.35m SCT/FLI IMG-1001E, or 0.35m SCT/ST-9E. The scale for each was about 2.5 arcseconds/pixel. Exposure times were 120–240s. Images taken with the 0.5m scope were guided. The operating temperature for the FLI cameras was –30°C while the ST-9E was run between –10° to –20°C, depending on ambient conditions.

When selecting targets, first priority was given to members of the Hungaria group, those being part of an ongoing study at the Palmer Divide Observatory. When no suitable Hungarias were available, other targets were chosen by comparing the list of known lightcurve periods maintained by Harris and Warner (Harris 2006) against a list of well placed asteroids. Asteroids were often selected with the intent of removing the observational biases against faint objects (due to size and/or distance) as well as those with lightcurves of small amplitudes, long periods, or a complex nature. All images were measured using MPO Canopus, which employs differential aperture photometry to determine the values used for analysis. Canopus was also used for period analysis, using the Fourier analysis algorithm developed by Harris (1989).

The results are summarized in the table below. Individual plots are presented afterwards. The data and curves are presented without comment except when warranted. Column 3 gives the full range of dates of observations; column 4 gives the number of data points used in the analysis. Column 5 gives the range of phase angles. If there are three values in the column, the phase angle reached a minimum with the middle value being the minimum. Columns 6 and 7 give the range of values (or average if the range was relatively small) for the Phase Angle Bisector (PAB) longitude and latitude respectively. Columns 8 and 10 give the period and amplitude of the curve while columns 9 and 11 give the respective errors in hour and magnitudes.

216 Kleopatra. This asteroid was observed in support of Lucy Lim of Goddard Space Flight Center, who was doing observations of the asteroid with the Spitzer Telescope in early February. The asteroid has been well studied, with the adopted period being 5.385h (Harris 2006).

618 Elfriede. Weidenschilling (1987) previously reported a period of >6hr. Velichko (1995) found a period of 9.029hr. Attempts to fit the PDO data to that period failed to produce a reasonable fit.

633 Zelima. Lagerkvist (1978) found a period of 10.0hr using

#	Name	Date Range (mm/dd) 2006	Data Pts	Phase	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (m)	AE
216	Kleopatra	04/02-04/03	283	2.1	193.9	-6.0	5.379	0.002	0.36	0.02
314	Rosalia	04/21-05/02	151	10.7,12.8	172.3	1.8	20.43	0.02	0.21	0.02
618	Elfriede	05/12-06/02	297	14.6,16.9	183.6	18.4	14.801	0.001	0.15	0.02
633	Zelima	04/08-04/19	265	3.8,6.3	194.4	10.0	11.724	0.003	0.14	0.02
1064	Aethusa	03/16-03/31	209	10.3,14.9	150.8	-9.6	8.621	0.004	0.18	0.02
1115	Sabauda	04/12-04/13	158	17.2	161.1	18.2	6.72	0.01	0.27	0.02
1320	Impala	05/08-05/15	177	8.4,10.2	217.6	14.0	6.167	0.001	0.52	0.03
1384	Kniertje	03/16-03/31	209	11.8,16.6	149.7	0.9	12.255	0.004	0.33	0.02
1546	Izsak	04/08-04/10	116	0.9,1.5	196.4	2.1	7.35	0.006	0.31	0.02
1592	Mathieu	05/02-05/29	490	11.2,19.9	212.0	16.8	14.23	0.02	0.50	0.02
2047	Smetana	04/09-04/17	219	9.0,8.7,9.3	199.2	11.6	2.4969	0.0004	0.12	0.02
3318	Blixen	05/16-05/19	145	9.0,9.9	216.5	13.3	6.456	0.003	0.20	0.02
3642	Frieden	03/25-04/08	446	7.2,6.9,7.9	189.4	14.9	14.491	0.003	0.13	0.02
4077	Asuka	04/23-04/27	202	6.6,7.7	198.7	10.6	7.919	0.002	0.40	0.02
4085	Weir	05/17-06/02	115	9.7,15.8	220.2	7.3	14.602	0.005	0.18	0.02
4091	Lowe	03/05-03/31	184	7.8,14.1	147.8	14.1	12.570	0.005	0.10	0.03
5222	Ioffe	06/02-06/15	283	13.8	261.7	30.6	19.4	0.2	0.27	0.03
5430	Luu	04/06-04/12	188	20.9	199.0	33.7	13.55	0.02	0.06	0.02
6296	Cleveland	06/02—06/27	163	17.6,15.7,17.	258.4	22.3	15.38	0.2	0.20	0.03
7563	1988 BC	04/20-04/21	196	11.7	194.6	15.6	6.510	0.006	0.24	0.02
21022	Ike	05/02-05/11	209	22.1	223.7	34.0	7.550	0.001	0.40	0.02
68950	2002 QF15	05/29—06/14	275	46.7,43.2	259.5	39.4	47.0 (23.5)	0.5	>0.30	0.02

photographic photometry. The PDO data did not produce an acceptable fit when phased to values near that period.

1320 Impala. Behrend et al (2006) reported a period of approximately 4.0hr. A very poor monomodal fit at about 3.55h was found using the PDO data but no reasonable fit to a mono- or bimodal curve could be found around the 4.0hr period.

1384 Kniertje. Behrend (2006) previously reported a period of 9.44hr. Attempts to fit the PDO data to that period found a possible solution at 9.816hr. However, the fit of the data was not quite as good as when the data were phased to the adopted period of 12.255hr, even though the formal error for the larger period was about twice that for the shorter one. On the other hand, the RMS error for the fit of the data to the 12.255hr period was less than for the shorter period by about 2%. The next opportunity to resolve the ambiguity will be in May 2007.

1592 Mathieu. The adopted period is for a monomodal curve. A bimodal solution was found at 28.48hr with a formal error about three times that for the shorter period. The bimodal curve would seem to make better sense given the amplitude of the curve and phase angle (Alan Harris, private communication). However, Petr Pravec (private communication) noted that while the longer period was more plausible, the symmetry of the curve for the shorter period was too good to be dismissed out of hand. Two plots, phased to the two periods, are shown.

2047 Smetana. This is a Hungaria asteroid and so part of the ongoing program at PDO to study these inner main-belt objects. The period tends to make it a candidate for being a binary. However, no evidence was found during this apparition. It should be observed again at the next opportunity, November 2007, when it will be only 15.9 at brightest but still the best apparition until 2012.

4091 Lowe. The low amplitude of the curve made finding a solution difficult. The asteroid's next apparition, May 2007, may provide a larger amplitude curve since the PAB_L will differ by about 90° from the 2006 apparition.

(68950) 2002 QF15. This asteroid was worked in support of radar observations by Michael Shepard, Bloomburg (PA) University. Those observations favored a period of approximately 48hr, based partly on the derived size of the asteroid. Analysis of the optical lightcurve data found almost equally valid solutions 23.5±0.5hr and 47.0±0.5hr with the shorter period producing a monomodal curve and the long a bimodal curve. Unfortunately, observations from other stations could not be obtained and the asteroid faded before the period could be resolved with certainty.

Acknowledgements

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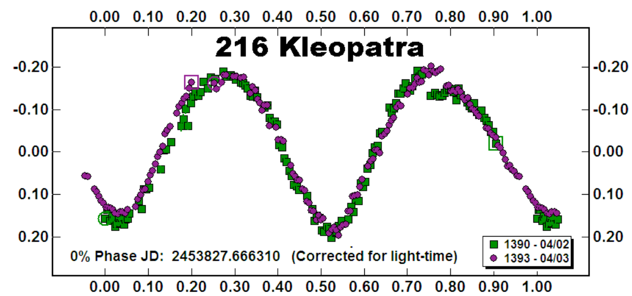

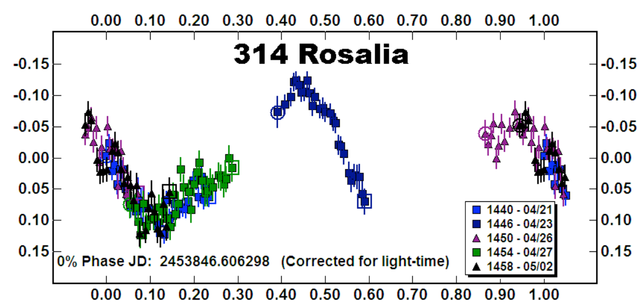

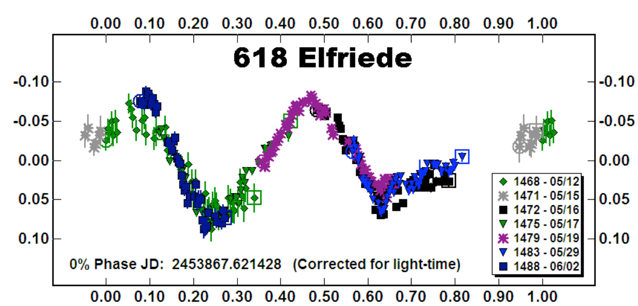

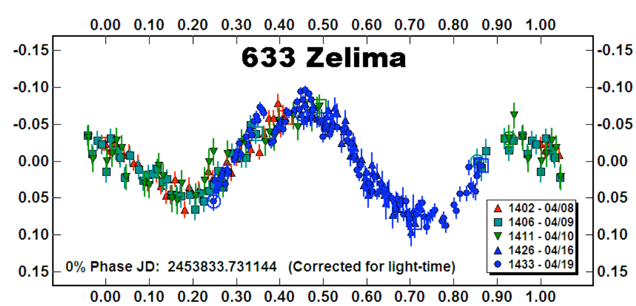

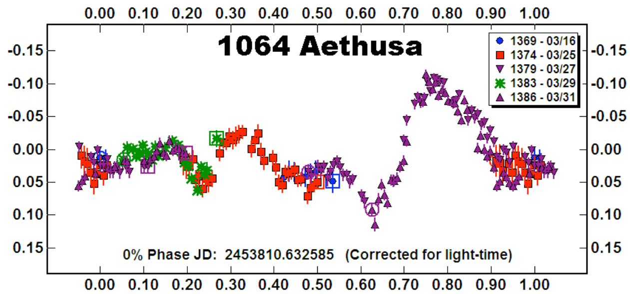
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1379 - 03/27
1383 - 03/29
1386 - 03/31
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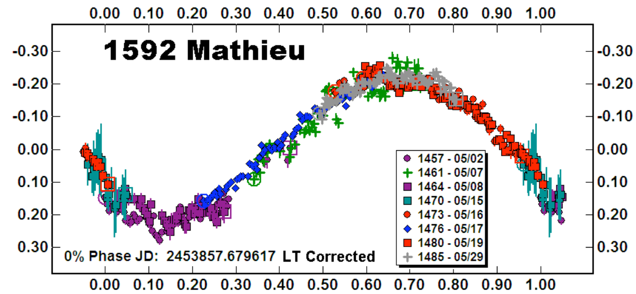
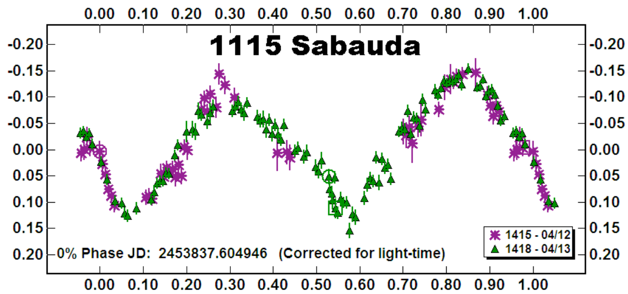

1592 Mathieu
1457 - 05/02
1461 - 05/07
1464 - 05/08
1470 - 05/15
1473 - 05/16
1476 - 05/17
1480 - 05/19
1485 - 05/29
0% Phase JD: 2453857.679617 LT Corrected


1115 Sabauda
1415 - 04/12
1418 - 04/13
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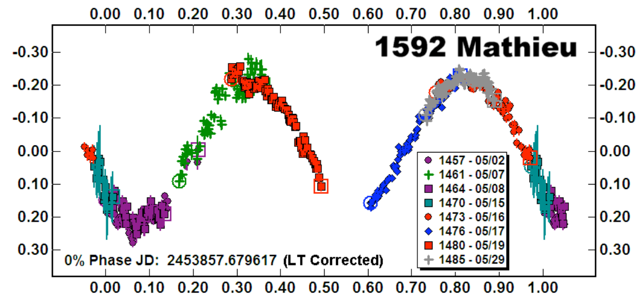
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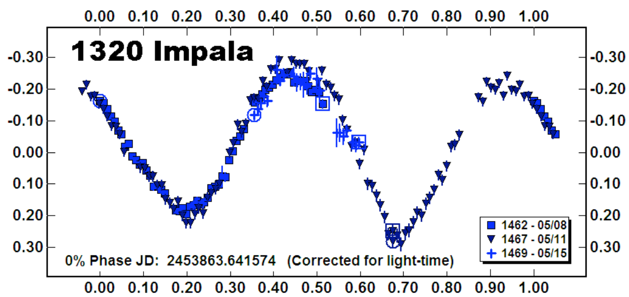
1457 - 05/02
1461 - 05/07
1464 - 05/08
1470 - 05/15
1473 - 05/16
1476 - 05/17
1480 - 05/19
1485 - 05/29
0% Phase JD: 2453857.679617 (LT Corrected)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1462 - 05/08
1467 - 05/11
1469 - 05/15
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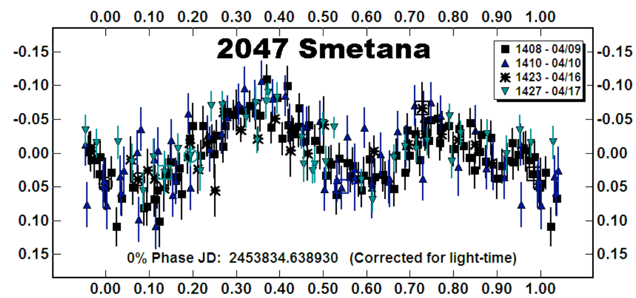
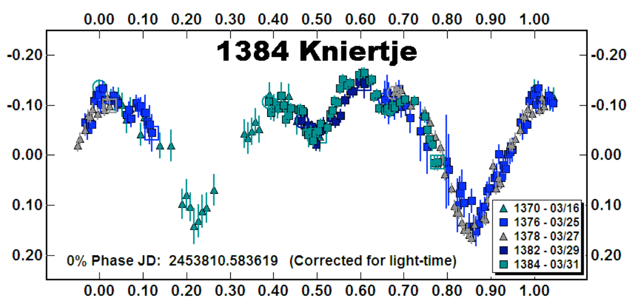

