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LIGHTCURVES OF 10452 ZUEV, (14657) 1998 YU27, AND (15700) 1987 QD

Gary A. Vander Haagen
Stonegate Observatory, 825 Stonegate Road
Ann Arbor, MI 48103
garyvh2@att.net

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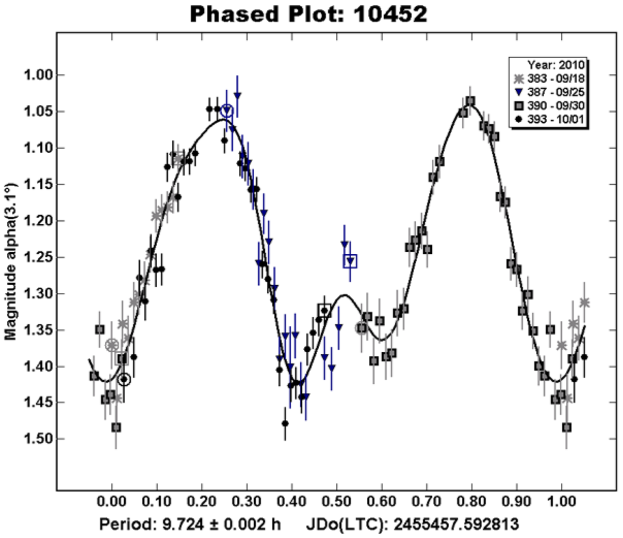
Lightcurve observations and analysis revealed the following periods and amplitudes for three asteroids: 10452 Zuev, 9.724 ± 0.002 h, 0.38 ± 0.03 mag; (14657) 1998 YU27, 15.43 ± 0.03 h, 0.21 ± 0.05 mag; and (15700) 1987 QD, 9.71 ± 0.02 h, 0.16 ± 0.05 mag.

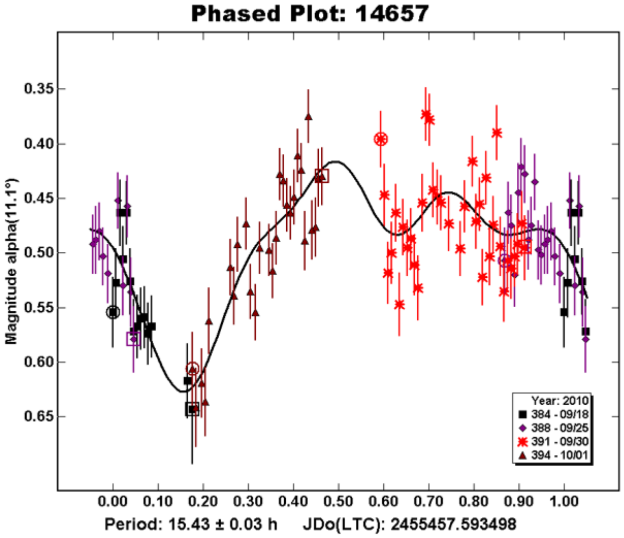
Photometric data of three asteroids were collected using a 0.43-meter PlaneWave f/6.8 corrected Dall-Kirkham astrograph, a SBIG ST-10XME camera, and V-filter at Stonegate Observatory. The camera was binned 2x2 with a resulting image scale of 0.95 arc-seconds per pixel. Image exposures were 120 seconds at –15C. Candidates for analysis were selected using the *MPO2011 Asteroid Viewing Guide* and all photometric data were obtained and analyzed using *MPO Canopus* (Bdw Publishing, 2010). Published asteroid lightcurve data were reviewed in the Asteroid Lightcurve Database (LCDB; Warner *et al.*, 2009).

The magnitudes in the plots (Y-axis) are not sky (catalog) values but differentials from the average sky magnitude of the set of comparisons. The value in the Y-axis label, "alpha", is the solar phase angle at the time of the first set of observations. All data were corrected to this phase angle using $G = 0.15$, unless otherwise stated.

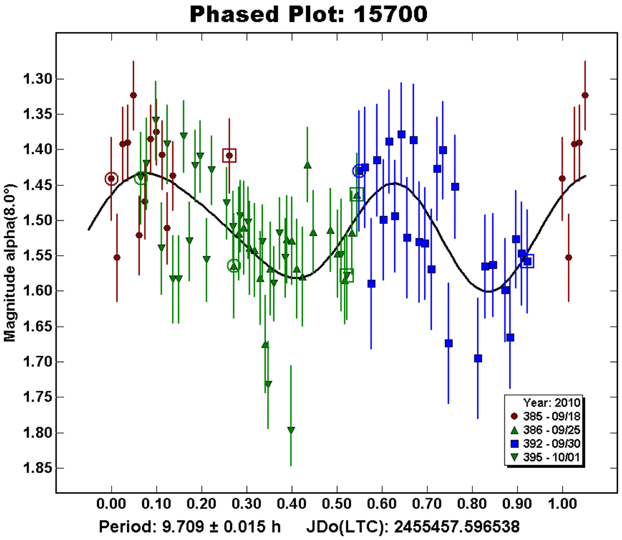
<u>10452 Zuev.</u> Data were collected from 2010 September 18 through October 1 resulting in 4 data sets and 99 data points. A period of 9.724 ± 0.002 h with amplitude of 0.38 ± 0.03 mag was determined. There are no previous data reported in the *LCDB*.

<u>(14657) 1998 YU27.</u> This asteroid was V = 15.0 to 15.3 over the period with poor S/N due to geometry and sky conditions. Data were collected from 2010 September 18 through October 1 resulting in 4 data sets and 100 data points. A period of 15.43 ± 0.03 h with amplitude of 0.21 ± 0.05 mag was determined. The poor S/N and limited data made the solution uncertain. There are no previously reported data in the *LCDB*.





<u>(15700) 1987 QD.</u> This asteroid was V = 15.3 to 15.9 over the period with poor S/N due to geometry and sky conditions. Data were collected from 2010 September 18 through October 1 resulting in 4 data sets 82 data points. The short visibility and sky conditions precluded any further observations. A period of 9.71 ± 0.02 h with amplitude of 0.16 ± .05 mag was the most probable solution with a second nearly-equal probability solution of 8.15 ± 0.02 h. There are no previously reported data in the *LCDB*.



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THE LIGHTCURVE FOR THE LONG-PERIOD ASTEROID 1663 VAN DEN BOS

Robert D. Stephens
Goat Mountain Astronomical Research Station (GMARS)
11355 Mount Johnson Court, Rancho Cucamonga, CA 91737
RStephens@foxandstephens.com

David Higgins
Hunters Hill Observatory
7 Mawalan Street
Ngunnawal ACT 2913 AUSTRALIA

(Received: 8 December)

The main-belt asteroid 1663 van den Bos was observed 2010 September to November. The derived lightcurve has a synodic period of 740 ± 10 h and amplitude of 0.8 ± 0.05 mag.

Observations of the main-belt asteroid 1663 van den Bos were made by the authors from 2010 September 27 through November 01. The combined data set consists of 3088 data points. Most images were unbinned with no filter. Stephens’ observations were with a 0.30-m or a 0.35-m SCT with a SBIG STL-1001e CCD camera. Higgins observations were made with a 0.35-m SCT using a SBIG STL-8e CCD Camera. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris et al., 1989).

Night-to-night calibration of the zero points was done by using 2MASS magnitudes of up to five comparison stars of similar color to an asteroid. See Warner (2007) and Stephens (2008) for a further discussion of this process that provides calibration of the nightly zero points typically good to within 0.05 magnitudes. When working long-period asteroids where a single observing session typically produces a flat curve, it is necessary to calibrate the night-to-night zero points.

1663 van den Bos does not have a previously reported rotational period. Stephens and Higgins independently selected it from the list of asteroid photometry opportunities published on the Collaborative Asteroid Lightcurve Link (CALL) website (Warner et al., 2010).

The combination of the 720 h period and estimated size of 12 km make the asteroid a good candidate for tumbling, or non-principal axis rotation (Pravec et al., 2005). After observing the asteroid for a full rotational period, the first maximum was 0.1 magnitude brighter than it was on the previous rotation. However, the conversion of the 2MASS magnitudes has errors up to ± 0.05 mag. For this reason we cannot say for certain whether or not van de Bos is tumbling.

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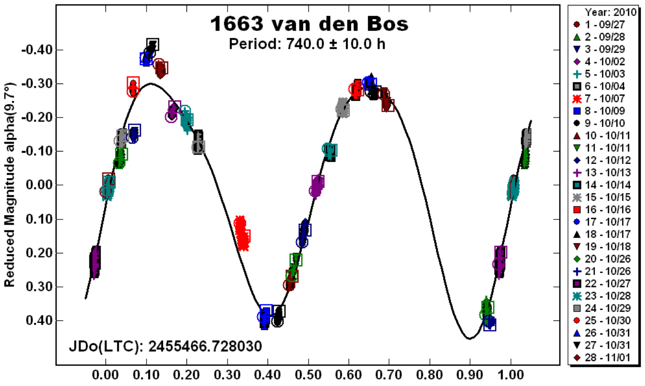

Figure 1: Lightcurve of 1663 van den Bos. Avg. L_{PAB} = 17°, Avg. B_{PAB} = -7°.

ASTEROID LIGHTCURVE ANALYSIS AT THE VIA CAPOTE OBSERVATORY: 4TH QUARTER 2010

James W. Brinsfield
Via Capote Observatory
5180 Via Capote, Thousand Oaks CA 91320
jbrinsfi@viacapotesky.com

(Received: November 21)

Eight asteroids were observed and their lightcurves measured at the Via Capote Observatory from 2010 May through November: 1699 Honkasalo (11.159 h), 1730 Marceline (3.836 h), 1811 Bruwer (17.565 h), 1982 Cline (5.78 h), 3104 Durer (6.327 h), 4003 Schumann (5.601 h), 4063 Euforbo (8.846 h), and 5630 Billschaefer (>24 h).

Observations of eight asteroids were made using a Meade LX200 0.35-m f/10 Schmidt-Cassegrain telescope (SCT) with an Alta U6 CCD camera with a 1024x1024 array of 24-micron pixels. All observations were made unfiltered at 1x binning, yielding an image scale of 1.44 arcsec/pixel, and were dark and flat field corrected. Images were measured using *MPO Canopus* (Bdw Publishing) with a differential photometry technique. The data were light-time corrected. Period analysis was also done with *MPO Canopus* using an implementation of the Fourier analysis algorithm of Harris *et al*. (1989). Most target selections were made using the Collaborative Asteroid Lightcurve Link (CALL) web-site and "Lightcurve Opportunities" articles from the *Minor Planet Bulletin*. Priority was given to asteroids that did not have a published rotational period.

The results are summarized in the table below and include average phase angle information across the observational period. Where 3 numbers are indicated for phase angle, measurements of the target occurred over opposition. The middle value is the minimum phase angle observed and the two end values are the phase angles at the beginning and end of the observing campaign. Individual lightcurve plots along with additional comments, as required, are also presented. Only 1699 Honkasalo and 1730 Merceline had previously reported lightcurve data.

<u>1699 Honkasalo</u>. Behrend (2010) reports a provisional period of 12.3 h and amplitude of 0.15 mag based on partial coverage of the lightcurve. The data reported here suggests a period of 11.159 h and amplitude of 0.17 mag on complete coverage of the target lightcurve.

<u>1730 Marceline</u>. Behrend (2010) reports a period of 3.826 h and amplitude of 0.99 mag. These results agree well with those reported here, where the period was determined to be 3.836 h and a slightly lower amplitude of 0.94 mag.

<u>5630 Billschaefer</u>. This apparent long period rotator dropped below practical limits for lightcurve measurement before the curve could be fully characterized. The data obtained suggest that the period may be just over 69 h.

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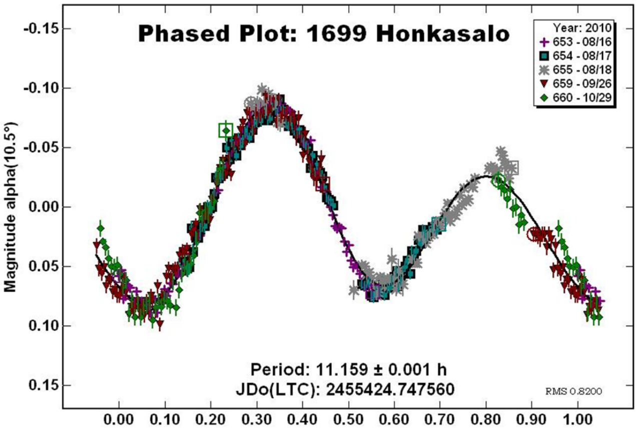
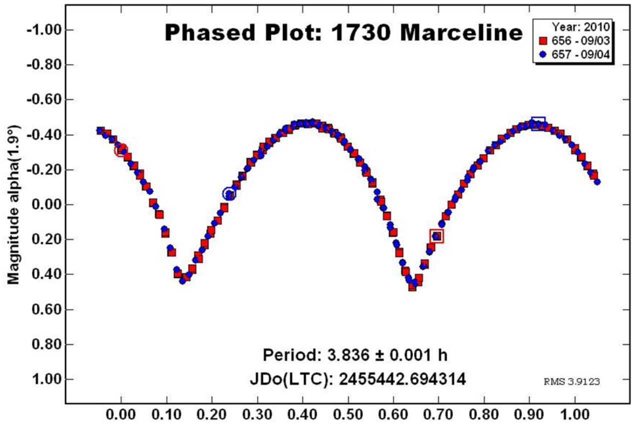
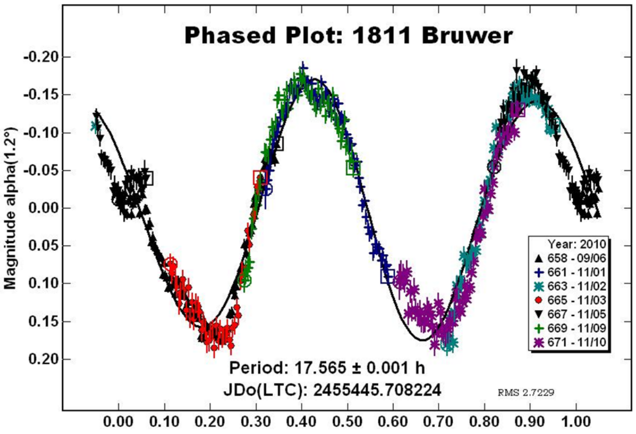
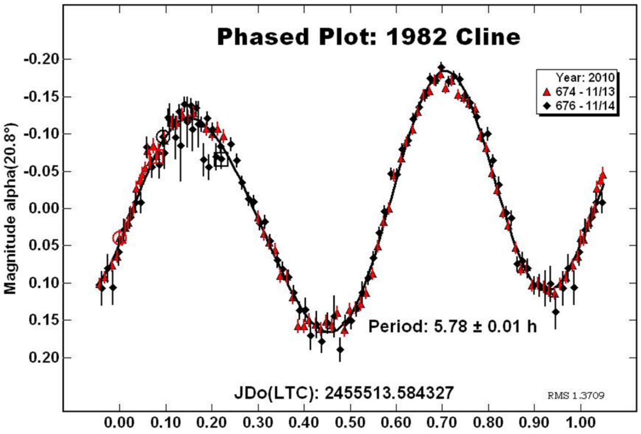
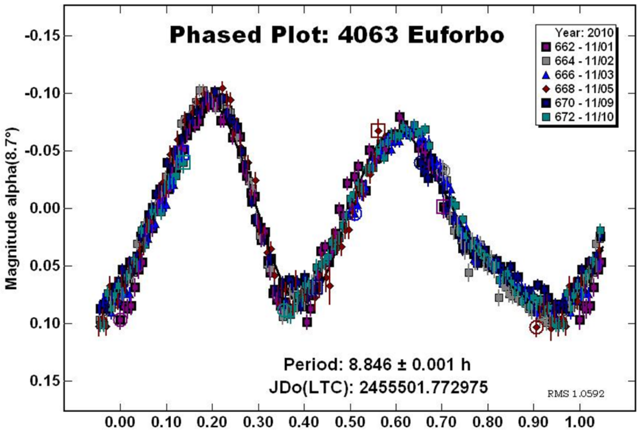
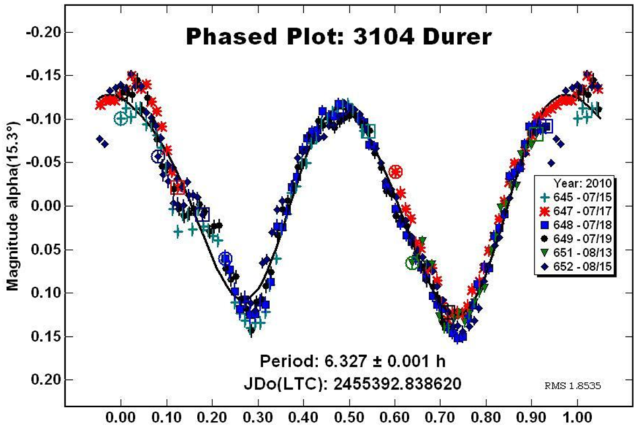


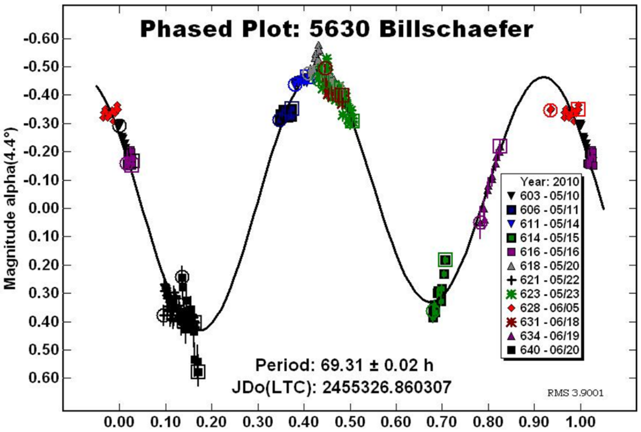


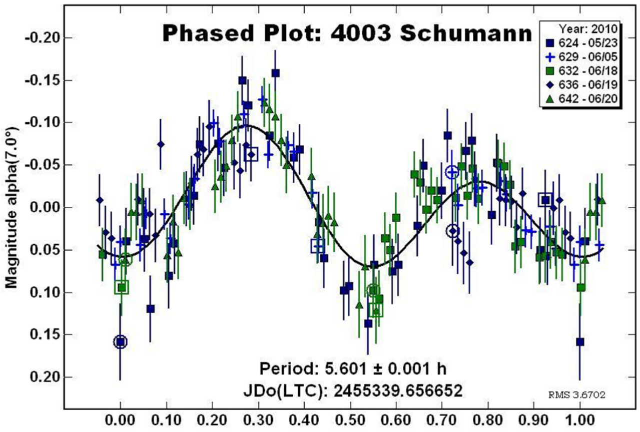












# Name	Date Range (mm/dd) 2010	Data Points	Phase	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (m)	AE
1699 Honkasalo	08/16 - 10/29	445	11,2,27	343	3	11.159	0.001	0.17	0.02
1730 Marceline	09/03 - 09/04	234	2	343	2	3.836	0.001	0.94	0.01
1811 Bruwer	09/06 - 11/10	469	1,0,18	348	-1	17.565	0.001	0.35	0.02
1982 Cline	11/13 - 11/14	174	21	17	-2	5.78	0.01	0.36	0.02
3104 Durer	07/15 - 08/15	330	11	333	7	6.327	0.001	0.28	0.03
4003 Schumann	05/23 - 06/20	144	11	223	4	5.601	0.001	0.20	0.03
4063 Euforbo	11/01 - 11/10	519	8	76	-14	8.846	0.001	0.19	0.02
5630 Billschaefer	05/10 - 06/20	282	14	227	3	>24		>0.30	

Table I. Observing circumstances. If multiple values for the phase angle are given, the object reached a minimum value during the span of observations. The middle value is the minimum phase angle. PAB is the Phase Angle Bisector.

LIGHTCURVES FOR 938 CHLOSINDE AND 3408 SHALAMOV

Dr. Melissa Hayes-Gehrke,
Joseph Benik, Zsombor Kovacs, Sam Knutson, Charles Mills
Department of Astronomy, University of Maryland
College Park, Maryland 20742
mhayesge@umd.edu

(Received: 9 December)

CCD observations yielded lightcurves and synodic periods for two asteroids: 938 Chlosinde, 19.204 ± 0.006 h; and 3408 Shalamov, 10.495 ± 0.001 h.

CCD observations of two asteroids were made at Tzec Maun Foundation's New Mexico Skies observatory, located near Mayhill, New Mexico, in 2010 September and October. A 0.4-m f/9 Ritchey-Chretien with 0.5 arcseconds per pixel resolution was used along with a 0.35-m f/3.8 Maksutov-Newtonian reflector with 1.05 arcseconds per pixel resolution. Both cameras were binned 2x2 and images were acquired through a clear filter. Exposures were 420 seconds at -20°C. All photometric data were analyzed using *SIP* v2.20 (Simonetti, 1999) and *APT* v1.0.6 (Laher, 2010). The SNR was greater than or equal to 100 for 43% of asteroid targets and comparison stars. Differential aperture photometry was used with comparison stars of similar brightness. Two comparison stars were used for each image; however, it was necessary to choose different comparison stars for each evening of observation.

<u>938 Chlosinde.</u> An initial search of the Asteroid Lightcurve Database (LCDB; Warner *et al.* 2009) identified 938 Chlosinde as an asteroid for which no lightcurve data exist. Observations were made from 2010 September 25 through September 28, producing 49 data points in five data sets. Five data points were discarded before doing photometry due to severe vignetting or elongation. Early analysis revealed a tentative rotation period of 6.65 h with an approximate amplitude of 0.15 mag.

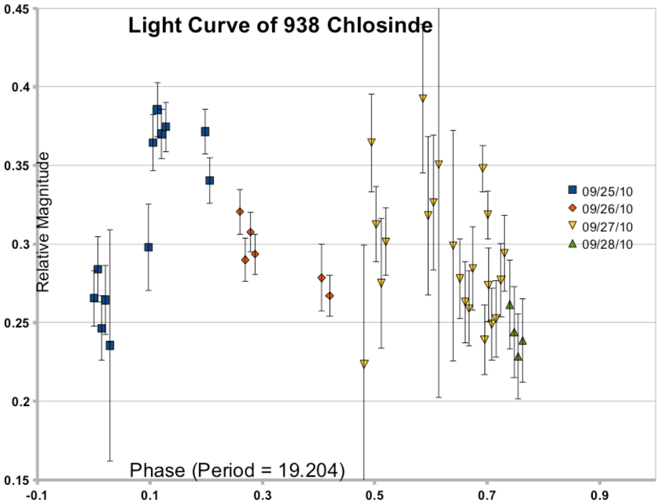
A post-observational search of the LCDB yielded a period of 19.204 ± 0.006 h with an amplitude of 0.16 ± 0.03 as reported by Stephens (2010). Further investigation identified a misspelling of "Chlosinde" in the LCDB that led to our duplicate efforts. Stephens' data are as complete as his lightcurve is convincing. A re-analysis of our observations confirms Stephens's results that he submitted to the CALL website by producing a reasonable lightcurve with $P = 19.204$ h.

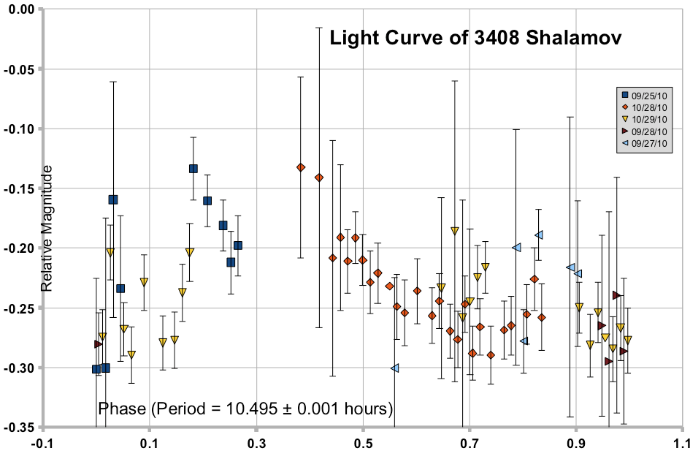
<u>3408 Shalamov.</u> A search of the LCDB does not reveal any reported lightcurve results for 3408 Shalamov. Observations were made from 2010 September 25 through September 28 and from 2010 October 28 through October 30, producing 97 data points in six data sets. Twenty data points were discarded before doing photometry due to severe vignetting or elongation. A rotation period of 10.495 ± 0.001 h was determined with an amplitude of 0.28 ± 0.10 mag. The authors suggest that further observations be done to confirm this result.

This research was done as part of an undergraduate class, taught by Dr. Hayes-Gehrke, at the University of Maryland. The purpose of this class was to teach the concepts and applications of aperture photometry and lightcurve analysis, as well as to contribute to our knowledge of asteroid rotation periods.

Acknowledgements

We would like to thank Robert Stephens for his correspondence in sharing the results of his submission to the *Minor Planet Bulletin* regarding 938 Chlosinde as well as the Tzec Maun Foundation for the use of their New Mexico Skies observatory in New Mexico, USA. We would also like to thank Brian D. Warner for his correspondence in aiding us with the preparation of this paper.





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ROTATION PERIOD DETERMINATIONS FOR 25 PHOCAEA, 140 SIWA, 149 MEDUSA, 186 CELUTA, 475 OCLLO, 574 REGINHILD, AND 603 TIMANDRA

Frederick Pilcher
4438 Organ Mesa Loop
Las Cruces, NM 88011-8403 USA
pilcher@ic.edu

(Received: 1 January)

Synodic rotation periods and amplitudes are found for: 25 Phocaea 9.9341 ± 0.0002 h, 0.26 – 0.16 mag; 140 Siwa 34.407 ± 0.002 h, 0.05 ± 0.01 mag; 149 Medusa 26.038 ± 0.002 h, 0.56 ± 0.03 mag; 186 Celuta 19.842 ± 0.001 h, 0.54 ± 0.02 mag; 475 Ocllo 7.3151 ± 0.0002 h, 0.66 ± 0.04 mag; 574 Reginhild 14.339 ± 0.001 h, 0.17 ± 0.02 mag with 3 maxima and minima per cycle; 603 Timandra 41.79 ± 0.02 h, 0.10 ± 0.02 mag.

All observations reported here were made at the Organ Mesa Observatory. Equipment consists of a 35 cm Meade LX200GPS S-C, SBIG STL-1001E CCD, R filter for 25 Phocaea and 186 Celuta, clear filter for other fainter objects, unguided, instrumental magnitudes only. Due the large number of data points acquired the lightcurves have been binned in sets of three data points with maximum of 5 minutes between points, except for 603 Timandra in which the binning is in sets of 5 data points with maximum of 10 minutes between points.

25 Phocaea. Previous period determinations are: Groeneveld and Kuiper (1954), 9.945 h; Buchheim (2007), 9.945 h; Pilcher (2009), 9.935 h in 2008 and 9.927 h in 2009. These show irregular lightcurves with shapes varying greatly with longitude of observations and amplitudes 0.03 – 0.16 magnitude. All of these periods are compatible with each other and with the new results reported here. New observations on 7 nights 2010 Sept. 25 – Dec. 10 show a period 9.9341 ± 0.0002 hours. An amplitude change occurred in the deepest minimum near phase 0.40 which correlates positively with phase angle, from 0.26 mag at phase angle 21 degrees, the largest yet observed, to 0.16 mag at phase angle 4 degrees. This is caused by shadowing of irregularities and will be useful in spin/shape modeling. Otherwise the lightcurve was very stable throughout the apparition.

140 Siwa. Harris and Young (1980) and Schober and Stanzel (1979) independently obtained single night 7 hour lightcurves separated by 32 hours which looked similar and surmised a 32 hour period, or perhaps 22 hours. Lagerkvist et al. (1992) on the basis of 4 consecutive nights claimed a period of 18.5 hours. Le Bras et al. (2001) found a period of 18.495 hours with a shape very similar to that published by Lagerkvist et. al. (1992). Riccioli et al. obtained a period of 14.654 hours. Behrend (2010) shows a period of 17.16 hours represented by a lightcurve of amplitude 0.15 magnitudes, the largest reported, and one maximum and minimum per cycle. New observations on 10 nights 2010 Oct. 23 – Dec. 25 show a period 34.407 ± 0.002 hours, amplitude 0.05 ± 0.01 mag. Trial lightcurves phased to all local minima in the period spectrum between 15 and 80 hours were drawn. Those at periods 34.407 and 68.817 hours had the lowest and nearly the same rms residuals, and were the only ones which did not show significant misfits between data on different nights. Phase coverage for the double period 68.817 hours was only 90% complete, but the sections of the lightcurve separated by ½ cycle looked identical to each other and to the 34.407 hour lightcurve. A shape model sufficiently irregular to produce the 34.407 hour lightcurve yet invariant over a 180 degree rotation is highly unlikely. Therefore I claim the 34.407 hour period is the correct one. This period may be consistent with Behrend (2010) if one assumes Behrend missed the second maximum and minimum, and perhaps also with the very sparse data of Harris and Young (1980) and Schober and Stanzel (1979), but not consistent with any of the other reported periods. The next opposition of 140 Siwa is 2012 Mar. 9, at almost the same location in the sky in which Behrend's 0.15 magnitude amplitude was observed. It is recommended that Siwa be observed again in early 2012 with special attention to full phase coverage for an alleged 34.4 hour period and an expected bimodal lightcurve with sufficient asymmetry between the two halves to rule out all aliases.

149 Medusa. The only previous period determination is by Harris et al. (1992) of 26 hours based on less than 50% lightcurve coverage on 2 consecutive nights. New observations on 9 nights 2010 Oct. 1 – Nov. 23 improve the earlier period determination to 26.038 ± 0.002 hours and amplitude 0.56 ± 0.03 mag.

186 Celuta. Bailey (1913) with visual photometry found a period 17.5 h. Lagerkvist (1978) with photographic photometry on one night established a period >12 h. Lagerkvist and Pettersson (1978) used photoelectric photometry on four well separated nights to obtain a period consistent with 19.6 hours, although other periods could not be ruled out. New observations on 7 nights 2010 Oct. 15 – Nov. 27 show a period 19.842 ± 0.001 hours, amplitude 0.54 ± 0.02 mag. This is consistent with, and improves upon, the period by Lagerkvist and Pettersson (1978).

475 Ocllo. This writer (unpublished) observed 475 Ocllo visually with a Celestron 14 in 1985, finding a large amplitude short period brightness variation. He timed two minima with accuracy ± 20 minutes 1985 Nov. 17 7:30 UT and Nov. 23 6:30 UT (JD 2446386.81 and 2446392.77, respectively). These data were insufficient to find a unique period. They are now shown to be consistent with the newly determined 7.3151 hour rotation period, implying 19.55 ± 0.05 cycles between observed minima. These crude observations are published here because they may help to resolve sidereal period ambiguities in future spin/shape modeling. Behrend (2010) states a period of 7.6461 hours. New observations on 4 nights 2010 Nov. 2 – Dec. 1 show a period 7.3151 ± 0.0002 hours, amplitude 0.66 ± 0.04 mag, and rule out Behrend's period.

574 Reginhild. Harris et al. (2010) show no previous observations. New observations on 6 nights 2010 Oct. 11 – Nov. 30 show a period 14.339 ± 0.001 hours, amplitude 0.17 ± 0.02 mag with 3 unequal maxima and minima per cycle. J. Tieman, Chicago, Illinois, USA, has kindly sent unpublished observations of 574 Reginhild which are fully consistent with those presented here.

603 Timandra. Harris et al. (2010) show no previous observations. Due to this object being fainter than magnitude 15 throughout the apparition the lightcurve shows a scatter of about 0.05 magnitudes. The first night's observations showed a long period and fairly small amplitude, and it required 7 sessions for a period near 41.8 hours to appear. This is almost exactly 7/4 of the Earth's sidereal rotation period. Hence different segments of the lightcurve are observed on 7 consecutive nights, after which an identical sequence repeats. With 10 to 11 hour sessions attainable at a declination near +34 degrees in the northern hemisphere in November and December, there is a 4 to 5 hour overlap between adjacent segments of the lightcurve. On 12 nights 2010 Nov. 13 – Dec. 24 all seven segments were observed with five of them

observed twice. This allowed complete lightcurve coverage with about 95% of the lightcurve sampled twice. These observations show a period 41.79 ± 0.02 hours, amplitude 0.10 ± 0.02 magnitudes.