2047 Smetana
1408 - 04/09
1410 - 04/10
1423 - 04/16
1427 - 04/17
0% Phase JD: 2453834.638930 (Corrected for light-time)


1384 Kniertje
1370 - 03/16
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1378 - 03/27
1382 - 03/29
1384 - 03/31
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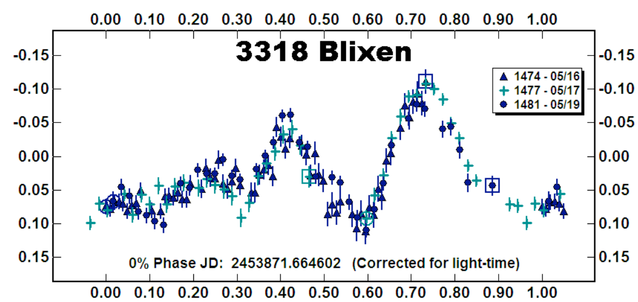
3318 Blixen
1474 - 05/16
1477 - 05/17
1481 - 05/19
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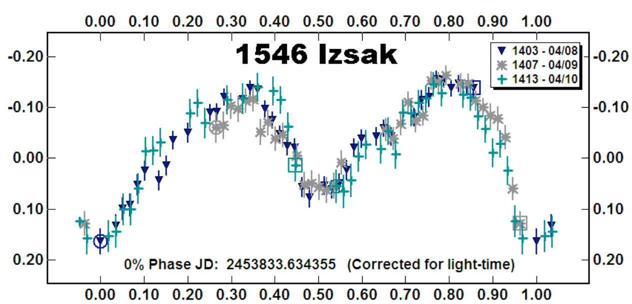
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1403 - 04/08
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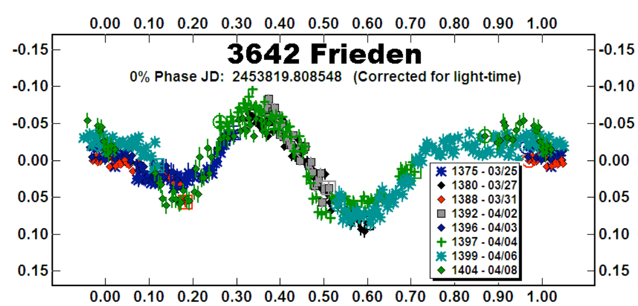
1413 - 04/10
0% Phase JD: 2453833.634355 (Corrected for light-time)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0% Phase JD: 2453819.808548 (Corrected for light-time)
1375 - 03/25
1380 - 03/27
1388 - 03/31
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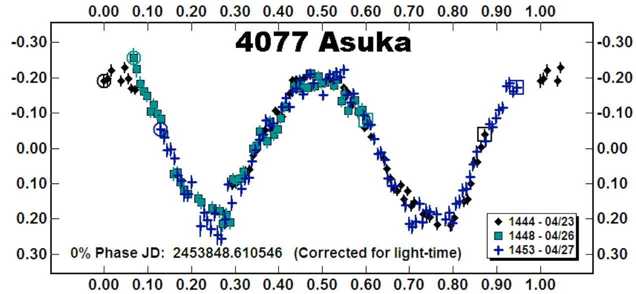
1396 - 04/03
1397 - 04/04
1399 - 04/06
1404 - 04/08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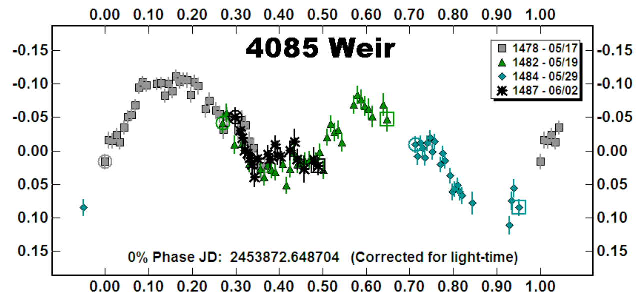
1444 - 04/23
1448 - 04/26
1453 - 04/27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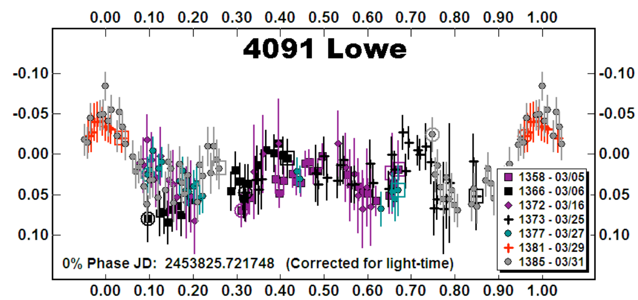
4091 Lowe
1358 - 03/05
1366 - 03/06
1372 - 03/16
1373 - 03/25
1377 - 03/27
1381 - 03/29
1385 - 03/31
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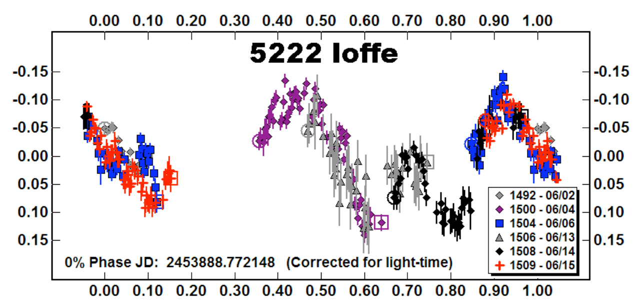
5222 Ioffe
1492 - 06/02
1500 - 06/04
1504 - 06/06
1506 - 06/13
1508 - 06/14
1509 - 06/15
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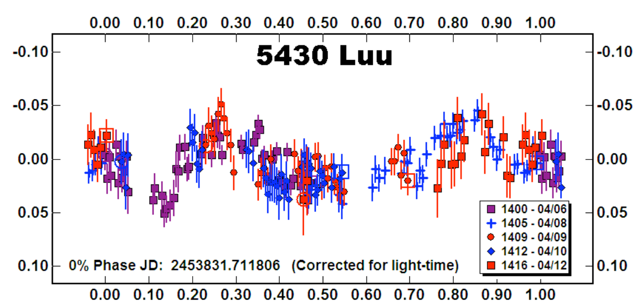
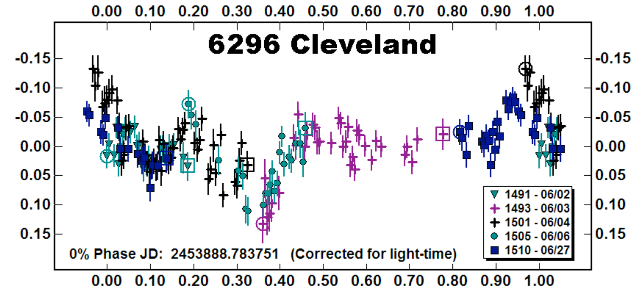

5430 Luu
1400 - 04/06
1405 - 04/08
1409 - 04/09
1412 - 04/10
1416 - 04/12
0% Phase JD: 2453831.711806 (Corrected for light-time)


6296 Cleveland
1491 - 06/02
1493 - 06/03
1501 - 06/04
1505 - 06/06
1510 - 06/27
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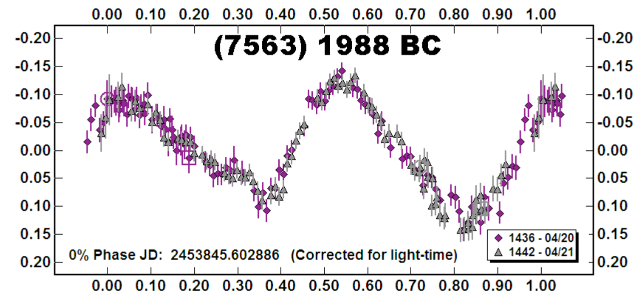
(7563) 1988 BC
1436 - 04/20
1442 - 04/21
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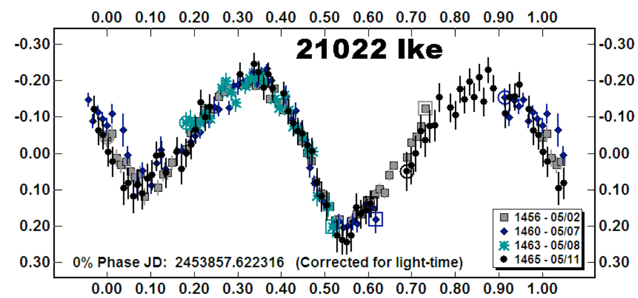
21022 Ike
1456 - 05/02
1460 - 05/07
1463 - 05/08
1465 - 05/11
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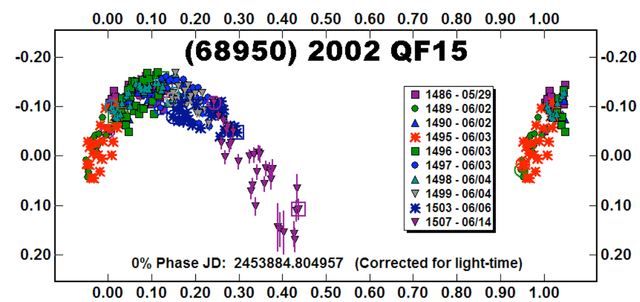
(68950) 2002 QF15
1486 - 05/29
1489 - 06/02
1490 - 06/02
1495 - 06/03
1496 - 06/03
1497 - 06/03
1498 - 06/04
1499 - 06/04
1503 - 06/06
1507 - 06/14
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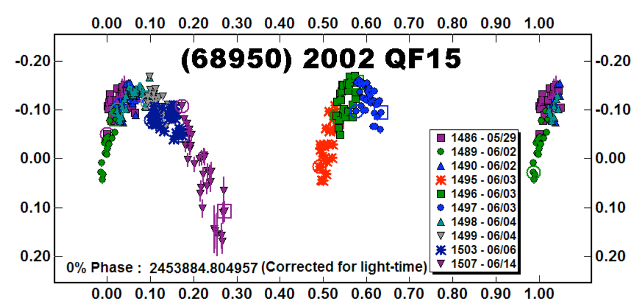
(68950) 2002 QF15
1486 - 05/29
1489 - 06/02
1490 - 06/02
1495 - 06/03
1496 - 06/03
1497 - 06/03
1498 - 06/04
1499 - 06/04
1503 - 06/06
1507 - 06/14
0% Phase : 2453884.804957 (Corrected for light-time)

ASTERIOD LIGHTCURVE ANALYSIS AT HUNTERS HILL OBSERVATORY AND COLLABORATING STATIONS – AUTUMN 2006

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(Received: 31 May)

Lightcurves for the following asteroids were obtained at Hunters Hill Observatory and one or more collaborating stations: 2195 Tengstrom, 2501 Lohja, 4580 Child, 9423 Abt, (9992) 1997 TG19, (10909) 1997 XB10, (12271) 1998 RC2, (12290) 1991 LZ, 12317 MadiCampbell, (31383) 1998 XJ94, (33116) 1998 BO12, (34442) 2000 SS64

Hunters Hill Observatory is equipped as described in Higgins (2005). All observations for this paper were made using a Clear filter with guided exposure times ranging from 180 seconds to 240 seconds. MaxIm DL/CCD, driven by ACP4, was used for Telescope and Camera control whilst calibration and image measurements were undertaken by MPO Canopus version 9. Ondrejov Observatory is equipped as described in Pravec et al. (1998) though they have fitted a new Apogee AP7p. Absolute calibrations were done in the Cousins R system using Landolt (1992) standards to a level of 0.01 mag for Ondrejov data for (6456) and (30825). Modra Observatory is equipped with a 0.6-m f/5.5 reflector and AP8p CCD-camera in its primary focus. FOV is 25 arcmin squared with a pixel scale of 1.5 arcsec. Images were taken with exposures of 60 s long with clear filter. MaxIm DL was used for all image calibration. Carbuncle Hill Observatory is equipped with 0.35m f/6.5 SCT and SBIG ST-10XME CCD camera, binned 3x3. This system produced image dimensions of 21x14 arc min. All observations were taken through the “clear” filter. MaxIm DL/CCD was used for image calibration with dark/bias and flat field correction. Antelope Hills Observatory is equipped as described in Koff 2004.

The strategy is to work objects carefully for potential deviations that would indicate the presence of a satellite. Considerable effort was made to identify and eliminate sources of observational errors that might corrupt the observations and lead to false attenuation events. It was particularly important to identify and eliminate data points affected by faint background stars, bad pixels, and cosmic ray hits. Targets were chosen either from the CALL list provided by Warner (2005) or from Binary Asteroid Photometric Survey list provided by Pravec (2005a). Results are summarized in the table below with the individual plots presented at the end. Additional comment, where appropriate, is provided.

(9423) Abt. This was a serendipitous target as it appeared on the images for BinAstPhotSurvey Target 2002 Euler. Abt was also captured by Modra and Antelope Hills Observatories who obtained coverage on 2 nights and 3 nights respectively.

(9992) 1997 TH19. Original data from Hunters Hill indicated a deviation that needed to be investigated. Additional data obtained by Ondrejov, Modra and Carbunkle Hill revealed no deviations. Further re-measuring of the offending data by Hunters Hill revealed the original deviation to be in error.

(34442) 2000 SS64. Additional data taken by Ondrejov Observatory to support observations due to the noisiness of Hunters Hill initial moon effected data.

Acknowledgements

The SBIG ST-8E used by Hunters Hill was funded by The Planetary Society under the 2005 Gene Shoemaker NEO Grants program. Thanks go to Brian D Warner for his continued development and support for the Equipment Control and Capture

#	Name	Date Range	Session	Period Hrs	P.E.	Amp Mag
2195	Tengstrom	15Apr-16Apr06	2	2.816	0.003	0.20
2501	Lohja	21Mar-08Apr06	7	3.8083	0.0001	0.38
4580	Child	17Mar-26Mar06	6	4.1810	0.0004	0.50
9423	Abt	15May-18May06	6	3.281	0.005	0.30
9992	1997 TG19	09Apr-22Apr06	11	5.7402	0.0005	0.40
10909	1997 XB10	10May-21May06	7	3.2483	0.0002	0.40
12271	1998 RC2	03Mar-03Mar06	1	2.54	0.03	0.40
12290	1991 LZ	22May-30May06	5	21.96	0.03	0.16
12317	MadiCampbell	24Apr-26Apr06	3	7.264	0.005	0.65
31383	1998 XJ94	01Apr-08Apr06	4	4.1678	0.0002	0.58
33116	1998 BO12	18May-24May06	4	6.345	0.002	0.34
34442	2000 SS64	09Apr-25Apr06	8	5.3320	0.0003	0.84

software, MPO Connections and the data analysis software, MPO Canopus. The work at Modra is supported by the Slovak Grant Agency for Science VEGA, Grant 1/3074/06. The work at Ondrejov was supported by the Grant Agency of the Czech Republic, Grant 205/05/0604.

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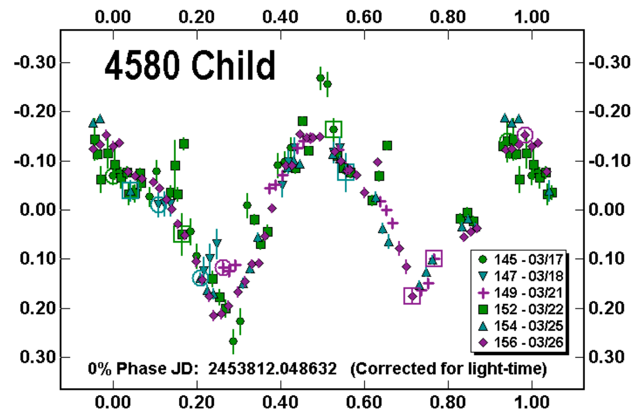

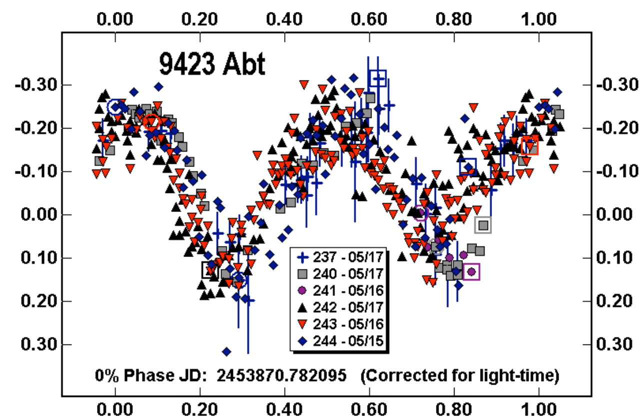

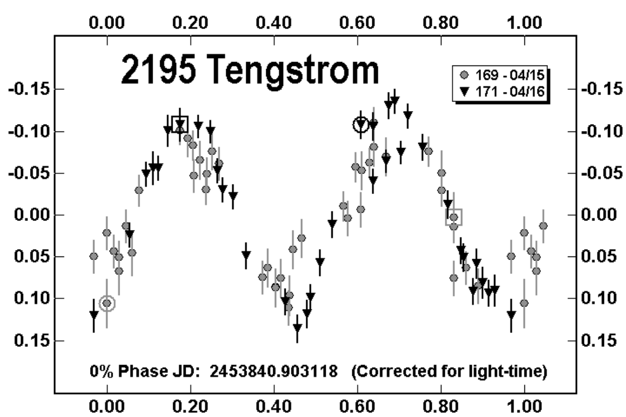

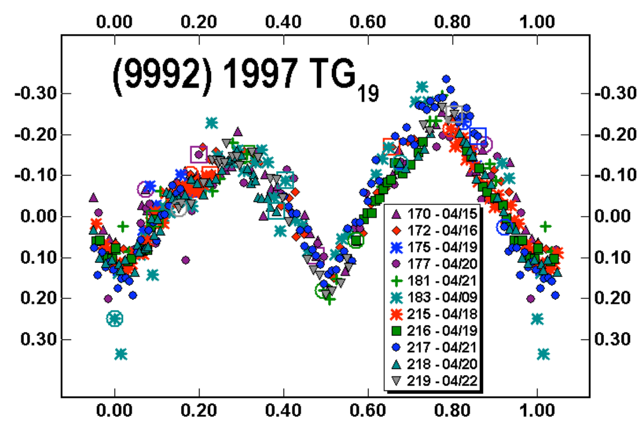

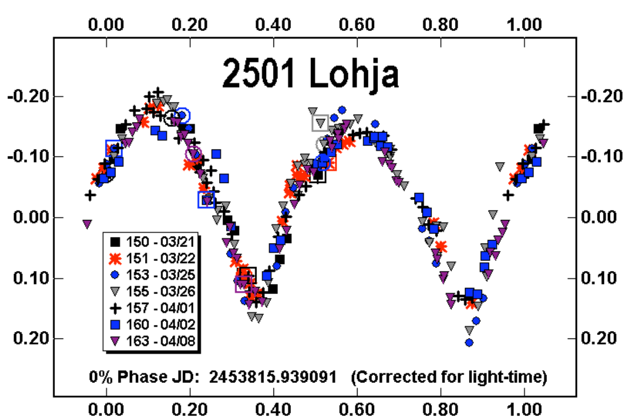

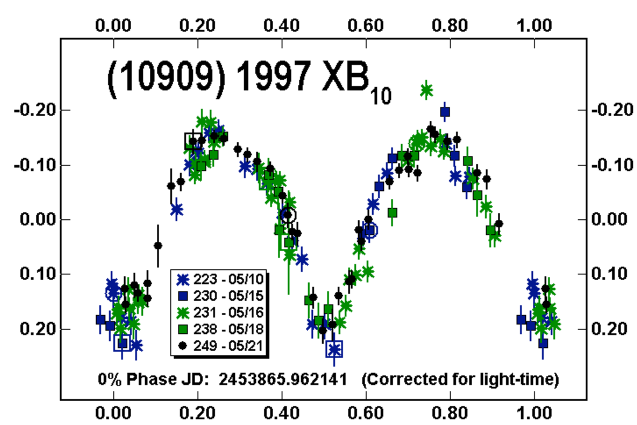

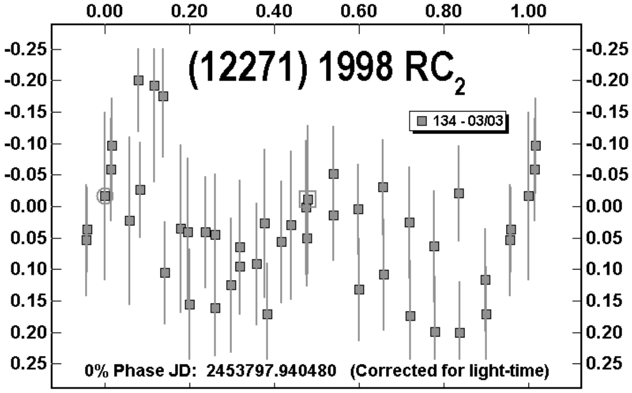

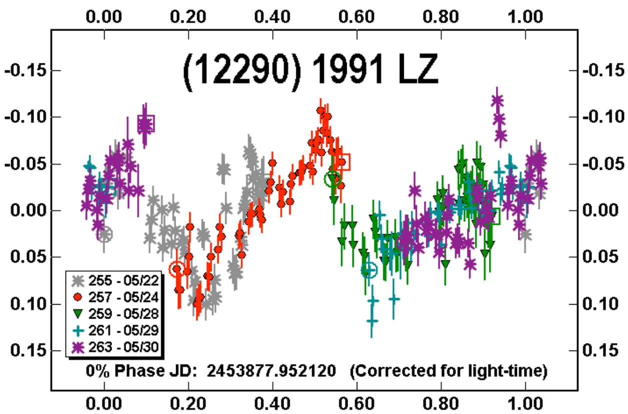

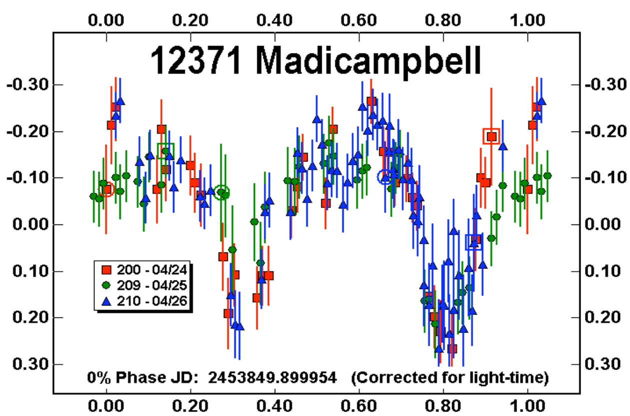

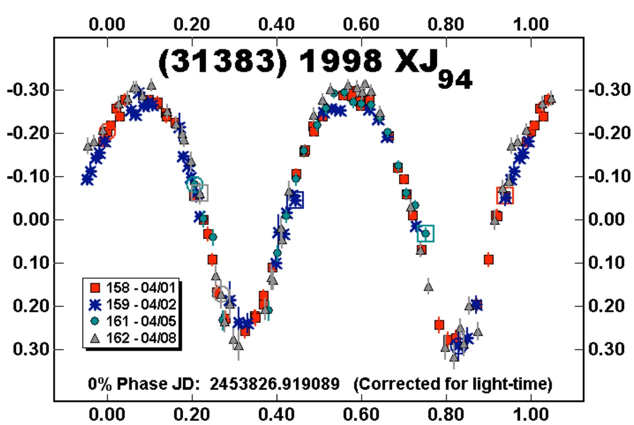

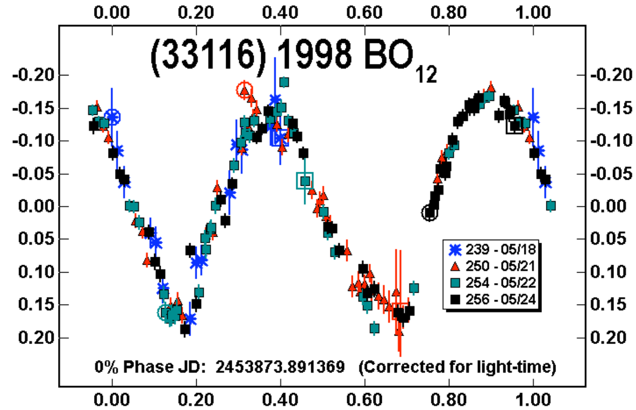

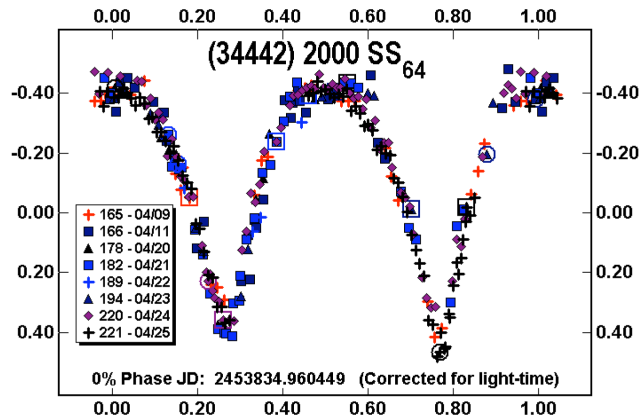

BOOK REVIEW

Richard P. Binzel, Editor

A Practical Guide to Lightcurve Photometry and Analysis (Second Edition) by Brian D. Warner. Springer Science + Business Media, 2006. 298 pages, 110 illustrations. ISBN: 0-387-29365-5. (Price $39.95, available at www.springer.com)

With its first publication in 2003, Brian D. Warner's *Practical Guide* became the "must have" guidebook for new observers looking to make new contributions with their science capable telescopes and CCD cameras. (See original review in *MPB* **31**, page 45.) The second edition is polished and updated with a crisper and more streamlined style. All the basics and more advanced topics in observing and reduction techniques are still here, with their presentation simplified and better than before. Like its predecessor, this second edition is a "must have" for every serious lightcurve observer, whether a beginner or veteran. With the *Guide* in hand, there is a clear path from planning, to observing, to publishing important scientific contributions in the study variable stars, asteroids, extra-solar planets, and more. Springer Science is the new publisher, meaning the second edition should enjoy even wider exposure and wider popularity. There is no better ambassador than Warner and his *Practical Guide* for sparking new interest and encouraging new observers to the field of lightcurve studies.

LIGHTCURVE ANALYSIS OF ASTEROIDS 53, 698, 1016, 1523, 1950, 4608, 5080, 6170, 7760, 8213, 11271, 14257, 15350 AND 17509

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(Received: 29 May)

Lightcurve period and amplitude results are reported for fourteen asteroids observed at Carbuncle Hill Observatory and other sites during October 2005-May 2006. The following synodic periods and amplitudes were determined: 53 Kalypso, 18.075±0.005hr, 0.14mag; 698 Ernestina, 5.0363±0.0005hr, 0.30mag; 1016 Anitra, 5.928±0.001hr, 0.30mag; 1523 Pieksamaki, 5.3202±0.0005hr, 0.50mag; 1950 Wempe, 16.788±0.001hr, 0.98mag; 4608 Wodehouse, 13.95±0.01hr, 0.10mag; 5080 Oja, 7.2220±0.0004hr, 0.37mag; 6170 Levasseur, 2.6529±0.0003hr, 0.14mag; (7760) 1990 RW3, 25.940±0.005hr, 0.32mag; (8213) 1995 FE, 2.911±0.001hr, 0.38mag; (11271) 1988 KB, 6.326±0.001hr, 0.36mag; (14257) 2000 AR97, 13.584±0.002hr, 0.67mag; 15350 Naganuma, 2.5835±0.0001hr, 0.20mag; 17509 Ikumadan, 5.788±0.001hr, 0.40mag.

Carbuncle Hill Observatory (CHO), MPC code I00, is located about twenty miles west of Providence, RI, in one of the darkest spots in this diminutive state. Of the asteroids reported here, seven were observed exclusively at CHO, while the remaining seven involved collaborations with nine observers from five other observatories. Targets in Table I are noted to show contributors and their affiliation (Table II). Below, is a description of equipment used by collaborating observatories. Observations at CHO were made using two CCD/telescope systems housed in separate buildings. One was a SBIG ST-10XME CCD camera, binned 3x3, coupled to a 0.35m f/6.5 SCT. The other was a SBIG ST-7ME CCD camera, binned 1x1, coupled to a 0.25m f/4 Schmidt-Newtonian. These systems produced image dimensions of 21x14 arcmin (1.9 arcsec per pixel), and 23x16 arcmin (1.8 arcsec per pixel), respectively. All observations were taken through the “clear” filter. Hunters Hill Observatory is equipped as described in Higgins (2005). All observations for this paper were made using a Clear filter with guided exposure times ranging from 180 seconds to 240 seconds. Modra Observatory used a 0.6m, f/5.5 reflector with AP8p CCD camera. Image dimensions were 25 arcmin squared (1.5 arcsec per pixel). All images were taken through the “clear” filter. Ondrejov Observatory used a 0.65m, f/3.6, reflector with an Apogee AP7p CCD at the prime focus, and an R filter designed to closely match the Cousins system. The image dimensions were 18x18 arcminutes. Skalnaté Pleso Observatory used a 0.65-m f/4.2 Newtonian reflector and a SBIG ST-8XME CCD camera. Frames were binned 2x2 (1.4 arcsec per pixel). The system produced image dimensions of 19x13 arcminutes. Differential photometry was performed through a Johnson-Cousins R filter. Sonoita Observatory used a 0.35m SCT (C-14), at f/11, and imaged with a clear filter, using 5 minute, unguided exposures.

All but three of the targets were selected from a list provided by Pravec (2006) as part of his “Photometric Survey of Asynchronous Binary Asteroids” study. Two asteroids, 53 and 1016, were selected from the “CALL” website’s “List of Potential Lightcurve Targets” (Warner 2006). The remaining object, 698, was selected from a list of control group objects compiled for a study of the Koronis family of asteroids being carried out by Slivan (2006). At CHO, image calibration via dark frames, bias frames and flat field frames was performed using *“MaxIm DL”*. Lightcurve construction and analysis was accomplished using “*Canopus*” developed by Brian Warner. Differential photometry was used in all cases, and all measurements were corrected for light travel time.

Results are shown in Table I. Column headings are self-explanatory. Plots of the lightcurves are also shown. Five of the asteroids, 53, 698, 1016, 1523 and 5080, had been previously studied by other observers, as noted below.

53 Kalypso. This asteroid had been found, photoelectrically, to have a rotational period of 17. hours (Harris and Young, 1989). This is reasonably close to the current determination of 18.075hr, particularly considering that the Harris and Young value came from a single night’s data.

698 Ernestina. This asteroid was found, in January, 2002, to have a period of 5.033±0.003hr and a lightcurve amplitude 0.71mag (Behrend, 2006). The currently determined period of 5.0363±0.0005hr agrees well with this. However, the Behrend amplitude value is more than twice the 0.30mag value found here. The reason for this is unknown, although it’s likely caused by changes in the viewing geometry.

1016 Anitra. Menke (2005) determined the period and amplitude of this to be 5.9300±0.0003hr, and 0.30mag respectively from data collected in 2002 and 2003. These agree very closely with parameters currently presented.

1523 Pieksamaki. Lagerkvist (1979) found a period of 5.328hr, and an amplitude of ~0.5mag. These values were derived from photographic plates taken on two successive nights. The lightcurve parameters found in the current paper agree closely with those.

#	Name	Observation Date Range	Sessions	Images	Period (h)	PE (h)	Amplitude (m)	Phase angle Range	LPAB Range	BPAB Range
53	Kalypso (7)	03/01-03/17, 2006	7	145	18.075	0.005	0.14	17.1-22	128.4-131.2	(-.08)-(-0.1
698	Ernestina (7)	10/22-10/31, 2005	3	140	5.0363	0.0005	0.30	3.4-0.5	36.8-36.7	(-1.5)-(-1.0
1016	Anitra (7)	10/01-10/20, 2005	5	186	5.928	0.001	0.30	0.9-10.5	9.3-10.3	0-1.0
1523	Pieksamaki (7)	12/22-12/28, 2005	5	334	5.3202	0.0005	0.50	11.7-8.6	109.4-109.8	5.0-4.9
1950	Wempe (2,5,7,8)	12/10-01/10, 2006	7	357	16.788	0.001	0.98	24.2-11.3	122.0-126.7	3.5-4.7
4608	Wodehouse (5,8,	12/3-12/9, 2005	6	394	13.95	0.01	0.10	7.1-6.4	75.7-76.1	(-8.9)-(-9.1
5080	Oja (1,5,7)	12/31-01/10, 2006	3	218	7.2220	0.0004	0.37	7.7-4.2	109.1-109.6	6.8-6.6
6170	Levasseur (4,7)	12/3-12/7, 2005	5	191	2.6529	0.0003	0.14	27.1-26.9	88.3-89.3	33.2-33.9
7760	1990 RW3 (1,2,7)	10/02-10/31, 2005	12	261	25.940	0.005	0.32	1.1-15.2	9.6-12.3	(-1.4)-(0.9)
8213	1995 FE (5,7)	03/18-03/21, 2006	4	78	2.911	0.001	0.38	9.1-4.5	176.8-177.2	9.2-6.0
11271	1988 KB (6,7)	05/01-05/03, 2006	2	184	6.361	0.001	0.36	20.9-20.5	230.1-230.3	27.8-27.5
14257	2000 AR97 (7)	10/22-11/03, 2005	5	260	13.584	0.002	0.67	2.4-7.5	29.0-29.8	(-3.5)-(-2.9
15350	Naganuma (3,7)	11/3-11/20, 2005	17	922	2.5835	0.0001	0.20	3.1-10.1	42.9-45.5	(-3.1)-(-4.0
17509	Ikumadan (7)	04/16-04/22, 2006	4	236	5.788	0.001	0.40	13.6-16.1	194.5-195.5	13.2-13.2

Table I. Summary of Results

5080 Oja. Previously determined parameters of P=7.68hr and A=0.31mag are reported by Lagerkvist (1978). The current values presented here, P=7.222hr, and A=0.39mag are refinements to this. The Lagerkvist data was obtained using photographic plates.

Acknowledgements

Research at Modra was supported by VEGA, the Slovak Grant Agency for Science Grant 1/3074/06. The work at Ondrejov was supported by the Grant Agency of the Czech Republic, Grant 205/05/0604. Research at Skalnaté Pleso Observatory was supported by a grant from VEGA, the Slovak Grant Agency for Science (grant No. 4012). Thanks are given to Brian Warner for his continued development of the program, "*Canopus*", and to Petr Pravec for his general help and encouragement in the field of asteroid research.