Acknowledgments

The author wishes to thank Alan Harris for helpful suggestions in data analysis for the difficult case of 140 Siwa

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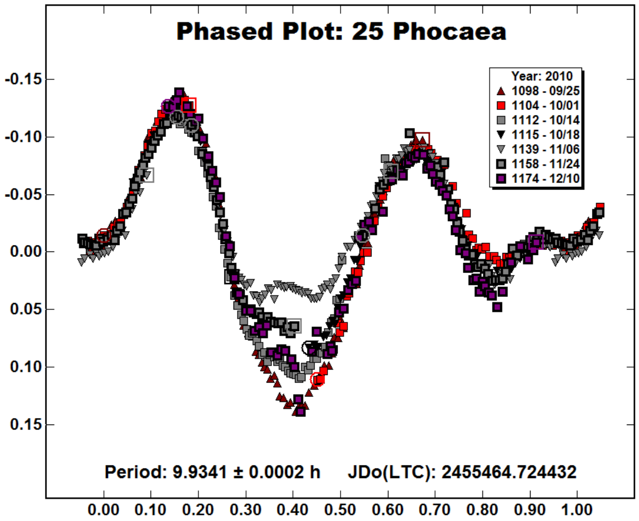

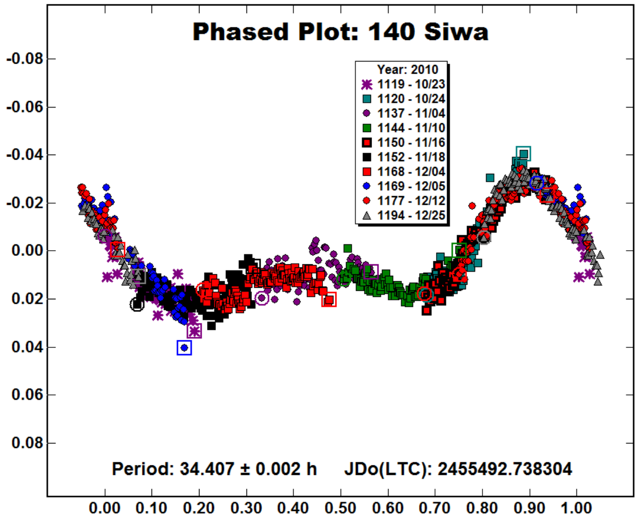

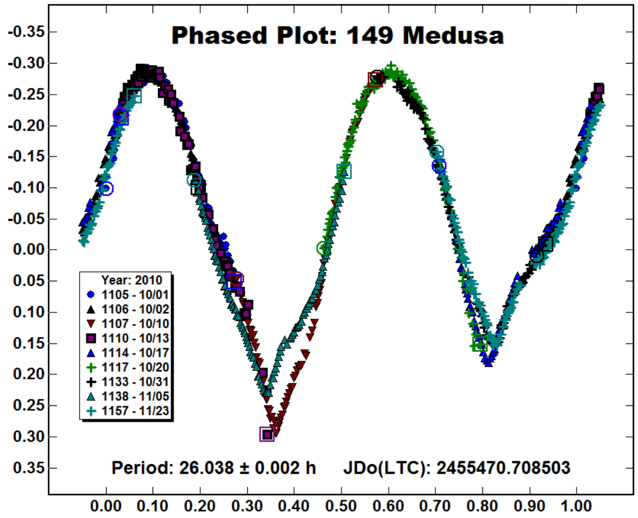

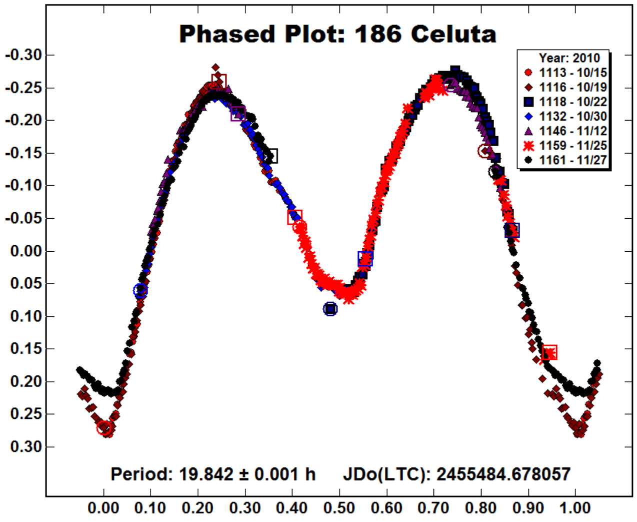

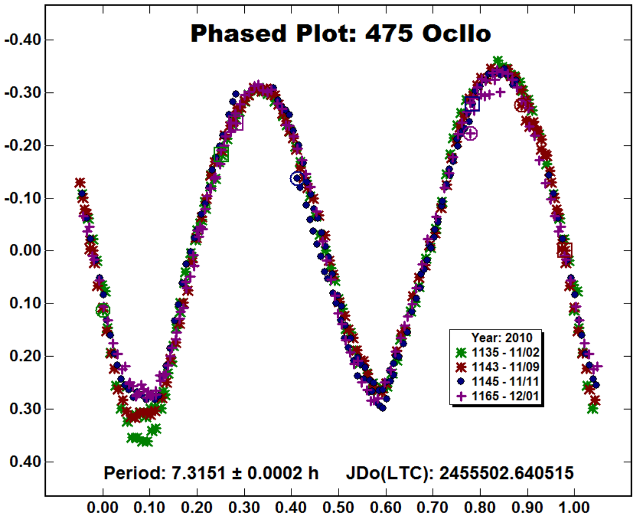

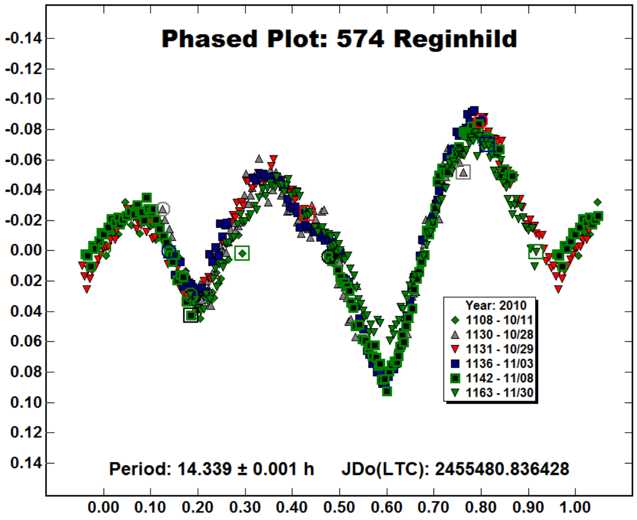

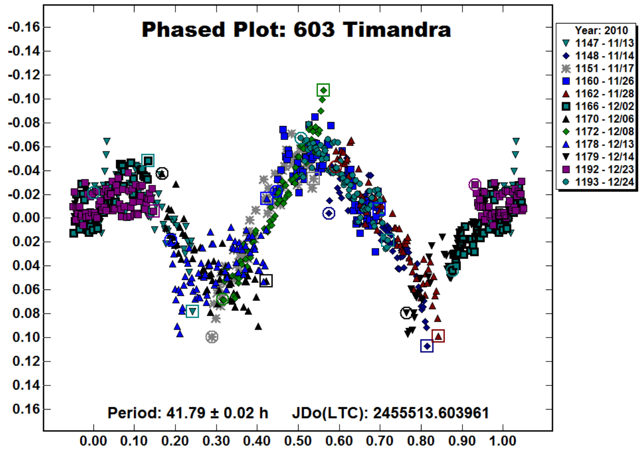

PERIOD DETERMINATION OF ASTEROID 912 MARITIMA

David Higgins
Hunters Hill Observatory
7 Mawalan Street, Ngunnawal, ACT 2913, AUSTRALIA
higginsdj@bigpond.com

Luis Martinez
Lenomiya Observatory
Casa Grande, Arizona, USA

(Received: 4 January)

Asteroid 912 Maritima was observed over a period of 3 months. Analysis reveals a possible synodic period of 1332 □□5 h and an amplitude of 0.18 ± 0.02 mag.

Asteroid 912 Maritima is a C-type asteroid (Bus and Binzel, 2002a,b) with a diameter of about 83 km. The measured albedo of p_v = 0.11 (Tedesco *et al.*, 2004) is unusually high for a C-type asteroid and as such, the inferred diameter is likely a minimum. The target had been observed previously by Blanco (2000), Warner (2006), and Behrend (2010), revealing periods of 6.066 h, 48.43 h, and 6 h respectively. All were rated U ≤ 2 and amplitudes varying from 0.02 to 0.14 mag (Warner *et al.*, 2010). Warner has since re-measured his 2005 data (Warner, private communication) using 2MASS to BVRI magnitudes (Warner, 2007) supplied with the latest version of *MPO Canopus,* resulting in a period of 20.83 hrs from 3 nights of data with a little less than 80% coverage of the phase curve. The revised had an amplitude of 0.08 mag.

Observations of Maritima were obtained at Hunters Hill Observatory (HHO) using a 0.36-m f/4 Meade LX200GPS Schmidt-Cassegrain and SBIG ST-8E CCD camera. All images were guided and taken through a clear filter. Image measurement and lightcurve analysis were undertaken using the latest release of *MPO Canopus*. One night of additional data were obtained at Lenomiya Observatory using a 0.28-m f/6.8 Celestron CPC1100 Schmidt-Cassegrain and SBIG ST-8XME CCD camera. All images were guided and taken through a clear filter and were reduced by HHO using *MPO Canopus*. All nightly sessions were combined with the Comp Star Selector (CSS) feature within *MPO Canopus* using the 2MASS to BVRI magnitudes, which have known catalogue errors of up to 0.05 mag in V and 0.03 mag in R.

The Lenomiya data were spanned by 2 sessions from HHO and linked in to within 0.02 mag.

The data in each session indicated no significant magnitude variation (less than 0.02 mag in all sessions except one, which showed a 0.03 mag change). Noise assessments by Petr Pravec of data previously obtained from HHO indicate a typical RMS of 0.015 to 0.018 mag in nightly data with targets and comparison stars of similar magnitude. The small variations in the nightly data taken for Maritima were thus dismissed as noise. Even so, all sessions were adjusted to a mean magnitude (some sessions adjusted by slightly more than 0.1 mag but most kept to within 0.05 mag) and a period search undertaken. No reliable solution was found. The nightly session offsets were then set back to zero and a plot of the raw data checked. It became apparent that there was a periodicity in the raw, unadjusted data and a search at harmonic order 2 indicated a period of 1310 h. Not all sessions fit this curve exactly so small adjustments (≤ 0.05 mag) were made to the non-fitting data to conform to the curve, which resulted in a refined period of 1332 h.

Super slow rotators, those with periods longer than a few days, are generally small asteroids. The current paradigm is that slowing of an asteroids spin rate is the result of YORP radiation pressure, which acts on a target as the inverse square of its size and the inverse square of its semi-major axis. At ~83 km and an outer main belt asteroid, these latest results challenge the current thinking. However, given that the catalogue errors account for as much as 2/3 of the target's observed amplitude, the typical RMS noise in HHO data could account for the other 1/3, and the low amplitude of the nightly sessions, we would suggest that the period reported here is less than conclusive.

Some time in the next two years will see the expected completion of the AAVSO Photometric All-Sky Survey (APASS, http://www.aavso.org/apass). This catalog is planned to cover the entire sky in BVgri from 10th-17th magnitude with errors on the order of 0.02 mag. When this becomes available, the authors plan to re-measure the original images and review the results. In the meantime, Maritima will be observable again starting in late 2011 but from the Northern Hemisphere only. The authors urge additional observations at that time.

Acknowledgements

Our thanks go to Dr Alan Harris of MoreData! for his assistance with the analysis of the results.

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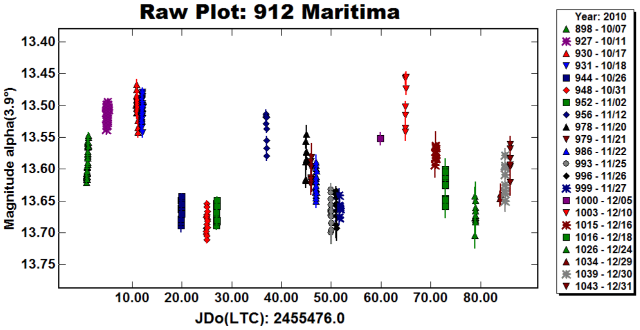
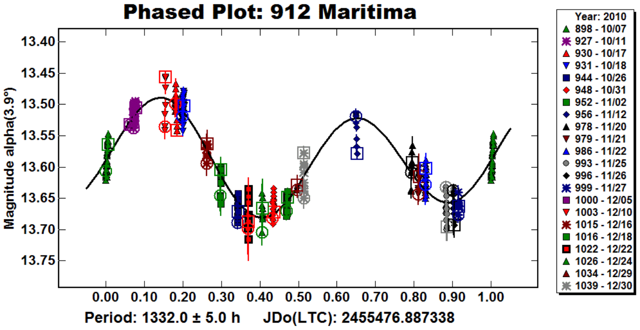
Obs.	Dates yyyy/mm/dd	PA	PAB_L	PAB_B
Blanco	1996 05/11-17	17.2,18.2	184	8
Warner	2005 11/13-20	2.8,4.0	51	7.0
Behrend	2005 12/15	12.8	51	9.0
Behrend	2007 04/08	11.4	174	13.6
Higgins	2010 10/07-12/31	3.7,18.2	11	-6

Table I. Observing circumstances for 912 Maritima during 5 apparitions. PAB is the Phase Angle Bisector.





PERIOD DETERMINATION OF ASTEROID 1550 TITO

David Higgins
Hunters Hill Observatory
7 Mawalan Street, Ngunnawal, ACT 2913, Australia
higginsdj@bigpond.com

Vladimir Benishek
Belgrade Astronomical Observatory
Volgina 7, 11060 Belgrade 38, Serbia

(Received: 4 January)

Asteroid 1550 Tito was observed over a period of two months. Analysis revealed a synodic period of 54.534 ± 0.003 h and an amplitude of 0.40 ± 0.02 mag.

The asteroid 1550 Tito is an S-type object with an approximate diameter of 13 km. It had been observed previously by Cooney *et* *al.* (2004) and Behrend (2010), who found periods of 54.2 h and 30.0 h, respectively. Both results were rated U = 2 (see Warner *et. al.*, 2009) and amplitudes varying from 0.16 to 0.23 mag.

Observations of Tito were obtained at Hunters Hill Observatory (HHO) using a 0.36-m f/4 Meade LX200GPS Schmidt-Cassegrain and SBIG ST-8E CCD camera. All images were guided and taken through a clear filter. Image measurement and lightcurve analysis were undertaken using the latest release of *MPO Canopus*. Additional data were obtained at Belgrade Astronomical Observatory (BAO) using a 0.41-m f/10 Meade LX200 Schmidt-Cassegrain and SBIG ST-10XME CCD camera. All images were unguided and taken through a clear filter. The images were reduced by Benishek, also using *MPO Canopus*.

The individual data sets were combined into a single set of 1418 data points with the Comp Star Selector (CSS) feature within *MPO Canopus* using 2MASS to BVRI magnitudes (Warner, 2007), which have estimated errors of ~0.05 mag in the V band and ~0.03 mag in R. Using R magnitudes, the data from both stations aligned to within 0.01 mag. The resulting lightcurve had several overlapping sections and covered about 85% of the entire cycle. Up to November 15, the data from both stations aligned without adjustment. However, since that time, the target appeared to have brightened gradually by up to 0.23 ± 0.05 mag. It is assumed that this brightening is due to the phase effect with increasing phase angle over the period of observation and is not unexpected. The final plot shows all sessions adjusted with offsets applied to the post November 15 data to fit the curve and revealed a synodic period of 54.534 h, which is in close agreement to the period found by Cooney *et al*.

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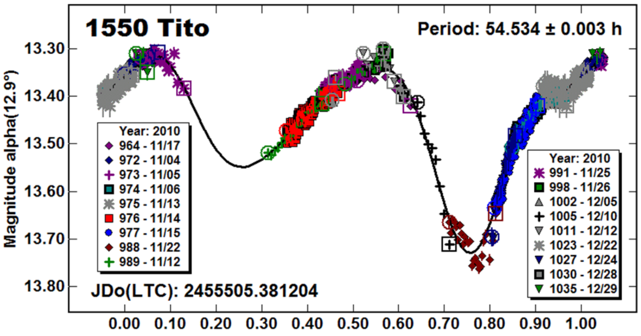
Obs.	Dates yyyy/mm/dd	PA	L_{PAB}	B_{PAB}
Cooney	2002/3 12/27-01/08	14.5,19.2	72	3
Behrend	2006 12/15	17.1	56	0
Higgins	2010 11/04-12/29	6.4,27.3	41	-3

Table I. Observing circumstances for 1550 Tito during 3 apparitions. PAB is the Phase Angle Bisector.



BRIAN G. MARSDEN 1937 - 2010

Frederick Pilcher
4438 Organ Mesa Loop
Las Cruces, NM 88011-8403 USA
pilcher@ic.edu
ALPO Minor Planets Section Coordinator

In modern times life is easy. Click on the desired asteroid, click on "Go To," after a few seconds click on "Take image," and there is the desired asteroid, right in the center of the field. Such facility is built upon positional astronomy, knowing where your target is located, and is the basis upon which all other astronomy is built. For asteroid positions, Brian G. Marsden, director of the Minor Planet Center 1978 – 2006, developed many of the modern computational procedures for handling a broad input of astrometric data from a diversity of observers. These enabled the calculation of precise orbits and ephemerides that make it easy for asteroid observers today. We should thank him every time we use the telescope.

During his long tenure at the Minor Planet Center Brian Marsden communicated with a very large number of astronomers, both amateur and professional. His conversations drew many to astrometry, offering them advice and encouragement, and he possessed the talent for encouraging them to seek the same high standards as he set for himself. He equally respected amateur and professional astronomers, understanding that both can do excellent work.

In the early 1970's we relied on the "Ephemerides of Minor Planets," by the Institute of Theoretical Astronomy, St. Petersburg, (then Leningrad, USSR) for asteroid positions, drew finder charts on the Atlas Falkau or Atlas Stellarum by Hans Vehrenberg, and star hopped to the position. Sometimes the asteroid wasn't where predicted. In some cases I could search the line of variation and find it up to a degree away, in other cases this procedure failed and the asteroid went unobserved. Brian Marsden took an interest in these observations. We exchanged much correspondence through the years. His talent for conversation really shined when we sat together at the banquet for the Asteroids II conference in Tucson in 1978.

Paul Herget of University of Cincinnati Observatory initiated the development of the computer procedures to obtain accurate ephemerides. But it was Brian Marsden who refined them and increased the number of asteroids with reliable ephemerides from about 2050 to several hundred thousand today. Brian G. Marsden, we salute and remember you.

LIGHTCURVE AND PERIOD OF THE NEA 2010 WA9

Luca Buzzi
G.V. Schiaparelli Astronomical Observatory
Varese, ITALY
lucabuzzi.204@gmail.com

Albino Carbognani
Astronomical Observatory of the Autonomous Region of the
Aosta Valley (OAVdA), ITALY

(Received: 5 January)

The authors report on the results of photometric observations of near-Earth asteroid (NEA) 2010 WA9. The synodic rotation period is 0.097 ± 0.002 h, with an amplitude of 1.4 ± 0.2 mag.

The asteroid 2010 WA9 was discovered by Andrea Boattini, Mt. Lemmon Survey, on 2010 Nov. 30.27 and announced on MPEC 2010-X05. Astrometric observations continued until 2010 Dec. 10.96, with one of us (LB) supplying the last observations. From the analysis of its orbital parameters (a = 1.225 AU, q = 0.839 AU), the asteroid belongs to the Apollo class of near-Earth asteroids (NEA). From its absolute magnitude (H) of 25.6 taken from JPL Small-Body Database Browser, we can derive a diameter ranging from 20 to 50 meters, depending on its albedo.

Here we present a lightcurve obtained from Dec.10.9567 to 10.9650 at G.V. Schiaparelli Astronomical Observatory and analyzed at OAVdA. One hundred images, each of 5 seconds exposure, were obtained with the 0.60-m f/4.64 reflector and CCD SBIG ST10-XME (2184×1672 pixels, 6.8 microns). No filter was used and the camera was binned 3×3. This gave a field-of-view of 18.4×12.3 arcminutes and a pixel scale of 1.51 arcsec/pixel. At the time of the observations, the asteroid was 0.014 AU from Earth and 0.995 AU from the Sun, at phase angle α = 41°, and travelling at an average rate of 26.68 arcsec/minute.

One of us (AC), used *MPO Canopus* v10.2 (Warner, 2009) to measure the images and do the period analysis of the lightcurve. For a first reduction, all 88 images were used. The raw lightcurve (Fig. 1) shows an obvious oscillation centered at about R = 17.8. The errors are larger near the minima, when the SNR was very low. In order to increase the SNR, the images were summed 4 at a time to create a new set of 22 images with higher SNR. The images were stacked with a drift velocity intermediate between the sidereal tracking and the asteroid's tracking and with the same PA of the target. In this way, the elongation of the target and reference stars is the same. We used elliptical aperture in *MPO Canopus*, with the semi-axes proportional to those of the elongated star images and with the major axis parallel to the motion direction. Fig. 2 shows the result after measuring the stacked images.

Our analysis of the revised data set found a period of 0.097 ± 0.002 h (349 ± 7 s). The amplitude of second lightcurve was more easily determined than by using Fig. 1. Adopting the method outlined in Carbognani (2010) with a polynomial interpolation of fifth degree, the amplitude is A(41°) = 1.4 ± 0.2 mag. If we correct the amplitude to zero phase angle using the empirical formula by Zappala *et al.* (1990) m = 0.03/deg, the mean value for S-type asteroids and common among NEAs, we have A(0°) = 0.6 ± 0.2 mag. Assuming a triaxial ellipsoid (semi-major axis a, b, c), then we found a lower limit for the ratio (a/b) using $a/b = 10^{(A/2.5)} = 1.8 \pm 0.3$ (Warner, 2006).

The rotation period of this asteroid is under the spin barrier value of about 2.2 h, which is consistent with its small size (Pravec and Harris, 2000). The period and the lower limit for the a/b ratio provide constraints on the internal structure of the asteroid, i.e., it is most likely an elongated body that is strength-bound (e.g., monolithic) rather than gravity-bound (a so-called "rubble pile").

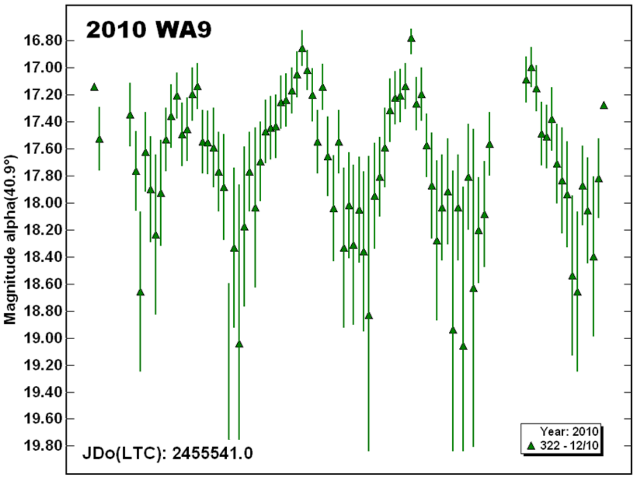


Figure 1. The raw lightcurve of 2010 WA9 with all 88 data points.

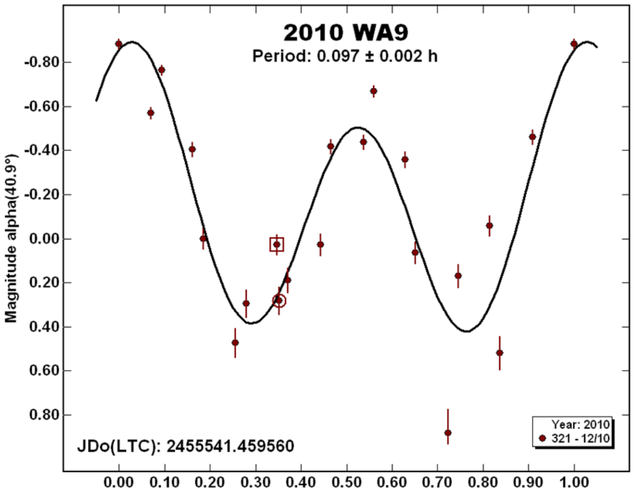


Figure 2. The full lightcurve and period of 2010 WA9 using 22 binned images (see text).

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ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: 2010 SEPTEMBER-DECEMBER

Brian D. Warner
Palmer Divide Observatory
17995 Bakers Farm Rd., Colorado Springs, CO 80908 USA
brian@MinorPlanetObserver.com

(Received: 6 January)

Lightcurves for 23 asteroids were obtained at the Palmer Divide Observatory (PDO) from 2010 September through December: 795 Fini, 1506 Xosa, 1600 Vyssotsky, 2518 Rutllant, 3873 Roddy, 8380 Tooting, 9774 Annjudge, 1118 Modra, (11279) 1989 TC, 11976 Josephthurn, (16026) 1999 CM118, (24815) 1994 VQ6, (44600) 1999 RU10, (48601) 1995 BL, (48707) 1996 KR1, (74219) 1998 RM78, (75489) 1999 XO178, (86192) 1999 SV1, (86217) 1999 TB35, (86257) 1999 TK207, (100926) 1998 MQ, (107668) 2001 FY4, and (150370) 2000 CG65.

CCD photometric observations of 23 asteroids were made at the Palmer Divide Observatory (PDO) from 2010 September through December. See the introduction in Warner (2010) for a discussion of equipment, analysis software and methods, and overview of the plot scaling. The “Reduced Magnitude” in the plots uses Cousins R magnitudes corrected to unity distance by applying –5*log (Rr) with R and r being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the phase angle given in parentheses, e.g., alpha(6.5°), using $G = 0.15$ unless otherwise stated.

795 Fini. This outer main-belt asteroid was worked by the author in 2003 (Warner 2003) with a period of 8.641 h reported. The 2003 images were subsequently re-measured using better session-to-session calibration techniques and a new period of 9.292 h was found. Observations in 2010 found no signs of the long period but, instead, a very low-amplitude curve with a period of 7.59 h but a solution of 9.01 h was also possible. The viewing aspects (phase angle bisector longitudes) at 2003 and 2010 were nearly orthogonal at 90 degree apart. Given the very low amplitude under both circumstances, the object is probably nearly spheroidal.

1506 Xosa. Robison and Warner (2002) reported a period of 5.9 h as did Stecher (2009) while Behrend (2010) found 6.0 h. All of these solutions were rated U=1 in the asteroid lightcurve database (LCDB; Warner *et al.* 2009). Observations at PDO in 2010 found a period of $P = 292 \pm 3$ h with $A = 0.70$ mag. A search for a short-period component within the long period was inconclusive.

1600 Vyssotsky. This Hungaria asteroid was worked in 2010 to provide additional data for spin axis modeling. The period agrees with those previously published (see references in the LCDB).

3873 Roddy. This is another Hungaria asteroid worked to provide data for spin axis modeling. The period agrees with those previously found by the author in three previous apparitions.

11976 Josephthurn. The period of $P = 3.579$ h is in reasonable agreement with the previous finding by the author (Warner, 2009).

Acknowledgements

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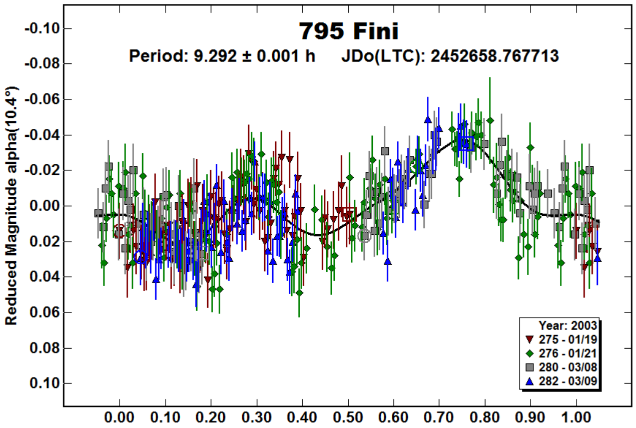
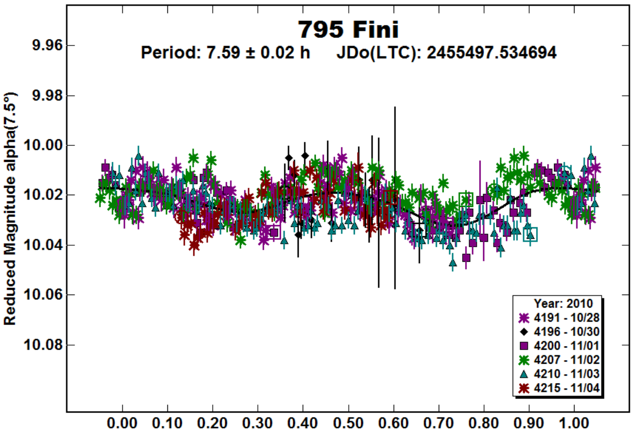
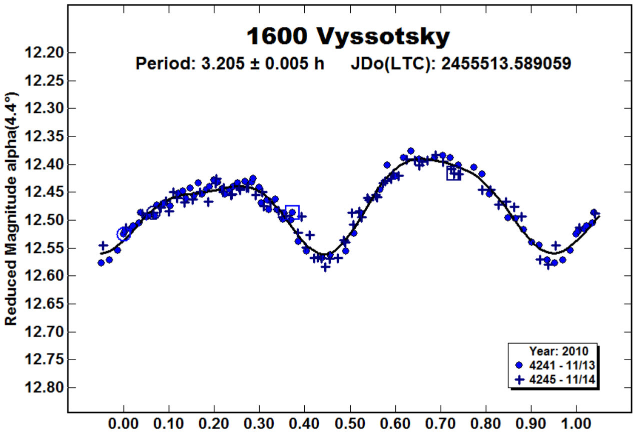
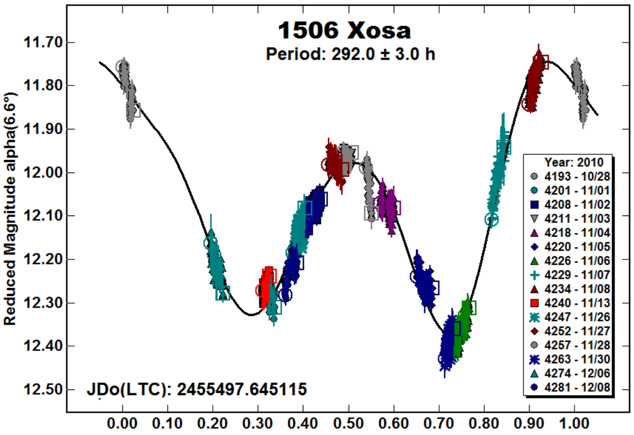
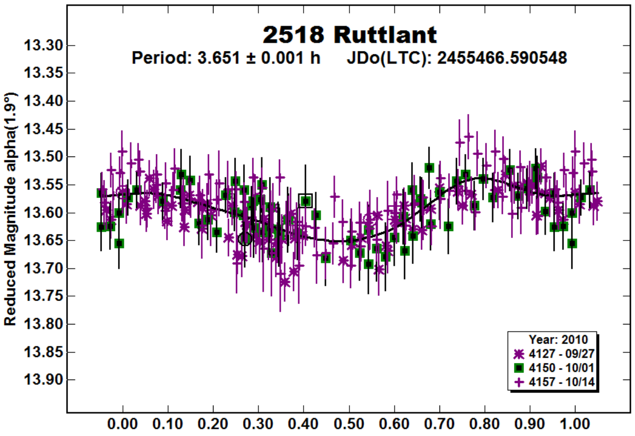




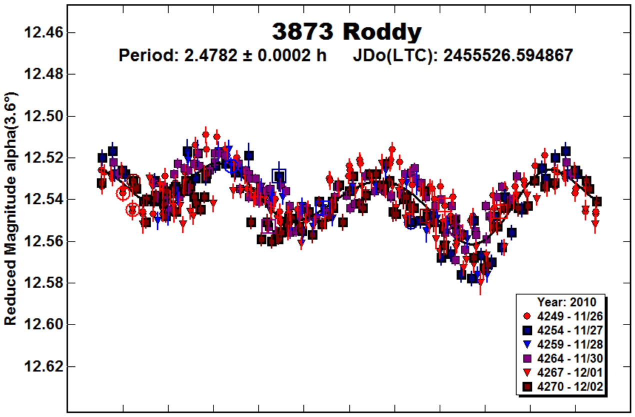


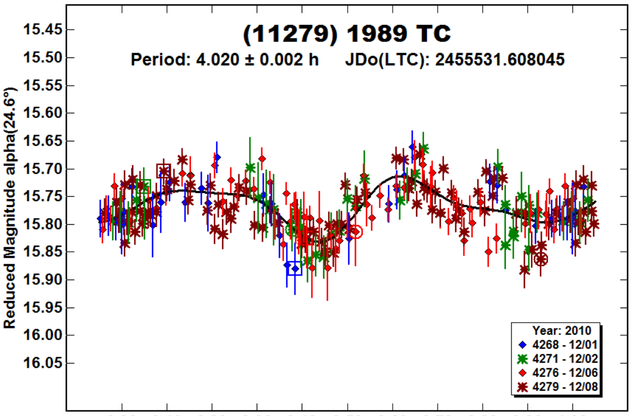


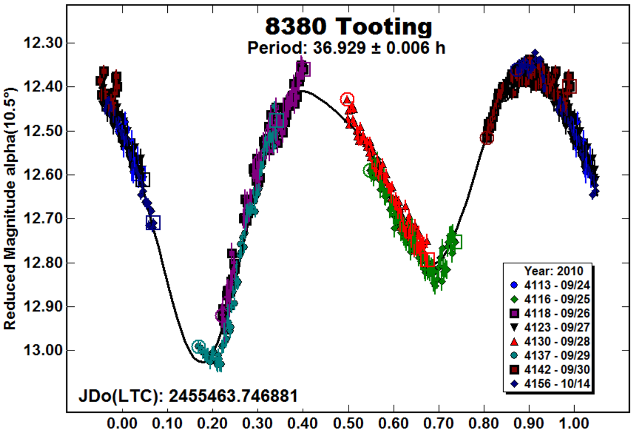


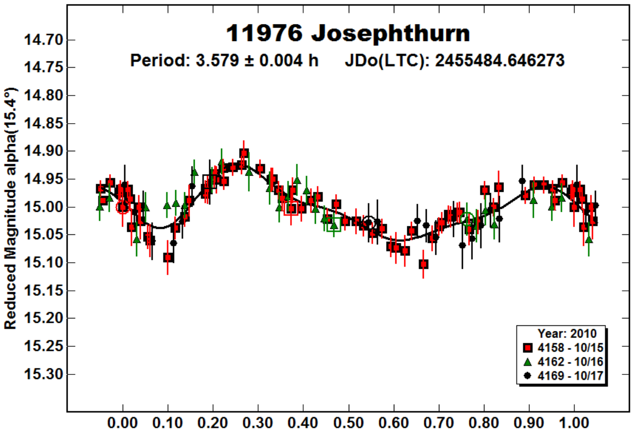
#	Name	mm/dd 2010	Data Pts	α	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
795	Fini	01/19-03/09*	481	10.3,19.9	113	22	9.292	0.001	0.06	0.01
795	Fini	10/28-11/04	473	7.4,9.8	15	0	7.59	0.02	0.02	0.01
1506	Xosa	10/28-12/08	1235	6.6,9.8	50	1	292.	3.	0.70	0.05
1600	Vyssotsky (H)	11/13-11/14	145	4.5,4.0	54	-5	3.205	0.005	0.19	0.01
2518	Ruttlant	09/27-10/14	227				3.651	0.001	0.12	0.02
3873	Roddy (H)	11/26-12/02	391	3.8,1.1	68	1	2.4782	0.0002	0.05	0.01
8380	Tooting	09/24-10/14	567	10.4,15.6	354	18	36.929	0.006	0.72	0.02
9774	Annjudge	11/26-11/28	171	7.5,8.5	50	1	10.51	0.05	0.20	0.02
11118	Modra	09/15-09/29	385	7.6,0.7	7	0	27.12	0.02	0.53	0.03
11279	1989 TC (H)	12/01-12/09	212	24.5,23.4	89	34	4.020	0.002	0.13	0.02
11976	Josephthurn	10/15-10/17	109	15.5,14.3	44	1	3.579	0.004	0.12	0.02
16026	1999 CM118	10/28-10/30	166	11.0,12.1	17	0	11.3	0.2	0.21	0.02
24815	1994 VQ6 (H)	10/15-10/27	541	12.3,4.2	36	5	31.17	0.05	0.53	0.03
44600	1999 RU10 (H)	10/28-11/01	145	16.2,16.8	29	26	6.211	0.005	0.98	0.03
48601	1995 BL (H)	11/05-11/08	281	21.2,20.4	65	25	4.590	0.003	0.56	0.03
48707	1996 KR1 (H)	09/30-11/02	995	16.1,5.9,10.9	24	8	230.	2.0	0.75	0.10
74219	1998 RM78	11/08	59	2.3	50	1	5.7	0.2	0.41	0.03
75489	1999 XO178	11/06-11/07	121	4.4,3.9	50	2	8.70	0.03	0.65	0.03
86192	1999 SV1	10/21-10/27	164	14.4,12.2	42	17	7.164	0.005	0.29	0.02
86217	1999 TB35	10/26-10/27	170	11.3,11.0	43	12	6.00	0.02	1.00	0.02
86257	1999 TK207 (H)	12/01-12/08	246	9.7,9.0	72	14	32.49	0.10	1.05	0.05
100926	1998 MQ	10/16-10/21	268	55.6,49.1	58	12	2.328	0.001	0.11	0.01
107668	2001 FY4 (H)	09/15-09/28	313	10.3,2.3	6	1	32.9		0.06	
150370	2000 CG65	11/02-11/04	139	5.1,4.1	50	2	16.6	0.2	0.76	0.05
* Year = 2003										