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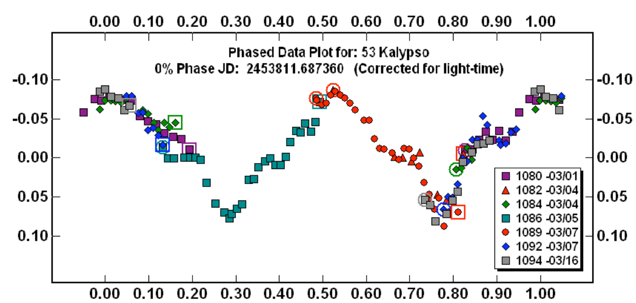
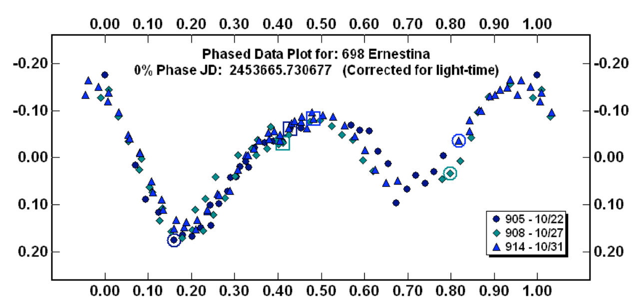
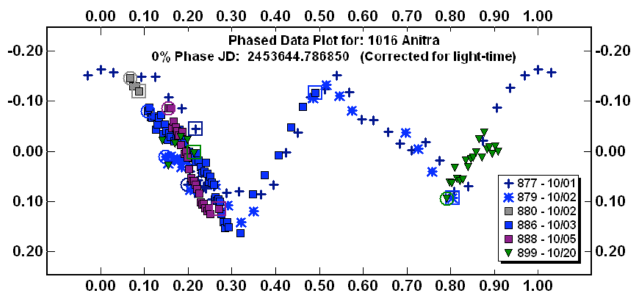
http://www.MinorPlanetObserver.com/astlc/default.htm

	Observers
1	Adrian Galad (Modra)
2	Marek Husarik (Skalnate Pleso)
3	David Higgins (Hunter's Hill), Walt Cooney, John Gross, Dirk Terrel (Sonoita Research)
4	Marek Husarik, Marian Jakubik, Gabrial Cervak, Michal Pikler (Skalnate Pleso)
5	Stefan Gajdos (Modra)
6	Peter Kusnirak (Ondrejov)
7	Donald Pray (Carbuncle Hill)
8	Jozef Világi (Modra)

Table II. List of Observers



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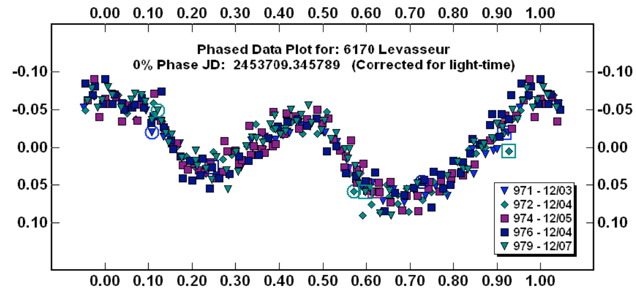
879 - 10/02
880 - 10/02
886 - 10/03
888 - 10/05
899 - 10/20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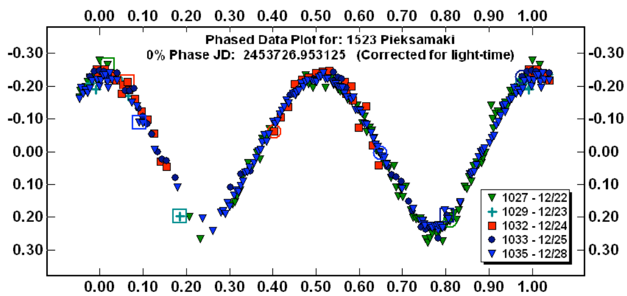
979 - 12/07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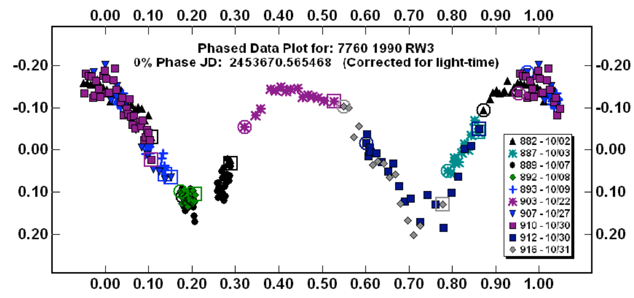
1027 - 12/22
1029 - 12/23
1032 - 12/24
1033 - 12/25
1035 - 12/28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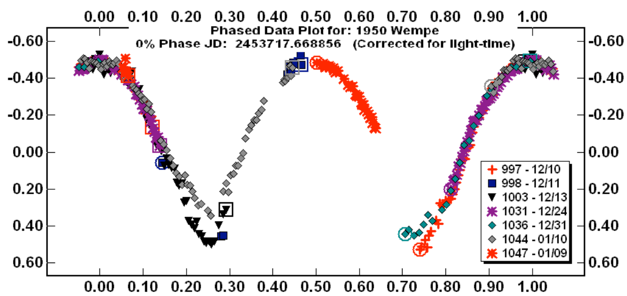
882 - 10/02
887 - 10/03
889 - 10/07
892 - 10/08
893 - 10/09
903 - 10/22
907 - 10/27
910 - 10/30
912 - 10/30
916 - 10/31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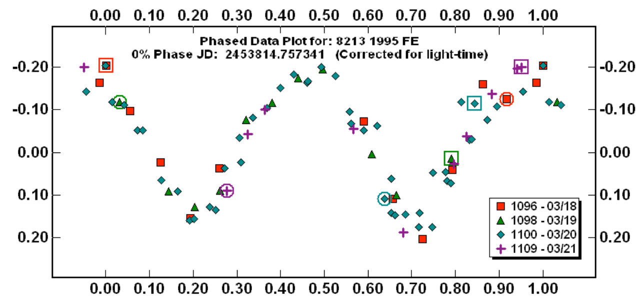
998 - 12/11
1003 - 12/13
1031 - 12/24
1036 - 12/31
1044 - 01/10
1047 - 01/09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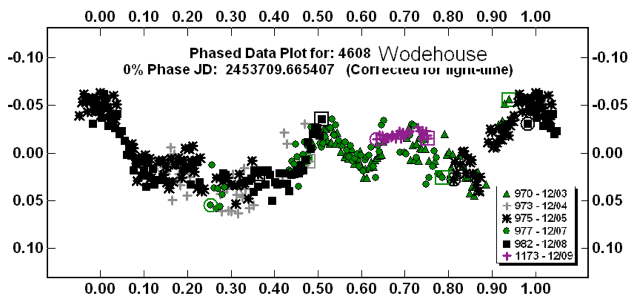
1096 - 03/18
1098 - 03/19
1100 - 03/20
1109 - 03/21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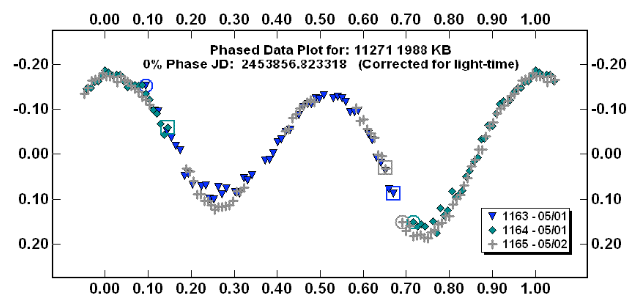
970 - 12/03
973 - 12/04
975 - 12/05
977 - 12/07
982 - 12/08
1173 - 12/09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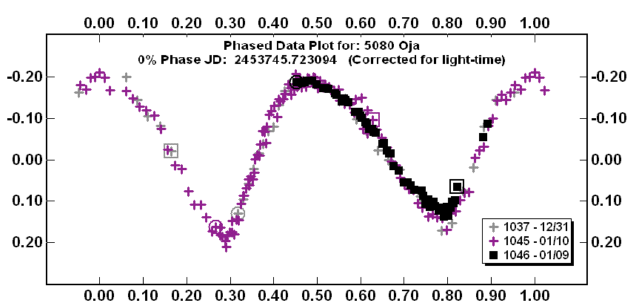
1163 - 05/01
1164 - 05/01
1165 - 05/02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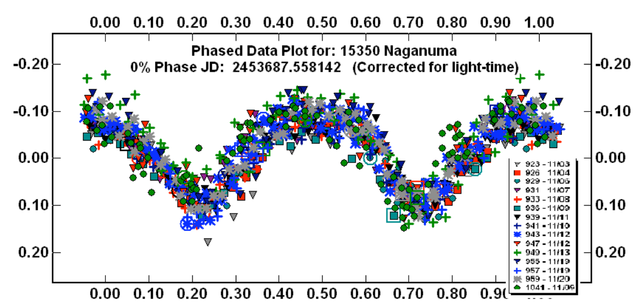
1037 - 12/31
1045 - 01/10
1046 - 01/09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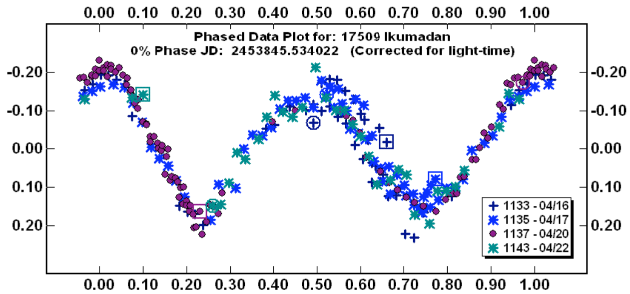

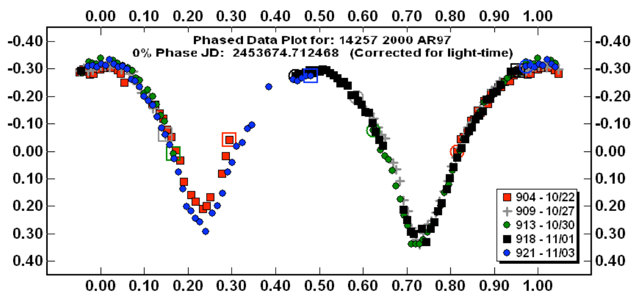

THE LIGHTCURVE OF MAIN-BELT ASTEROID 774 ARMOR

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Observations spanning more than two months reveal the synodic period of the main-belt asteroid 774 Armor to be 25.162±0.002hr with an amplitude of 0.37±0.02mag. This study affirmed the importance of both collaboration and having data from widely separated locations.

In early February and approximately one month later, authors Bennett and Fauerbach observed 774 Armor using a 0.4m Ritchey-Chretien telescope and Apogee AP7p at Florida Gulf Coast University. Assuming a period of about 22hr, their combined data covered a good portion of the entire lightcurve. However, due to the large lapses in time between runs, the possibility of aliases could not be entirely removed.

Starting in mid-April, Warner, not knowing of the earlier observations, started observing the asteroid using a 0.35m SCT and SBIG ST-9E. It became immediately clear that the period was long, possibly nearly commensurate with 24hr, which would have made resolving the lightcurve period very difficult from a single station. Higgins, who's Hunter's Hill Observatory is located about 140° west of the Palmer Divide Observatory, was contacted and agreed to contribute observations. Despite short observing runs the first two nights, Higgins – using a 0.36m SCT and SBIG ST-8E, managed to capture an extreme point each time, which made period analysis more certain.

Table I shows the phase angle and Phase Angle Bisector values for the first and last dates of observations in the combined data set. The phase angle reached a minimum of 2.3° on February 24 and was about 3.0° on the dates of observation at the first of March.

Date	Phase	L_{PAB}	B_{PAB}
2006 Feb 01	8.2	155.6	-6.5
2006 Apr 18	15.7	155.9	-6.2

Table I. The phase and Phase Angle Bisector values for the extreme dates of observations for 774 Armor.

Fauerbach saw Warner's report on the CALL site (http://www.MinorPlanetObserver.com/astlc/default.htm) and suggested a collaboration. A plot using the merged data set from all three locations and phased to the adopted period is shown in Figure 1. The combination of extended coverage, about 10 weeks, and a series of sessions spaced only one day apart allowed elimination of many suspected aliases, pointing to a synodic period of 25.162±0.002hr. The amplitude of the lightcurve is 0.37±0.02mag.

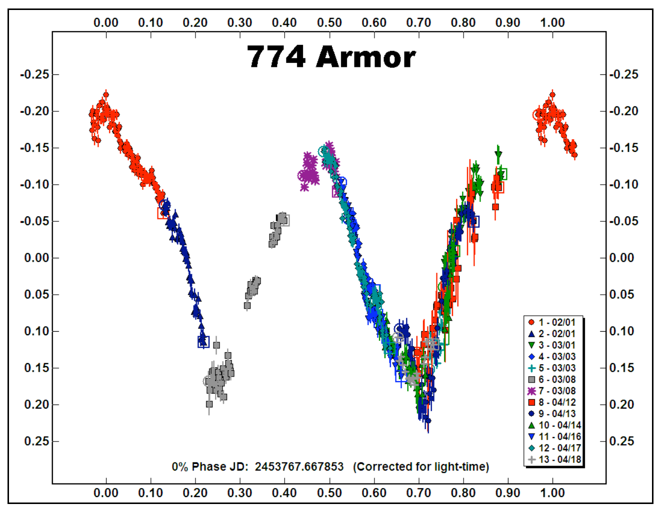

Figure 1. The lightcurve of 774 Armor phased to 25.162hr.

While the individual sets of data from Bennett/Fauerbach and Warner/Higgins arrived at similar results to the adopted period, each alone did not provide a complete and certain solution. In this case, sharing of data that covered an overall large span in time as well as extending a single run on consecutive dates provided a much higher degree of confidence in the results. This collaboration showed once again the importance in asteroid lightcurve work of making results and, more important, data openly available.

Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNG06GI32G and by National Science Foundation grant AST-0607505.

LIGHTCURVES ANALYSIS OF 10 ASTEROIDS FROM LEURA OBSERVATORY

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Lightcurves and period solutions for 10 asteroids were obtained in the first six months of 2006.

171	Ophelia	6.6666±0.0002hr	0.50±0.02mag
291	Alice	4.313±0.002hr	0.20±0.03mag
293	Brasilia	8.173±0.002hr	0.20±0.03mag
683	Lanzia	8.631±0.001hr	0.20±0.02mag
710	Gertrud	8.288±0.002hr	0.30±0.02mag
762	Pulcova	5.8403±0.0005hr	0.20±0.02mag
2104	Toronto	8.9669±0.0002hr	0.35±0.02mag
7360	Moberg	4.699±0.001hr	0.38±0.01mag
(35369)	1997 UJ11	2.48±0.09hr	0.15±0.05mag
(85804)	1998 WQ5	3.0089±0.0001hr	0.35±0.10mag

Leura Observatory is located at an altitude of 950m in the quaint little town of Leura in the Blue Mountains, Australia. The observatory is equipped with a 0.35m f/11 Schmidt-Cassegrain telescope on a CGE mount and SBIG ST9XE camera with a Kodak KAF-0261 CCD giving 1.07 arc second/pixel for 1x1 binning. This telescope is controlled remotely from Sydney by means of broadband Internet connection. The data were downloaded for processing immediately after completion of each nightly run. Analysis was done using MPO Canopus, which employs differential aperture photometry and the Fourier period analysis algorithm developed by Harris et al. (1989).

All images were unfiltered. Dark frames and Flat Field frames were used for image calibration. Any poor quality images were discarded. Targets were chosen from the list provided from Minor Planet Observatory CALL website by Brian Warner where light curve photometry opportunities were selected. The main criteria being little or no lightcurve work done previously.

171 Ophelia. This asteroid has been previously studied by Tedesco (1979), who derived a period of 6.672±0.072hr. Works compiled in Raoul Behrend et al. of Geneva Observatory website for shape determination indicate a period of 6.66624±0.00012hr. Six nights of observation derived a period of 6.6666±0.0002hr, agreeing well with previous work above.

291 Alice. Alice has been very well studied, with Binzel and Mulholland (1983) reporting a pole position also by Piironen et al.(1998) reported a period of 4.32hr. This asteroid was observed when it was in the same field as 293 Brasilia on the nights of June 11 and 12. The derived period is 4.313±0.002hr is in close agreement with the previous results.

293 Brasilia. No previous lightcurve work has been published for this asteroid. A regular bimodal curve was found with a period of 8.173±0.002hr.

683 Lanzia. This asteroid was selected as one of my original trial asteroids in early February. Three months later I decided to try completing the whole curve. Unfortunately, the asteroid was no longer in a favorable position. Four short sessions resulted in a reasonably overlapped but incomplete curve. The period was found to be 8.631±0.001hr. This is in agreement with previously derived value of 8.630hr by Stephens (2003).

710 Gertrud. No previous lightcurve work has been published for this asteroid. Due to unseasonable weather conditions, only short sessions were possible over a period of six consecutive nights deriving a synodic period of 8.288±0.002hr. The curve is unusual and warrants further studies in determining its shape.