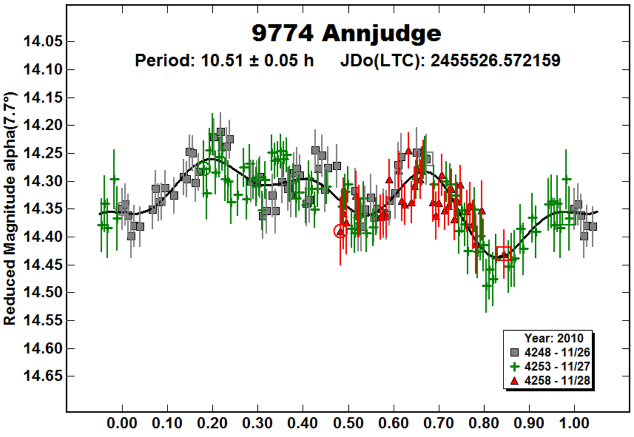
Table I. Observing circumstances. Asteroids with "(H)" after the name are members of the Hungaria group. The phase angle (α) is given at the start and end of each date range, unless it reached a minimum, which is then the second of three values. If a single value is given, the phase angle did not change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

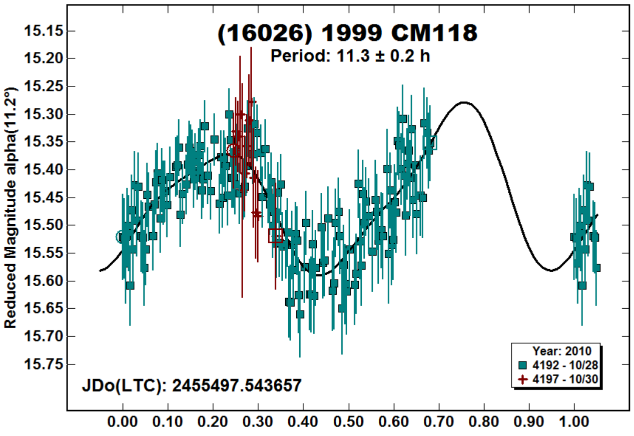

3873 Roddy
Period: 2.4782 ± 0.0002 h JDo(LTC): 2455526.594867
Reduced Magnitude alpha(3.6°)
12.46
12.48
12.50
12.52
12.54
12.56
12.58
12.60
12.62
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
4249 - 11/26
4254 - 11/27
4259 - 11/28
4264 - 11/30
4267 - 12/01
4270 - 12/02

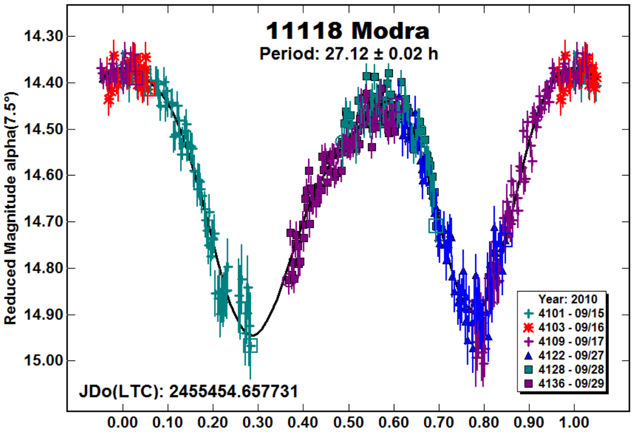

(11279) 1989 TC
Period: 4.020 ± 0.002 h JDo(LTC): 2455531.608045
Reduced Magnitude alpha(24.6°)
15.45
15.50
15.55
15.60
15.65
15.70
15.75
15.80
15.85
15.90
15.95
16.00
16.05
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
4268 - 12/01
4271 - 12/02
4276 - 12/06
4279 - 12/08

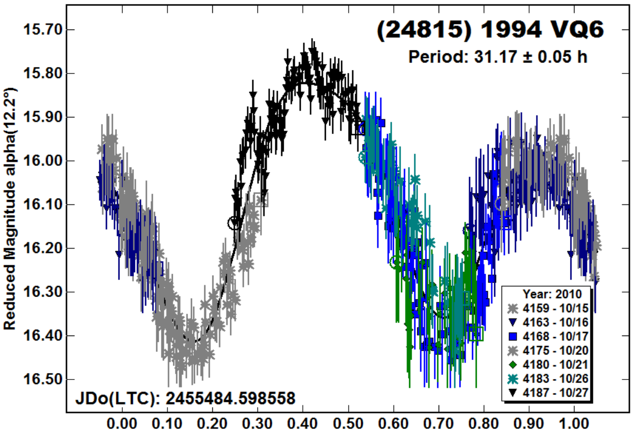

8380 Tooting
Period: 36.929 ± 0.006 h
Reduced Magnitude alpha(10.5°)
12.30
12.40
12.50
12.60
12.70
12.80
12.90
13.00
JDo(LTC): 2455463.746881
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
4113 - 09/24
4116 - 09/25
4118 - 09/26
4123 - 09/27
4130 - 09/28
4137 - 09/29
4142 - 09/30
4156 - 10/14

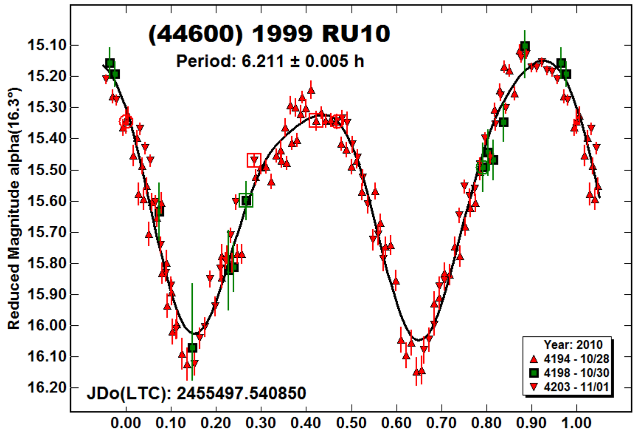

11976 Josephthurn
Period: 3.579 ± 0.004 h JDo(LTC): 2455484.646273
Reduced Magnitude alpha(15.4°)
14.70
14.75
14.80
14.85
14.90
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
4158 - 10/15
4162 - 10/16
4169 - 10/17

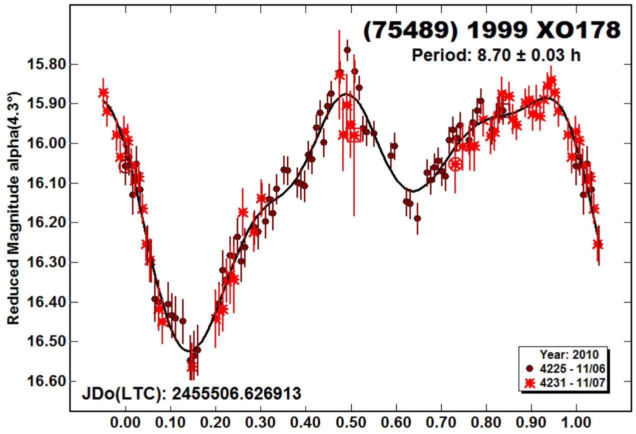

9774 Annjudge
Period: 10.51 ± 0.05 h JDo(LTC): 2455526.572159
Reduced Magnitude alpha(7.7°)
14.05
14.10
14.15
14.20
14.25
14.30
14.35
14.40
14.45
14.50
14.55
14.60
14.65
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
4248 - 11/26
4253 - 11/27
4258 - 11/28

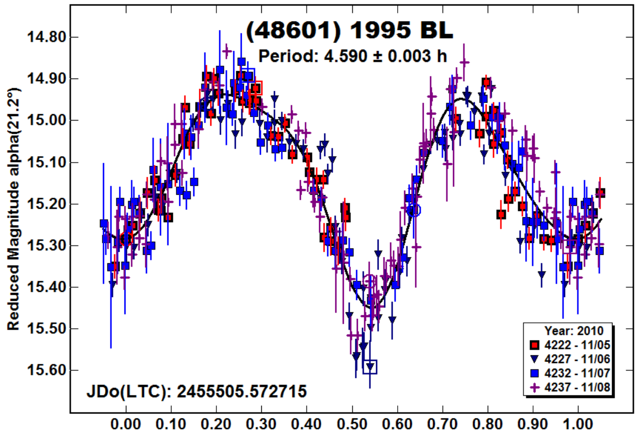

(16026) 1999 CM118
Period: 11.3 ± 0.2 h
Reduced Magnitude alpha(11.2°)
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
15.55
15.60
15.65
15.70
15.75
JDo(LTC): 2455497.543657
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
4192 - 10/28
4197 - 10/30

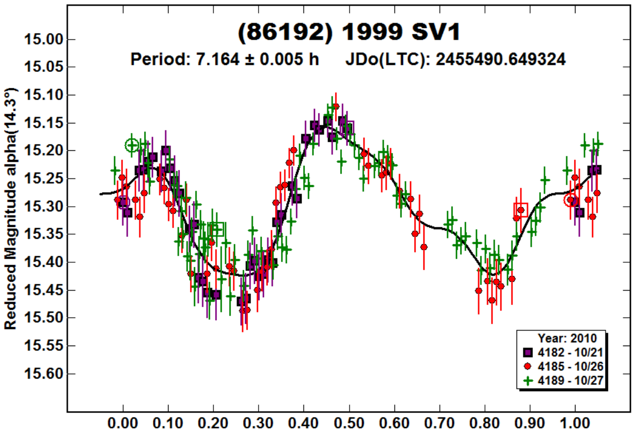

11118 Modra
Period: 27.12 ± 0.02 h
Reduced Magnitude alpha(7.5°)
14.30
14.40
14.50
14.60
14.70
14.80
14.90
15.00
JDo(LTC): 2455454.657731
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
4101 - 09/15
4103 - 09/16
4109 - 09/17
4122 - 09/27
4128 - 09/28
4136 - 09/29

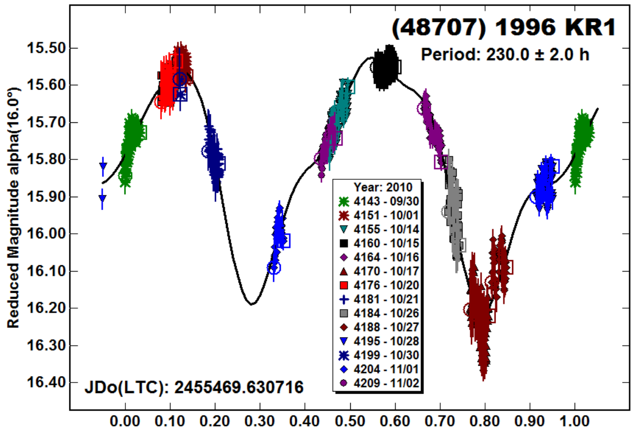

(24815) 1994 VQ6
Period: 31.17 ± 0.05 h
Reduced Magnitude alpha(12.2°)
15.70
15.80
15.90
16.00
16.10
16.20
16.30
16.40
16.50
JDo(LTC): 2455484.598558
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
4159 - 10/15
4163 - 10/16
4168 - 10/17
4175 - 10/20
4180 - 10/21
4183 - 10/26
4187 - 10/27

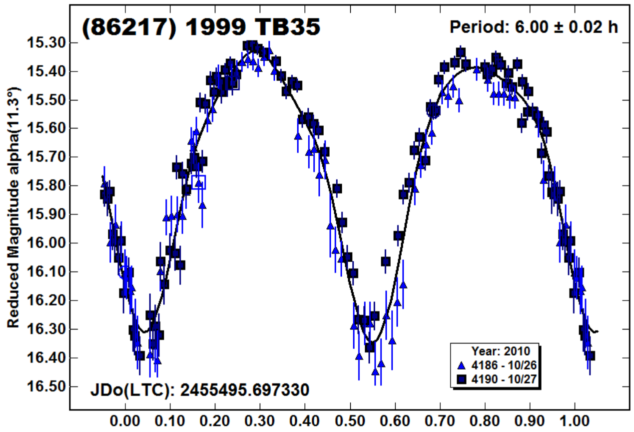

(44600) 1999 RU10
Period: 6.211 ± 0.005 h
Reduced Magnitude alpha(16.3°)
15.10 15.20 15.30 15.40 15.50 15.60 15.70 15.80 15.90 16.00 16.10 16.20
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2455497.540850
Year: 2010
4194 - 10/28
4198 - 10/30
4203 - 11/01

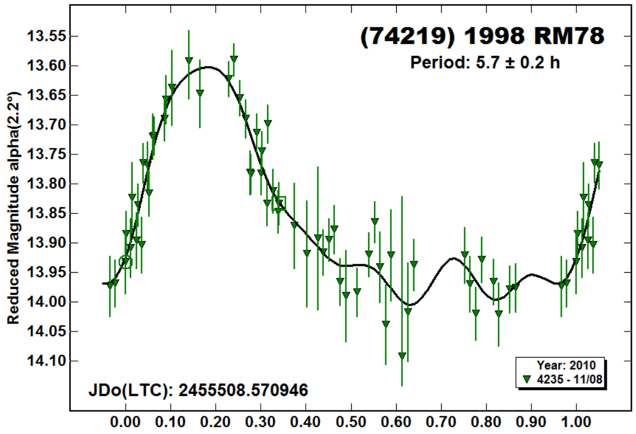

(75489) 1999 XO178
Period: 8.70 ± 0.03 h
Reduced Magnitude alpha(4.3°)
15.80 15.90 16.00 16.10 16.20 16.30 16.40 16.50 16.60
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2455506.626913
Year: 2010
4225 - 11/06
4231 - 11/07

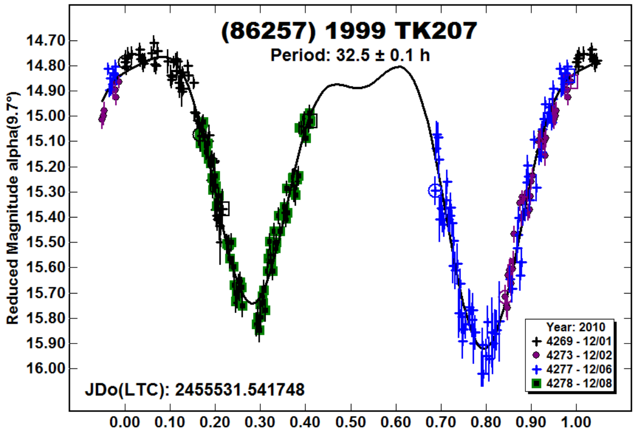

(48601) 1995 BL
Period: 4.590 ± 0.003 h
Reduced Magnitude alpha(21.2°)
14.80 14.90 15.00 15.10 15.20 15.30 15.40 15.50 15.60
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2455505.572715
Year: 2010
4222 - 11/05
4227 - 11/06
4232 - 11/07
4237 - 11/08

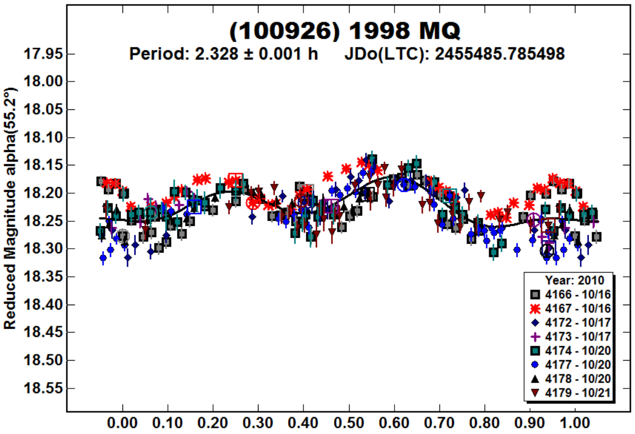

(86192) 1999 SV1
Period: 7.164 ± 0.005 h
JDo(LTC): 2455490.649324
Reduced Magnitude alpha(14.3°)
15.00 15.05 15.10 15.15 15.20 15.25 15.30 15.35 15.40 15.45 15.50 15.55 15.60
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
4182 - 10/21
4185 - 10/26
4189 - 10/27

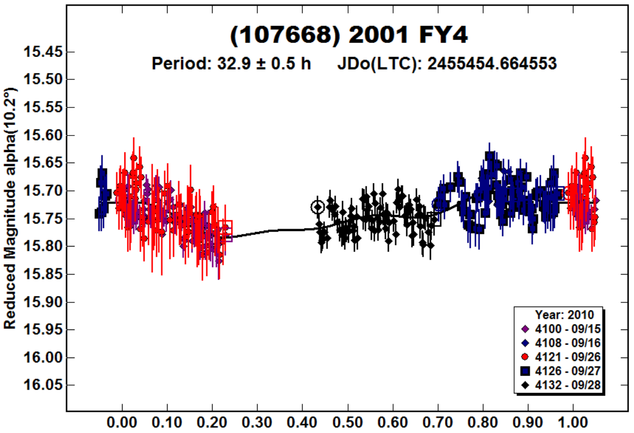

(48707) 1996 KR1
Period: 230.0 ± 2.0 h
Reduced Magnitude alpha(16.0°)
15.50 15.60 15.70 15.80 15.90 16.00 16.10 16.20 16.30 16.40
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2455469.630716
Year: 2010
4143 - 09/30
4151 - 10/01
4155 - 10/14
4160 - 10/15
4164 - 10/16
4170 - 10/17
4176 - 10/20
4181 - 10/21
4184 - 10/26
4188 - 10/27
4195 - 10/28
4199 - 10/30
4204 - 11/01
4209 - 11/02

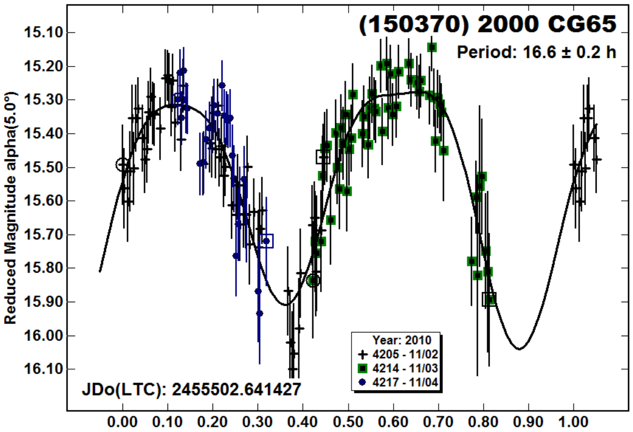

(86217) 1999 TB35
Period: 6.00 ± 0.02 h
Reduced Magnitude alpha(11.3°)
15.30 15.40 15.50 15.60 15.70 15.80 15.90 16.00 16.10 16.20 16.30 16.40 16.50
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2455495.697330
Year: 2010
4186 - 10/26
4190 - 10/27


(74219) 1998 RM78
Period: 5.7 ± 0.2 h
Reduced Magnitude alpha(2.2°)
13.55 13.60 13.65 13.70 13.75 13.80 13.85 13.90 13.95 14.00 14.05 14.10
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2455508.570946
Year: 2010
4235 - 11/08


(86257) 1999 TK207
Period: 32.5 ± 0.1 h
Reduced Magnitude alpha(9.7°)
14.70 14.80 14.90 15.00 15.10 15.20 15.30 15.40 15.50 15.60 15.70 15.80 15.90 16.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2455531.541748
Year: 2010
4269 - 12/01
4273 - 12/02
4277 - 12/06
4278 - 12/08







CALL FOR OBSERVATIONS

Frederick Pilcher
Minor Planets Section Recorder
4438 Organ Mesa Loop
Las Cruces, NM 88011 USA
pilcher@ic.edu

Observers who have made visual, photographic, or CCD measurements of positions of minor planets in calendar year 2010 are encouraged to report them to the Minor Planets Section Recorder on or before April 1, 2011. This will be the deadline for receipt of reports that can be included in the "General Report of Position Observations for 2010," to appear in *MPB* Vol. 38, No. 3.

LIGHTCURVE ANALYSIS OF EIGHT MAIN-BELT ASTEROIDS AND A REVISED PERIOD FOR 185 EUNIKE

John C. Ruthroff
Shadowbox Observatory
12745 Crescent Drive
Carmel, IN 46032
john@theastroimager.com

(Received: 8 January)

Seven asteroids were the subject of the lightcurve program at Shadowbox Observatory form 2010 October through 2011 January: 1080 Orchis, 1663 Van den Bos, 2437 Amnestia, 2853 Harvill, 3252 Johnny, 3277 Aaronson and 3605 Davy. In addition, data for 1498 Lahti from 2009 October are included. Also revised a period of 14.56 ± 0.05 h is reported for 185 Eunike.

CCD photometry observations were made from 2010 October to 2011 January on main-belt asteroids 1080 Orchis, 1663 van den Bos, 2437 Amnestia, 2853 Harvill, 3252 Johnny, 3277 Aaronson, and 3605 Davy. Asteroid 3252 Johnny was observed using the 0.37-meter Rigel Telescope at the Iowa Robotic Telescope Facility (IRTF). All other observations were made using the 0.30-m f/6.1 Schmidt-Cassegrain at Shadowbox Observatory (see Ruthroff, 2010, for equipment and technique details). In addition, data for 1498 Lahti obtained in 2009 October were recovered from a failed hard drive and analyzed.

1080 Orchis, 1663 van den Bos, 2437 Amnestia, 2853 Harvill, 3277 Aaronson, and 3605 Davy were observed in support of a call for lightcurves of asteroids having either no or poorly constrained lightcurve parameters (Warner *et al.*, 2010). 3252 Johnny was in the field-of-view of another targeted object. With the exception of 1663 van den Bos and 3605 Davy, the author was unable to find previously reported lightcurve parameters for these objects. During analysis, the assumption that a lightcurve with an amplitude of $A \geq 0.2$ mag at low-to-moderate phase angles will be bimodal (two maximums/minimums) was applied to constrain the possible solutions.

185 Eunike. Previously reported results for 185 Eunike by the author (Ruthroff 2010) stated that the period was likely to be 11.2 h. Subsequent analysis (Warner, private communication) suggested that a period close to 14.5 h should be considered. Upon a more critical review of the observations, a revised rotation period of 14.56 ± 0.05 h is presented.

1080 Orchis. 359 data points were analyzed. The period found was 16.1 ± 0.1 h with estimated amplitude of 0.24 ± 0.05 mag. Another possible period is 24.2 hours, but the fit is significantly worse. After observations and analysis were complete, Justin Tieman (private communication) indicated that analysis of his unpublished observations, which predated those obtained at Shadowbox by a few weeks, resulted in a period within 0.1 h of the 16.1 h period.

1498 Lahti. The lightcurve data for 1498 Lahti, which were initially lost on a crashed hard drive, were recovered and analyzed. 173 data points were acquired over 3 nights from 2009 October 1-6. The data are broken into 5 sessions, each night having 2 sessions due to the need for the German equatorial mount to do a "meridian flip" as the asteroid went west of the meridian. Bad weather late meant getting data on only the first half of the night of October 6. The sparse data set prevents a reasonable conclusion for the period.

The plot shows 58.8 h, which is one of many possible solutions. It's likely that the period is > 20 h and amplitude is at least 0.4 mag.

1663 van den Bos. 243 data points were analyzed. The derived period was 152.49 ± 0.06 h with estimated amplitude of 0.50 ± 0.1 mag. Subsequent results posted by Stephens and Higgins on the CALL web site (http://www.MinorPlanet.info/call.html) show a period of 740 hours.

2437 Amnestia. 528 data points were analyzed. The period found was 84.8 ± 0.1 h with an estimated amplitude of 0.4 ± 0.05 mag. Other periods are possible.

2853 Harvill. 119 data points were obtained over two consecutive nights and analyzed. All extrema were observed in one observing session. The period found was 6.30 ± 0.05 h with estimated amplitude of 0.6 ± 0.2 mag.

3252 Johnny. 34 data points were gathered in one night using the 0.37-m f/14 classical Cassegrain Rigel telescope at the Iowa Robotic Telescope Facility (IRTF) near Sonoita, AZ. The imager was a Finger Lakes ProLine camera with a Kodak 09000 3056x3056x12-micron chip. The camera was operating in 2x2 binning mode, giving a resolution of 1 arc seconds/pixel. The period found was 3.54 ± 0.02 h with estimated amplitude of 0.50 ± 0.05 mag.

3277 Aaronson. 296 data points were analyzed. A period of 9.8 ± 0.05 h and amplitude of 0.16 ± 0.09 mag were found. This amplitude range falls slightly under the 0.2 mag amplitude threshold used to constrain the lightcurve to bimodal (Binzel 1987).

3605 Davy. 306 data points were collected over 2 nights. The period found was 2.72 ± 0.01h with estimated amplitude of 0.26 ± 0.08 mag. These results are consistent with those of Behrend (2010).

Acknowledgements

This paper makes use of data products from The Third U.S. Naval Observatory CCD Astrograph Catalog (UCAC3). Greatly appreciated are the Sierra Stars Observatory Network and the University of Iowa's Robotic Telescope Facility for making the Rigel telescope available for use. I would like to thank Brian Warner for his years of guidance and support of the community of minor planet observers.

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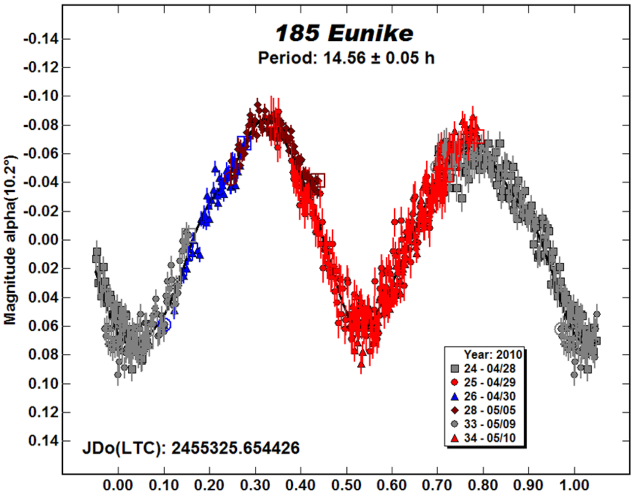
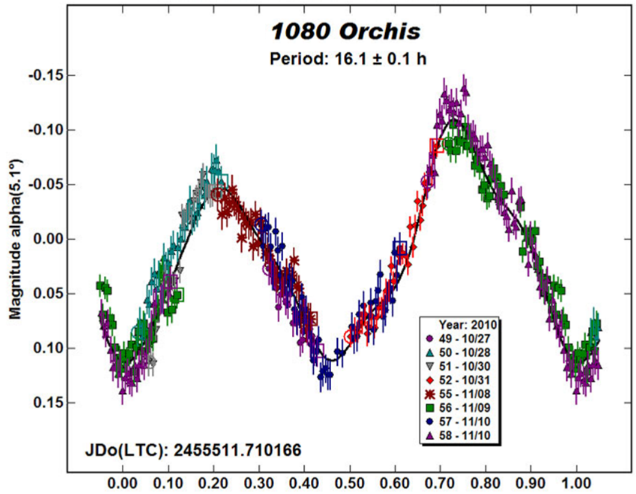
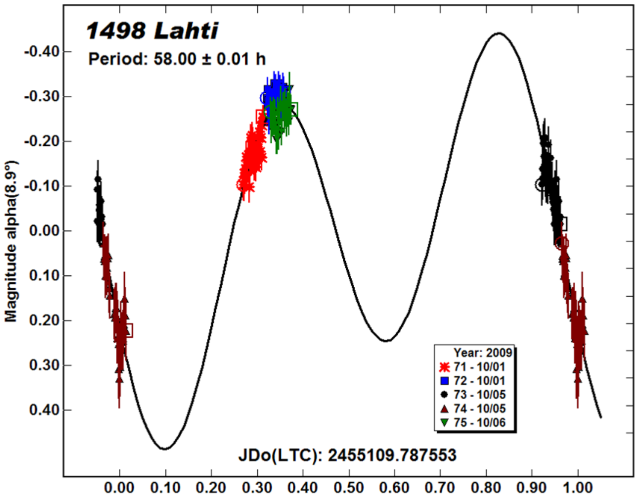
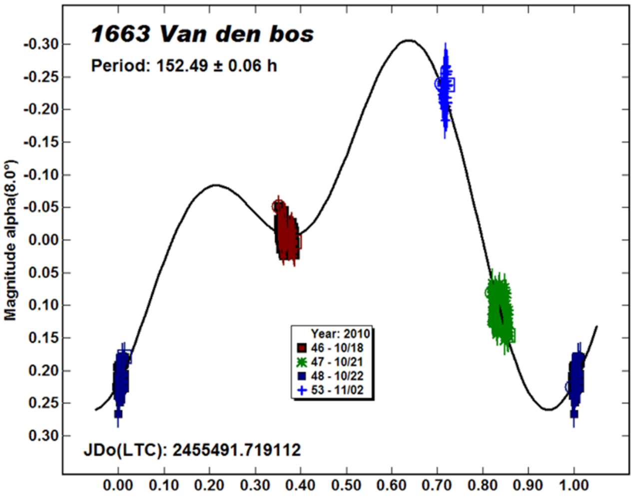
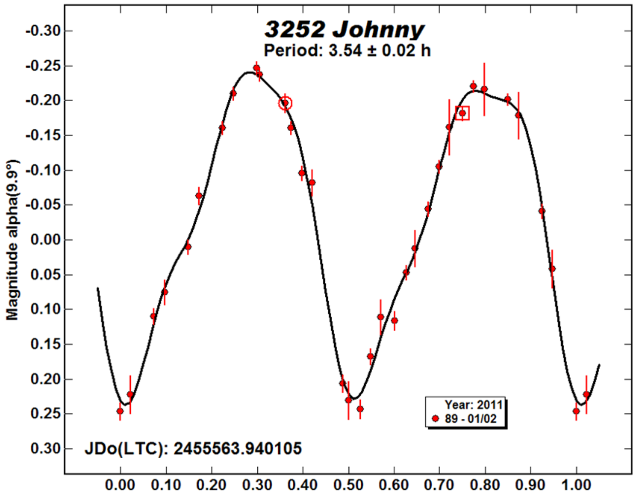
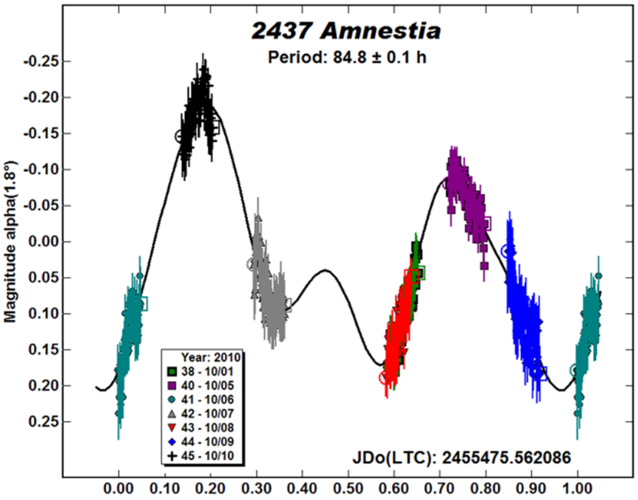


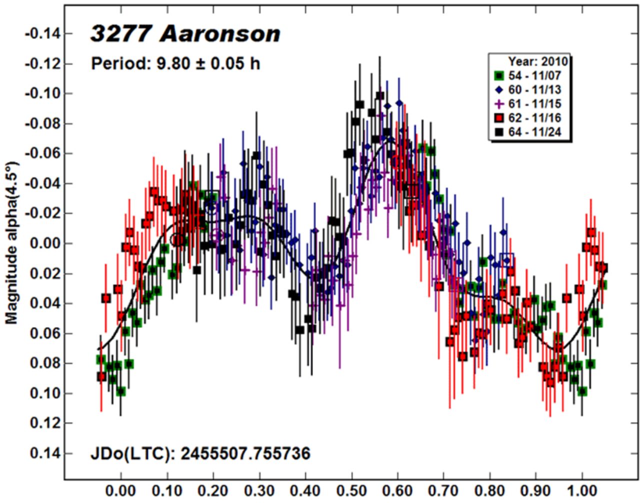





1663 Van den bos
Period: 152.49 ± 0.06 h
Magnitude alpha(8.0°)
Year: 2010
46 - 10/18
47 - 10/21
48 - 10/22
53 - 11/02
JDo(LTC): 2455491.719112
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


3252 Johnny
Period: 3.54 ± 0.02 h
Magnitude alpha(9.9°)
Year: 2011
89 - 01/02
JDo(LTC): 2455563.940105
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


2437 Amnestia
Period: 84.8 ± 0.1 h
Magnitude alpha(1.8°)
Year: 2010
38 - 10/01
40 - 10/05
41 - 10/06
42 - 10/07
43 - 10/08
44 - 10/09
45 - 10/10
JDo(LTC): 2455475.562086
-0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


3277 Aaronson
Period: 9.80 ± 0.05 h
Magnitude alpha(4.5°)
Year: 2010
54 - 11/07
60 - 11/13
61 - 11/15
62 - 11/16
64 - 11/24
JDo(LTC): 2455507.755736
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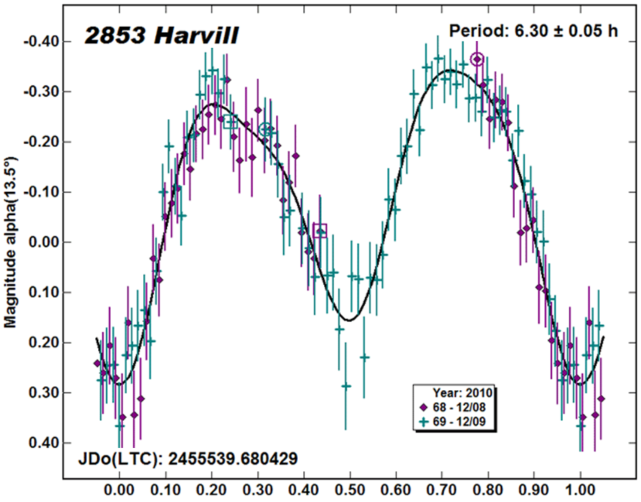
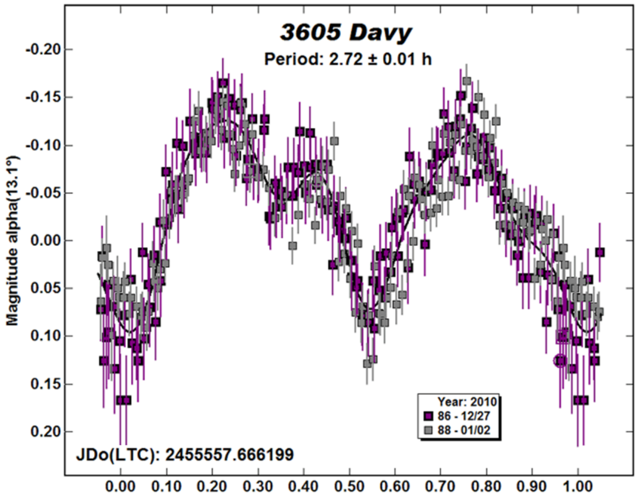

2853 Harvill
Period: 6.30 ± 0.05 h
Magnitude alpha(13.5°)
Year: 2010
68 - 12/08
69 - 12/09
JDo(LTC): 2455539.680429
-0.40 -0.30 -0.20 -0.10 0.00 0.10 0.20 0.30 0.40
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


3605 Davy
Period: 2.72 ± 0.01 h
Magnitude alpha(13.1°)
Year: 2010
86 - 12/27
88 - 01/02
JDo(LTC): 2455557.666199
-0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: UNPUBLISHED RESULTS FROM 1999 TO 2008

Brian D. Warner
Palmer Divide Observatory
17995 Bakers Farm Rd., Colorado Springs, CO 80908 USA
brian@MinorPlanetObserver.com

(Received: 8 January)

Lightcurves for 16 asteroids obtained at the Palmer Divide Observatory (PDO) from 2001 through 2008 that were previously unreported are presented: 151 Abundantia, 635 Vundtia, 893 Leopoldina, 982 Franklina, 2352 Kurchatov, 2263 Shaanxi, 2846 Ylppo, 3368 Duncombe, 3747 Belinskij, (6361) 1978 VL11, (7870) 1987 UP2, (10722) 1990 YM, (14668) 1999 CB67, (22357) 1992 YJ, (126074) 2001 YE85, and 2004 GD2.