762 Pulcova. The lightcurve of this minor planet is well known. Davis (2001) measured a high precision lightcurve period of 5.83923±0.00004hr. It is also a known binary system (Merline et al. 2000). The companion has an orbital period of 4.0 days. A total of 383 images taken over five nights showed a synodic period of 5.8403±0.0005hr and amplitude of 0.20±0.02 mag., which agree well with the previous values. A small dip during the maximum on March 9 and 27 may be due to the satellite.

2104 Toronto. Again no previous lightcurve work has been published for this asteroid. A typical bimodal curve was obtained from six nights spanning from March 6 to April 17. The derived period is 8.9669±0.0002hr.

7360 Moberg. No previous lightcurve work has been published for this asteroid. 176 images were taken over a period of three nights. The curve shows a typical bimodal curve with a synodic period of 4.699±0.001hr and amplitude of 0.38±0.01mag.

(35369) 1997 UJ11. This asteroid was a target opportunity, being in the same field as 710 Gertrud on April 6. The period derived from only 1 session as 2.48±0.09hr.

(85804) 1998 WQ5. This asteroid was selected from the Collaborative Asteroid Lightcurve Link homepage (CALL) for its southerly position and the challenge to obtain a lightcurve for a relatively faint target. Later on I discovered that the Binary

#	Name	Date Range	Sessions	# Points	Period (h)	Amplitude (mag)
171	Ophelia	Mar 9 – Apr 5	6	435	6.6666 ± 0.0002	0.50 ± 0.02
291	Alice	Jun 11 – 12	2	130	4.313 ± 0.002	0.20 ± 0.03
293	Brasilia	Apr 18 – Jun 13	4	243	8.173± 0.002	0.20 ± 0.03
683	Lanzia	Feb 12 - May 25	5	226	8.631 ±0.001	0.20 ± 0.02
710	Gertrud	Apr 6 – 12	5	246	8.288 ±0.002	0.30 ± 0.02
762	Pulkova	Mar 17 – 27	5	383	5.8403 ± 0.0005	0.20 ± 0.02
2104	Toronto	Mar 6 – Apr 17	6	256	8.9669 ± 0.0002	0.35 ± 0.02
7360	Moberg	Apr 1 – 5	3	176	4.699 ± 0.001	0.38 ± 0.01
35369	1997 UJ11	Apr 6	1	41	2.48 ± 0.09	0.15 ± 0.05
85804	1998 WQ5	Jan 23 – Apr 26	10	332	3.0089 ± 0.0001	0.35 ± 0.10

Asteroid Photometric Survey placed the asteroid on its list of possible binary asteroids. Following observations by the group, Petr Pravec of the Ondrejov observatory suggested that there exists a non-unique solution for the asteroid lightcurve. He indicated that with tough objects (instrument magnitude limit and low amplitude), further observations will be needed preferably a collaboration with multiple observatories across the globe. Unfortunately, for this apparition due to its southerly position only the southern observers are able to follow it closely. A period of 3.0089±0.0001hr was found based on analysis of the Leura data and this remain a U=2 result.

Acknowledgements

Many thanks to Brian Warner for his tireless work on the CALL website, his program MPO CANOPUS and I would also like to thank him for his patience in answering my numerous questions.

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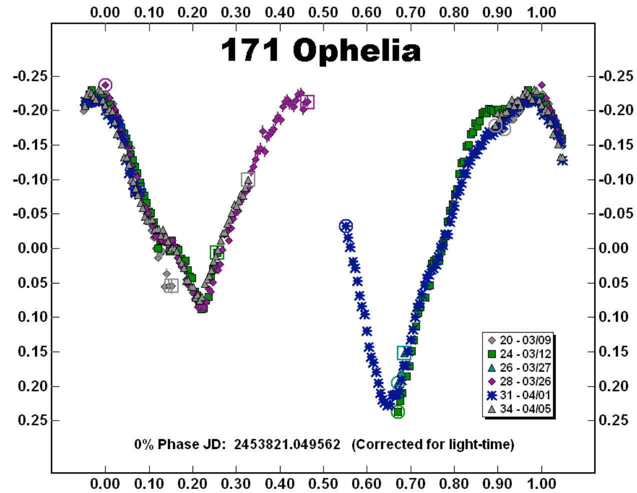

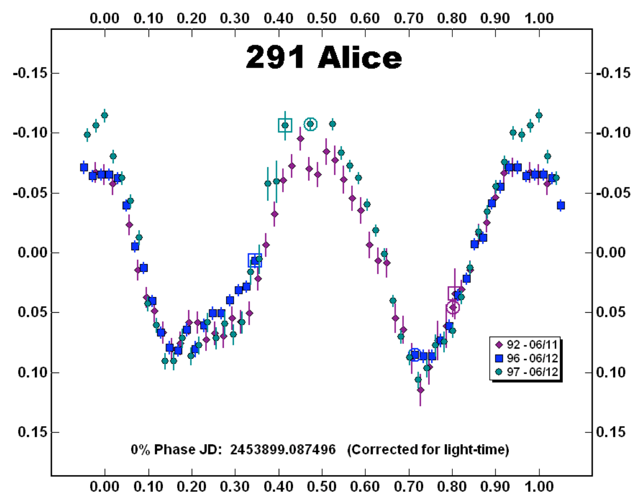

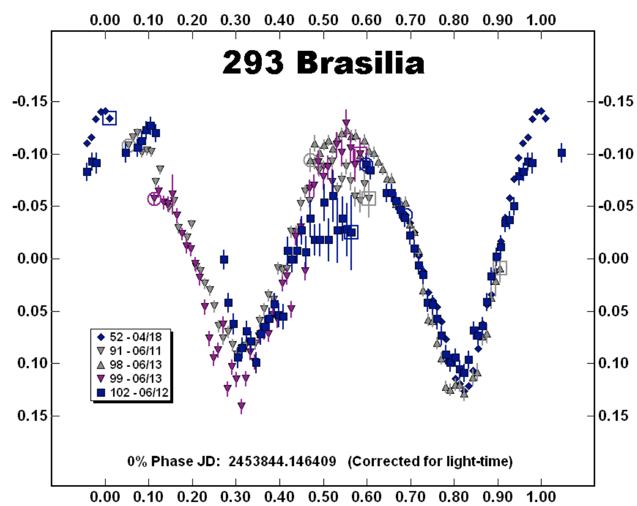

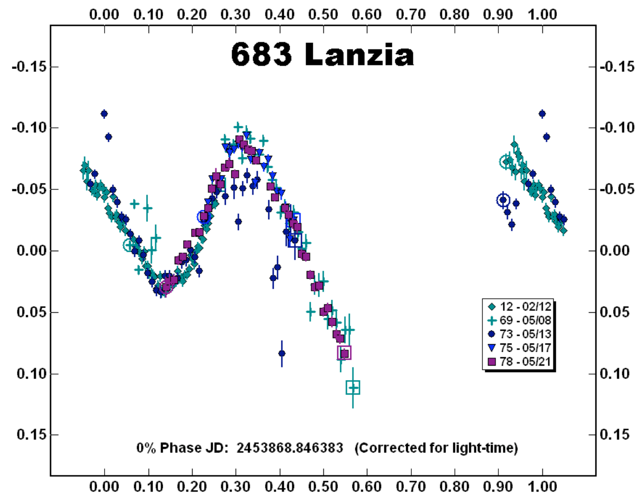
683 Lanzia
12 - 02/12
69 - 05/08
73 - 05/13
75 - 05/17
78 - 05/21
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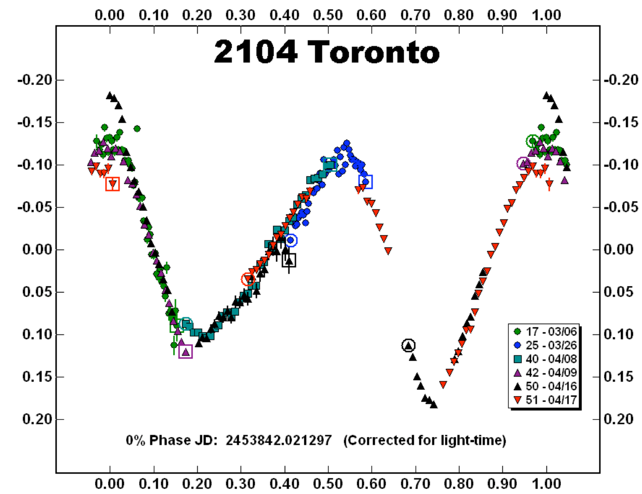
2104 Toronto
17 - 03/06
25 - 03/26
40 - 04/08
42 - 04/09
50 - 04/16
51 - 04/17
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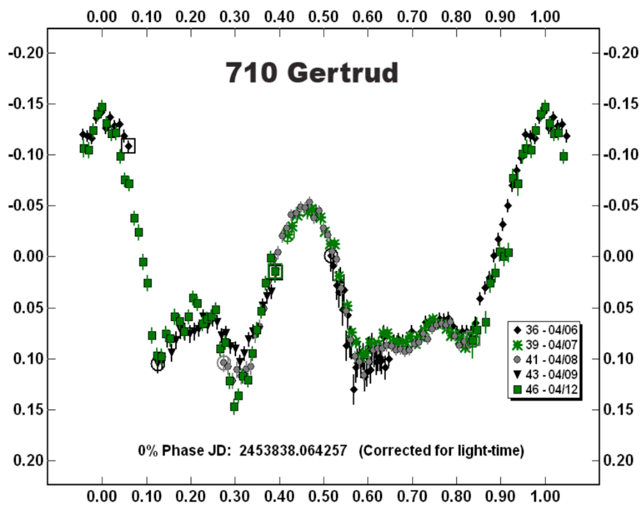
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36 - 04/06
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46 - 04/12
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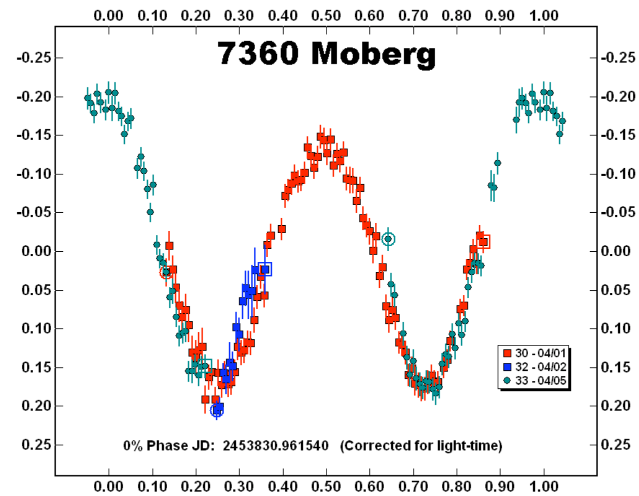
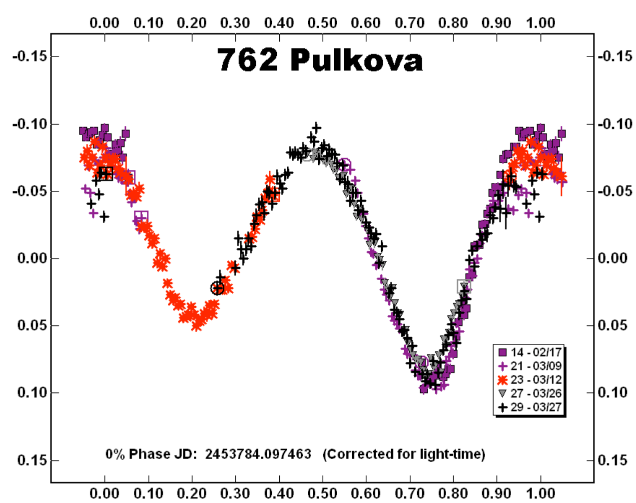

7360 Moberg
30 - 04/01
32 - 04/02
33 - 04/05
0% Phase JD: 2453830.961540 (Corrected for light-time)


762 Pulkova
14 - 02/17
21 - 03/09
23 - 03/12
27 - 03/26
29 - 03/27
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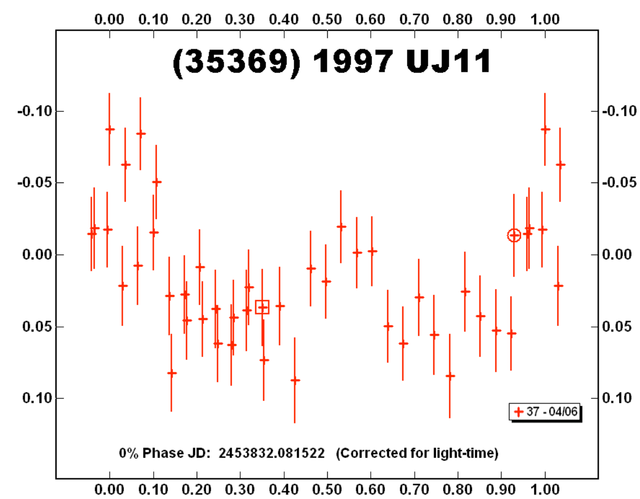
(35369) 1997 UJ11
37 - 04/06
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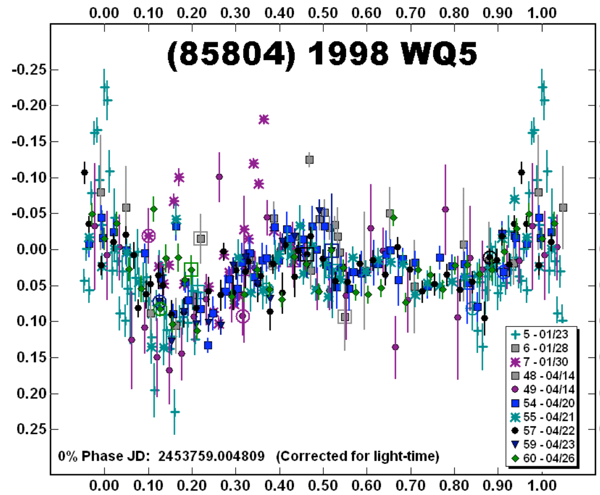

THE LIGHTCURVE OF HUNGARIA ASTEROID 6384 KERVIN

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(Received: 6 July)

Hungaria asteroid 6384 Kervin is found to have a synodic lightcurve period of 3.6203±0.0003hr and amplitude 0.10±0.02mag. The period and size are such that the asteroid was a binary candidate. No signs of mutual events were seen; however, initial runs showed slight, but eventually unsubstantiated, indications of a secondary period. Observations at other viewing aspects are encouraged to rule out a binary nature completely.

Initial observations of 6384 Kervin were made by Warner in late March and early April 2006. The data were somewhat noisy despite exposures of up to five minutes using a 0.5m telescope. Qualitatively, the asteroid was fainter than predicted by the H and G values listed in the MPCORB file (MPC 2006), possibly by up to a full magnitude. Calibrated images were not taken to establish an accurate estimate of the difference between observed and computed magnitudes.

The data from the earliest runs were sent to Pravec, who found indications of a secondary period, indicating the possibility of a binary nature with the second period representing the rotation of the satellite. No signs of mutual events, i.e., eclipses or occultations were seen. Additional observations after the full moon by both Warner and Pray almost certainly excluded any secondary period. Checks were made to assure that the effects were not due to field stars and/or bad flat frames, so the cause of the deviations in the early data remain unexplained.

Table I shows the equipment used by Warner and Pray. The 0.35m at the PDO was used once, on March 31. Pray observed exclusively on April 27-30.

Observer	Scope / Camera
Warner	0.35m / ST-9E
	0.50m / FLI-1001E
Pray	0.36m / ST-10XME

Table I. Observer and equipment details.

Fourier analysis of the data found the synodic rotation period to be 3.6203±0.0003hr and a lightcurve amplitude of 0.10±0.02mag.

Date	Phase	L_{PAB}	B_{PAB}
2006 March 31	21.8	218.3	27.3
2006 April 30	15.4	219.4	24.4

Table II. The phase and Phase Angle Bisector values for the extreme dates of observations for 6384 Kervin.

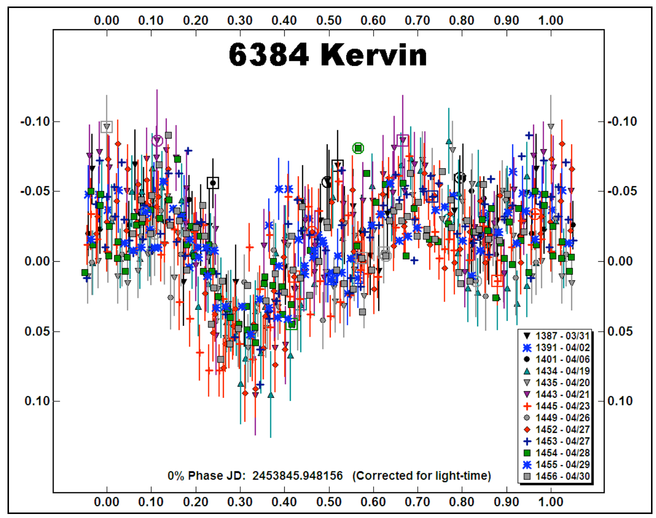

Figure 1. The lightcurve of 6384 Kervin phased to 3.6203hr.

Priority should be given to this asteroid around the next opposition, late December 2007, when the asteroid will be at mag 14.8 and +36° declination. At that time, the PAB longitude will differ by about 130° from the 2006 apparition.

Acknowledgements

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ASTEROID LIGHTCURVE PHOTOMETRY FROM SANTANA AND GMARS OBSERVATORIES – WINTER AND SPRING 2006

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Lightcurve period and amplitude results from Santana and GMARS Observatories are reported for 2006 January-June.
58 Concordia (9.895±0.002hr and 0.10mag.), 268 Adorea (7.800±0.002hr and 0.16mag.), 293 Brasilia (8.17±0.01hr and 0.20mag.), (6185) 1997 YD (21.05±0.01hr and 0.34mag.), (19204) 1992 ME (3.17±0.01hr and 0.04mag.)

The author operates telescopes at two observatories. Santana Observatory (MPC Code 646) is located in Rancho Cucamonga, California at an elevation of 400 meters and contains a Meade 0.3m RCX400 telescope. GMARS (Goat Mountain Astronomical Research Station, MPC G79) is located at the Riverside Astronomical Society's observing site at an elevation of 879 meters and contains several observatories. The author's observatory contains a Celestron 0.35m mounted on a Paramount from Software Bisque. All observations were obtained with an SBIG ST1001 CCD camera. Further details of the equipment used can be found at the author's web site (http://members.dslextreme.com/users/rstephens/). The images were measured and period analysis were done using the software program MPO Canopus which uses differential aperture photometry to determine the values used for analysis.

Results

The results are summarized in the table below. Column 2 gives the dates over which the observations were made, Column 3 gives the number of actual runs made during that time span and column 4 gives the number of observations used. Column 5 is the range of phase angles over the full data range. If there are three values in the column, this means the phase angle reached a minimum with the middle valued being the minimum. Columns 6 and 7 give the range of values for the Phase Angle Bisector (PAB) longitude and latitude respectively. Column 8 gives the period and column 9 gives the error in hours. Columns 10 and 11 give the amplitude and error in magnitudes.

58 Concordia. This asteroid was previously observed by Gil-Hutton (Gill-Hutton 1993) who could not determine a period but estimated it to be longer than 16 hours. X. Wang (Wang 2002) also reported a period of 9.90 hours, in good agreement with the current data.

268 Adorea. Holliday (1995) previously reported a period of 9.44 hours while Tedesco (1979) reported at period of 6.1 hours. Behrend (2006) reported a period of 15.595 hours resulting in a four extrema light curve. All of these periods were tested with the 2006 data and did not yield a reasonable fit. The 7.80 period is in agreement with the preferred period listed on the known lightcurve periods maintained by Harris and Warner (Harris 2006).

293 Brasilia. Observations were initially obtained with Santana's 0.3m telescope in suburban city skies. When adequate signal to noise could not be obtained, additional observations were acquired with the 0.35m telescope at GMARS under dark desert skies.

(6185) 1987 YD. This asteroid was selected as part of the Survey of Asynchronous Binary Asteroids (Pravec 2005). After four sessions it was apparent that the asteroid was not a binary candidate. Further observations could not be obtained due to the winter weather.

(19204) 1992 ME. This asteroid was also selected as part of the Survey of Asynchronous Binary Asteroids. Its amplitude was very low and it moved into crowded star fields. Observations were halted when it was felt that any potential binary nature could not be resolved. The period of 3.17 hours is a best fit, but the substantial noise and scatter reduces confidence in this solution.

Acknowledgements

Thanks are given to Dr. Alan Harris of the Space Science Institute, Boulder, CO, and Dr. Petr Pravec of the Astronomical Institute, Czech Republic, for their ongoing support of all amateur asteroid research. Also, thanks to Brian Warner for his continuing work and enhancements to the software program "Canopus" which makes it possible for amateur astronomers to analyze and collaborate on asteroid rotational period projects and for maintaining the CALL Web site which helps coordinate collaborative projects between amateur astronomers.

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Asteroid	Dates	Sess	Obs	Phase	L_{PAB}	B_{PAB}	Per (h)	PE	Amp	AE
58 Concordia	2006 02/04 - 13	4	916	1.7, 3.9	132.8	-3.0, -2.9	9.895	0.002	0.10	0.04
268 Adorea	2006 02/23 – 03/02	3	857	0.7, 3.3	153.6	1.6, 1.7	7.80	0.02	0.16	0.03
293 Brasilia	2006 04/18 – 05/01	5	704	8.7, 3.8	226.8	6.5, 5.6	8.17	0.01	0.20	0.03
(6185) 1997 YD	2006 01/21 - 23	4	273	7.9, 7.6	124.4	11.3, 11.4	21.05	0.01	0.34	0.02
(19204) 1992 ME	2006 05/20 – 06/04	4	392	25.2, 22.6	253.1	31.6, 29.4	3.17	0.01	0.04	0.03

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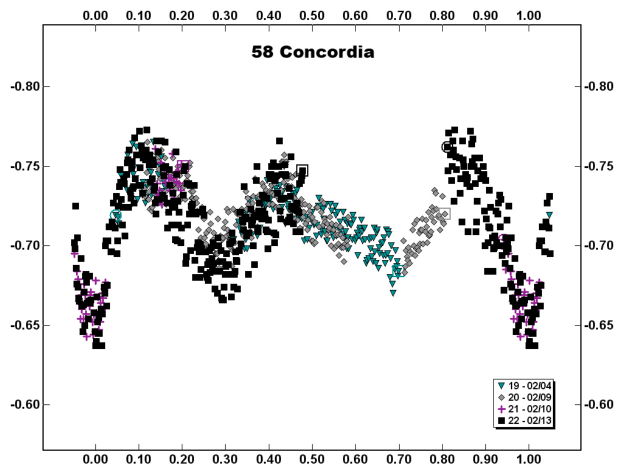

Figure 1: Lightcurve of 58 Concordia. The 0% Phase is equal to JD 2453799.709833 (corrected for light time).

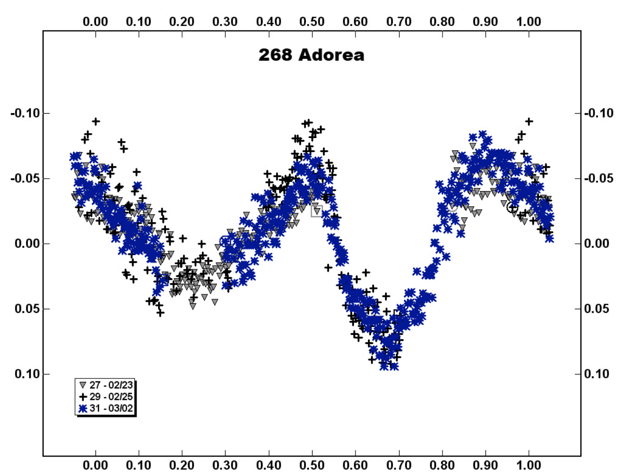

Figure 2: Lightcurve of 268 Adorea. The 0% Phase is equal to JD 2453791.671533 (corrected for light time).

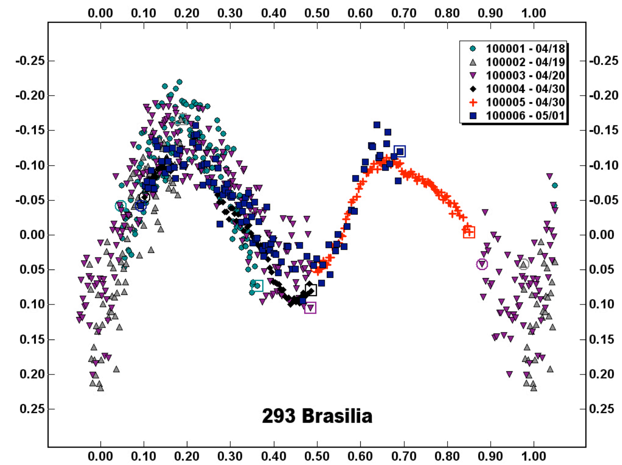

Figure 3: Lightcurve of 293 Brasilia. The 0% Phase is equal to JD 2453844.781647 (corrected for light time).

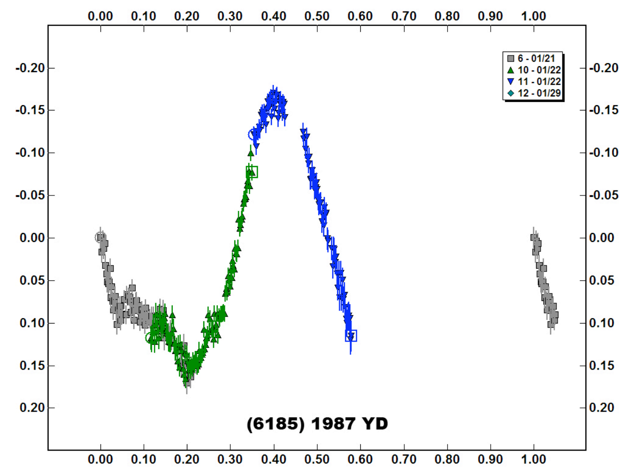

Figure 4: Lightcurve of (6185) 1987 YD. The 0% Phase is equal to JD 2453756.663623 (corrected for light time).

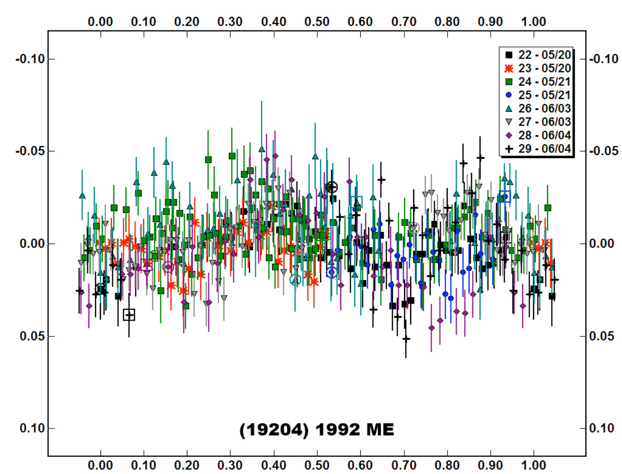

Figure 5: Lightcurve of (19204) 1992 ME. The 0% Phase is equal to JD 2453875.755866 (corrected for light time).

ANALYSIS OF THE LIGHTCURVE OF 71 NIOBE

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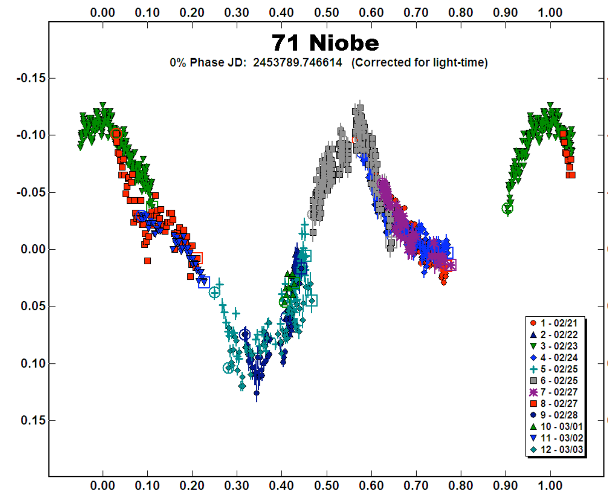
(Received: 29 April)

The main-belt asteroid, 71 Niobe, was the target of radar observations in early 2006 by Shepard. Supporting optical observations (lightcurve) were requested. Initial optical observations by Warner indicated the previously reported period of 14.38h (Harris 1989a) may have been incorrect. Follow up observations, optical and radar, showed that a synodic period of 35.6±0.1h is more likely correct. The observed amplitude is 0.22±0.02mag.

71 Niobe had been studied several times before this latest effort. Lustig (1975) reported a period of 11.21h while Harris (1989a) and Piironen (1998) reported periods near 14.3h. The Harris period was believed to be the mostly likely correct value based on the number of data points and range of observation dates.

In early 2006 co-author Shepard began observing the asteroid as part of a study of M/X asteroids using the radar facility at Arecibo Observatory. He sent a request to Warner for optical observations in order to have a lightcurve made at about the same time as the radar observations. The lightcurve data (rotation period) was needed as part of the radar solution for the size of the asteroid, which in turn allows its albedo (and possible composition) to be estimated. Warner first observed the asteroid on 2006 Feb 21 UT. The analysis of that run indicated that the period might be 24 hours or more, based on the assumption of a bimodal curve. Subsequent observations on Feb. 22-24 supported the possibility for a longer period. Given the commensurability with the interval between observations, the assistance of observers at different longitudes was requested. Crawford (Australia) and Husárik (Europe) joined in the collaboration and provided the critical data needed to find the period. The table below summarizes the



observations that provided more than 1100 photometric measurements.

Warner	Feb. 21-25, 27-28; Mar. 03
Crawford	Feb. 25
Husárik	Feb. 27; Mar. 1-2

Crawford and Warner used MPO Canopus to measure their images. Crawford then sent the export files to Warner to merge into a common data set. Husárik provided date/magnitude pairs that were also merged into that set. The data from each session was shifted by arbitrary amounts in order to match them to a common zero point. This allowed the period analysis to proceed using the Fourier analysis algorithm developed by Harris (1989b) that is incorporated into MPO Canopus.

Based on the radar observations, a period of 14.3h indicated a maximum equatorial diameter of 38km, which was inconsistent with the published size of 83 km in the IRAS survey (Tedesco 1989). As more data became available, it was apparent that a period of 35.6±0.1h was the correct solution and not the previously reported 14.3h. Using the revised period, the radar data indicate a maximum equatorial diameter of 94 km, consistent with the IRAS diameter (an average of all three axes) if the object is modestly elongate and our aspect was equatorial.

A plot phased to the proposed period of 35.6h is shown below. The amplitude is 0.22±0.02mag. As a check, a plot was made forcing the period to 14.3h. There was no doubt that the data did not fit that solution.

Acknowledgements

The work at Ondrejov was supported by the Grant Agency of the Czech Republic, Grant 205/05/0604. The Arecibo Observatory is part of the National Astronomy and Ionosphere Center, which is operated by Cornell University under a cooperative agreement with the National Science Foundation.

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LIGHTCURVE ANALYSIS OF 1304 AROSA

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The main-belt asteroid 1304 Arosa was observed in late 2005 and early 2006 in a collaborative effort by observers in France, Italy and the United States. A period of 7.7478±0.0001hr with an amplitude 0.375±0.011 mag was derived.

In a collaborative effort between observatories in France, Italy and the United States, lightcurve observations of main-belt asteroid 1304 Arosa were obtained during 9 nights between December 23, 2005 and February 11, 2006. Table I provides details of the observational equipment used. The geometric parameters at the extreme dates of the observation period are shown in Table II.

Observer	Telescope	Camera
Bernasconi	Takahashi CN212, 0.2m	ST-7ME
Casulli	Newtonian 0.4m	ST-9XE
Fauerbach, Bennett	OGS RC, 0.4m	AP7ap

Table I. Observer and Equipment Detail

Date	L_{PAB}	B_{PAB}	Phase
2005 Dec. 23.8	61.1	-8.3	9.6
2006 Feb. 11.8	64.3	-5.2	16.2

Table II. Phase Angle Bisector and Phase for 1304 Arosa

Independent analysis of the combined data was performed by Raoul Behrend using the code CourbRot (Behrend 2001) and by Thomas Bennett using MPO Canopus. A period of 7.7478±0.0001hr with an amplitude of 0.375±0.011 mag was derived by both programs. The origin of the rotational phase was chosen at 2005 Dec. 23.943 UT, light-time corrected.