CCD photometric observations of 16 asteroids made at the Palmer Divide Observatory (PDO) from 2001 through 2008 are reported for the first time. See the introduction in Warner (2010) for a general discussion of analysis software, methods, and overview of the plot scaling. The "Reduced Magnitude" in the plots uses Cousins R magnitudes corrected to unity distance by applying –5*log (Rr) with R and r being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. Unless otherwise stated, the magnitudes were normalized to the phase angle given in parentheses, e.g., alpha(6.5°), using $G = 0.15$.

151 Abundantia. Previously reported results included $P = 19.8$ h (Robinson, 2010) and $P = 9.8640$ h (Behrend, 2010). Analysis of the PDO data found $P = 9.861 \pm 0.003$ h and amplitude $A = 0.20 \pm 0.01$ mag.

635 Vundtia. This main-belt object was worked in 2007 June and July. Analysis of the data set of 495 data points found $P = 11.816$ h. Behrend (2010) gives a period of 11.790 h.

893 Leopoldina. The author worked this asteroid in 2004 (Warner, 2005) and found a period of $P = 10.51$ h. Data obtained in 2008 found $P = 14.115$ h. While the lightcurve in 2008 had a lower amplitude, the quality of the fit was higher and so the longer period is considered more likely.

982 Franklina. Behrend (2010) reports a period of 3.6 h. The PDO data from 2004 favor a much longer period. The plot shows the two sessions on the same horizontal scale but with different zero points. The reduced magnitudes for the October 8 session are brighter than those from September 24 and show a slow incline over approximately 8 h.

2263 Shaanxi. The unusual shape of the lightcurve makes the solution of $P = 41.7$ h less than certain but no other solution provides nearly as good an RMS fit.

2352 Kurchatov. This was a one-night stand that showed a steady decline of >0.3 mag over 6 h.

2846 Ylppo. A steady increase of >0.25 mag over 4 hours favors a period of at least 16 h.

3368 Duncombe. Depending on minor zero point shifts, there are numerous possibilities, ranging from 30 to 300 hours. The plot presents one solution but is presented just to show the data and should not be taken to be any more likely than any other solution.

3747 Belinskij. The solution of $P = 3.31$ h could be just the Fourier analysis "latching onto noise" in this one-night stand.

(6361) 1978 VL11. The PDO data were contributed to the Binary Asteroid Survey by Pravec *et al.* (2010) who found $P = 9.1122$ h. Only the PDO data, which gave a period of 9.115 h, are shown in the plot.

(7870) 1987 UP2. Behrend (2010) gives a period of 12. h. The PDO data favor $P = 6.15$ h but a solution of $P = 12.30$ h cannot be ruled out.

(10772) 1990 YM. Pravec *et al*. (2010) give $P = 68.7$ h and suggest that the asteroid might be in non-principal axis rotation (tumbling). The PDO data give a solution of $P = 65$ h but are insufficient to determine if the asteroid is tumbling.

(14668) 1999 CB67. This inner main-belt asteroid was worked one night in 2001. The low amplitude and high noise make for a tentative solution at best.

(126074) 2001 YE85. This outer main-belt asteroid was worked one night. The high noise in the data made for a weak solution of $P = 2.4 \pm 0.1$ h.

2004 GD2. Hergenrother *et al*. (2005) reported a period of 0.235 h but did not publish a lightcurve. Behrend (2010) reported a period of 0.23717 h. The PDO data obtained over two nights yield a solution of $P = 0.23538$ h (14.12 min). This is the fastest rotator worked at PDO to date.

Acknowledgements

Funding for observations at the Palmer Divide Observatory is currently provided by NASA grant NNX10AL35G, by National Science Foundation grant AST-1032896, and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society.

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Hergenrother, C.W. and Whiteley, R.J. (2005). "The Rotation State of Small Rapidly Rotating Asteroids." *Bul. Amer. Astron. Soc.* **37**, 636-637.

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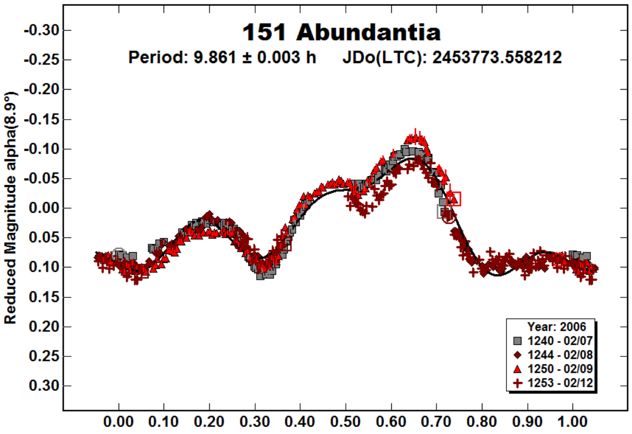
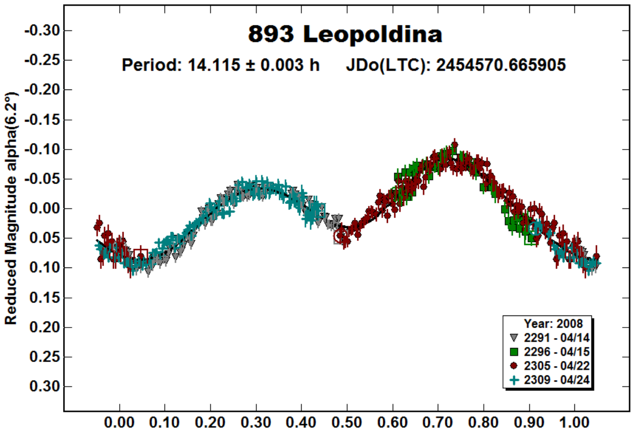
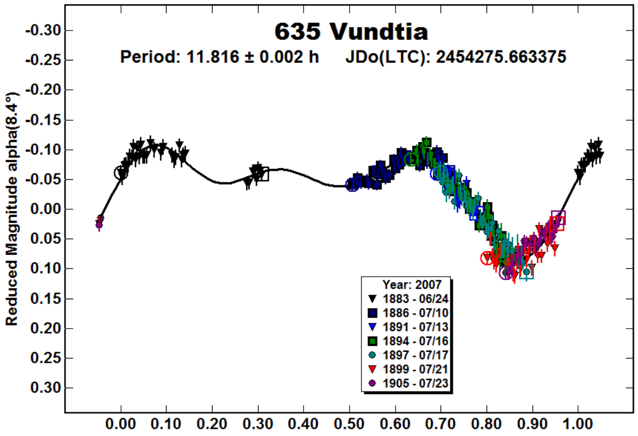
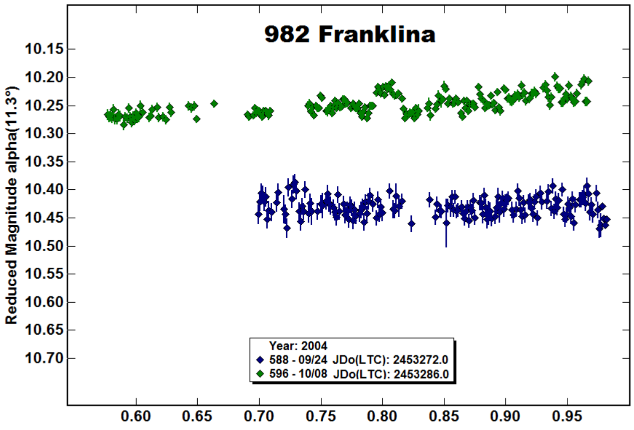
#	Name	mm/dd/yy	Data Pts	α	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
151	Abundantia	02/07-02/12/2006	483	8.8,10.7	121	8	9.861	0.003	0.20	0.01
635	Vundtia	06/24-07/23/2007	495	8.3,14.6	251	12	11.816	0.002	0.17	0.01
893	Leopoldina	04/14-04/24/2008	893	6.1,8.2	193	16	14.115	0.003	0.18	0.02
982	Franklina	09/24-10/08/2004	370	11.3,7.8	25	17	>16.		>0.05	
2263	Shaanxi	01/31-02/04/2006	216	5.2,5.9	125	13	41.7	0.1	0.36	0.03
2352	Kurchatov	09/05/2007	180	9.7	328	18	>12.		>0.3	
2846	Ylppo	05/02/2006	29	16.6	170	7	>12.		>0.25	
3368	Duncombe	10/18-12/01/2004	552	3.6,14.0	27	11	?		0.10	0.03
3747	Belinskij	03/04/2006	44	13.0	144	28	3.31	0.07	0.02	0.01
6361	1978 VL11	02/28-03/03/2006	155	5.5,4.9	164	8	9.116	0.003	0.67	0.03
7870	1987 UP2	09/20-09/22/2007	123	16.6,17.7	335	5	6.15	0.02	0.07	0.01
10772	1990 YM	04/02-04/04/2006	236	22.2	189	35	65.	5.	1.05	0.05
14668	1999 CB67	11/10/2001	71	18.3	17	12	2.89	0.04	0.06	0.01
22357	1992 YJ	08/21-08/28/2004	685	22.6,23.4	332	31	103.	5.	0.54	0.03
126074	2001 YE85	11/04/2005	28	2.6	46	-4	2.4	0.1	0.17	0.03
	2004 GD2	04/13-04/14/2004	118	40.4,33.8	190	14	0.23538	0.00003	0.88	0.03

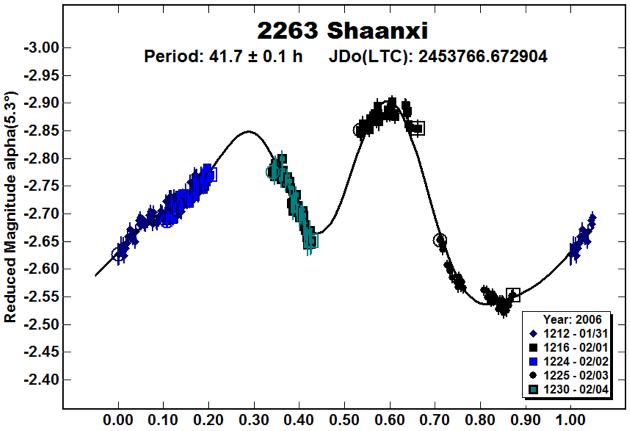
Table I. Observing circumstances. The phase angle (α) is given at the start and end of each date range, unless it reached a minimum, which is then the second of three values. If a single value is given, the phase angle did not change significantly and the average value is given. L_{PAB} and B_{PAB} are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










2263 Shaanxi
Period: 41.7 ± 0.1 h JDo(LTC): 2453766.672904
Reduced Magnitude alpha(5.3°)
Year: 2006
◆ 1212 - 01/31
■ 1216 - 02/01
■ 1224 - 02/02
● 1225 - 02/03
■ 1230 - 02/04
-3.00 -2.95 -2.90 -2.85 -2.80 -2.75 -2.70 -2.65 -2.60 -2.55 -2.50 -2.45 -2.40
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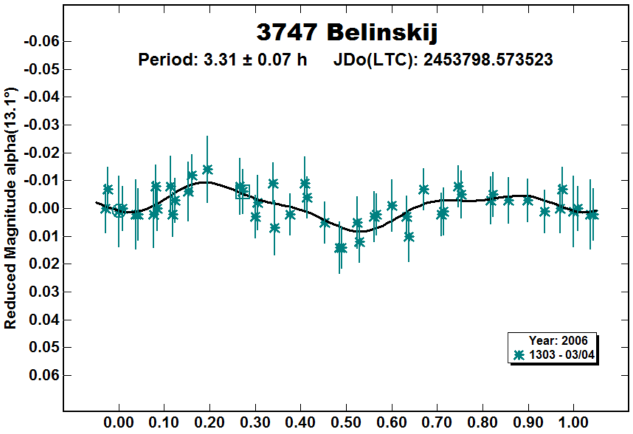
3747 Belinskij
Period: 3.31 ± 0.07 h JDo(LTC): 2453798.573523
Reduced Magnitude alpha(13.1°)
Year: 2006
✱ 1303 - 03/04
-0.06 -0.05 -0.04 -0.03 -0.02 -0.01 0.00 0.01 0.02 0.03 0.04 0.05 0.06
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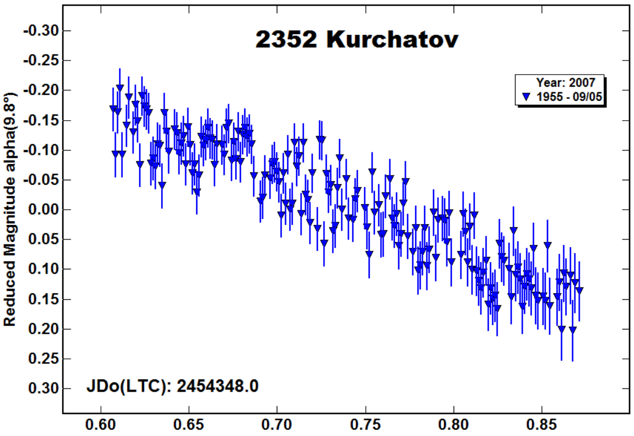
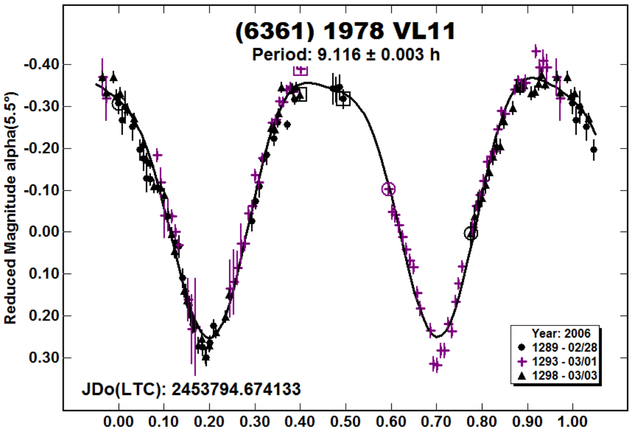

2352 Kurchatov
Reduced Magnitude alpha(9.8°)
Year: 2007
▼ 1955 - 09/05
JDo(LTC): 2454348.0
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
0.60 0.65 0.70 0.75 0.80 0.85


(6361) 1978 VL11
Period: 9.116 ± 0.003 h
Reduced Magnitude alpha(5.5°)
Year: 2006
● 1289 - 02/28
+ 1293 - 03/01
▲ 1298 - 03/03
JDo(LTC): 2453794.674133
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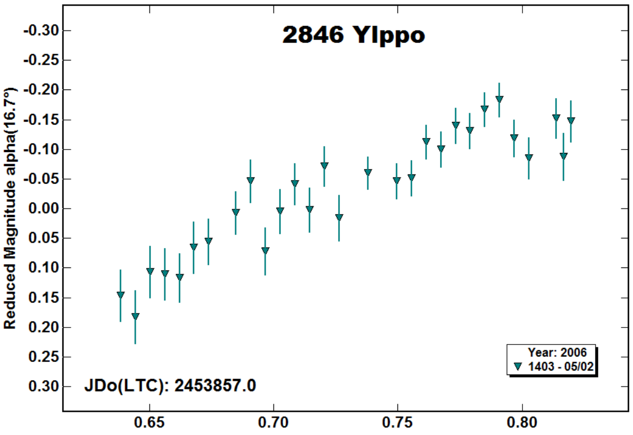
2846 Ylppo
Reduced Magnitude alpha(16.7°)
Year: 2006
▼ 1403 - 05/02
JDo(LTC): 2453857.0
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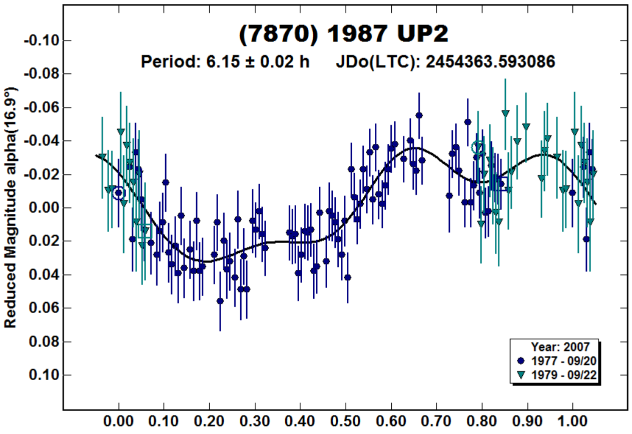
0.65 0.70 0.75 0.80


(7870) 1987 UP2
Period: 6.15 ± 0.02 h JDo(LTC): 2454363.593086
Reduced Magnitude alpha(16.9°)
Year: 2007
● 1977 - 09/20
▼ 1979 - 09/22
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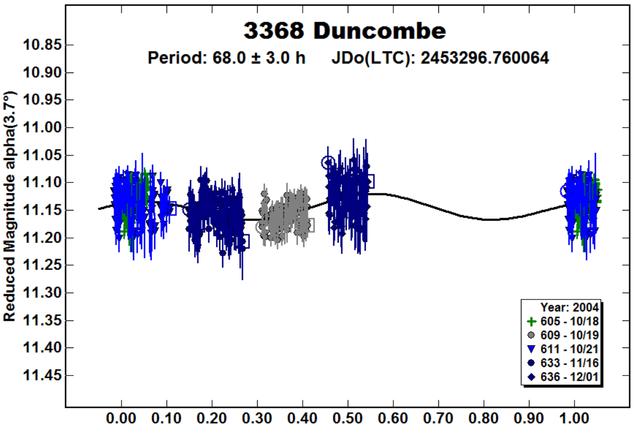
3368 Duncombe
Period: 68.0 ± 3.0 h JDo(LTC): 2453296.760064
Reduced Magnitude alpha(3.7°)
Year: 2004
+ 605 - 10/18
● 609 - 10/19
▼ 611 - 10/21
● 633 - 11/16
◆ 636 - 12/01
10.85 10.90 10.95 11.00 11.05 11.10 11.15 11.20 11.25 11.30 11.35 11.40 11.45
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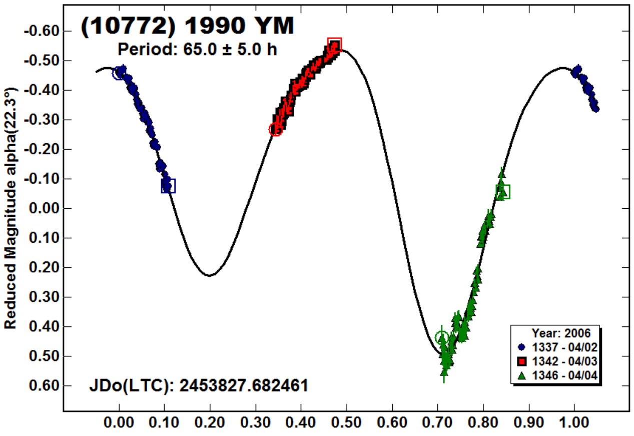
(10772) 1990 YM
Period: 65.0 ± 5.0 h
Reduced Magnitude alpha(22.3°)
Year: 2006
● 1337 - 04/02
■ 1342 - 04/03
▲ 1346 - 04/04
JDo(LTC): 2453827.682461
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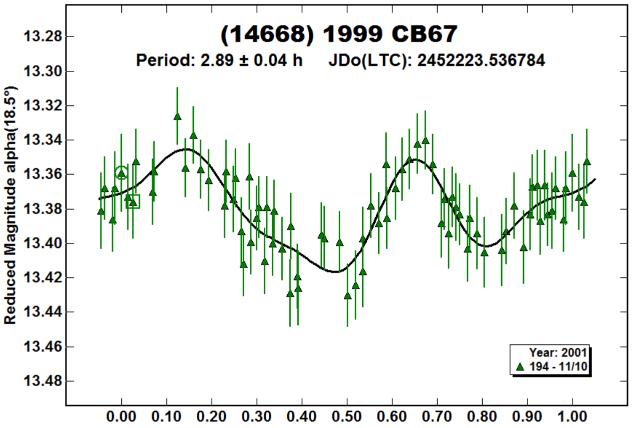
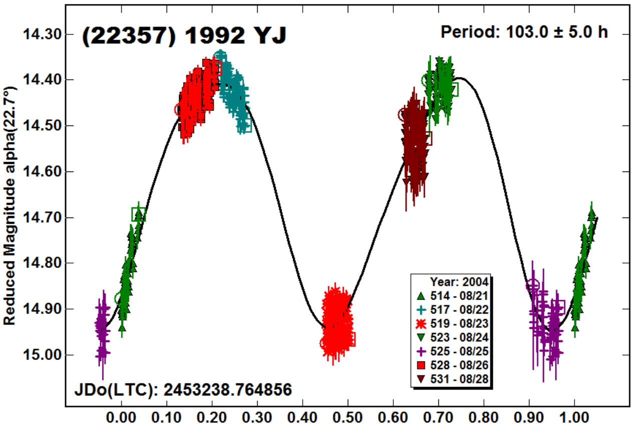
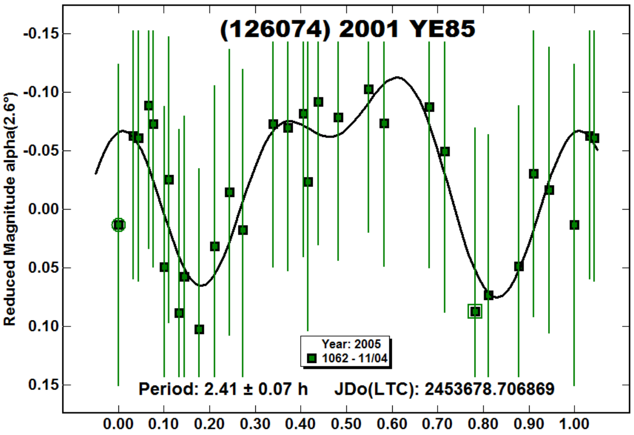
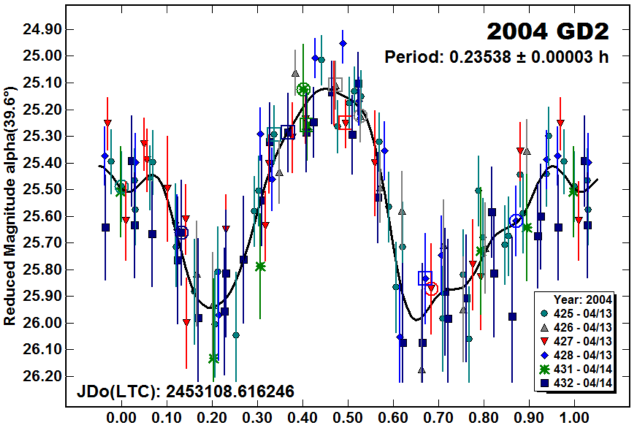
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00









LIGHTCURVE PHOTOMETRY RESULTS FROM BIGMUSKIE OBSERVATORY: LATE 2010

Andrea Ferrero
Bigmuskie Observatory (B88)
via Italo Aresca 12, 14047 Mombercelli–Asti (Italy)
bigmuskie@alice.it

(Received: 9 January Revised: 18 February)

CCD photometric observations were made of four asteroids in 2010 September-December at the Bigmuskie Observatory, Italy, to determine rotation periods and lightcurve amplitudes. The results were: 1448 Lindbladia, P = 10.969 ± 0.002 h, A = 0.22 ± 0.02 mag; 5288 Nankichi, P = 12.763 ± 0.003 h, A = 0.19 ± 0.02 mag; 10217 Richardcook, P = 23.33 ± 0.01 h, A = 0.45 ± 0.02 mag; (14657) 1998 YU27, P= 33.58 ± 0.02 h, A=0.30 ± 0.02 mag.

CCD photometric observations of four asteroids were carried out at the Bigmuskie Observatory from 2010 September to December. The asteroids were chosen from the CALL website (*http://www.MinorPlanet.info*). They were 1448 Lindbladia, 5388 Nankichi, 10217 Richardcook, and (14657) 1998 YU27. Of these, only 5288 Nankichi had previously known lightcurve parameters. Long intervals of poor weather permitted only scattered observing sessions, many often cut short as conditions deteriorated as the night progressed. This made analysis of the lightcurves difficult because of gaps in coverage. The situation was particularly difficult for (14657) 1998 YU27. For that asteroid, the derived period seems to be affected by some bad linkage between sessions.

All the asteroids were observed with a 0.3-m f/8 Marcon Ritchey-Chretien coupled to an FLI Max Cam CM-9 CCD camera that was water-cooled to -20°C. The standard exposures were 180 sec with no filter and unguided. *Maxim DL* was used to control the camera and *MPO Canopus* was used to calibrate and measure the images. For every session, 3 to 5 comparison stars were used for differential photometry to produce the lightcurve. The Comp Star Selector (CSS) in *MPO Canopus* was used to choose solar-colored stars, which closely matched the color of the asteroids. This made it possible to match the individual sessions with adjustments on the order ± 0.05 mag, often less.

<u>1448 Lindbladia.</u> Analysis of data obtained in 6 sessions from 2010 December 10-26 found a synodic period of 10.969 ± 0.002 h with an estimated amplitude of 0.22 ± 0.02 mag. This was a “second target” in the sense that it was worked in the latter part of the night, when the primary target was too close to the western horizon. Because of foggy conditions, the data were noisy. The analysis was helped by binning the data point to average out the noise. The plot shows the binned data.

<u>5288 Nankichi.</u> Behrend (2011) reports a period of 13.78 h with an amplitude of 0.19 mag. However, the linked data from 5 sessions from 2010 December 12 to 2011 January 5 reveals a period of 12.763 ± 0.003 h. The zero point for the last session had to be adjusted by 0.2 mag, probably because the asteroid was in a very sparse field that night and the available comparisons were not well-matched to the asteroid’s color.

<u>10217 Richardcook.</u> This asteroid was observed on 8 nights from 2010 October 7 to December 12. The analysis found a period of 23.33 ± 0.01 h. It was necessary to increase the exposure from 180

to 300 seconds for the last session (141) in order to reach a minimum SNR. After that, the asteroid was too faint to follow any further and so the data don’t cover the full lightcurve.

<u>(14657) 1998 YU27</u>. No secure period could be found for this asteroid. The only reliable solution is the 33.58 ± 0.02 h period, even if the DeltaComp values for sessions 72, 73, 78-80, were changed, with the largest shifting in the range of 0.15 mag in session 72 . This seems to be the nearest one to the right period, but this is still not a perfect solution with data not fitting the curve as much as liked. This is a case where more data are required.

Acknowledgment

Thanks to Brian Warner for the assistance to interpret the results on (14657) 1998 YU27

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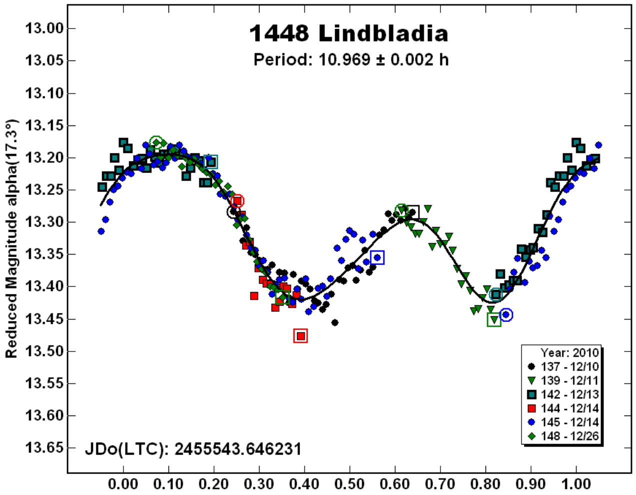

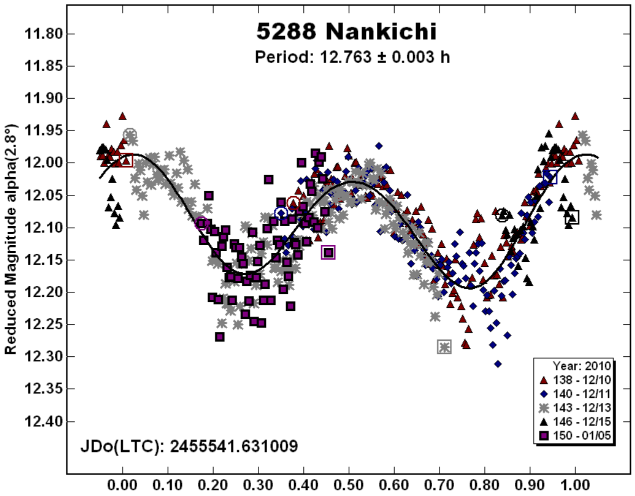

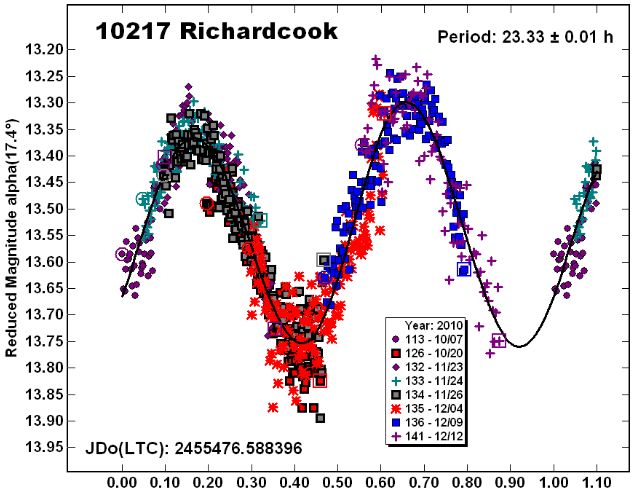

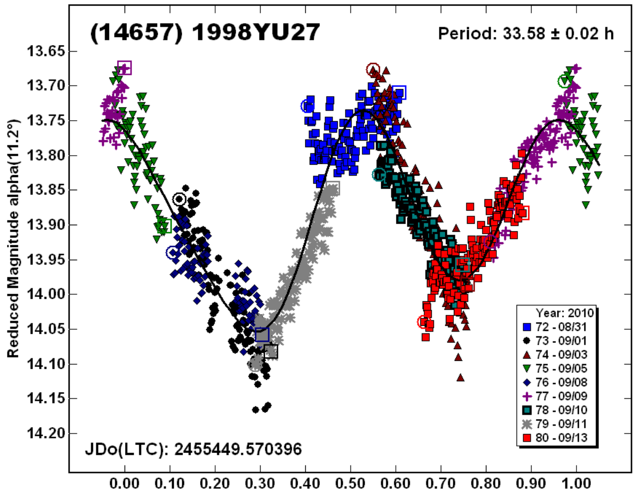

THE LIGHTCURVE OF ASTEROID 2715 MIELIKKI

Andrea Ferrero
Bigmuskie Observatory
via Italo Aresca 12, 14047 Mombercelli-Asti, ITALY
bigmuskie@alice.it

Russell I. Durkee
Shed of Science Observatory
5213 Washburn Ave S. Minneapolis, MN 55410 USA

(Received: 9 January)

CCD photometric observations of asteroid 2715 Mielikki over 13 nights in 2010 September-October were used to determine a synodic rotation period of 33.62 ± 0.01 h and lightcurve amplitude of 0.5 mag.

2715 Mielikki is a main-belt object with a diameter of approximately 13 km. Starting from 2010 late September until the end of October, the asteroid was observed at the Bigmuskie and Shed of Science Observatories. The target was chosen by Ferrero from the “Potential Lightcurve Targets of July September 2010” on the CALL website (Warner, 2011) because no previous period was reported and it reached a favorable position to be studied during September – October.

After observing seven nights at the Bigmuskie Observatory, a preliminary period of about 36 h (1.5 d) started to emerge. Because of the long period, it was difficult to record the whole lightcurve from one location, e.g., all the sessions showed similar ascending or descending parts of the period. This led a collaboration with Durkee with the hope that he could record some maxima and/or minima. After three nights, 2010 October 14-16, Durkee captured a maximum and minimum in the lightcurve. These, along with the previous and two additional sessions obtained at the Bigmuskie Observatory, resulted in the final lightcurve with a period of 33.62 ± 0.01 h. Poor weather conditions prevented capturing the second ascending part of the curve but, even so, the total curve is well determined .

Ferrero worked with a 0.3-m f/8 Ritchey-Chretien with an unfiltered FLI Max Cam CM9 CCD at -20°. Durkee used a 0.36-m f/8.6 Schmidt-Cassegrain with an SBIG ST10XE CCD binned 2x2 and a Celestron UHC filter. All images were unguided. Both observatories used *MPO Canopus* to measure the images.

Acknowledgements

Partial funding for work at the Shed of Science is provided by a 2009 Gene Shoemaker NEO Grant from the Planetary Society.

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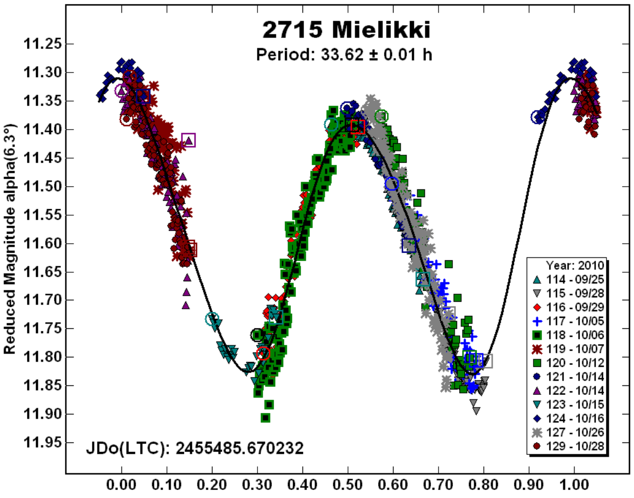

ROTATION PERIOD OF THE "ASTEROID PAIR" (25884) 2000 SQ4

David Polishook
The Wise Observatory and
The Benoziyo Center for Astrophysics
Weizmann Institute of Science, Rehovot 76100 ISRAEL
david@wise.tau.ac.il

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An asteroid pair is the result of a rubble pile asteroid that disintegrated into two components due to rotational fission. The lightcurve and period analysis of the primary component (25884) 2000 SQ4 of such an asteroid pair, taken by the 1-m telescope of the Wise Observatory, is reported here.

The newly discovered category of *asteroid pairs* consists of two objects that may be millions of kilometers apart but circle the Sun on the same orbit. Vokrouhlický and Nesvorný (2008) integrated the orbits of each pair and found possible contacts within the last 1 Myr, where a few objects appear to have separated only a few Kyr ago. Pravec and Vokrouhlický (2009) developed and continued the search for asteroid pairs and found 84 pairs in different levels of certainty. Pravec *et al.* (2010) showed that the rotation periods of the primaries are correlated with the mass ratio between the primary and the secondary of each pair in a way that matches the rotational fission mechanism: following the spin-up of an asteroid by the YORP effect, the body gains sufficient angular momentum to cross the “rubble pile spin barrier” and the asteroid disrupts into two components. The measurements showed that there is a limit on the secondary mass fraction at ~20% of the primary, as predicted previously by theoretical models (Scheeres 2007). Larger secondaries do not have sufficient energy to leave the primary; thus they remain in its vicinity, forming a binary asteroid.

The asteroid (25884) 2000 SQ_4, which is the primary component of (48527) 1993 LC_1, was observed photometrically to derive its lightcurve and rotation period. These two asteroids belong to the Hungaria group (Milani *et al.* 2010) with a = 1.954 AU, e = 0.08, and i = 21.6 degrees. Observations were performed using the 1-m Ritchey-Chrétien telescope of the Wise Observatory (MPC 097) during 2010 March-April. The telescope is equipped with a cryogenically-cooled Princeton Instruments (PI) CCD. At the f/7 focus of the telescope, this CCD covers a field of view of 13'x13' with 1340x1300 pixels (0.58" per pixel, unbinned). Observations were performed in “white light” with no filters (Clear). Exposure times were 180s, all with auto-guider. The asteroid was observed while crossing a single field per night, thus the same comparison stars were used while calibrating the images.

The observational circumstances are summarized in Table I, which lists the observation date, the time span of the observation during that night, the number of images obtained, the object's heliocentric

Asteroid	Date	Time span [hours]	N	r [AU]	Δ [AU]	α [Deg]	L_{PAB} [Deg]	B_{PAB} [Deg]
(25884) 2000 SQ_4	Mar 20, 2010	1.54	27	2.07	1.14	13.5	174.5	19.5
	Mar 21, 2010	3.51	62	2.07	1.14	13.59	174.5	19.4
	Apr 9, 2010	7.83	120	2.05	1.18	18.29	176.6	16.9
	Apr 10, 2010	5.24	92	2.05	1.19	18.6	176.7	16.8

Table I. Observing circumstances. See the text for an explanation of the columns.

distance (r), geocentric distance (Δ), phase angle (α), and the Phase Angle Bisector (PAB) ecliptic coordinates (L_{PAB} and B_{PAB}).

The images were reduced in a standard way. The IRAF *phot* function was used for the photometric measurements. After measuring, the photometric values were calibrated to a differential magnitude level using an average of 15 local comparison stars per field. The brightness of these stars remained constant to ± 0.02 mag. The asteroid was identified in the MPC web database. Analysis for the lightcurve period and amplitude was done by Fourier series analysis (Harris and Lupishko, 1989). See Polishook and Brosch (2009) for complete description about reduction, measurements, calibration and analysis.

The folded lightcurve is presented at Fig. 1. The derived rotation period of (25884) 2000 SQ_4 is 4.9169 ± 0.0003 h and its amplitude is 0.55 ± 0.05 mag. The absolute magnitude difference between (25884) 2000 SQ_4 and (48527) 1993 LC_1 is $\Delta H = 1.40 \pm 0.3$ mag (Pravec and Vokrouhlický, 2009), which fits a mass ratio of 0.14, assuming similar albedo and density values. It is interesting to note that these values fit, within the error range, the correlation presented by Pravec *et al.* (2010) between the rotation period of the primary to the mass ratio of the two components, as can be seen on Fig. 2. Therefore, we can conclude that the progenitor of (25884) 2000 SQ_4 and (48527) 1993 LC_1 was probably disintegrated by the rotational fission mechanism in the last 1 Myr.

Acknowledgement

The author is grateful to the Wise Observatory staff for their continuous support.

Reference

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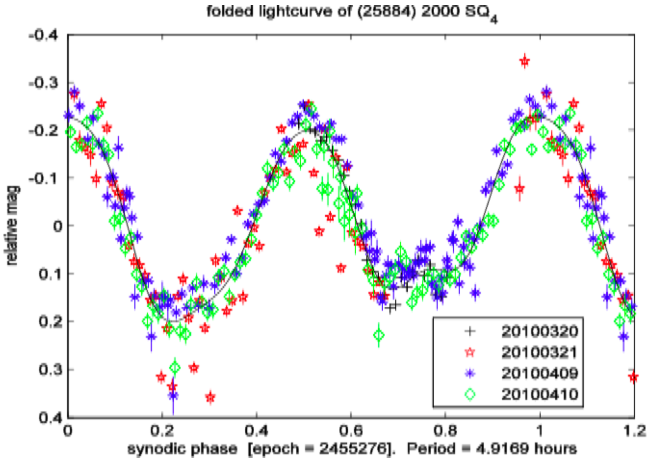

Fig. 1: The lightcurve of (25884) *2000 SQ_4* folded by a period of 4.9169 hours.

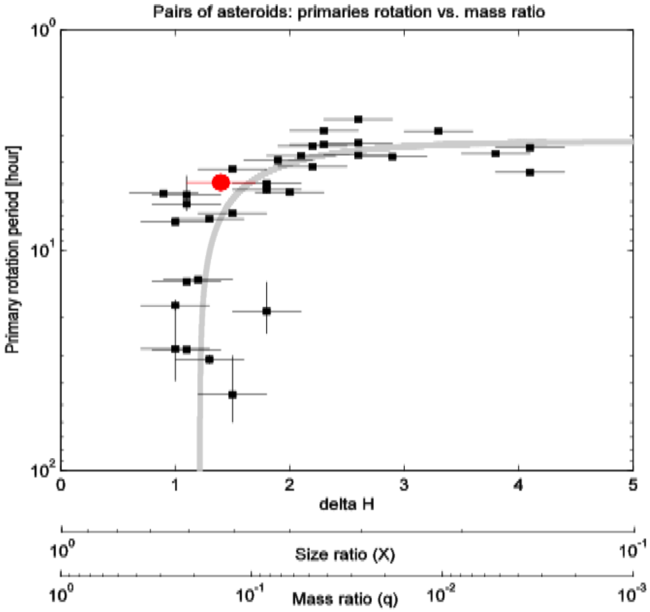

Fig. 2: Correlation between the rotation period of the primary to the size/mass ratio between the two components of each pair. The data and the model were published by Pravec et al. 2010. (25884) *2000 SQ_4* is marked with a red circle.

ERRATUM

*Pilcher, F. (2011). "Minor Planets at Unusally Favorable Elongations in 2011." MPB **38**, 16-18.*

In both Table I and Table II, for asteroid "99915" read instead "99913". All tabulated information applies to asteroid 99913. In Warner et al. (2011; *MPB **38**, 65-69*), the referenced information to asteroid (99913) 1997 CZ5 is fully correct. We thank G. Roger Harvey for finding this typographical mistake.

UPON FURTHER REVIEW: VI. AN EXAMINATION OF PREVIOUS LIGHTCURVE ANALYSIS FROM THE PALMER DIVIDE OBSERVATORY

Brian D. Warner
Palmer Divide Observatory/Space Science Institute
17995 Bakers Farm Rd., Colorado Springs, CO 80908 USA
brian@MinorPlanetObserver.com

(Received: 10 January)

Updated results of lightcurve analysis are given for 31 asteroids previously reported from the Palmer Divide Observatory (PDO). The original images were remeasured to obtain new data sets using the latest version of MPO Canopus photometry software, analysis tools, and revised techniques for linking observing runs that ranged from several days to several weeks. Moderately to significantly different results were found for: 301 Bavaria, 436 Patricia, 507 Laodica, 549 Jessonda, 585 Bilkis, 596 Scheila, 607 Jenny, 630 Euphemia, 875 Nymphe, 912 Maritima, 926 Imhilde, 1177 Gonnessia, 1203 Nanna, 1333 Cevenola, 1679 Nevanlinna, 1796 Riga, 2000 Herschel, 2266 Tchaikovsky, 2460 Mitlincoln, 2494 Inge, 3915 Fukushima, 3940 Larion, 4091 Lowe, 4209 Briggs, 4431 Holeungholee, 4690 Strasbourg, 5390 Huichiming, 5940 Feliksobolev, (16558) 1991 VQ2, (18108) 2000 NT5, and (45646) 2000 EE45. This is expected to be the final paper in a current series that has examined results obtained during the initial years of the asteroid lightcurve program at PDO.

The availability of improved analysis tools and techniques along with the experience gained over more than a decade of asteroid lightcurve photometry lead to a program to re-examine the early work and results at the Palmer Divide Observatory (ca 1999-2006) and to recheck as needed the results obtained from 2006 to present. In most cases, any changes in the period and/or amplitude as a result of the new analysis were statistically insignificant. Some, however, were worth noting. This is expected to be the final paper in a current series that gives updated results from that review process that used approximately 4100 individual lightcurves obtained from 1999 to 2010 to generate more than 750 composite lightcurves for 700 unique asteroids.

For background on the justification and methodology of this project, see the first paper in the series (Warner, 2010).

Presentation of the New Analysis

A brief analysis of the new data set, as needed, and the revised lightcurve are given below. Even if there is no significant difference in the period, the "improvement" may be a revised amplitude or "simply better data" to be used for modeling in the future (e.g., the U code may have a higher rating; see Warner *et al.*, 2009, for information about the U code rating system). The exact observing details are not given. Instead, the table lists the original and new results along with a reference to the original paper. The original reference gives data on the equipment used and references to results from other authors and so they will not be repeated here.

The plots that have non-differential values for the vertical axis (magnitude) show the Cousins R reduced magnitude of the asteroid This means that the data for each night were corrected to "unity distance" using –5*log(rR) where r was the Earth-asteroid distance and R was the Sun-asteroid distance, both in AU. Unless otherwise stated, the data were also corrected to the phase angle of the earliest session (the "alpha" value in the vertical axis title) using $G = 0.15$.

596 Scheila. In late 2010, this main-belt asteroid was found to have developed a coma, due either to cometary activity or a recent impact with another, small body (Larson, 2010; Warner and Harris, 2010). The 2005 images were re-measured so that the data could be put onto a standard system (Cousins R). This resulted in a slight change in the period but, more important, allowed finding the H (absolute magnitude) and G (phase slope parameter) values for the asteroid. Assuming a value of V-R = 0.45, the derived value $H_R = 8.39 \pm 0.05$ gives $H = 8.84$, which compares favorably to the MPC-adopted value of $H = 8.90$ for $G = 0.15$. The observations found $G = 0.08 \pm 0.06$. This is compatible for a low albedo object, which is expected for the asteroid.

1177 Gonnessia. The raw plot of the five sessions suggests a period > 200 h. However, a period search found somewhat reasonable solutions at 42 and 82 h. The slopes of the individual sessions fit the longer period curve better.

2000 Herschel. The revised data show indications that this asteroid is a tumbler (in non-principal axis rotation (NPAR); see Pravec *et al.*, 2005, for a thorough discussion on tumbling asteroids).

2460 Mitlincoln. Instead of finding a definitive solution, the revised data lead to multiple possibilities due to the low amplitude. Periods of 2.399 , 2.667 h, and 4.802 h are all possible.

4690 Strasbourg. Analysis by Petr Pravec, Astronomical Institute, Czech Republic, of the revised data for this asteroid show that it is a tumbler. He found $P_1 = 69.50$ and $P_2 = 52.05$ h. It is not certain which of the two is the rotation period and which is the precession period. Furthermore, it's possible that the true periods are linear combinations of the frequencies, i.e., $X/P_1 + Y/P_2$.

(45646) 2000 EE45. Periods of 5.08 h and 5.47 h cannot be formally excluded. However, a search for the half-period (monomodal lightcurve) favors $P = 5.26$ h, the one adopted here.

Acknowledgements

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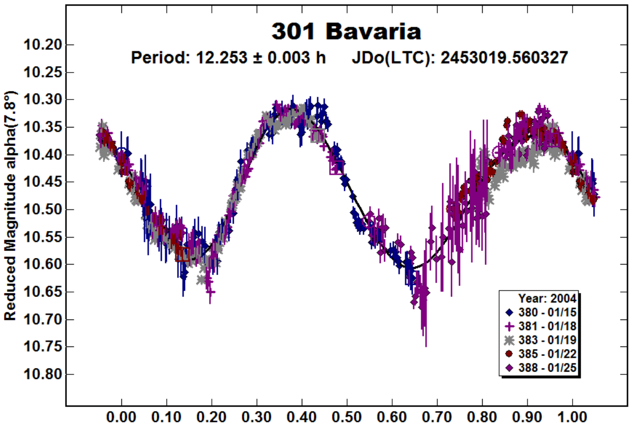
		Original				Revised				
#	Name	Per	Amp	U	Ref	Per	PE	Amp	AE	U
301	Bavaria	12.24	0.25	3	Warner; MPB 31, 67-70	12.253	0.003	0.28	0.01	3
436	Patricia	16.133	0.22	3	Warner; MPB 30, 21-24	16.10	0.01	0.28	0.01	3
507	Laodica	4.705	0.22	3	Robinson; MPB 29, 13	6.737	0.001	0.29	0.02	2
549	Jessonda	5.938	0.10	2	Warner; MPB 33, 58-62	2.971	0.001	0.10	0.01	2
585	Bilkis	6.442	0.38	2	Robinson; MPB 29, 6-7	8.5742	0.0005	0.40	0.02	2+
596	Schelia	15.848	0.09	2	Warner; MPB 33, 58-62	15.877	0.005	0.06	0.01	2
607	Jenny	7.344	0.22	2	Warner; MPB 30, 33-35	8.526	0.002	0.26	0.01	3-
630	Euphemia	79.18	0.20	2	Warner; MPB 32, 90-92	350.	50.	0.45	0.05	2
875	Nymphe	12.64	0.42	2	Warner; MPB 31, 19-22	12.618	0.003	0.33	0.02	3-
912	Maritima	48.43	0.15	2	Warner; MPB 33, 39-41	20.83	0.03	0.10	0.01	2-
926	Imhilde	26.1	>0.2	2	Warner; MPB 31, 19-22	26.8	0.5	0.27	0.02	2
1177	Gonnessia	6.81	0.11	1	Warner; MPB 30, 33-35	82.	5.	0.25	0.10	2-
1203	Nanna	25.80	0.15	2A	Warner; MPB 37, 24-27	18.54	0.01	0.12	0.02	2
1333	Cevenola	4.88	0.97	3	Warner; MPB 29, 74-75	4.877	0.001	1.08	0.02	3
1679	Nevanlinna	17.94	0.16	2	Warner; MPB 31, 19-22	17.92	0.02	0.16	0.02	3-
1796	Riga	11.0	0.10	2-	Warner; MPB 31, 19-22	10.608	0.002	0.14	0.01	2
2000	Herschel	64.	0.40	2	Warner; MPB 36, 109-116	130.	3.	1.16	0.05	2
2266	Tchaikovsky	4.883	0.04	2	Warner; MPB 33, 39-41	37.7	0.2	0.09	0.01	2
2460	Mitlincoln	2.770	0.03	2	Warner; MPB 29, 74-75	2.667[1]	0.002	0.04	0.01	2
2494	Inge	6.76	0.92	3	Warner; MPB 32, 29-32	6.79	0.01	0.90	0.03	3
3915	Fukushima	8.40	0.64	2	Warner; MPB 31-19-22	9.418	0.001	0.67	0.02	3
3940	Larion	4.04	0.04	2	Warner; MPB 34, 104-107	32.4	0.1	0.08	0.01	1+
4091	Lowe	12.570	0.10	2-	Warner; MPB 33, 85-88	16.59	0.01	0.11	0.01	2
4209	Briggs	12.235	0.44	2	Warner; MPB 31, 19-22	12.22	0.02	0.45	0.02	3-
4431	Holeungholee	8.17	0.52	2	Warner; MPB 32, 29-32	9.81	0.01	0.52	0.02	2+
4690	Strasbourg	109.0	0.80	2	Warner; MPB 34, 32-37	69.20[2]	0.05	0.75	0.02	2
5390	Huichiming	33.6	0.25	2	Warner; MPB 34, 104-107	110.	20.	0.75	0.10	2
5940	Feliksobolev	6.578	0.23	2	Warner; MPB 30, 21-24	7.620	0.002	0.30	0.02	3-
16558	1991 VQ2	37.37	0.22	1	Warner; MPB 30, 21-24	170.	25.	1.0	0.1	2-
18108	2000 NT5	2.920	0.15	2	Warner; MPB 32, 4-7	2.910	0.002	0.15	0.01	3-
45646	2000 EE45	6.4	0.35	1	Warner; MPB 30, 21-24	5.26[3]	0.05	0.60	0.03	2-

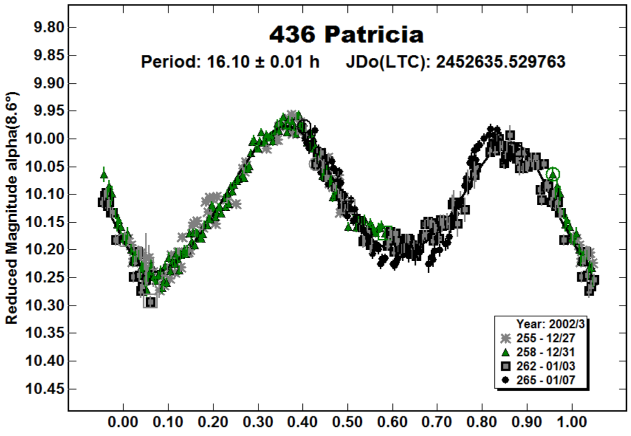
Table I. Summary of original and revised results. The period is in hour and the amplitude is in magnitudes. The U code rating is based on the criteria outlined in the Lightcurve Database (Warner *et al.*, 2009). Unless otherwise stated, the references are from the *Minor Planet Bulletin* for the original results, with only the volume and page numbers given.

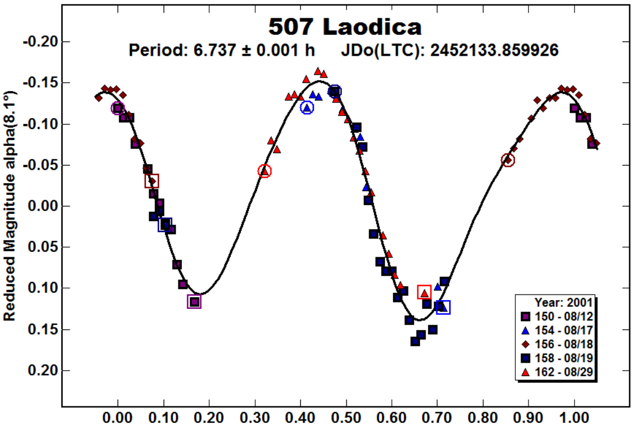
[1] Ambiguous; 2.399 and 4.802 h are also possible.

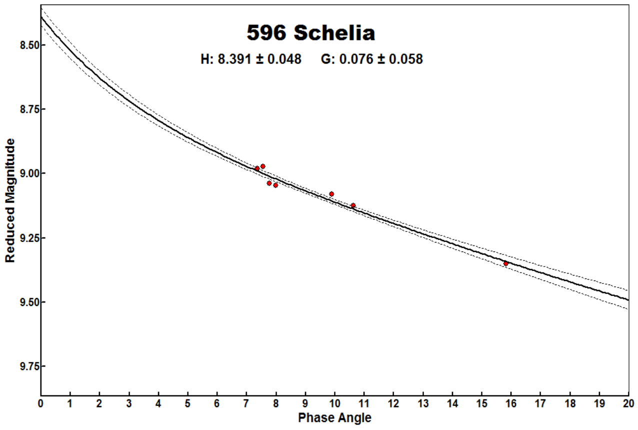
[2] Tumbling; second period $P = 52.05$ h.

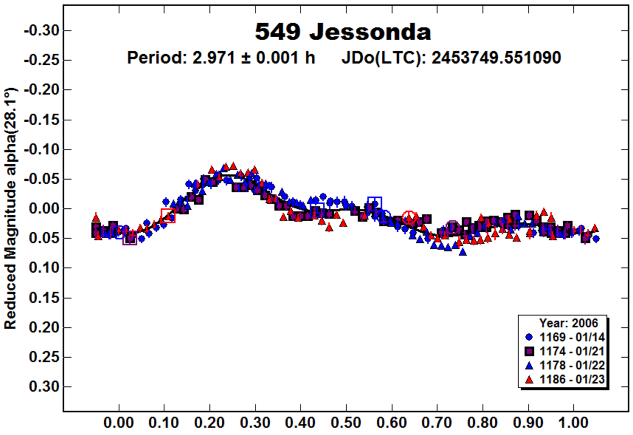
[3] Periods of 5.08 and 5.47 h cannot be formally excluded.






507 Laodica
Period: 6.737 ± 0.001 h JDo(LTC): 2452133.859926
Reduced Magnitude alpha(8.1°)
Year: 2001
150 - 08/12
154 - 08/17
156 - 08/18
158 - 08/19
162 - 08/29


596 Schelia
H: 8.391 ± 0.048 G: 0.076 ± 0.058
Reduced Magnitude
Phase Angle


549 Jessonda
Period: 2.971 ± 0.001 h JDo(LTC): 2453749.551090
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Year: 2006
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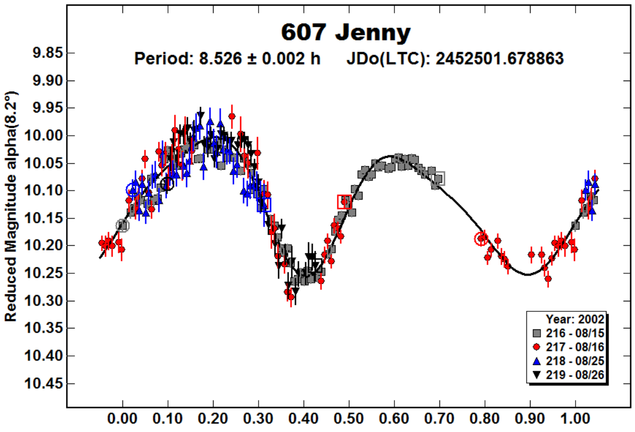
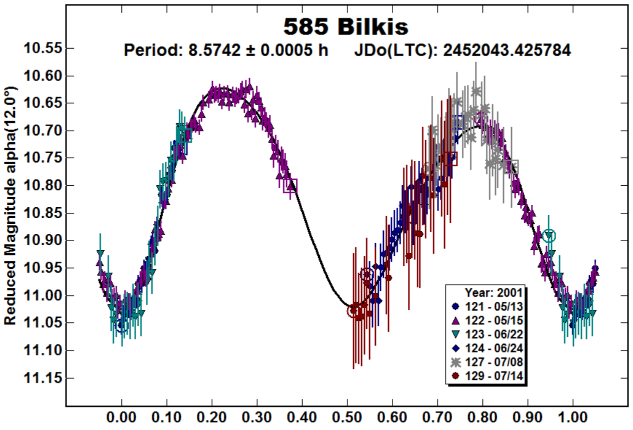
1174 - 01/21
1178 - 01/22
1186 - 01/23


607 Jenny
Period: 8.526 ± 0.002 h JDo(LTC): 2452501.678863
Reduced Magnitude alpha(8.2°)
Year: 2002
216 - 08/15
217 - 08/16
218 - 08/25
219 - 08/26


585 Bilkis
Period: 8.5742 ± 0.0005 h JDo(LTC): 2452043.425784
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Year: 2001
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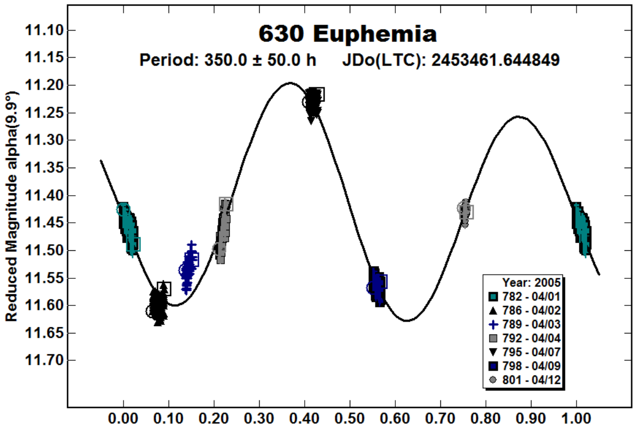
124 - 06/24
127 - 07/08
129 - 07/14


630 Euphemia
Period: 350.0 ± 50.0 h JDo(LTC): 2453461.644849
Reduced Magnitude alpha(9.9°)
Year: 2005
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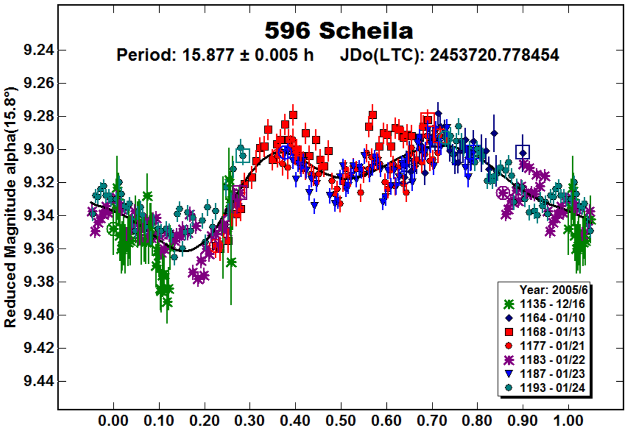
786 - 04/02
789 - 04/03
792 - 04/04
795 - 04/07
798 - 04/09
801 - 04/12


596 Scheila
Period: 15.877 ± 0.005 h JDo(LTC): 2453720.778454
Reduced Magnitude alpha(15.8°)
Year: 2005/6
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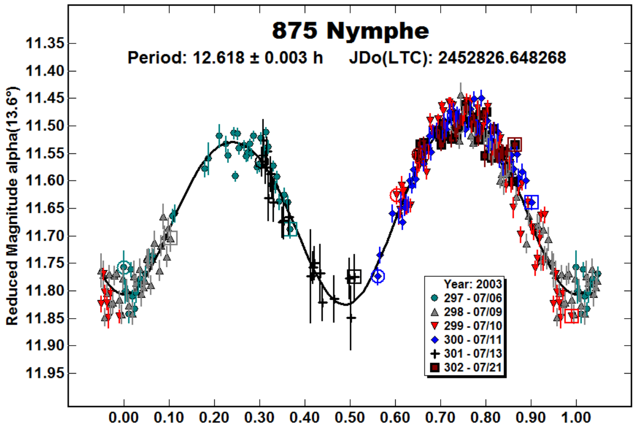
1164 - 01/10
1168 - 01/13
1177 - 01/21
1183 - 01/22
1187 - 01/23
1193 - 01/24


875 Nymphe
Period: 12.618 ± 0.003 h JDo(LTC): 2452826.648268
Reduced Magnitude alpha(13.6°)
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298 - 07/09
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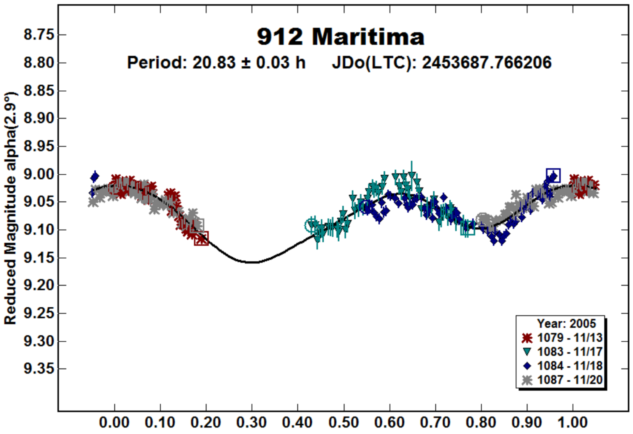
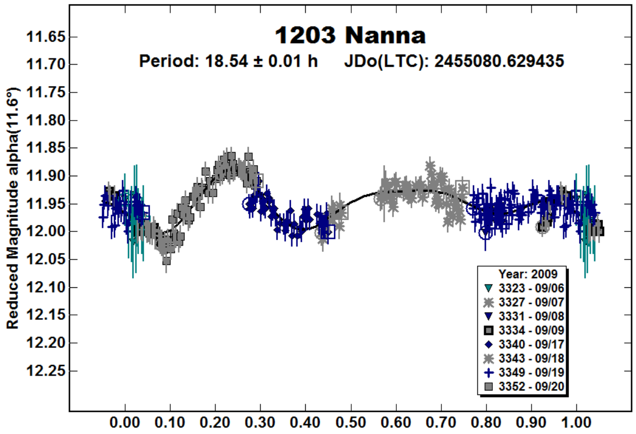
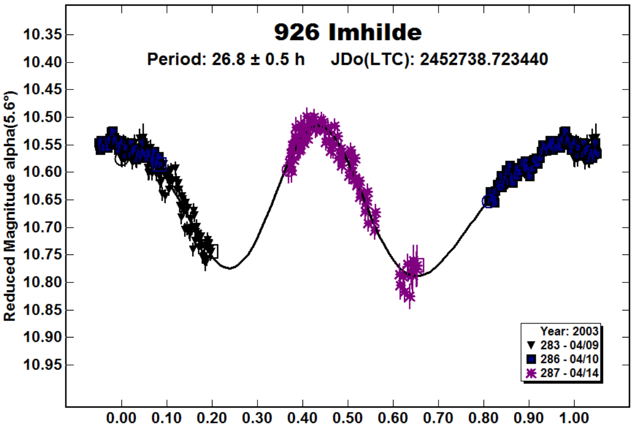
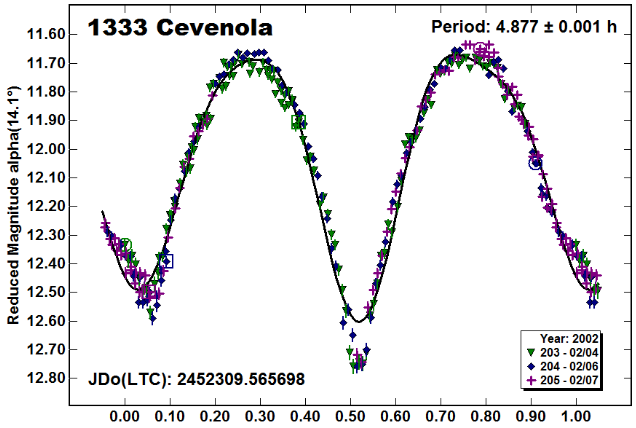
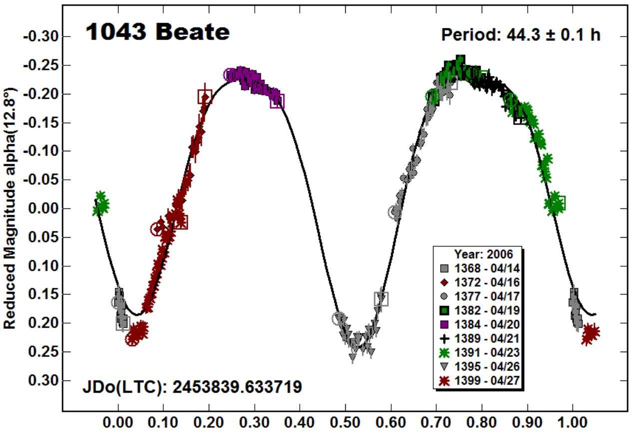
301 - 07/13
302 - 07/21