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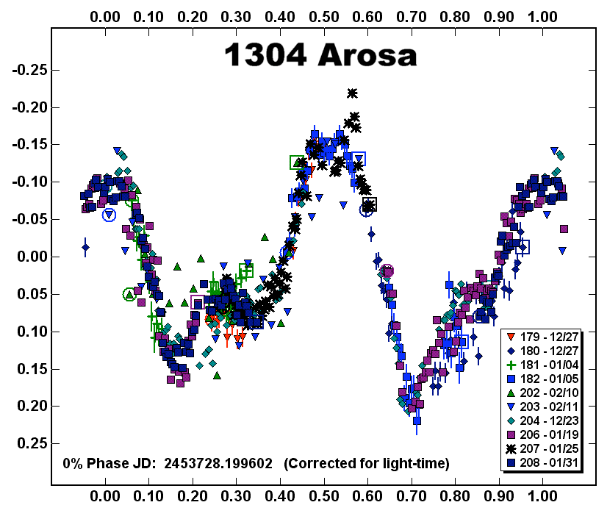

PERIOD DETERMINATION FOR 1484 POSTREMA

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Asteroid 1484 Postrema was observed on 5 nights in April thru May 2006. The lightcurve period and amplitude were 12.1923±0.0005hr and 0.20±0.05mag.

Observations of 1484 Postrema were carried out at Sandia View Observatory (MPC code H03). SVO is a roll-off roof design containing a permanently mounted 0.30m f/10 Meade SCT OTA and SBIG ST-10XME CCD camera mounted on a Bisque Paramount ME. Telescope control was handled thru *Astronomers Control Panel* (ACP) software, which handled automatic meridian flips and multiple target asteroids throughout the all night imaging sessions. The CCD was controlled via *MaxIm/DL* thru ACP. Imaging was done unfiltered to maximize signal-to-noise, with exposures of 120 seconds at bin 2 for an image scale of 0.95 arc seconds per pixel. Automatic bias, dark and flat reductions were handled thru ACP and *MaxIm/DL* using master reduction files. Photometric measurements and lightcurves were prepared using *MPO Canopus*.

Asteroid 1484 Postrema was selected from the CALL website “List of Potential Targets” (Warner 2006). This asteroid was then checked with the list of known asteroid lightcurves parameters maintained by Alan Harris (Harris 2006). I wanted to observe an asteroid that had no known period. After gathering the first nights of data, I came up with a lightcurve of 6 hours. However, after checking with Brian (Warner 2006) on the shape of this monomodal curve, he suggested that I was probably only looking at half phase since most asteroids are likely to have a bimodal curve. Gathering more data showed that the period was converging on ~12.2 hours thus proving Warner’s hunch of 6 hours being half phase.

In total, 442 images were used to obtain a bimodal lightcurve of 12.1923 hours with a 0.20 magnitude amplitude. Periods between 6-18 hours were also tried but either showed half period, 6 hours, or just didn’t fit when more data were added. 12.1923 hours seems to be the most probable period from this data. No data have been collected for phase period 0.4-0.6 yet so its full amplitude curve could not be estimated.

Acknowledgements

I wish to thank Brian D Warner for his advice and help through private emails as I was working my first minor planet lightcurve. His enthusiasm to help amateurs with scientific contributions from minor planet lightcurves is what got me hooked on this endeavor.

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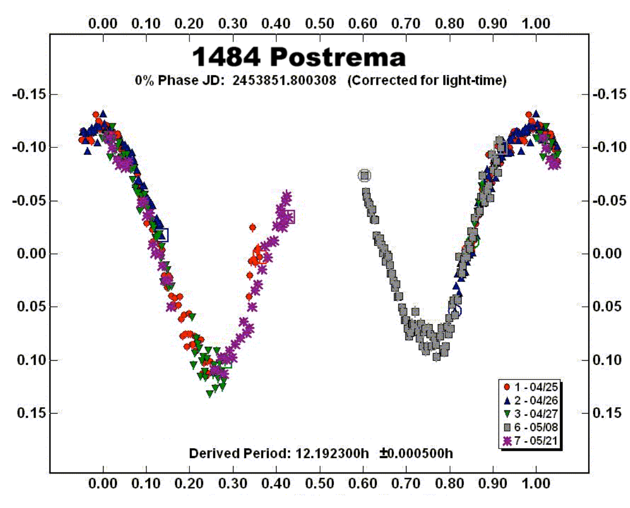

THE LIGHTCURVES OF 1043 BEATE AND 1186 TURNERA

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Observations of 1043 Beate in April 2006 found the synodic period to be 22.05±0.10hr or, possibly, 44.10±0.10hr. The lightcurve amplitude was 0.32±0.02mag. The synodic period for 1186 Turnera was determined to be 12.066±0.004hr based on observations also obtained in April 2006; its lightcurve amplitude was 0.34±0.02mag. With both having adopted periods nearly commensurate with 24hr, the importance of collaboration among observers at different longitudes was again demonstrated. This was particularly true in the case of 1043 Beate, where combined runs allowed forming a single long run on more than one occasion, and so provided additional clues in finding a solution.

Warner initially observed both asteroids 1043 Beate and 1186 Turnera in early April 2006 at the Palmer Divide Observatory using 0.35m SCT and ST-9E on asteroid 1043 and a 0.5m R-C and FLI-1001E on asteroid 1186. In each case, it became immediately apparent that the period was long and maybe commensurate with 24hr. If a solution was to be found in a reasonable time, help from a different location would be required. Higgins, who's Hunter's Hill Observatory is about 140° west of PDO, agreed to provide data on the two asteroids with his 0.36m SCT and ST-8E.

#	Date Range 2006	Phase	L_{PAB}	B_{PAB}
1043	Apr 14-27	12.7,15.6	165.8	2.3
1186	Apr 14-20	13.4,14.5	161.0	10.1

Table I. The phase and Phase Angle Bisector values for the extreme dates of observations for 1043 Beate and 1186 Turnera.

<u>1043 Beate</u>. As more data became available, it was found that they fit one of two solutions almost equally well. Figure 1 shows the complete data set phased to a period of 22.050hr while Figure 2 shows the same data set phased to 44.10hr. We favor the shorter period despite the unusual monomodal solution. This is the result of careful examination of sessions 4-9, which cover April 19-23 and include overlapping runs, i.e., the end of one observer's run was covered by the start of the other's.

Specifically, session 4 (April 19) leads up to and just past a maximum where it shows signs of "flattening out". Session 5 followed by 24 hours, or about 0.08 later in the 22hr phase curve. This session covered the rise to and then extended the flattened portion of the curve. Session 6 – also 24hr later – extended the flattened portion further. Finally, session 9, approximately 45hr, or 2.04 revolutions later, seems to complete the flattened portion of the curve and then drop down to where session 8 picked up, it being 24hr after session 7 and the expected 0.08 later in phase. Such apparent duplication of a feature within the lightcurve is not as readily apparent with the longer solution, and the fit of some overlapping sessions is not as clean, e.g., sessions 2, 5, 12, and 14 (April 16, 20, 25, and 27 respectively).

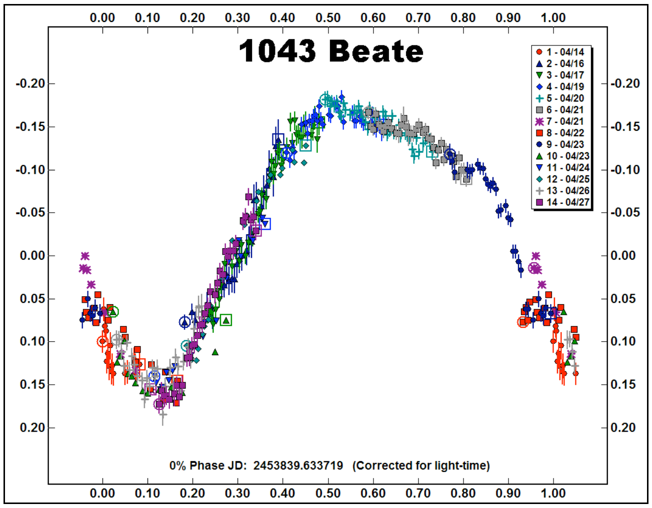

Figure 1. The lightcurve of 1043 Beate phased to 22.05hr.

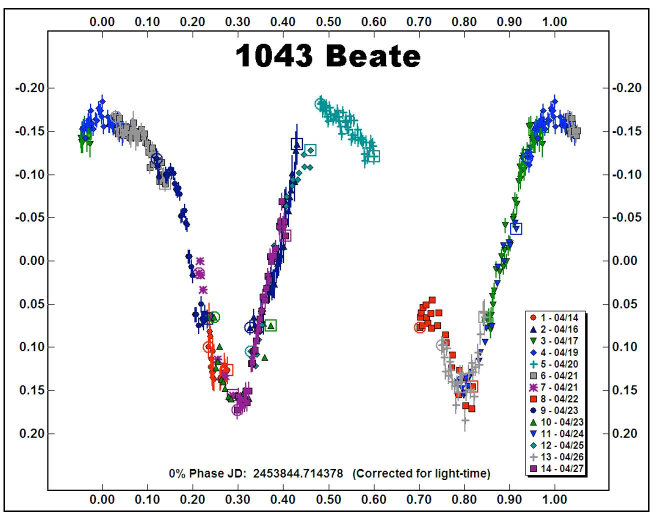

Figure 2. The lightcurve of 1043 Beate phased to 44.10hr.

All observations were made with a clear filter and the zero-point adjustments of the sessions were somewhat arbitrary, save where overlapping runs allowed matching them to approximately 0.01m. As noted by Petr Pravec (private communication), small changes in the zero points of some sessions provide reasonable solutions that differed by 0.1m, and possibly more. However, the fitting of the several sessions described above seems also to provide a reasonable "anchor" of its own and gives reasonable credence to the shorter, adopted solution. However, Alan Harris (private communication) favored the longer period, noting that "the absence of odd harmonics in the bimodal curve is more plausible than a 0.3mag amplitude monomodal curve." All of this pointing to the need for linked observations on a standard system in general and follow up work on this asteroid as circumstances allow.

1186 Turnera. Fortunately, the period for this main-belt asteroid proved to be much easier to resolve, with sessions 4-7 providing two sets of overlapping runs. The first three runs by Warner alone could not resolve several aliases. The addition of the two runs by Higgins (sessions 5 and 7) that extended runs by Warner (sessions 4 and 6) on the last two nights eliminated all aliases and allowed finding a synodic period of 12.066±0.004hr. Figure 3 shows a plot phased to this period using the complete data set.

What helped in particular was catching the second minimum at phase 0.70 and seeing that it was not symmetric with the first minimum. The two runs covering the second minimum were the result of Higgins observations. Given the period, it would take about 90 rotations, or 45 days, for the sampling window open to one given location to move 1/2 cycle. With data from two widely spaced locations, the period was resolved after only two days of joint observations.

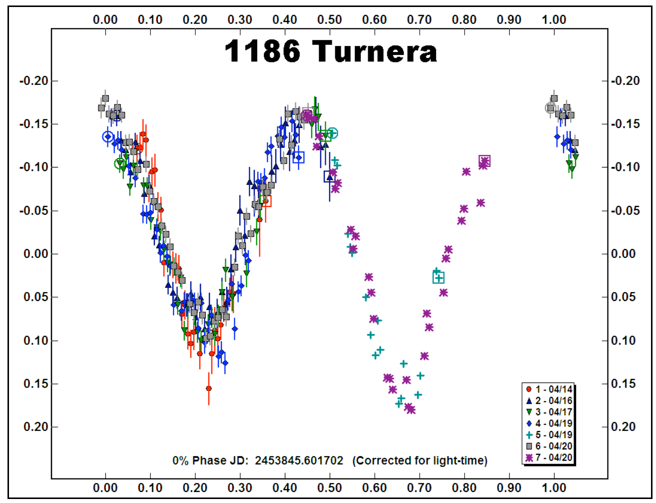

Figure 3. The lightcurve of 1186 Turnera phased to 12.066hr.

Acknowledgements

The authors thank Alan Harris of Space Science Institute, USA, and Petr Pravec, Astronomical Institute, Czech Republic, for their review and comments on this paper. Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNG06GI32G and by National Science Foundation grant AST-0607505.

LIGHTCURVE ANALYSIS OF ASTEROIDS 453 TEA AND 454 MATHESIS

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CCD images recorded December 2005 to February 2006 yielded lightcurves and periods for two asteroids: 453 Tea 6.812±0.001hr, 0.30±0.02mag and 454 Mathesis, 8.378±0.001hr, 0.29±0.02mag.

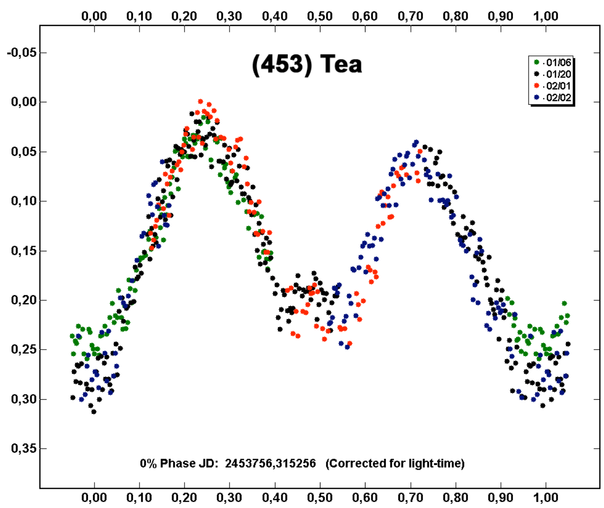
R.P.Feynman Observatory is located in the south of Italy. Details of the observatory, equipment and observing strategy are reported in Licchelli (2006). CCD images recorded in December 2005-February 2006, yielded lightcurves and periods for two asteroids:

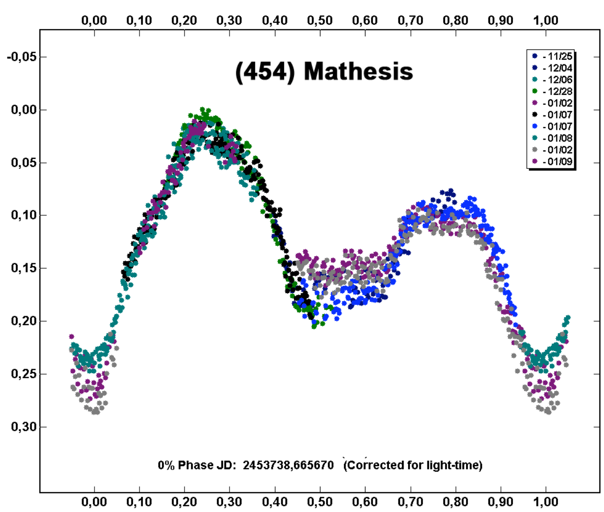
<u>453 Tea</u>. I observed this asteroid over four nights, 2006 January 6, 20, February 1 and 2. Wisniewski et al. (1997) reported a period of 6.4hr, while Behrend (2005) in his website suggests a longer value of 10.567hr. Plots against these values didn't show a reasonable lightcurve. The best fit with my data indicates a period of 6.812±0.001h with an amplitude of 0.30±0.02mag.

<u>454 Mathesis</u>. Observations were made on nine nights, during the period from November 25, 2005, to January 9, 2006. The best fit of the data suggests a period of 8.378 ± 0.001h and an amplitude of 0.29±0.02 mag. This period is in very good agreement with that reported by Buchheim (2006), while the amplitude is slightly different, probably due to changed observing geometry. I tried to test the new data with other suggested periods (7.7hr, Lagerkvist et al. (1978), 7.075hr, Di Martino et al. (1994) and 7.04hr, Cieza et al. (1999)), but the resulting lightcurves were not satisfactory.

Acknowledgements

I thank Brian Warner for his help in improving the original manuscript. His comments and suggestions are gratefully acknowledged.





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DEFINITION OF A PLANET: PRAGUE 2006 IAU RESOLUTIONS

Richard P. Binzel, Editor

For members of the ALPO Minor Planets Section and readers of the *Minor Planet Bulletin*, it is useful to review the outcome and implications of the resolutions passed at the XXVIth General Assembly of the International Astronomical Union (IAU) held August 14-25 in Prague.

The General Assembly passed a resolution defining an object to be a "planet" in our Solar System if: (a) it is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighborhood around its orbit. By this definition, Ceres resides in the asteroid belt and cannot be a planet (its neighborhood is not "significantly cleared"). Similarly, Pluto's neighborhood of the Kuiper Belt also indicates Pluto cannot be placed in the "planet category."

The IAU resolutions further define a "dwarf planet" to be a celestial body that: (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) does not have to have cleared its neighborhood, and (d) is not a satellite of a planet. Ceres, Pluto, and 2003 UB313 are "dwarf planets" by this definition. Smaller bodies, whose shapes are not controlled by self-gravity, are collectively referred to as "small solar system bodies". A committee within IAU Division III (Planetary Systems) will assess objects near the "dwarf planet" boundary for categorization.