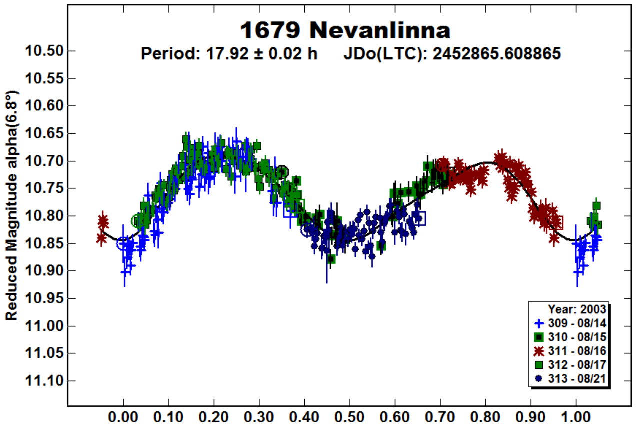

912 Maritima
Period: 20.83 ± 0.03 h JDo(LTC): 2453687.766206
Reduced Magnitude alpha(2.9°)
8.75
8.80
8.85
8.90
8.95
9.00
9.05
9.10
9.15
9.20
9.25
9.30
9.35
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2005
1079 - 11/13
1083 - 11/17
1084 - 11/18
1087 - 11/20

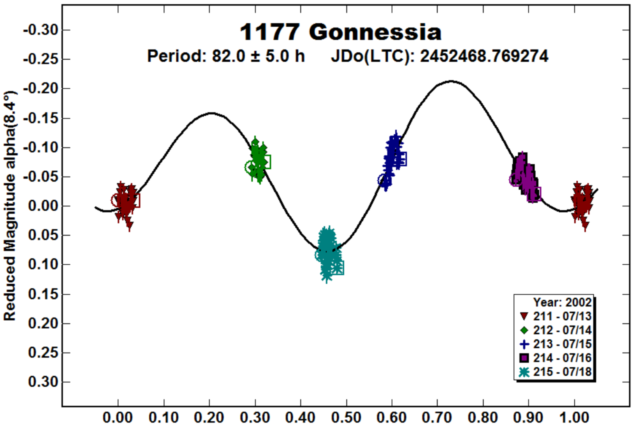

1203 Nanna
Period: 18.54 ± 0.01 h JDo(LTC): 2455080.629435
Reduced Magnitude alpha(11.6°)
11.65
11.70
11.75
11.80
11.85
11.90
11.95
12.00
12.05
12.10
12.15
12.20
12.25
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2009
3323 - 09/06
3327 - 09/07
3331 - 09/08
3334 - 09/09
3340 - 09/17
3343 - 09/18
3349 - 09/19
3352 - 09/20

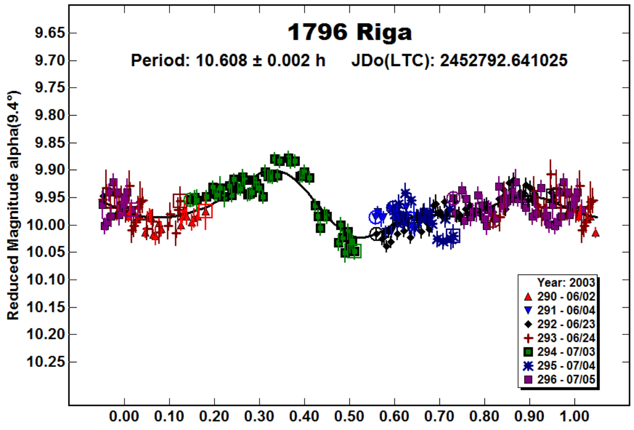

926 Imhilde
Period: 26.8 ± 0.5 h JDo(LTC): 2452738.723440
Reduced Magnitude alpha(5.6°)
10.35
10.40
10.45
10.50
10.55
10.60
10.65
10.70
10.75
10.80
10.85
10.90
10.95
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2003
283 - 04/09
286 - 04/10
287 - 04/14

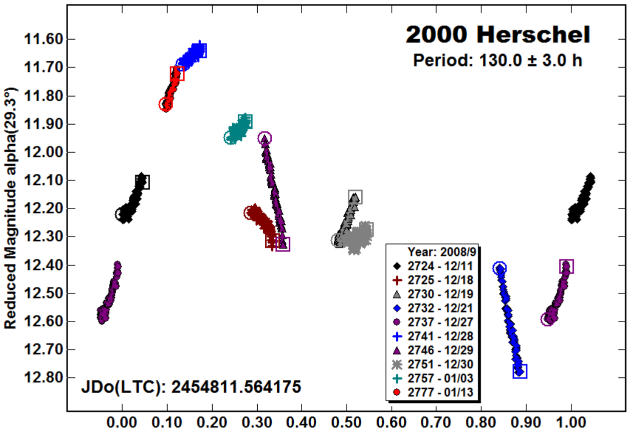

1333 Cevenola
Period: 4.877 ± 0.001 h
JDo(LTC): 2452309.565698
Reduced Magnitude alpha(14.1°)
11.60
11.70
11.80
11.90
12.00
12.10
12.20
12.30
12.40
12.50
12.60
12.70
12.80
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2002
203 - 02/04
204 - 02/06
205 - 02/07

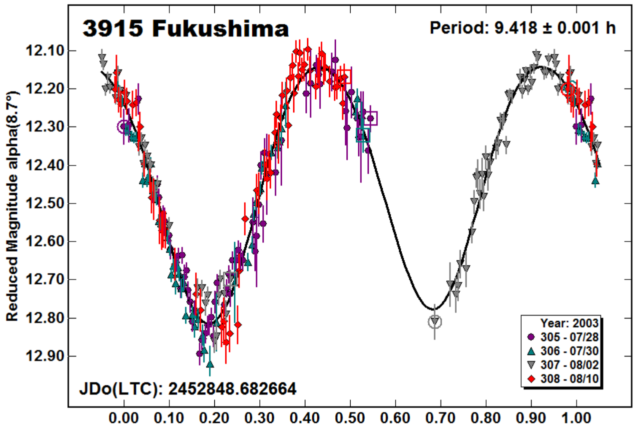

1043 Beate
Period: 44.3 ± 0.1 h
JDo(LTC): 2453839.633719
Reduced Magnitude alpha(12.8°)
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2006
1368 - 04/14
1372 - 04/16
1377 - 04/17
1382 - 04/19
1384 - 04/20
1389 - 04/21
1391 - 04/23
1395 - 04/26
1399 - 04/27

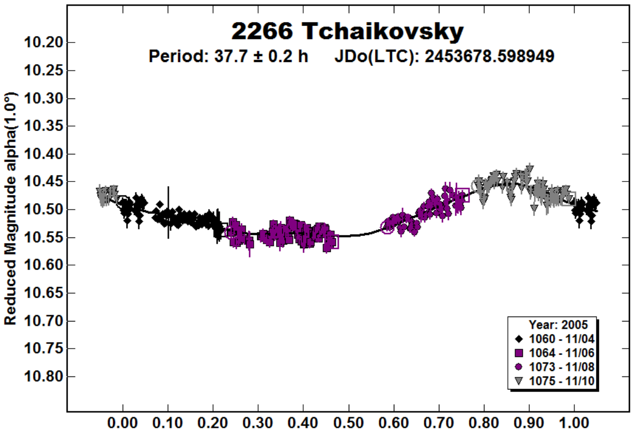

1679 Nevanlinna
Period: 17.92 ± 0.02 h JDo(LTC): 2452865.608865
Reduced Magnitude alpha(6.8°)
10.50
10.55
10.60
10.65
10.70
10.75
10.80
10.85
10.90
10.95
11.00
11.05
11.10
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2003
309 - 08/14
310 - 08/15
311 - 08/16
312 - 08/17
313 - 08/21

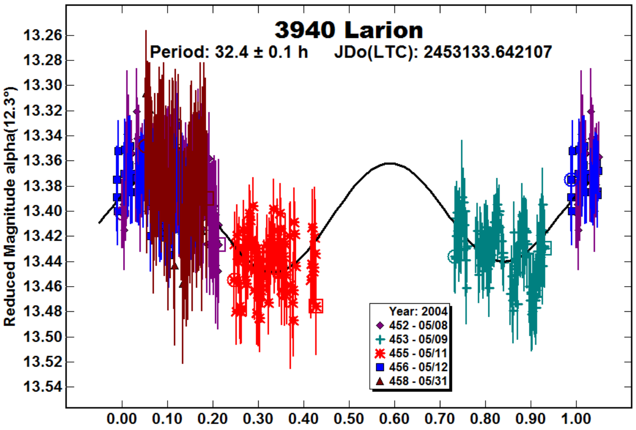

1177 Gonnessia
Period: 82.0 ± 5.0 h JDo(LTC): 2452468.769274
Reduced Magnitude alpha(8.4°)
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2002
211 - 07/13
212 - 07/14
213 - 07/15
214 - 07/16
215 - 07/18

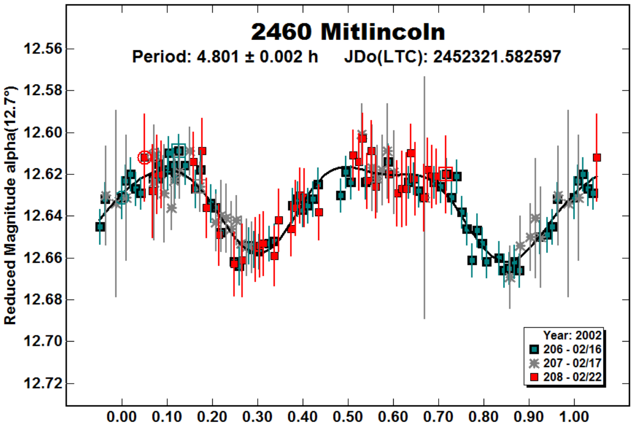

1796 Riga
Period: 10.608 ± 0.002 h JDo(LTC): 2452792.641025
Reduced Magnitude alpha(9.4°)
9.65
9.70
9.75
9.80
9.85
9.90
9.95
10.00
10.05
10.10
10.15
10.20
10.25
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2003
290 - 06/02
291 - 06/04
292 - 06/23
293 - 06/24
294 - 07/03
295 - 07/04
296 - 07/05

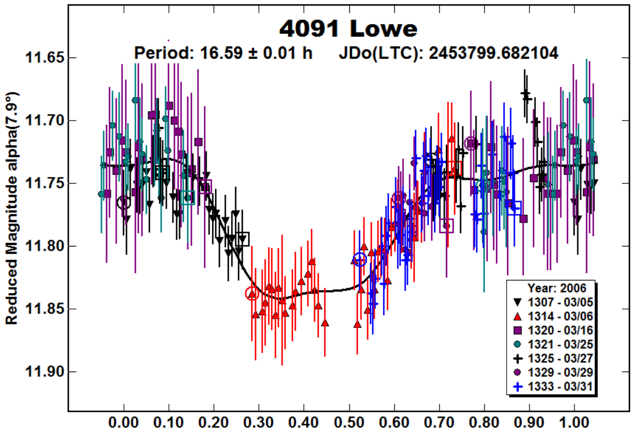

2000 Herschel
Period: 130.0 ± 3.0 h
JDo(LTC): 2454811.564175
Reduced Magnitude alpha(29.3°)
11.60
11.70
11.80
11.90
12.00
12.10
12.20
12.30
12.40
12.50
12.60
12.70
12.80
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2008/9
2724 - 12/11
2725 - 12/18
2730 - 12/19
2732 - 12/21
2737 - 12/27
2741 - 12/28
2746 - 12/29
2751 - 12/30
2757 - 01/03
2777 - 01/13

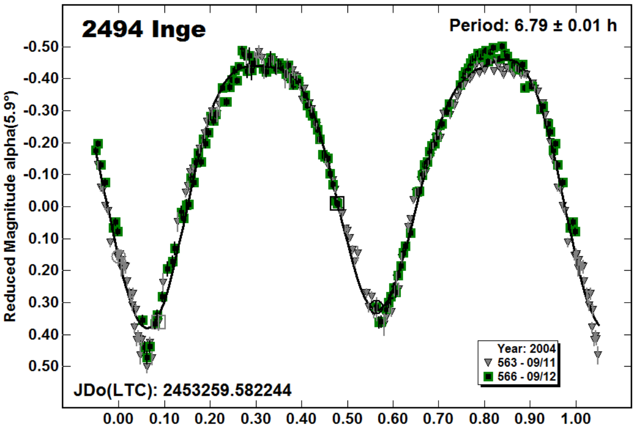

3915 Fukushima
Period: 9.418 ± 0.001 h
JDo(LTC): 2452848.682664
Reduced Magnitude alpha(8.7°)
12.10
12.20
12.30
12.40
12.50
12.60
12.70
12.80
12.90
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2003
305 - 07/28
306 - 07/30
307 - 08/02
308 - 08/10

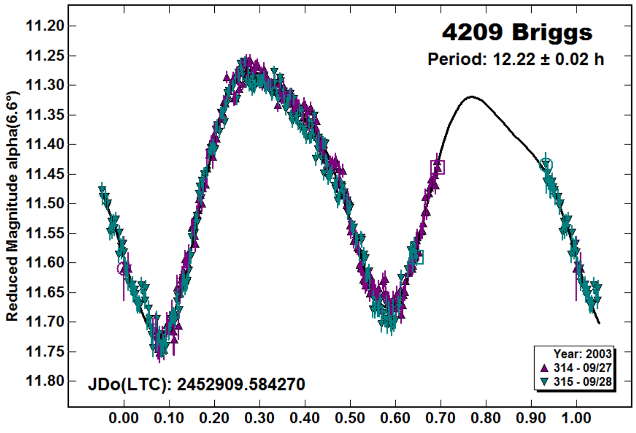

2266 Tchaikovsky
Period: 37.7 ± 0.2 h
JDo(LTC): 2453678.598949
Reduced Magnitude alpha(1.0°)
10.20
10.25
10.30
10.35
10.40
10.45
10.50
10.55
10.60
10.65
10.70
10.75
10.80
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2005
1060 - 11/04
1064 - 11/06
1073 - 11/08
1075 - 11/10

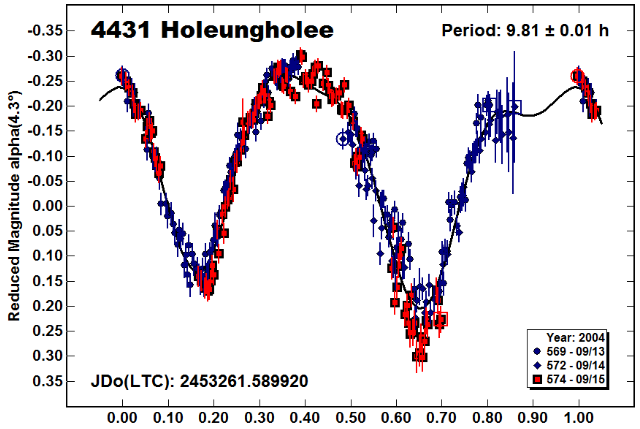

3940 Larion
Period: 32.4 ± 0.1 h
JDo(LTC): 2453133.642107
Reduced Magnitude alpha(12.3°)
13.26
13.28
13.30
13.32
13.34
13.36
13.38
13.40
13.42
13.44
13.46
13.48
13.50
13.52
13.54
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2004
452 - 05/08
453 - 05/09
455 - 05/11
456 - 05/12
458 - 05/31

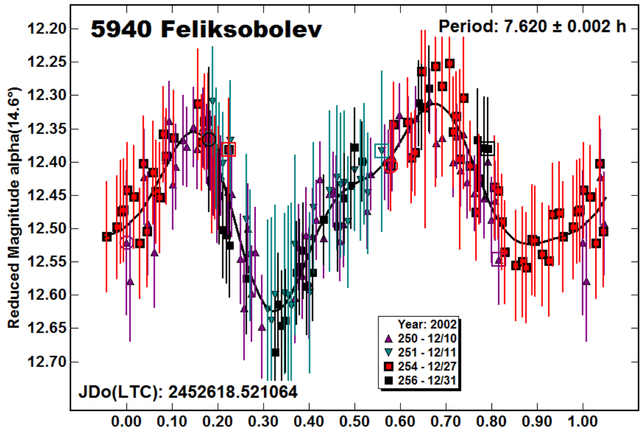

2460 Mitlincoln
Period: 4.801 ± 0.002 h
JDo(LTC): 2452321.582597
Reduced Magnitude alpha(12.7°)
12.56
12.58
12.60
12.62
12.64
12.66
12.68
12.70
12.72
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2002
206 - 02/16
207 - 02/17
208 - 02/22

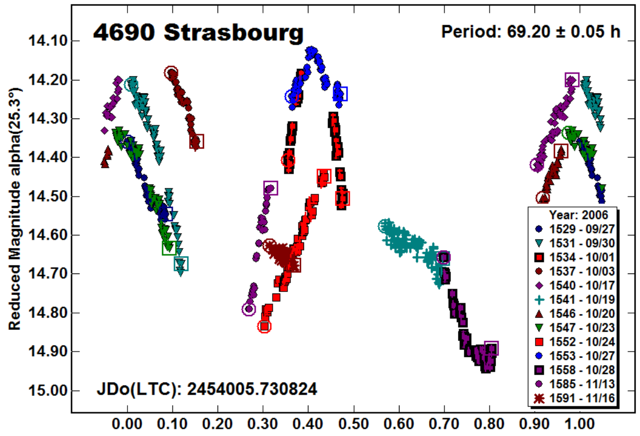

4091 Lowe
Period: 16.59 ± 0.01 h
JDo(LTC): 2453799.682104
Reduced Magnitude alpha(7.9°)
11.65
11.70
11.75
11.80
11.85
11.90
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2006
1307 - 03/05
1314 - 03/06
1320 - 03/16
1321 - 03/25
1325 - 03/27
1329 - 03/29
1333 - 03/31

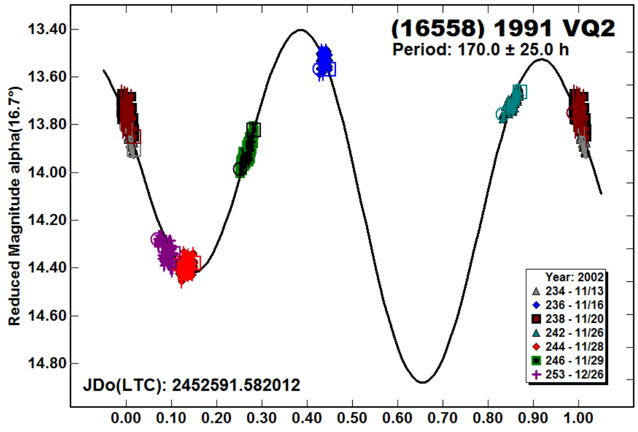

2494 Inge
Period: 6.79 ± 0.01 h
JDo(LTC): 2453259.582244
Reduced Magnitude alpha(5.9°)
-0.50
-0.40
-0.30
-0.20
-0.10
0.00
0.10
0.20
0.30
0.40
0.50
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2004
563 - 09/11
566 - 09/12

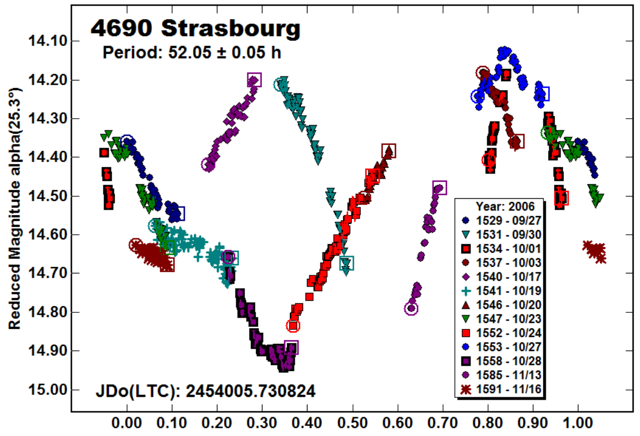

4209 Briggs
Period: 12.22 ± 0.02 h
JDo(LTC): 2452909.584270
Reduced Magnitude alpha(6.6°)
11.20
11.25
11.30
11.35
11.40
11.45
11.50
11.55
11.60
11.65
11.70
11.75
11.80
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2003
314 - 09/27
315 - 09/28

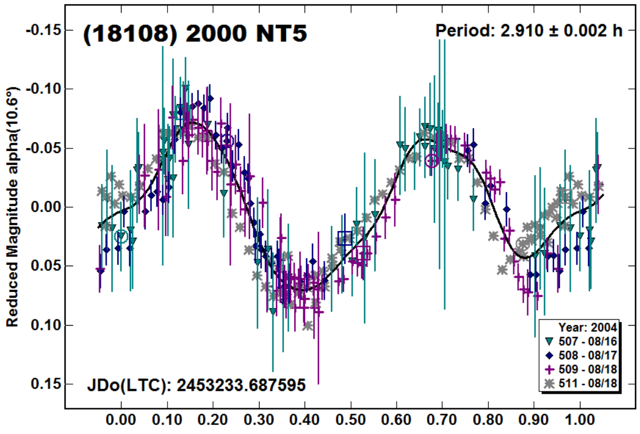

4431 Holeungholee
Period: 9.81 ± 0.01 h
Reduced Magnitude alpha(4.3°)
-0.35 -0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2453261.589920
Year: 2004
569 - 09/13
572 - 09/14
574 - 09/15

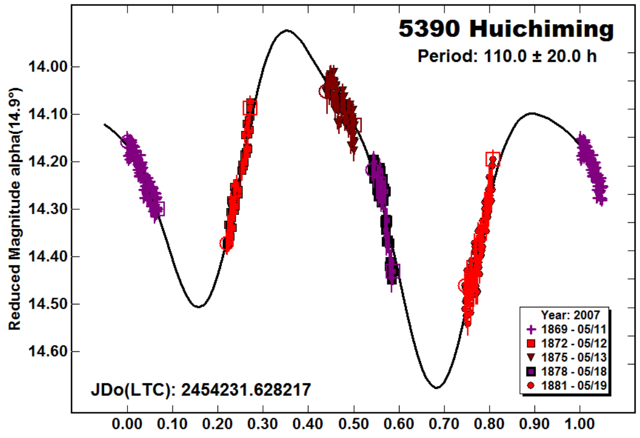

5940 Feliksobolev
Period: 7.620 ± 0.002 h
Reduced Magnitude alpha(14.6°)
12.20 12.25 12.30 12.35 12.40 12.45 12.50 12.55 12.60 12.65 12.70
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2452618.521064
Year: 2002
250 - 12/10
251 - 12/11
254 - 12/27
256 - 12/31

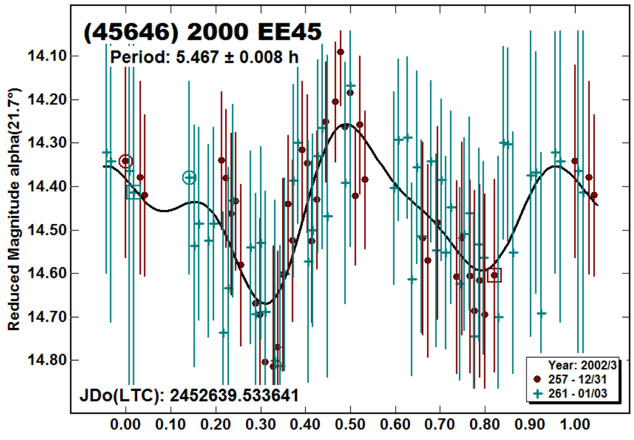

4690 Strasbourg
Period: 69.20 ± 0.05 h
Reduced Magnitude alpha(25.3°)
14.10 14.20 14.30 14.40 14.50 14.60 14.70 14.80 14.90 15.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2454005.730824
Year: 2006
1529 - 09/27
1531 - 09/30
1534 - 10/01
1537 - 10/03
1540 - 10/17
1541 - 10/19
1546 - 10/20
1547 - 10/23
1552 - 10/24
1553 - 10/27
1558 - 10/28
1585 - 11/13
1591 - 11/16


(16558) 1991 VQ2
Period: 170.0 ± 25.0 h
Reduced Magnitude alpha(16.7°)
13.40 13.60 13.80 14.00 14.20 14.40 14.60 14.80
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2452591.582012
Year: 2002
234 - 11/13
236 - 11/16
238 - 11/20
242 - 11/26
244 - 11/28
246 - 11/29
253 - 12/26


4690 Strasbourg
Period: 52.05 ± 0.05 h
Reduced Magnitude alpha(25.3°)
14.10 14.20 14.30 14.40 14.50 14.60 14.70 14.80 14.90 15.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2454005.730824
Year: 2006
1529 - 09/27
1531 - 09/30
1534 - 10/01
1537 - 10/03
1540 - 10/17
1541 - 10/19
1546 - 10/20
1547 - 10/23
1552 - 10/24
1553 - 10/27
1558 - 10/28
1585 - 11/13
1591 - 11/16


(18108) 2000 NT5
Period: 2.910 ± 0.002 h
Reduced Magnitude alpha(10.6°)
-0.15 -0.10 -0.05 0.00 0.05 0.10 0.15
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2453233.687595
Year: 2004
507 - 08/16
508 - 08/17
509 - 08/18
511 - 08/18


5390 Huichiming
Period: 110.0 ± 20.0 h
Reduced Magnitude alpha(14.9°)
14.00 14.10 14.20 14.30 14.40 14.50 14.60
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2454231.628217
Year: 2007
1869 - 05/11
1872 - 05/12
1875 - 05/13
1878 - 05/18
1881 - 05/19


(45646) 2000 EE45
Period: 5.467 ± 0.008 h
Reduced Magnitude alpha(21.7°)
14.10 14.20 14.30 14.40 14.50 14.60 14.70 14.80
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2452639.533641
Year: 2002/3
257 - 12/31
261 - 01/03

PERIOD DETERMINATION FOR 1996 ADAMS AND 2699 KALININ BY AOACM

Carlos Ambrosioni
Observatorio Los Campitos, Cañuelas (MPC I36)
ambrosioniprosen@gmail.com

Carlos Colazo
Observatorio El Gato Gris (MPC I19)
San Luis 145, Tanti, ARGENTINA

Fernando Mazzone
Observatorio Río Cuarto (MPC I20)
Achalay 1469, Río Cuarto, ARGENTINA

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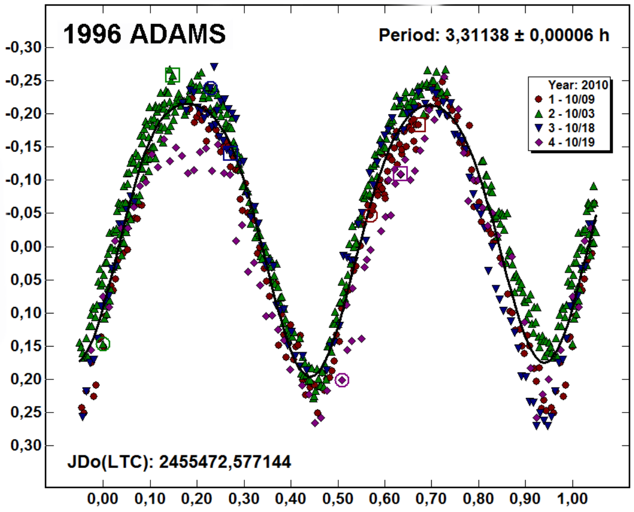
Synodic rotation periods and amplitudes are reported for 1996 Adams: 3.31138 ± 0.00006 h, 0.45 ± 0.04 mag; and 2699 Kalinin: 2.9279 ± 0.0001 h, 0.24 ± 0.04 mag.

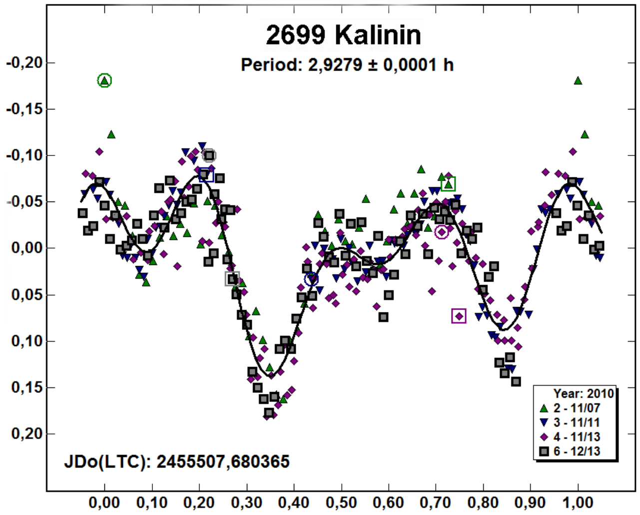
The AOACM (Asociación Observatorios Argentinos de Cuerpos Menores) is an Argentinean association of amateur astronomical observatories. For more details about the group's objectives, equipment, and activities, please visit our web page at http://www.aoacm.com.ar. The observations reported here were done with a range of equipment. Observatory I36, Los Campitos: 0.20-m f/4 Newtonian reflector, SBIG ST7-XME CCD camera. Observatory I19, El Gato Gris: 0.35-m Schmidt-Cassegrain with focal reducer working at f/3.2, Starlight SXV-M7 CCD camera. Observatory I20 Río Cuarto: 0.20 f/4 Schmidt-Newtonian, Meade DSI I Pro CCD camera.

The targeted asteroids were selected from the quarterly lightcurve photometry opportunities article published in *The Minor Planet Bulletin* (Warner *et al.* 2010). In all cases unfiltered images were obtained and were appropriately dark, bias and flat calibrated. The data were light-time corrected. Period analysis was done with *MPO Canopus,* which incorporates the Fourier analysis algorithm developed by Harris (Harris *et al.* 1989). Alternatively, we analyzed the data with Matlab scripts developed by Mazzone that fit the coefficients and frequencies of trigonometric polynomials. Moreover, they fit the offsets of the several sessions. See Mazzone (2010) for these scripts. The results from the two methods are practically the same, except for small differences of the order of the errors.

1996 Adams. Our observations span the entire rotation four times. We collected 748 data points in four sessions on 2010 October 3, 9, 18, and 19. The synodic rotation period was found to be P = 3.31138 ± 0.00006 h with an amplitude of A= 0.45 ± 0.04 mag. These results are in close agreement with the period and amplitude found by Aymamí (2011) and Durkee (2011).

2699 Kalinin. A search of the Asteroid Lightcurve Database (LCBD, Warner *et al*. 2009) did not reveal any previously reported results for this asteroid. Our observations span the entire period five times. We collected 352 data points in four sessions on 2010 November 7, 11, and 13 and December 13. The synodic rotation period was found to be P = 2.9279 ± 0.0001 h with an amplitude of A = 0.24 ± 0.04 mag.





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LIGHTCURVE ANALYSIS OF HUNGARIA ASTEROID (49667) 1999 OM2

Brian D. Warner
Palmer Divide Observatory/Space Science Institute
17995 Bakers Farm Rd., Colorado Springs, CO 80908 USA
brian@MinorPlanetObserver.com

Adrián Galád
Modra Observatory
Department of Astronomy, Physics of the Earth, and Meteorology
FMFI UK, 842 48 Bratislava, SLOVAKIA
and
Astronomical Institute AS CR, 251 65 Ondřejov,
CZECH REPUBLIC

Peter Vereš
Modra Observatory
Department of Astronomy, Physics of the Earth, and Meteorology
FMFI UK, 842 48 Bratislava, SLOVAKIA

Petr Pravec, Peter Kušnirák
Astronomical Institute, Academy of Sciences
Ondřejov, CZECH REPUBLIC

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A month-long campaign to obtain CCD photometric observations of (49667) 1999 OM2 was conducted at the Palmer Divide (USA) and Modra (Slovakia) Observatories in 2010 November and early December. The resulting lightcurve was found to have a period of 3.48608 ± 0.00004 h and amplitude of 0.45 ± 0.02 mag. Initial indications of a long secondary period were eventually rejected.

CCD photometric observations of the Hungaria asteroid (49667) 1992 OM2 were started in early 2010 November at the Palmer Divide Observatory using a 0.35-m Schmidt-Cassegrain telescope and SBIG STL-1001E CCD camera. Exposures were unfiltered and 240 s. Observations at Modra were made using a 0.6-m telescope with Apogee AP8 CCD. Exposures used a clear filter and were 90 s. Night-to-night calibration of the data from PDO was done by using 2MASS magnitudes for field stars from the 2MASS (Neugebaur and Leighton, 1969) or UCAC2 catalog (Zacharias et al. 2004) with the J-K magnitudes converted to Cousins R using formulae by Warner (2007). See Stephens (2008) for more details on the calibration process using these magnitudes.

Initial observations at PDO indicated the possibility of a long secondary period of either ~26 or ~52 h. If such a period were real, capturing sufficient data for reliable analysis from one station, or two or more too close in longitude, would be difficult at best. A call for assistance was made and Galád responded. After a month-long campaign (2010 November 3 – December 2), a data set of more than 1000 observations was obtained. Analysis of the data showed that the secondary period was too weak to rise sufficiently above the noise and was rejected, even though subtracting a period of 25.5 h noticeably reduced the noise in the primary curve.

Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNX10AL35G, by National Science Foundation grant AST-1032896, and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society. The work at Modra was supported by the Slovak Grant Agency for Science VEGA, Grants 2/0016/09, and 1/0636/09, as well as the Grant Agency of the Czech Republic, Grant 205/09/1107. This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation.