The educational and practical implications are a matter for ongoing discussion. From my own point of view, I find it most useful to refer to the eight planets Mercury through Neptune as the "classical planets". Pluto resides in a growing category of dwarf planets being discovered beyond Neptune, for which a separate IAU resolution recognizes as a new (but yet unnamed) category. My provisional preference for this category is to call Pluto the first of many "Plutonian planets", all of which are likely to be physically described as "dwarf planets." The term "minor planets" may still be used, though the distinctions such as 'asteroid' and 'comet' are generally preferred to describe these subsets of "small solar system bodies". There are no changes planned for the name "Minor Planets Section" and *Minor Planet Bulletin*, as none are required. There are no plans for creating a dwarf planet catalog – Ceres retains its designation as (1) Ceres. Whether Pluto receives a permanent catalog number is to be decided by IAU Division III, currently presided by Dr. Edward Bowell, Lowell Observatory.

LIGHTCURVE PHOTOMETRY OPPORTUNITIES OCTOBER – DECEMBER 2006

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We welcome Dr. Lance Benner to the group of authors who prepare this regular article. Dr. Benner is well known for his radar studies of asteroids as well as for his efforts to promote pro-am collaborations for joint optical-radar observations. He will be providing targets of opportunity for the period covered by this article where optical observations, often by amateurs, can provide the additional data needed to help determine the rotation period and other characteristics of radar targets.

We present here four lists of “targets of opportunity” for the period 2006 October through December. The first list is those asteroids reaching a favorable apparition during this period, are <15m at brightest, and have either no or poorly constrained lightcurve parameters. By “favorable” we mean the asteroid is unusually brighter than at other times. In many cases, a favorable apparition may not come again for many years. The goal for these asteroids is to find a well-determined rotation rate, if at all possible. Don’t hesitate to solicit help from other observers at widely spread longitudes should the initial finding for the period indicated that it will be difficult for a single station to find the period.

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”, which is when objects near opposition brighten more than simple geometry would predict.

The third list gives those asteroids needing only a small number of lightcurves to allow Kaasalainen and others to complete a shape model. Some of the asteroids have been on the list for some time, so work on them is strongly encouraged in order to allow models to be completed. For these objects, we encourage you to do absolute photometry, meaning that the observations are not differential but absolute values put onto a standard system, such as Johnson V. If this is not possible or practical, accurate relative photometry is also permissible. This is where all differential values are against a calibrated zero point that is not necessarily on a standard system.

Keep in mind that as new large surveys, e.g., Pan-STARRS, come on line and start producing data, individual lightcurves obtained by smaller observatories will become even more important – especially if the data are reduced to a standard system. Observers should not see the surveys as competition but as a means to obtaining the ever needed “more data” and the opportunity to make new discoveries.

The fourth list gives a brief ephemeris for planned radar targets. Supporting optical observations made to determine the lightcurve’s period, amplitude, and shape are needed to supplement the radar data. Reducing to standard magnitudes is not required but high precision work usually is, i.e., on the order of 0.01-0.03mag. A *geocentric* ephemeris is given for when the asteroid is brighter than 16.0. The date range may not always coincide with the dates of planned radar observations, which – for Arecibo – are limited to a relatively narrow band of declinations.

Those obtaining lightcurves in support of radar observations should contact Dr. Benner directly (email given above). There are two web sites of particular interest for coordinate radar and optical observations. Future targets (up to 2010) can be found at *http://echo.jpl.nasa.gov/~lance/future.radar.nea.periods.html* . Past radar targets, for comparison to new data, can be found at *http://echo.jpl.nasa.gov/~lance/radar.nea.periods.html*

Once you have data and have analyzed them, it’s important that you publish your results, if not part of a pro-am collaboration, then in the *Minor Planet Bulletin*. It’s also important to make the data available at least on a personal website or upon request. Previous issues have covered larger upload sites such as OLAF, SAPC, and the ADU. For more information about those sites, please contact Warner at the email address given above.

Note that the lightcurve amplitude in the tables could be more, or less, than what’s given. Use the listing as a guide and double-check your work. Also, if the date is '1 01. ' or '12 31. ', i.e., there is no value after the decimal, it means that the asteroid reaches its brightest just as the year begins (it gets dimmer all year) or it reaches its brightest at the end of the year (it gets brighter all year).

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Lightcurve Opportunities

#	Name	Brightest Date	V	Dec	U	Per.	Amp
14299	3162 T-2	10 01.8	15.0	– 5	0		
2910	Yoshkar-Ola	10 01.8	15.0	+ 0	0		
1051	Merope	10 02.2	13.9	– 1	2	>20.	>0.09
320	Katharina	10 02.4	14.2	+11	0		
3036	Krat	10 02.9	13.8	– 5	0		
8582	1997 AY	10 03.0	15.0	– 1	0		
3032	Evans	10 05.2	14.8	+ 0	0		
3024	Hainan	10 07.0	14.8	+ 0	0		
2183	Neufang	10 07.8	14.2	–20	?		

608	Adolfine	10 07.8	14.3	+19	0		
459	Signe	10 09.6	12.6	+ 2	2	6.38	0.25
3662	Dezhnev	10 09.8	14.8	+17	0		
2150	Nyctimene	10 09.1	14.7	+11	0		
19288	1996 FJ5	10 09.8	14.7	+ 8	2	2.659	0.13
10449	Takuma	10 09.8	14.9	+ 4	0		
4860	Gubbio	10 10.4	14.6	+23	0		
3258	Somnium	10 10.7	14.6	+ 0	0		
5827	Letunov	10 10.9	15.0	+ 0	0		
446	Aeternitas	10 11.9	12.2	+ 1	2	15.85	>0.33
177	Irma	10 12.5	11.4	+ 9	2	14.208	0.37
988	Appella	10 13.8	13.9	+ 7	0		
2023	Asaph	10 17.9	14.1	+28	2	4.74	0.06
1697	Koskenniemi	10 18.6	14.9	+17	0		
1996	Adams	10 18.4	14.7	+21	1	3.560	0.34
1797	Schaumasse	10 19.7	14.4	+10	0		
6111	Davemckay	10 19.1	14.7	+ 3	0		
1187	Afra	10 19.4	13.6	+26	0		
4335	Verona	10 19.8	14.3	+ 9	0		
1290	Albertine	10 20.6	14.4	+21	0		
957	Camelia	10 20.5	13.6	+20	2	5.391	0.32
7083	Kant	10 21.6	14.8	+17	0		
2705	Wu	10 21.5	15.0	+14	0		
2884	Reddish	10 21.1	14.9	+10	0		
2950	Rousseau	10 21.5	14.2	- 7	0		
3883	Verbano	10 22.0	14.9	- 2	0		
1050	Meta	10 23.2	14.6	+27	0		
2322	Kitt Peak	10 23.7	14.9	+10	0		
1953	Rupertwildt	10 25.4	14.9	+10	0		
606	Brangane	10 25.7	12.6	+28	1	>24.	>0.18
340	Eduarda	10 26.6	12.7	+13	2	7.7	0.17
6425	1994 WZ3	10 27.3	13.9	+11	0		
2233	Kuznetsov	10 27.3	14.7	+16	0		
1285	Julietta	10 27.1	14.5	+21	1	6.7	0.07
2651	Karen	10 27.5	13.7	-19	0		
1690	Mayrhofer	10 28.8	14.5	+18	0		
1190	Pelagia	10 28.1	14.4	+14	0		
1621	Druzhba	10 28.5	13.3	+10	1	>12.	>0.16
1242	Zambesia	10 30.3	12.7	+27	2	17.305	0.24
1786	Raahe	10 31.0	15.0	+20	0		
2430	Bruce Helin	11 01.3	13.9	+ 8	0		
4155	Watanabe	11 02.4	14.1	+20	0		
6273	Kiruna	11 02.7	14.9	+12	0		
3951	Zichichi	11 03.0	14.5	+23	0		
10064	1988 UO	11 03.6	14.9	+18	0		
1986	Plaut	11 04.3	14.8	+12	0		
2429	Schurer	11 05.6	15.0	+27	2	7.070	0.28
969	Leocadia	11 06.0	14.3	+20	0		
4299	WIYN	11 07.9	14.6	+ 8	0		
7389	Michelcombes	11 07.6	14.9	+11	0		
1515	Perrotin	11 08.1	14.6	+15	0		
12832	1997 CE1	11 08.2	15.0	+26	0		
26361	1999 AJ5	11 09.2	14.8	+10	0		
3987	Wujek	11 11.6	14.9	+17	0		
613	Ginevra	11 11.9	13.4	+27	1	16.45	0.63
2257	Kaarina	11 12.2	14.5	+18	0		
551	Ortrud	11 13.0	12.7	+18	2	13.05	0.16
1550	Tito	11 14.8	13.0	+14	2	54.2	0.23
4950	House	11 16.6	14.3	+ 4	0		
1309	Hyperborea	11 18.5	14.0	+11	2	13.95	0.4
5740	Toutoumi	11 19.7	14.8	+23	0		
74	Galatea	11 19.0	11.1	+15	2	8.629	0.09
6794	Masuisakura	11 21.9	14.2	+29	0		
880	Herba	11 21.7	14.2	+30	0		
1374	Isora	11 22.9	14.8	+31	1	8.	0.2
2645	Daphne Plane	11 25.1	15.0	+44	0		
5143	Heracles	11 29.4	14.3	+32	1	long?	<0.2
27215	1999 CK128	12 01.8	15.0	+12	0		
16720	1995 WT	12 01.9	14.8	+23	0		
266	Aline	12 01.5	11.8	+17	2	12.3	>0.05
4349	Tiburcio	12 02.3	14.1	+15	0		
2215	Sichuan	12 03.8	13.8	+22	0		
888	Parysatis	12 04.9	12.2	+ 3	2	5.49	0.23
3533	Toyota	12 05.5	14.5	+14	0		
4142	Dersu-Uzala	12 10.2	14.7	+46	0		
1756	Giacobini	12 11.6	14.2	+28	0		
2909	Hoshi-no-ie	12 11.3	14.6	+21	0		
13255	1998 OH14	12 13.1	15.0	+12	0		
6042	Cheshirecat	12 14.8	14.2	+20	0		
414	Liriope	12 16.1	14.0	+17	0		
1348	Michel	12 16.8	14.1	+23	2	3.334	0.12
3550	Link	12 17.1	14.8	+25	0		
623	Chimaera	12 18.9	13.6	+41	0		
1094	Siberia	12 24.1	14.7	+ 2	0		
1879	Broederstroom	12 25.9	13.9	+22	0		
3001	Michelangelo	12 25.3	15.0	+38	0		
5781	Barkhatova	12 29.5	14.7	+22	0		

Low Phase Angle Opportunities

#	Name	Date	PhA	V	Dec
177	Irma	10 12.5	0.66	11.5	+09
988	Appella	10 13.8	0.41	14.0	+07
187	Lamberta	10 17.1	0.14	12.7	+10
77	Frigga	10 17.2	0.67	11.2	+11
82	Alkmene	10 20.1	0.09	12.0	+10
5142	Okutama	10 20.1	0.16	12.8	+10
1013	Tombecka	10 21.7	0.17	13.4	+11
953	Painleva	10 22.9	0.65	13.8	+10
26	Proserpina	10 23.4	0.54	11.2	+10
215	Oenone	10 24.1	0.12	12.9	+12
24	Themis	10 26.2	0.10	11.4	+12
340	Eduarda	10 26.6	0.35	12.8	+13
6425	1994 WZ3	10 27.4	0.85	13.9	+11
276	Adelheid	10 27.7	0.53	12.7	+11
1204	Renzia	10 27.9	0.91	13.6	+15
90	Antiope	10 29.0	0.62	12.3	+12
184	Dejopeja	10 31.5	0.44	12.9	+16
1087	Arabis	11 02.6	0.95	13.3	+17
233	Asterope	11 11.9	0.63	11.2	+16
551	Ortrud	11 13.0	0.17	12.8	+18
947	Monterosa	11 15.1	0.44	11.7	+19
725	Amanda	11 17.2	0.89	13.6	+17
70	Panopaea	11 17.4	0.84	11.6	+21
122	Gerda	11 18.0	0.61	12.3	+17
156	Xanthippe	11 22.4	0.21	13.1	+21
1255	Schilowa	12 01.1	0.90	13.9	+19
2215	Sichuan	12 03.8	0.16	13.8	+22
701	Oriola	12 10.3	0.81	13.4	+20
488	Kreusa	12 12.3	0.52	11.7	+22
300	Geraldina	12 15.3	0.24	13.8	+24
158	Koronis	12 17.9	0.14	12.7	+24
822	Lalage	12 21.6	0.67	13.5	+22
1879	Broederstroom	12 25.9	0.71	14.0	+22
840	Zenobia	12 27.8	0.19	14.0	+23
1196	Sheba	12 30.2	0.55	13.5	+22

Shape/Spin Modeling Opportunities

#	Name	Brightest Date	V	Dec	Per (h)	Amp.	U
77	Frigga	10 17.2	11.2	+11	9.012	0.07-0.19	3
369	Aeria	10 17.4	11.7	-10	4.787	0.08	2
5	Astraea	10 25.6	10.3	+04	16.800	0.10-0.30	4
24	Themis	10 26.2	11.4	+12	8.374	0.09-0.14	3
276	Adelheid	10 27.7	12.7	+11	6.32	0.07-0.18	3
48	Doris	11 04.7	10.9	+10	11.89	0.35	3
1902	Shaposhnikov	11 08.0	14.5	+12	21.2	0.42	3
233	Asterope	11 11.8	11.2	+16	19.70	0.35	3
54	Alexandra	11 15.7	11.7	+36	7.024	0.10-0.31	4
441	Bathilde	11 18.1	11.8	+23	10.447	0.13	3
258	Tyche	12 11.0	11.7	+04	10.041	0.40	3
480	Hansa	12 22.0	11.9	+04	16.19	0.58	3
31	Euphrosyne	12 31.	12.2	-04	5.531	0.09-0.13	4
36	Atalante	12 31.	13.2	-14	9.93	0.15-0.17	3
51	Nemausa	12 31.	12.3	-02	7.783	0.10-0.14	4
221	Eos	12 31.	12.9	-03	10.436	0.04-0.11	4
416	Vaticana	12 31.	13.2	+24	5.372	0.17-0.38	4
419	Aurelia	12 31.	13.6	+10	16.709	0.08	2
471	Papagena	12 31.	11.1	-13	7.113	0.11-0.13	3

Radar-Optical Opportunities

2001 CB21

This asteroid has a period of 3.3020hr, amplitude 0.19mag.

Date mm/dd	Geocentric RA(2000)	DC(2000)	V	PA	E
10/02	16 53.25	+16 52.5	16.0	109.7	68
10/04	18 00.77	+22 12.8	15.3	94.4	83
10/06	19 04.09	+25 24.9	15.0	80.8	96
10/08	19 56.12	+26 42.7	14.9	70.1	107
10/10	20 36.00	+26 53.4	15.0	62.2	114
10/12	21 06.04	+26 33.4	15.2	56.5	120
10/14	21 28.93	+26 01.7	15.4	52.3	123
10/16	21 46.78	+25 27.0	15.6	49.2	126
10/18	22 01.07	+24 53.2	15.8	46.9	128

1866 Sisyphus

This asteroid has a period of 2.4hr, amplitude 0.12mag.

Date mm/dd	Geocentric RA(2000)	DC(2000)	V	PA	E
10/01	8 01.23	+12 23.5	15.0	63.1	68
10/08	8 16.33	+17 18.7	15.0	60.8	72
10/15	8 31.71	+22 18.2	15.0	58.3	77
10/22	8 47.17	+27 23.6	15.0	55.5	82
10/29	9 02.50	+32 35.9	15.0	52.6	87
11/05	9 17.49	+37 54.9	15.0	49.4	92
11/12	9 31.89	+43 19.0	15.0	46.1	98
11/19	9 45.33	+48 45.4	15.0	42.8	103
11/26	9 57.27	+54 09.5	15.0	39.6	108
12/03	10 07.02	+59 25.0	15.1	36.6	112
12/10	10 13.49	+64 25.2	15.1	34.0	116
12/17	10 14.93	+69 03.2	15.2	31.8	119
12/24	10 08.55	+73 11.0	15.3	30.0	121
12/31	9 50.16	+76 39.1	15.5	28.8	122
01/07	9 14.93	+79 15.2	15.6	28.0	122

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The deadline for the next issue (34-1) is October 15, 2006. The deadline for issue 34-2 is January 15, 2007.