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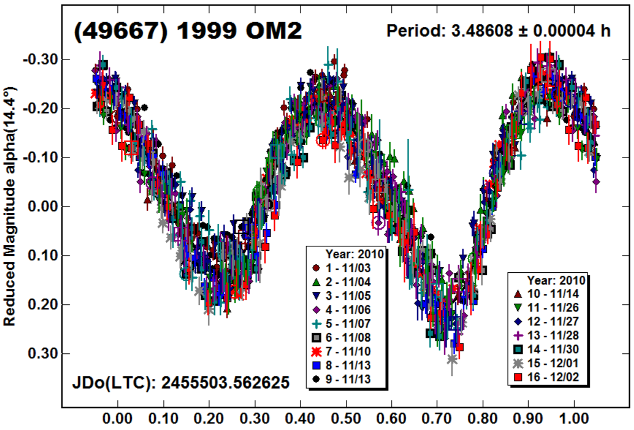
[Editor's Note: If an "Editor's Award" were ever given within an Issue, this work would be a recipient. Why? Beautiful and thorough application of the scientific method, through which it is often incredibly difficult to disprove an initial hypothesis. Here a long and intensive observational campaign was persevered to the solid conclusion of a null result. Null results get no glory, but nonetheless they can be the most difficult to demonstrate. -RPB]



CALL WEB SITE CHANGE

The Collaborative Asteroid Lightcurve Link (CALL) web site used by many asteroid photometrists and often referenced in *MPB* papers has moved to a new hosting site. This means the URL has changed from *www.MinorPlanetObserver.com/astlc/default.htm* to *www.MinorPlanet.info*. The new URL is a gateway to the CALL pages as well as downloads of full *MPB* issues from 1994 to present. Issue 38-3 will include more details.

LIGHTCURVES FOR FIVE CLOSE APPROACH ASTEROIDS

Peter Birtwhistle
Great Shefford Observatory
Phlox Cottage, Wantage Road
Great Shefford, Berkshire, RG17 7DA
United Kingdom
peter@birtwhi.demon.co.uk

(Received: 13 January)

Lightcurves for five very small (H > 22) near-Earth asteroids observed from Great Shefford Observatory during close approaches between 2010 October and 2010 December are reported: 2010 TG19, 2010 UJ7, 2010 VK139, 2010 XE11, and 2010 XM56. 2010 XM56 is a large amplitude slow rotator, all others are found to be super-fast rotators with periods less than 200 seconds. The abundance of new super-fast rotators is discussed.

Photometric observations of five newly discovered near-Earth asteroids during close approaches to Earth were made at Great Shefford Observatory between 2010 October and 2010 December using a 0.40-m Schmidt-Cassegrain and Apogee Alta U47+ CCD camera. All observations were made unfiltered and with the telescope operating with a focal reducer at f/6. The 1Kx1K, 13-micron CCD was binned 2x2 resulting in an image scale of 2.16 arc seconds/pixel. *MPO Canopus* (Warner 2010), incorporating the Fourier algorithm developed by Harris *et al*. (1989) was used for image measurement using differential aperture photometry and for lightcurve analysis for all objects apart from 2010 XM56, where *Astrometrica* (Raab 2010) was used for image stacking and photometry. Apart from 2010 XM56, all lightcurve plots are "phased" according to the period values given in Table I below. A search of the Asteroid Lightcurve Database (LCDB, Warner *et al*., 2010) does not reveal any previously reported results.

2010 TG19. The asteroid was observed continuously for 3.5 h on 2010 Oct. 20 and again for 2.1 h the next night. On the first night, exposures were kept to 10 s duration due to motion of 23"/min. On the second night, with the object at 2 lunar distances and moving at 85"/min, exposures were limited to 2 s throughout and showed large and very rapid brightness variations that were not noticeable in the images taken the night before. The resulting period of just 69.8 s indicated that the 10 s exposures from the first night had been too long and caused smoothing of the lightcurve. Even so, the period determined from the October 20 images with 1-sigma error is 0.0193930 ± 0.0000008 h (from 180 revolutions) and from October 21 is 0.0193958 ± 0.0000007 h (from 109 revolutions). The two solutions match together to within 15% of 1 revolution and the period derived by combining both nights is 0.0193935 ± 0.0000001 h. The lightcurve plot provided here is phased using the combined period, but using only observations from the second night, obtained with the shorter exposures. The asteroid completed 1310 revolutions during the 25.4 hour span of observations. The most rapidly changing part of the curve on the second night shows the magnitude falling 1.0 magnitudes in 12 s and then rising 1.1 magnitudes in 12 s. This amplitude, at phase angle = 62° suggests a minimum elongation of $a/b \geq 1.4$ (Kwiatkowski *et al.* 2010a).

2010 UJ7. Although 2010 UJ7 was relatively bright at ≈ mag. +14 during a very close-approach to within 0.0021 AU, conditions were poor and affected the consistency of some of the images obtained. Observations were possible for only 39 minutes, centered on 18 h UT on 2010 Nov 01, when its apparent motion was 200"/min and then for a further 14 minutes four hours later by which time its motion had accelerated to 335"/min. Exposures were set at 1 second throughout. Zero points for some of the sessions have had small adjustments of 0.2 mag. or less made, to reduce the RMS fit of the solution to a minimum.

2010 VK139. Images were obtained over a 3.8 h period on 2010 Nov 14 and for another 2.8 h on the next night when it was at its closest to Earth at 0.0073 AU. Exposures were limited to 4s on the first night, reducing to 2s and 0.9s on the second night due to the increased apparent speed. Over the two nights images were obtained from 55 different fields of view, ranging in declination from +57° to 18° and all were processed with *Canopus*. Problems with zero-pointing of some fields lead to an independent measurement of magnitudes using *Astrometrica* and the UCAC3 catalogue and those results showed good internal agreement and matched the predicted increase in brightness assuming H=23.7 and G=0.15, to within 0.2 mags on each night and agreement to 0.4 mags between the two nights. No obvious periodicity in a scale of hours was evident, though a very short period was apparent in all the measurements. The zero-points of all the *Canopus* sessions were then adjusted to investigate the short term variation, reducing the RMS fit of the short period solution to a minimum. The resulting period fitting both nights is 0.0299522 ± 0.0000002 h (1-sigma). Phased plots of independent reductions from the two nights are given and, although the periods agree well, they show a significant change in the shape of the lightcurve, probably due to the rapid (38°) reduction in phase angle between the two nights. Extrapolating the lightcurve with 1-sigma error from first night to second indicates there were 728.02 ± 0.02 revolutions between the start of the first and start of the second night. The equivalent extrapolation from second night to first is in good agreement, indicating 727.97 ± 0.04 revolutions. Thus the two phased plots by chance match in phase to ~5% and the changes in lightcurve are directly comparable.

2010 XE11. This was a mag. +17 target at a relatively distant 0.037-0.045 AU from Earth. Observations were obtained for 2.0 h on 2010 Dec 05, 1.4 h on Dec. 07 and then for 5.4 h on Dec. 08. Conditions on Dec. 05 and 08 were good but poor on Dec. 07. Exposures were 16 s on Dec. 05 and 14 s on the last two dates. An exposure of 14 s represents about 15% of the very fast rotation period of 96 seconds (see Table II) and will have caused a degree of smearing, smoothing out any small features in the lightcurve. The very fast rotation rate together with a diameter of 75 meters, assuming an albedo of 0.20, places 2010 XE11 beyond the spin limit for asteroids with strength coefficient $\kappa = 10^5$ Nm$^{-3/2}$ with density $\rho = 2500$ kgm^3 (see Figure 1). 2010 XE11 completed 2935 rotations during the 78 hour span of observations.

2010 XM56. During a close-approach to 0.0047 AU, 1588 usable images were obtained over a period of 5.9 hours, the telescope having to be repositioned 92 times due to the fast motion of the object. At the start of the series of images the apparent motion was 163"/min and 25 images were obtained in each field of view, but by the end of the session with the motion reaching 247"/min, that number was reduced to 17 images. A check was made from measurements of individual images for evidence of very fast rotation but none was found, so *Astrometrica* was then used to stack all the usable images in each of 88 of the fields to provide one (high SNR) measurement per field. The remaining four fields were each divided into two halves for measurement, resulting in 96 separate photometric measurements using the CMC-14 catalogue. JD, apparent (R) magnitude and SNR were imported from the

PhotReport.txt file generated by *Astrometrica* into *Canopus* for period determination. Rather than importing all measurements into one *Canopus* "session", an artificial division of the measurements into 12 sessions was made, each containing 8 data points. Each session spans approximately 30 minutes of time, allowing the rapidly changing phase angle to be better accommodated. A plot of the raw lightcurve, adjusted for distance and phase (assuming G=0.15) is given, showing the amplitude increasing from 2.6 to 4.4 magnitudes as the phase angle increased from 47° to 65°. A phased plot is also given, showing the amplitude changes but also indicating no obvious change in period during the observations. The rapidly increasing phase angle will have contributed to the change in amplitude, especially during the last two hours, but the behaviour of the apparent amplitude during the first four hours, where consecutive minima reduce in depth, up to the an apparent minimum around JD = 2455547.57, is most likely due to tumbling and on the scale of Pravec *et. al*. (2005) is expected to be at a level of PAR = -1 (Non-Principal Axis rotation possible, but not conclusively). For a conservative estimate of the elongation of the object, the 2.6 mag amplitude at the beginning of the session at phase angle 47° suggests a minimum elongation a/b of ≥ 2.7. During the period of observation the phase angle bisector was changing at a rate of 43.5°/day and according to Warner *et al.* (2010) the expected difference between the sidereal period and synodic period is estimated to be 0.028 h, slightly larger than the estimated error on the measured synodic period.

Abundance of Super-fast Rotators. Figure 1 plots diameter (D) vs. rotation period (P) for all objects in the LCDB with $D < 10$ km and lightcurve quality U > 1. The five objects reported in this paper, four having periods less than 200 seconds, are also included and identified as Birtwhistle (2011). A further six very fast rotators with periods less than 5 minutes are also plotted. The shaded area is an approximate representation of the spin limits for a range of likely strength coefficients and densities discussed in Kwiatkowski *et al*. (2010b) and three of the objects reported here (2010 TG19, 2010 VK139 and 2010 XE11) can be seen to be close to these limits.

The 10 new fast rotators represent a 45% increase in the number of objects with periods less than 5 minutes in the LCDB and it is suspected that this apparent abundance of new super-fast rotators may be due in part to very short periods being masked by relatively long integration times in other data and/or problems in analysis. It is noted that 2010 TG19, with a particularly short rotation period of 69.8 s, showed a notable smoothing of its lightcurve when initially imaged with 10 s exposures and additionally, the final period does not show up at all on a period spectrum using a step size of 0.001 hours = 3.6 seconds, only starting to become apparent in the period spectrum (though not yet dominant) with the step size reduced to 0.8 seconds.

Acknowledgments

The author is grateful to Dr. Petr Pravec for his advice and help in the interpretation of the lightcurves and also to Brian D. Warner for his continued help and great patience.

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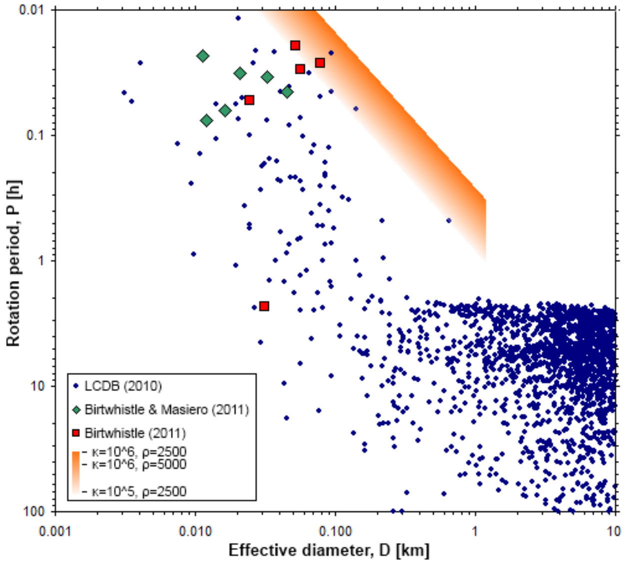


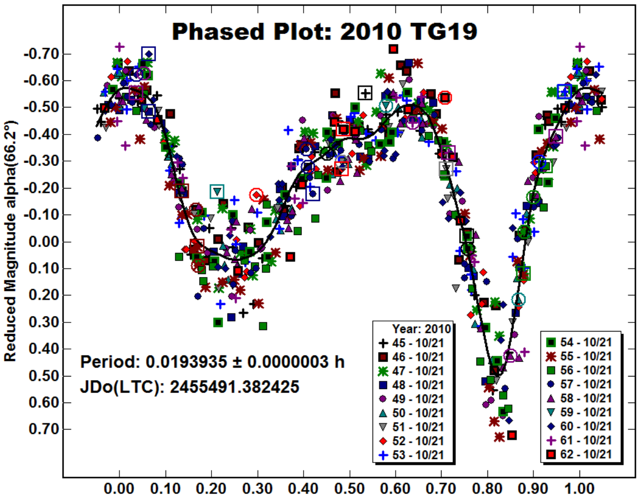
Figure 1. Plot of asteroid rotation periods (P) versus their effective diameters (D). The shaded area indicates maximum spin limits for strength coefficients $\kappa = 10^5$ Nm$^{-3/2}$, $k = 10^6$ Nm$^{-3/2}$ and densities ρ = 2500 kgm^3, ρ = 5000 kgm^3 (after Kwiatkowski *et al.*, 2010b)

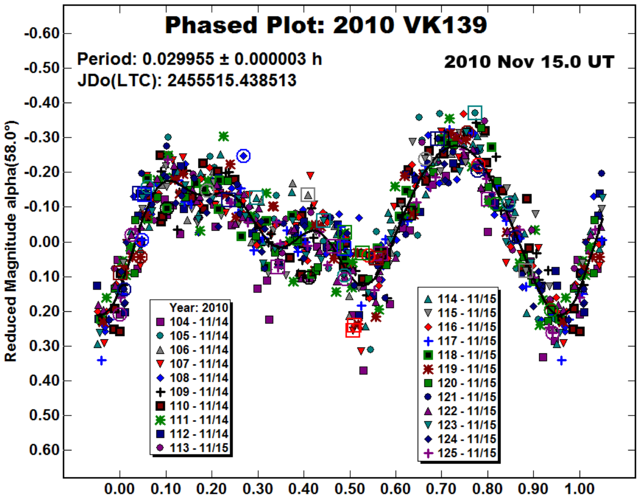
Name	Date range yyyy mm/dd	Phase (deg)	PAB$_L$ (deg)	PAB$_B$ (deg)	Period (h)	PE	Amp. (mag)	AE
2010 TG19	2010 10/20-10/21	52.2-71.7	359	10	0.0193935	0.0000003	1.1	0.05
2010 UJ7	2010 11/01	48.5-52.6	29	23	0.05305	0.00002	0.9	0.2
2010 VK139	2010 11/14-11/15	58.1-19.7	71	10	0.0299522	0.0000006	0.5	0.1
2010 XE11	2010 12/05-12/08	14.6-24.0	83	6	0.0265846	0.0000003	0.5	0.1
2010 XM56	2009 12/16-12/17	46.5-65.0	112	-5	2.35	0.02	4.4	0.2

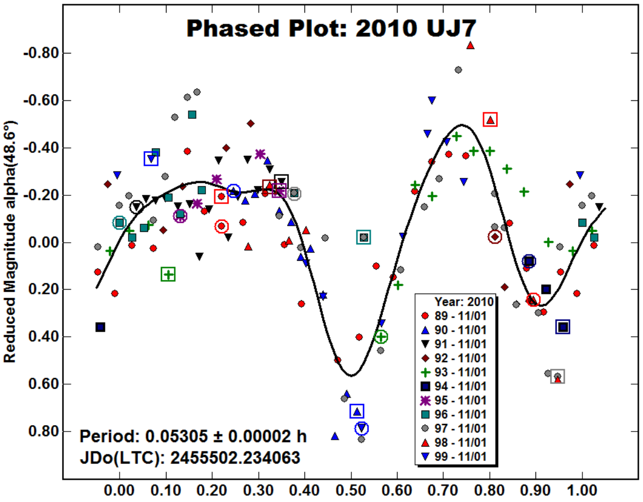
Table I. Observing circumstances, including observation dates, phase angle range, approximate longitude and latitude of the phase angle bisector, derived synodic rotation period with error estimate and lightcurve amplitude with error estimate.

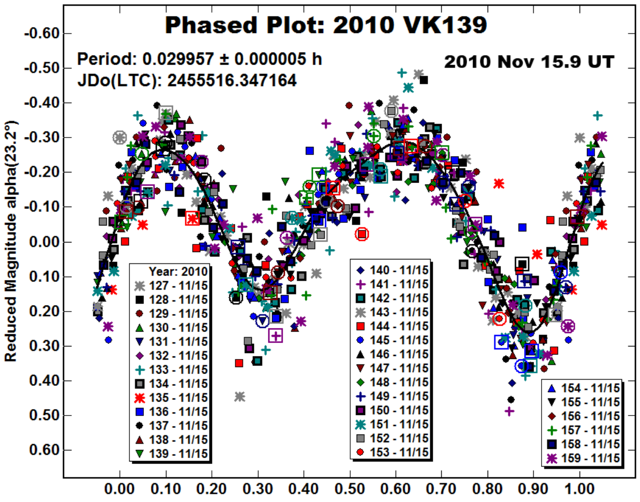
Name	Data points	Exposure (s)	Exposure / Period	Min a/b	H	Est. Size (m)
2010 TG19	1204	10,2	0.029	≥ 1.4	23.9	49
2010 UJ7	140	1	0.005	≥ 1.3	25.4	25
2010 VK139	1479	4,2,0.9	0.019	≥ 1.4	23.7	54
2010 XE11	576	16,14	0.146	≥ 1.3	23.0	75
2010 XM56	96	2	0.0002	≥ 2.7	25.0	30

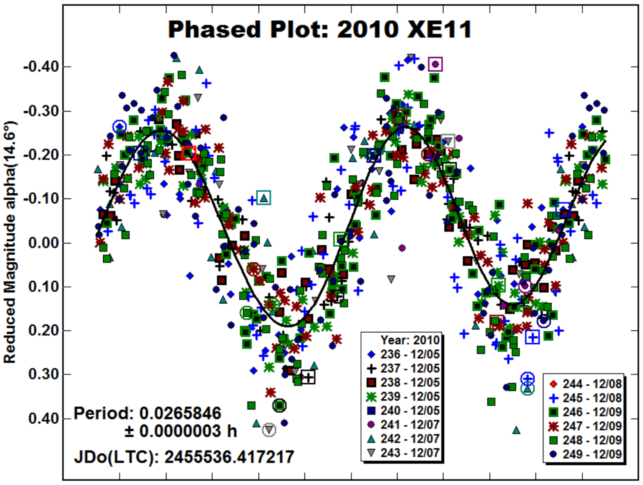
Table II. Ancillary details, including the number of data points used in analysis, exposure lengths, the primary exposure length as a fraction of the rotation period, the calculated minimum elongation of the asteroid, the Absolute Magnitude (from the MPC database) with associated size estimate assuming albedo for S-type minor planets of 0.20.

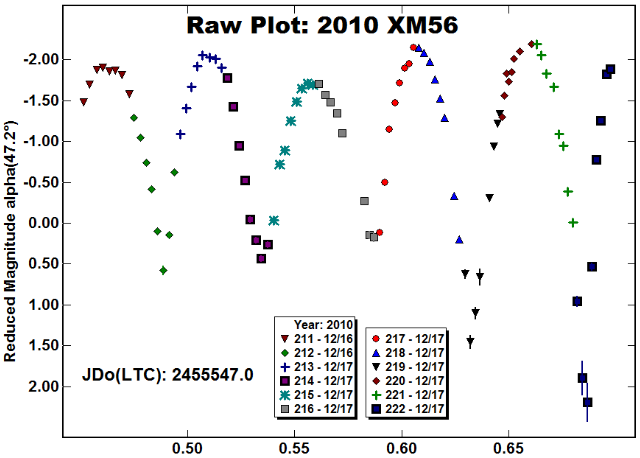


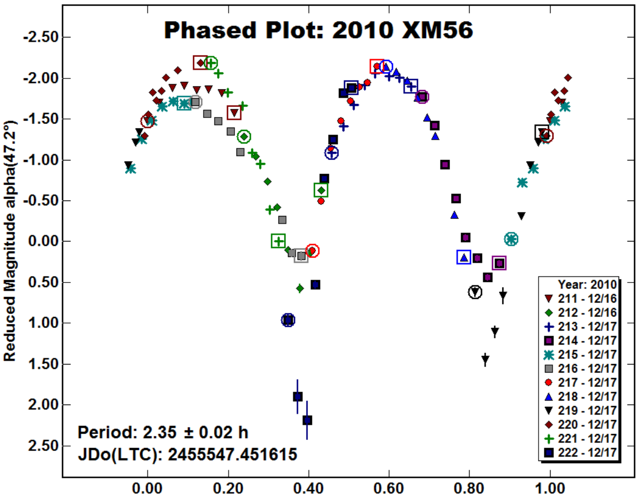












LIGHTCURVES FROM THE INITIAL DISCOVERY OF FOUR HUNGARIA BINARY ASTEROIDS

Brian D. Warner
Palmer Divide Observatory/Space Science Institute
17995 Bakers Farm Rd., Colorado Springs, CO 80908 USA
brian@MinorPlanetObserver.com

Petr Pravec, Peter Kušnirák
Astronomical Institute, Academy of Sciences
Ondřejov, CZECH REPUBLIC

Alan. W. Harris
MoreData!, La Cañada, CA USA

Walter R. Cooney, Jr., John Gross, Dirk Terrell
Sonoita Research Observatory, Sonoita, AZ USA

Shannon Nudds,
Elginfield Observatory, University of Western Ontario
London, Ontario CANADA

Jozef Világi, Štefan Gajdoš
Modra Observatory
Dept. of Astronomy, Physics of the Earth and Meteorology
Bratislava, SLOVAKIA

Gianluca Masi
Universita degli Studi di Roma, "Tor Vergata" ITALY

F. Mallia
Campo Catino ITALY

Donald P. Pray
Carbuncle Hill Observatory, Coventry, RI USA

Ron Dyvig
Badlands Observatory, Quinn, SD USA

Vishnu Reddy
Department of Space Studies, University of North Dakota
Grand Forks, ND USA

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Lightcurves from the initial discovery of four Hungaria binary asteroids are presented: 3309 Brorfeld, (5477) 1989 UH2, 9069 Hovland, and (76818) 2000 RG79. Announcements and some web postings were made at the time of the discoveries but the lightcurves were not formally published.

To date, more than a dozen binary asteroids have been discovered at the Palmer Divide Observatory as a result of an ongoing program involving the Hungaria asteroids. The initial discovery lightcurves for four of the asteroids were not formally published at the time of discovery. We present them now to complete the record. These and other binary discoveries are a tribute to the cooperation and collaboration among amateur observers around the world and to the need for and quality of pro-am collaborations. In this case, credit goes to the Binary Asteroid Photometric Survey (Pravec *et al.* 2006) conducted by Petr Pravec at the Ondřejov Observatory, Astronomical Institute, Czech Republic.

<u>3309 Brorfeld</u>. This asteroid was discovered to be binary in 2005 October-November (Warner *et al.* 2005a). The primary period was 2.5041 ± 0.0002 h and the orbital period, as determined by observation of mutual events (occultations and/or eclipses involving the satellite), was found to be 18.48 h. Observations at two subsequent apparitions (Warner 2009a, Pravec *et al.* 2011) have provided an extensive data set for modeling.

<u>(5477) 1989 UH2</u>. Initial discovery of (5477) being binary was made in 2005 November (Warner *et al.* 2005b). Follow-up observations in 2007 (Pravec et al. 2007) confirmed the binary nature and refined the system parameters.

<u>9069 Hovland</u>. Initial discovery of this asteroid being binary was made on the Minor Planet Mailing List (Warner *et al.* 2004). While the solution is not disputed, the lack of follow-up observations has prevented refining the system periods and modeling the system.

<u>(76818) 2000 RG79</u>. Observations by Warner and Pray and analysis by Pravec discovered this asteroid to be binary in mid-2005 (Warner *et al.* 2005c). Additional observations in 2008 (Warner 2009b) helped refine system parameters.

The Need for Follow-up Observations

Once an asteroid has been discovered to be binary, that should not be the end of things. Observations at future apparitions are critical for several reasons. First is to confirm the original system parameters of the primary and orbital period and, if seen, independent rotation of the satellite. Next, the additional data can help model the system, e.g., determine the shape of the primary or if the satellite orbit is circular or elliptical. Finally, and perhaps most important, is to confirm if mutual events are seen at every apparition. If so, this would indicate that the orbital plane of the satellite is approximately along the line of sight to Earth and, by extension, that the spin axis of the primary is approximately perpendicular to the line of sight. If mutual events are not seen at every apparition or change significantly, this can be used to determine the true orientation of the spin axis and satellite plane for each system. Research is already in progress to determine if the spin axis and orbital planet orientations are random, grouped, or somewhere in-between. The results may help reveal some critical secrets in the creation and evolution of binary asteroids.

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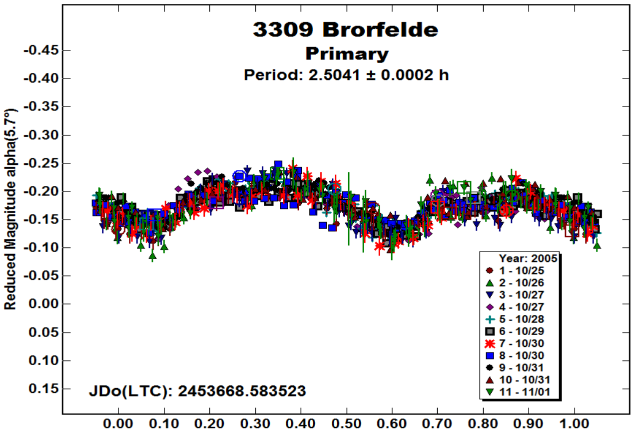

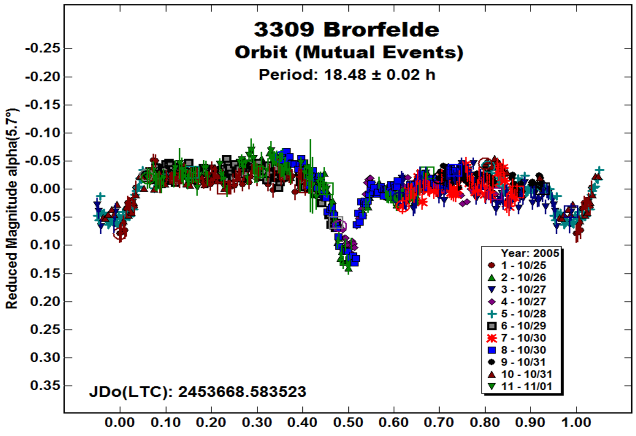

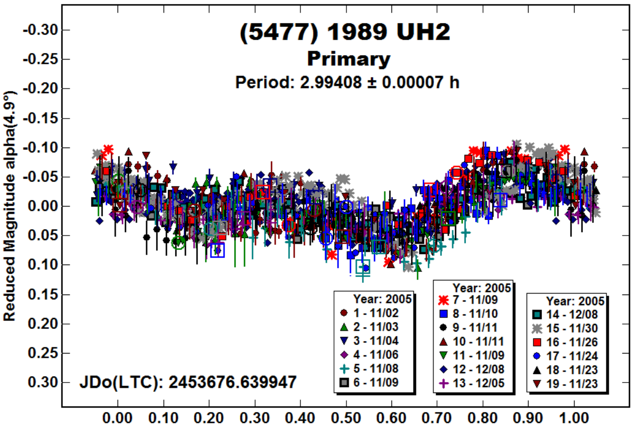

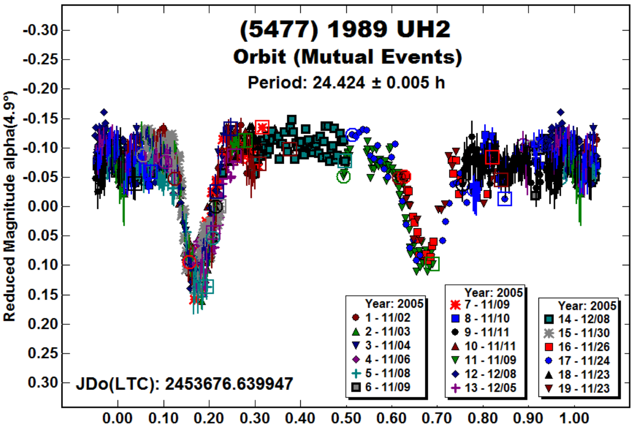

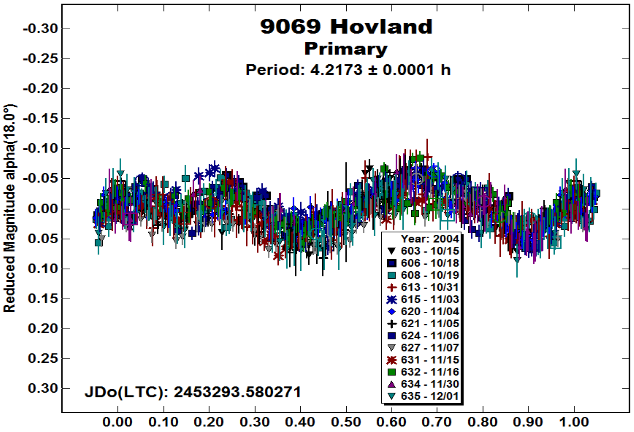

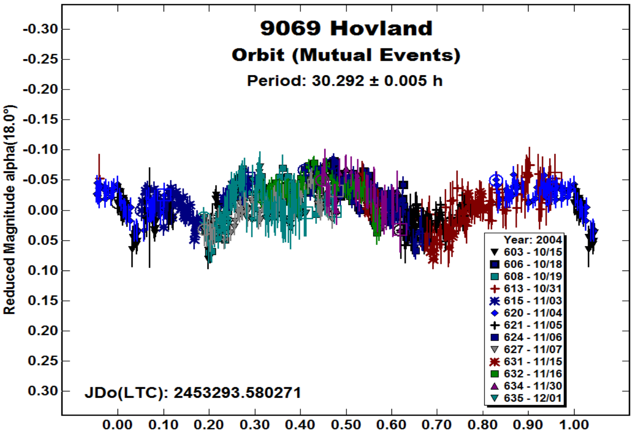

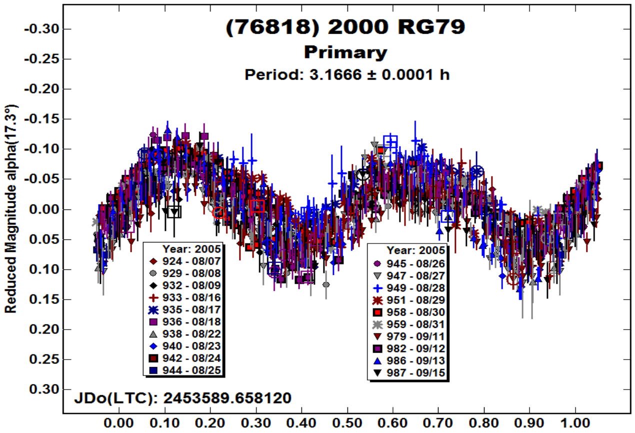

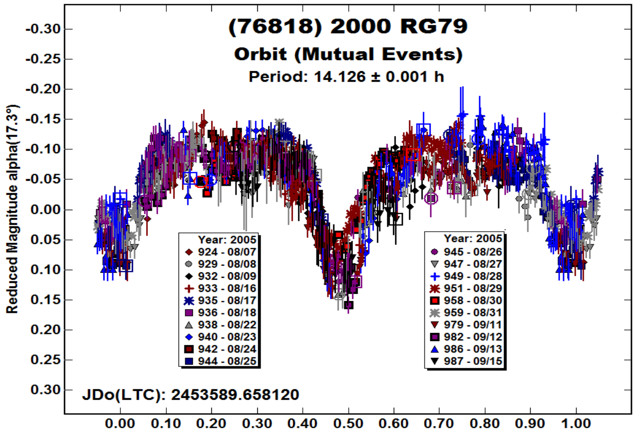

THE LIGHTCURVE OF (6425) 1994 WZ3

Russell I. Durkee
Shed of Science Observatory
Minneapolis, MN, 55410 USA
shedofscience@earthlink.net

James W. Brinsfield
Via Capote Observatory
5180 Via Capote, Thousand Oaks, CA 91320 USA

(Received: 12 January)

Asteroid (6425) 1994 WZ3 was observed over 13 nights. A period of 103.9 ± 0.5 h with an amplitude of 0.92 ± 0.1 mag was derived.

CCD photometry observations of (6425) 1994 WZ3 were started in 2010 October by Durkee at the Shed of Science Observatory using a 0.35-m f/8.5 Schmidt Cassegrain (SCT) and SBIG ST10XE CCD camera, yielding a scale of 0.94 arcsec/pixel. The object had been selected from a list of potential targets given on the CALL web site (*http://www.MinorPlanet.info/call.html*). Analysis of the initial data suggested that the object had a long period and so a request for supporting observations was posted on the CALL site. Brinsfield responded and provided data on 2010 December 1 and 2. The equipment at the Via Cope Observatory consisted of a Meade LX200 0.36-m SCT and Alta U6 CCD camera with a 1024x1024 array of 24-micron pixels. All observations were unfiltered at 1x binning yielding an image scale of 1.44 arcsec/pixel. Data on an additional 11 nights were obtained by Durkee.

All images were dark and flat field corrected and subsequently measured with *MPO Canopus* (Bdw Publishing) with a differential photometry technique. Both observers used the Comp Star Selector feature in Canopus to link the sessions on an internal system to ± 0.05 mag, usually less. Period analysis using light-time corrected data was done with *MPO Canopus*, which implements the FALC Fourier analysis algorithm developed by Harris (Harris *et al.* 1989). The analysis indicates a period of 103.9 ± 0.5 h with an amplitude of 0.92 ± 0.10 mag. The inflection points are not completely covered, so our amplitude estimate is a lower bound. Since the lightcurve was not fully covered, additional observations are required to refine the solution.

Acknowledgements

Thanks go to Brian Warner and his CALL website for making this collaboration possible. Partial funding for work at the Shed of Science is provided by a Gene Shoemaker NEO Grant from the Planetary Society.

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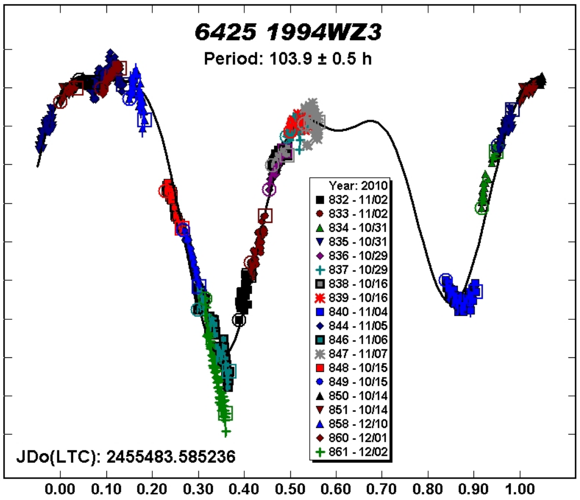


LIGHTCURVE ANALYSIS FOR A TRIO OF ASTEROIDS

Brian D. Warner
Palmer Divide Observatory/Space Science Institute
17995 Bakers Farm Rd., Colorado Springs, CO 80908 USA
brian@MinorPlanetObserver.com

Robert D. Stephens
Goat Mountain Asteroid Research Station (GMARS)
Landers, CA USA

(Received: 13 January)

CCD photometric observations were obtained at the Palmer Divide and GMARS Observatories for three asteroids: 1263 Varsavia, (13331) 1998 SU52, and (69406) 1995 SX48.

CCD photometric observations were made of three asteroids at the Palmer Divide (PDO) and GMARS Observatories. New observations were acquired in 2010 for the Jupiter Trojan (13331) 1998 SU52 and Hungaria (69406) 1995 SX48. Original images from PDO from 2003 for 1263 Varsavia were re-measured using improved software and night-to-night calibration. The revised data set for Varsavia that included the original observations from GMARS was used to find an improved period and overall solution.

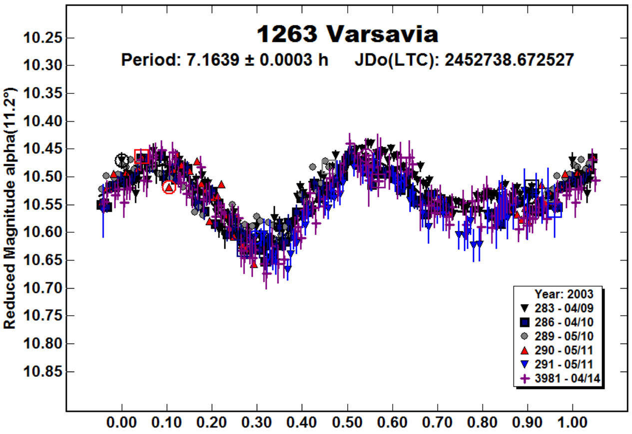
Night-to-night calibration of the data was done by using 2MASS magnitudes for field stars from the 2MASS (Neugebaur and Leighton 1969) or UCAC2 catalog (Zacharias et al. 2004) with the J-K magnitudes converted to Johnson-Cousins BVRI using formulae by Warner (2007). See Stephens (2008) for more details on the calibration process using these magnitudes. It is important to use some form of calibration, even if on an internal system, in order to assure that the data are properly interpreted. Since the 2MASS conversion formulae have error bars on the order of ± 0.05 mag, the night-to-night calibration is not perfect and we occasionally had to make minor adjustments to get the best RMS fit to the Fourier curve.

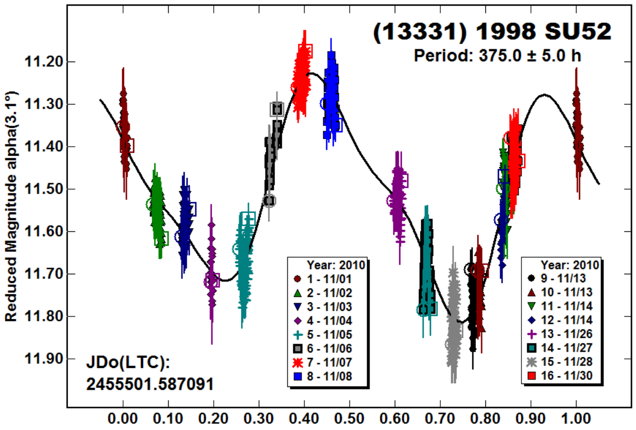
1263 Varsavia. The authors reported a period $P = 7.231$ h based on the original data obtained in 2003 (Stephens and Warner 2004). As part of a review of all data obtained at PDO from 1999 to present, the original PDO images were re-measured using the latest version of MPO *Canopus*, which uses the 2MASS to BVRI calibrations and allows selecting only those comparison stars similar in color to the asteroid. The revised data set gave a higher quality solution and revised the period to $P = 7.1639 \pm 0.0003$ h with an amplitude $A = 0.15 \pm 0.01$ mag.

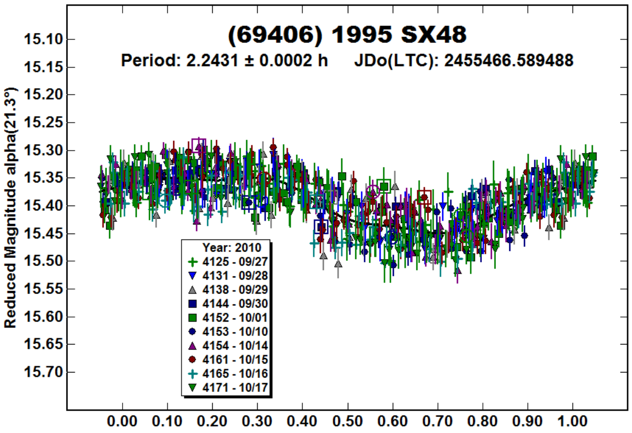
(13331) 1998 SU52. This Jupiter Trojan was in the same field as a targeted asteroid being worked at the PDO in 2010 November. Stephens has been concentrating his efforts of late on the Jupiter Trojans and so the asteroid was followed even after it was no longer in the field with the original target. A total of 764 data points obtained over nearly a month comprised the final data set, analysis of which found $P = 375 \pm 5$ h and amplitude $A = 0.55 \pm 0.05$. There were indications of a secondary component with $P = 15.15 \pm 0.02$ h and $A = 0.10$ mag. However, the data were of insufficient precision to confirm that with sufficient confidence.

(69406) 1995 SX48. This asteroid was initially observed in late 2010 September as part of the ongoing program at PDO involving the Hungaria asteroids. The initial analysis found a period and amplitude that made the object a good candidate to be binary (2 <

$P < 5$ h, $A < 0.25$ mag, $D < 10$ km). Analysis of the final data set of 625 data points yielded a period of $P = 2.2431 \pm 0.0002$ h and $A = 0.13 \pm 0.01$ mag but no evidence of mutual events (occultations and/or eclipses) or a second period that could be attributed to a satellite. A period of $P = 4.4861 \pm 0.0002$ h, with resulting bimodal solution and amplitude also $A = 0.13$ mag, cannot be formally excluded and, in fact, is just about as likely.







Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNX10AL35G, by National Science Foundation grant AST-1032896, and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society. This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation.

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PHOTOMETRIC OBSERVATIONS AND ANALYSIS OF 1082 PIROLA

Ronald E. Baker
Indian Hill Observatory (H75)
Chagrin Valley Astronomical Society
PO Box 11, Chagrin Falls, OH 44022 USA
rbaker52@gmail.com

Frederick Pilcher
4438 Organ Mesa Loop
Las Cruces, NM 88011 USA

Vladimir Benishek
Belgrade Astronomical Observatory
Volgina 7, Belgrade 38 SERBIA

(Received: 15 January)

CCD observations of the main-belt asteroid 1082 Pirola were recorded during the period 2010 October to 2011 January. Analysis of the lightcurve found a synodic period of $P = 15.8525 \pm 0.0005$ h and amplitude $A = 0.53 \pm 0.01$ mag. The phase curve referenced to mean magnitude suggests the absolute magnitude and phase slope parameter: $H = 10.507 \pm 0.014$ mag; $G = 0.080 \pm 0.016$. The phase curve referenced to maximum light suggests: $H = 10.320 \pm 0.013$ mag; $G = 0.107 \pm 0.016$.

Our collaborative observing campaign was conducted with a variety of telescopes and CCDs. Baker recorded observations at Indian Hill Observatory (IHO) using a 0.3-m Schmidt-Cassegrain telescope (SCT) reduced to f/5.1 coupled with an SBIG ST-402ME CCD. Pilcher recorded observations at Organ Mesa Observatory (OMO) using a 0.35-m SCT at f/10 coupled with an SBIG STL-1001E CCD. Benishek recorded observations at the Belgrade Astronomical Observatory (BAO) using a 0.40-m SCT at f/10 coupled with an SBIG ST-10XME CCD. In addition to the instruments at our local observatories, Baker recorded observations with robotic telescopes located at the Tzec Maun Observatory

(TMO) near Mayhill, NM, including a 0.4-m Ritchey-Chretien Telescope (RCT) at f/9 coupled with an SBIG STL-6303E CCD and a 0.35-m Maksutov-Newtonian telescope (MNT) at f/3.9 coupled with an SBIG ST-10ME CCD. All images recorded during the observing campaign were calibrated with dark and flat field frames.

Unfiltered observations were recorded at IHO, OMO and BAO local observatories during 17 separate time series sessions (Table I). *MPO Canopus* software (BDW Publishing, 2010) was used by all authors to perform differential photometry and period analysis. The data were binned in sets of 3 with a maximum time interval of 5 minutes. The bimodal composite lightcurve (1) suggests period $P = 15.8525 \pm 0.0005$ h, and amplitude $A = 0.53 \pm 0.01$ mag (Figure 1). Since the amplitude changed during the apparition, we also constructed lightcurves using 2 subsets of the observing sessions. Composite lightcurve (2A) is from time series sessions 1-14, when the phase angle (α) was between -9 and +3 degrees (Figure 2). Composite lightcurve (2B) is from the time series sessions 15-17, when phase angle $\alpha > 12$ degrees (Figure 3).

Phase Curve and H-G Parameters

Individual CCD observations with Bessel V filters were recorded throughout the apparition (Table I) and used to construct the phase curves. Standard V magnitudes of the asteroid were derived from the instrumental magnitudes using differential photometry. Formula 1 was used to estimate the standard V magnitudes of the comparison stars

$$V = 0.628*(J-K) + 0.995*r' \qquad (1)$$

where V is the estimated standard V band magnitude, J and K are magnitude bands from the Two-Micron All-Sky Survey, and r' is a magnitude band from the Sloan Digital Sky Survey (Dymock and Miles, 2009).

Depending on the field of view in our images, 5 to 20 stars of the proper color were usually available for use as comparisons and whose calculated standard V magnitudes were reasonably consistent with their corresponding instrumental magnitudes. The comparison star selection and data reduction were performed with *Astrometrica* software (Raab, 2010). The overall error stated for each data point in the table is a combination of the error as a function of the signal to noise ratio and the measure of the uncertainty in the comparison star magnitudes.

The observed magnitude of the asteroid in each observation was corrected for the varying brightness due to rotation by comparing the point on the lightcurve at the time of each observation with both mean magnitude and maximum light. Brightness variance due to changing orbital geometry was also removed by calculating reduced magnitudes with formula 2:

$$Vr = Vo - 5.0 \log(Rr) \qquad (2)$$

where Vr is the reduced magnitude, Vo is the observed magnitude, *R* is the Sun-asteroid distance, and *r* is the Earth-asteroid distance, both in AU (Warner, 2007). The Lightcurve Ephemeris and H-G Calculator utilities in *MPO Canopus* greatly facilitated this process.

The amplitude corrections for all data point observations were referenced to the mean magnitude in lightcurve (1). The resulting phase curve (A) indicates the absolute magnitude $H = 10.507 \pm 0.014$ mag, and the phase slope parameter $G = 0.080 \pm 0.016$ (Figure 4). However, since the lightcurve data show that the amplitude changed during the apparition, we note that the mean magnitude might not be the best reference for the amplitude corrections. So, using lightcurves 2A and 2B, we referenced the amplitude corrections for all data points to maximum light. In this case, data points recorded when $\alpha \leq 11$ degrees were corrected using lightcurve (2A). Data points recorded when $\alpha > 11$ degrees were corrected using lightcurve (2B). The resulting phase curve (B) indicates the absolute magnitude $H = 10.320 \pm 0.013$ mag, and the phase slope parameter $G = 0.107 \pm 0.016$ (Figure 5). We note that the larger amplitude corrections referenced to maximum light at the higher phase angles tend to reduce the slope of the curve, resulting in the corresponding increase in the G value.

We found no previous observational data in the literature for the asteroid's period, amplitude, and H-G parameters. However, according to the Planetary Data System (Neese, 2010), 1082 Pirola is a member of the C taxonomic class (Tholen, 1989). The Supplemental IRAS Minor Planet Survey (Tedesco *et al.*, 2002) indicates the asteroid's absolute magnitude, albedo, and diameter to be 10.41 mag, 0.0655, and 43.01 km, respectively. Correlation studies by Harris (1989) shows that members of the C taxonomic class are part of a group with albedo $pv = 0.058 \pm 0.004$ and mean phase slope parameter $G = 0.086 \pm 0.015$.

The relation $a/b = 10^{(0.4dm)}$ is often used to estimate the equatorial elongation of an asteroid from the amplitude of variation, dm. This relation follows directly from the definition of geometric scattering at zero phase angle and equatorial viewing direction. Generally, the amplitude of variation is larger at increasing phase angle, and smaller at non-equatorial viewing aspect, so the above relation is only an approximation, roughly valid when the viewing direction is not too far off equatorial and the phase angle is not large, say less than 15 degrees or so (A.W. Harris, private communication).

We estimate dm to be 0.47 mag at minimum α. Therefore the equatorial elongation is calculated to be 1.54 using this relation. Since we do not know the viewing direction, the ratio of maximum to minimum equatorial radii must be expressed ≥ 1.54.

Based on the absolute magnitude derived from our observations, and the albedo value from SIMPS, we calculate the diameter of 1082 Pirola to be 45 kilometers with the formula 3:

$$\log D = 3.125 - 0.2H - (0.5*\log(pv)) \qquad (3)$$

where *D* is the diameter (km), *H* is the absolute magnitude and *pv* is the geometric albedo in the V band (Warner, 2007).

Acknowledgements

We wish to thank the Tzec Maun Foundation for the use of their robotic telescopes during this project. We express our appreciation to Alan W. Harris, Brian D. Warner, and Richard Miles for their advice, especially with regards to extrapolating observed magnitudes to maximum light.

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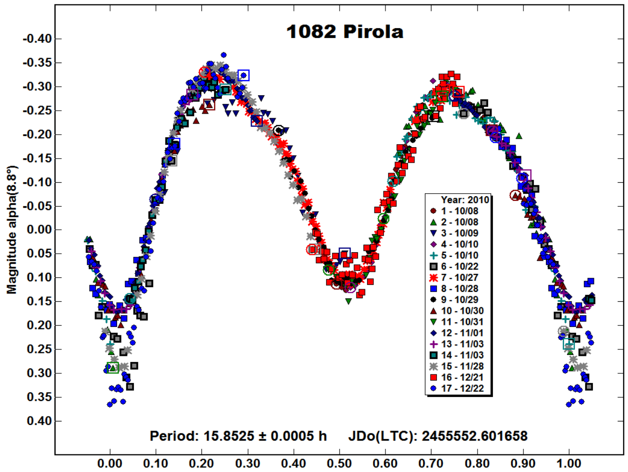

Figure 1. 1082 Pirola composite lightcurve.

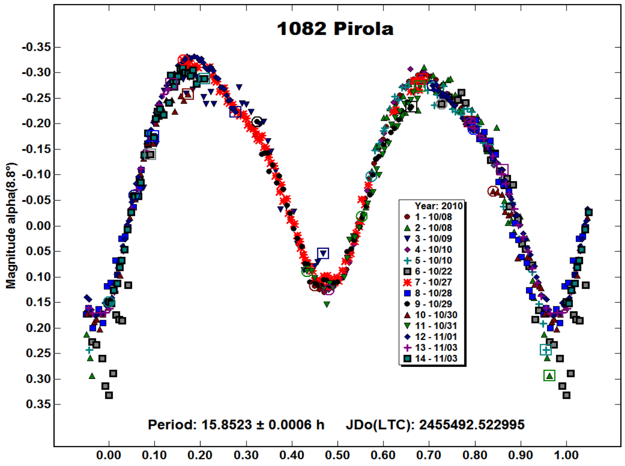

Figure 2. 1082 Pirola composite lightcurve at -9 < α < +3 degrees.

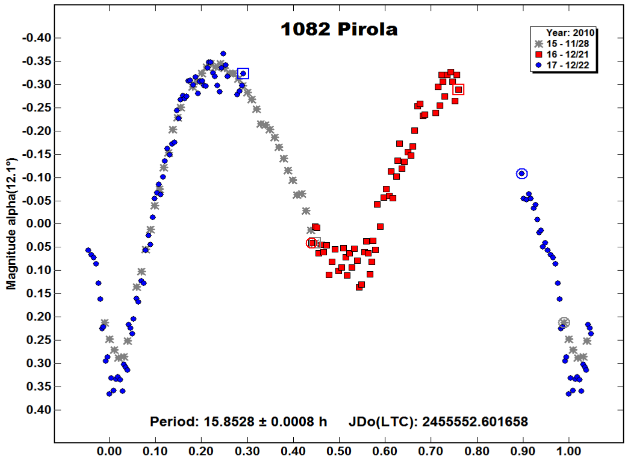

Figure 3. 1082 Pirola composite lightcurve at α > +12 degrees.

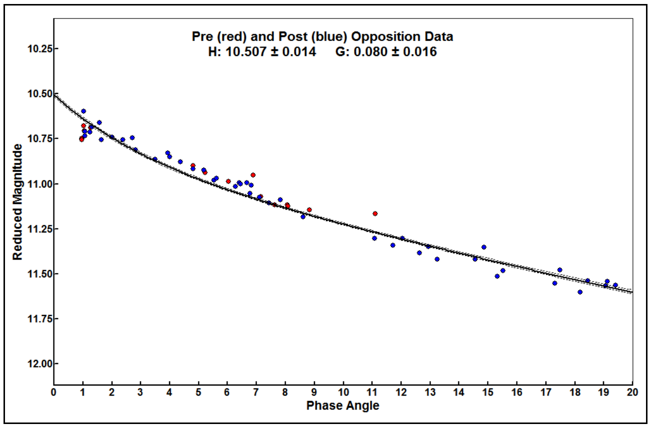

Figure 4. 1082 Pirola phase curve referenced to mean magnitude.

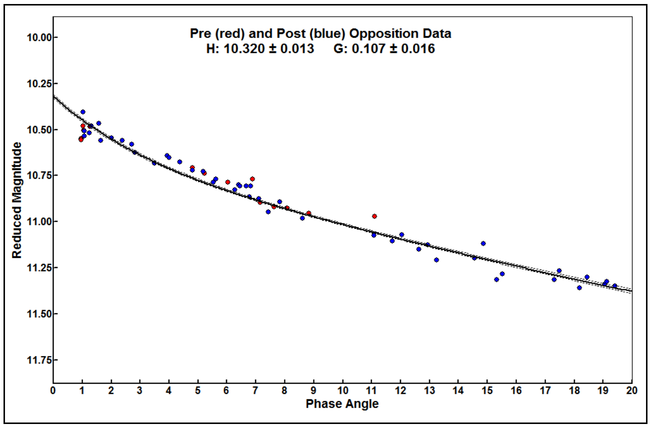

Figure 5. 1082 Pirola phase curve referenced to maximum light.

Date 2010	UT hh:mm	Observatory	Phase Angle	TS length h.h	Dpt SNR	Observed V mag	Mean mag correction	Max light correction
Oct 02	06:41	IHO	-11.11		102	14.632 ± 0.028	+0.007 (1)	-0.188 (2A)
Oct 08	05:57	IHO	-8.84	5.5	121	14.500 ± 0.022	+0.092 (1)	-0.100 (2A)
Oct 08	23:30	BAO	-8.54	6.5				
Oct 09	23:40	BAO	-8.15	6.5				
Oct 10	04:20	OMO	-8.08		118	14.680 ± 0.022	-0.113 (1)	-0.312 (2A)
Oct 10	05:27	IHO	-8.06	6.0	110	14.472 ± 0.028	+0.084 (1)	-0.106 (2A)
Oct 10	23:45	BAO	-7.75	6.0				
Oct 11	07:54	OMO	-7.62		101	14.420 ± 0.023	+0.136 (1)	-0.064 (2A)
Oct 12	11:37	OMO	-7.15		129	14.700 ± 0.022	-0.194 (1)	-0.371 (2A)
Oct 13	03:41	IHO	-6.88		104	14.518 ± 0.037	-0.132 (1)	-0.315 (2A)
Oct 15	04:14	OMO	-6.04		93	14.297 ± 0.023	+0.119 (1)	-0.082 (2A)
Oct 17	03:47	OMO	-5.22		92	14.250 ± 0.029	+0.118 (1)	-0.084 (2A)
Oct 18	03:51	OMO	-4.80		87	14.220 ± 0.027	+0.107 (1)	-0.085 (2A)
Oct 22	23:20	BAO	-2.80	6.0				
Oct 27	03:09	OMO	-1.27	8.5	123	13.927 ± 0.019	+0.200 (1)	-0.003 (2A)
Oct 28	03:02	OMO	-1.04		120	13.970 ± 0.028	+0.177 (1)	-0.024 (2A)
Oct 28	04:37	IHO	-1.03		144	14.048 ± 0.031	+0.071 (1)	-0.124 (2A)
Oct 28	20:19	BAO	-0.96	5.0	131	14.110 ± 0.040	+0.082 (1)	-0.111 (2A)
Oct 29	03:09	OMO	+0.95		117	14.013 ± 0.028	+0.188 (1)	-0.018 (2A)
Oct 29	20:05	BAO	+1.02	5.6	155	13.942 ± 0.094	+0.105 (1)	-0.089 (2A)
Oct 30	02:54	OMO	+1.07		114	13.993 ± 0.022	+0.165 (1)	-0.036 (2A)
Oct 30	04:28	IHO	+1.08		126	14.136 ± 0.039	+0.048 (1)	-0.150 (2A)
Oct 30	20:12	BAO	+1.24	5.5	89	14.108 ± 0.042	+0.058 (1)	-0.139 (2A)
Oct 31	02:56	OMO	+1.32		118	13.963 ± 0.025	+0.176 (1)	-0.029 (2A)
Oct 31	21:23	BAO	+1.56	4.0	84	14.237 ± 0.042	-0.121 (1)	-0.313 (2A)
Nov 01	02:58	OMO	+1.65	9.0	119	14.083 ± 0.016	+0.129 (1)	-0.067 (2A)
Nov 02	03:17	OMO	+2.02		119	14.093 ± 0.025	+0.112 (1)	-0.084 (2A)
Nov 03	02:46	IHO	+2.39	5.5	141	14.112 ± 0.033	+0.110 (1)	-0.085 (2A)
Nov 03	21:27	BAO	+2.70	5.5	86	14.528 ± 0.054	-0.311 (1)	-0.477 (2A)
Nov 04	03:51	OMO	+2.81		107	14.287 ± 0.020	-0.002 (1)	-0.189 (2A)
Nov 05	20:29	BAO	+3.49		104	14.563 ± 0.051	-0.216 (1)	-0.398 (2A)
Nov 06	23:24	BAO	+3.94		89	14.217 ± 0.048	+0.103 (1)	-0.087 (2A)
Nov 07	03:32	OMO	+4.01		99	14.407 ± 0.020	-0.068 (1)	-0.266 (2A)
Nov 08	01:26	IHO	+4.38		106	14.218 ± 0.029	+0.158 (1)	-0.045 (2A)
Nov 09	02:14	OMO	+4.80		93	14.373 ± 0.023	+0.049 (1)	-0.148 (2A)
Nov 10	01:31	IHO	+5.18		110	14.324 ± 0.017	+0.111 (1)	-0.085 (2A)
Nov 10	21:25	BAO	+5.53		101	14.580 ± 0.041	-0.082 (1)	-0.277 (2A)
Nov 11	02:24	OMO	+5.61		85	14.513 ± 0.024	-0.023 (1)	-0.224 (2A)
Nov 12	18:39	BAO	+6.26		102	14.660 ± 0.023	-0.111 (1)	-0.300 (2A)
Nov 13	02:24	OMO	+6.40		150	14.640 ± 0.021	-0.109 (1)	-0.305 (2A)
Nov 13	05:24	IHO	+6.44		115	14.488 ± 0.033	+0.051 (1)	-0.147 (2A)
Nov 13	18:28	BAO	+6.65		102	14.694 ± 0.051	-0.158 (1)	-0.348 (2A)
Nov 14	01:52	OMO	+6.78		102	14.640 ± 0.015	-0.044 (1)	-0.232 (2A)
Nov 14	03:40	TMO-RCT	+6.81		121	14.773 ± 0.022	-0.222 (1)	-0.421 (2A)
Nov 14	22:26	BAO	+7.11		101	14.453 ± 0.051	+0.172 (1)	-0.026 (2A)
Nov 15	19:15	BAO	+7.44		116	14.990 ± 0.051	-0.323 (1)	-0.485 (2A)
Nov 16	19:35	BAO	+7.82		81	14.831 ± 0.041	-0.172 (1)	-0.370 (2A)
Nov 18	22:19	BAO	+8.60		115	14.600 ± 0.031	+0.172 (1)	-0.029 (2A)
Nov 26	01:35	OMO	+11.09		115	15.130 ± 0.022	-0.162 (1)	-0.390 (2B)
Nov 28	01:27	OMO	+11.72		108	15.140 ± 0.022	-0.107 (1)	-0.345 (2B)
Nov 28	23:40	IHO	+12.05	7.5	88	14.848 ± 0.019	+0.158 (1)	-0.074 (2B)
Dec 01	01:31	OMO	+12.64		128	15.040 ± 0.022	+0.073 (1)	-0.164 (2B)
Dec 02	02:49	OMO	+12.95		140	14.910 ± 0.013	+0.178 (1)	-0.045 (2B)
Dec 03	03:12	OMO	+13.24		137	14.980 ± 0.022	+0.192 (1)	-0.020 (2B)
Dec 08	01:32	OMO	+14.56		118	15.060 ± 0.022	+0.179 (1)	-0.042 (2B)
Dec 09	06:48	TMO-MNT	+14.86		149	15.320 ± 0.021	-0.133 (1)	-0.368 (2B)
Dec 11	05:20	OMO	+15.32		102	15.603 ± 0.015	-0.225 (1)	-0.428 (2B)
Dec 12	01:26	OMO	+15.51		132	15.200 ± 0.022	+0.157 (1)	-0.042 (2B)
Dec 21	06:06	OMO	+17.31	5.0	119	15.400 ± 0.022	+0.159 (1)	-0.079 (2B)
Dec 22	06:59	OMO	+17.48	6.5	91	15.310 ± 0.016	+0.190 (1)	-0.023 (2B)
Dec 27	03:29	TMO-MNT	+18.18		88	15.700 ± 0.022	-0.007 (1)	-0.249 (2B)
Dec 29	03:38	TMO-MNT	+18.42		165	15.573 ± 0.021	+0.088 (1)	-0.151 (2B)
Jan 04	03:20	TMO-MNT	+19.05		65	15.600 ± 0.018	+0.177 (1)	-0.052 (2B)
Jan 05	02:34	TMO-MNT	+19.13		91	15.584 ± 0.027	+0.183 (1)	-0.037 (2B)
Jan 09	03:42	TMN-MNT	+19.41		142	15.700 ± 0.021	+0.147 (1)	-0.070 (2B)

Table I. Summary of observations. LC identifier (1) = sessions 1-17, (2A) = sessions 1-14, and (2B) = sessions 15-17.

ASTEROIDS OBSERVED FROM GMARS AND SANTANA OBSERVATORIES: 2010 OCTOBER - DECEMBER

Robert D. Stephens
Goat Mountain Astronomical Research Station (GMARS)
11355 Mount Johnson Court, Rancho Cucamonga, CA 91737
RStephens@foxandstephens.com

(Received: 15 January)

Lightcurves for two asteroids were obtained from Santana and GMARS Observatories from 2010 October to December: 571 Dulcinea and 1177 Gonnessia.

Observations at Santana Observatory (MPC Code 646) were made with a 0.30-m Schmidt-Cassegrain (SCT) with a SBIG STL-1001E. Observations at GMARS (Goat Mountain Astronomical Research Station, MPC G79) were made with a 0.35-m SCT using SBIG STL-1001E CCD Camera. All images were unguided and unbinned with no filter. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (1989). The asteroids were selected from the list of asteroid photometry opportunities published on the Collaborative Asteroid Lightcurve Link (CALL) website (Warner et al. 2010).

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

<u>571 Dulcinea</u>. Images on 11/12 and 11/13 were taken at GMARS. All others were taken at Santana Observatory. Based upon a single night's observations in February 2004, Behrend (2010) reported the period was approximately 24 h. Once a single rotational period was completed, Ducinea started showing signs of being a classic tumbler. The asteroid completed 6 rotational cycles during the observing run, with each cycle following a different Fourier curve. Petr Pravec (private communication) reported that a second period cannot be uniquely determined from the available data. A second period of 150 h is one of several possible solutions. The 126.3 h period is presented here as the primary period.

<u>1177 Gonnessia</u>. All images were obtained at Santana. Behrend (2010) reported a period of approximately 12 hours with an amplitude of about 0.25 magnitudes using a partial lightcurve from a single night in July 2002. Warner (2003) observed Gonnessia in for five nights July 2002, including the same night as Behrend. Warner remeasured his original images and reports the sparse 2002 data has a best fit to a 42 or 80 h period (private communication). The L_{PAB} was 312 for the 2002 observations. All nights observed in 2010/11 showed a small amplitude. It was difficult to differentiate between competing period solutions. Periods of about 35 h and 63 hours continues to be possibilities.

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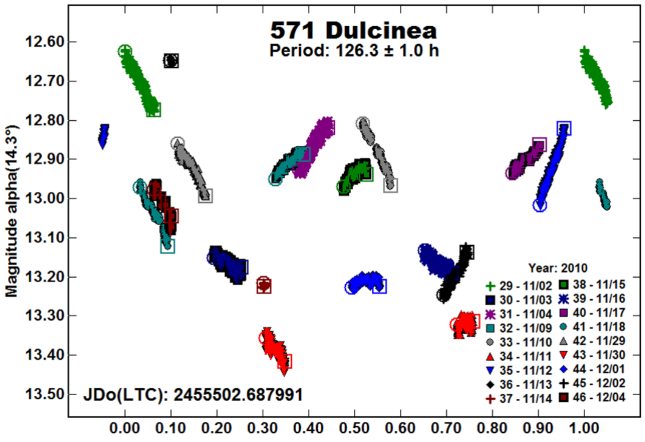
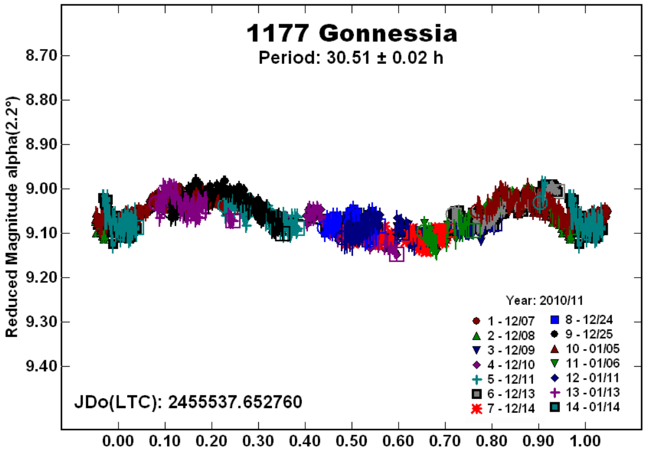
Warner, B.D., Harris, A.W., and Pravec, P. (2010). Lightcurve Targets *http://www.MinorPlanetObserver.com/astlc/default.htm.*





#	Name	mm/dd 2010/11	Data Pts	α	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
571	Dulcinea	11/02 - 12/04	2,675	14.4, 4.9, 8.0	60	6	126.3	1.0		
1177	Gonnessia	12/07 - 01/14	1,771	2.2, 0.9, 10.8	80	-4	30.51	.02	0.10	0.02

PRELIMINARY RESULTS FROM A STUDY OF TROJAN ASTEROIDS

Linda M. French
Department of Physics
Illinois Wesleyan University
P.O. Box 2900
Bloomington, IL 61702 USA
lfrench@iwu.edu

Robert D. Stephens
Goat Mountain Astronomical Research Station (GMARS)
Rancho Cucamonga, CA 91737

Susan M. Lederer
NASA JSC/Cal State Univ. San Bernardino
Houston, TX USA

Daniel R. Coley
Goat Mountain Astronomical Research Station (GMARS)
Corona, CA 92882

Derrick A. Rohl
Illinois Wesleyan University
Bloomington, IL USA

(Received: 15 January)

Lightcurve results are presented for 13 Jupiter Trojan asteroids from observations obtained at Cerro Tololo Interamerican Observatory and GMARS Observatory from October 2009 to January 2011.

Observations

Observations at GMARS (Goat Mountain Astronomical Research Station, MPC G79) were made by Stephens and Coley with three telescopes, all were 0.35-m SCTs, two using a SBIG STL-1001E CCD Cameras and the other using a SBIG ST-9e CCD camera. All images were unbinned with no filter. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *MPO Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (1989). Observations at CTIO (Cerro Tololo Interamerican Observation, MPC 807) were made with the CTIO 1.0-m or 0.9-m telescopes. All images taken at CTIO were unbinned; V and R filters were used. Data and period analysis was done using MPO Canopus.

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

1172 Aneas. Hartman (1988) reported a period of 8.33 h, in fair agreement with our period of 8.705 ± 0.001 h. Observations on July 22 were taken by Lederer and Rohl at CTIO. Observations from August 5 – 9 were taken by Stephens at GMARS.

1404 Ajax. Hartman (1988) reported a period of 34 h. Behrend (2010) reported a period of 28.4 h from a single night of observations in October 2009 covering less than one quarter of the phased lightcurve. Both results reasonably agree with our period of 29.38 ± 0.01 h.

1749 Telamon. No previous period has been reported. Telamon showed a low amplitude, irregular lightcurve *P* = 19.675 ± 0.001 h, with repeating features over the six week observing run at GMARS.

2241 Alcathous. De Sanctis (1994) reported a period of 9.41 h. Our data could not be phased to a period around nine hours. Observations on June 25 and 26 were obtained during French's service observing run at CTIO. All others were by Stephens at GMARS. We find *P* = 7.690 ± 0.001 h.

2357 Phereclos. No previous period has been reported. We find *P* = 7.16 ± 0.01 h. While observing Phereclos at CTIO, French and Stephens noticed a second asteroid in the field which turned out to be 878 Mildred. Mildred was originally discovered on September 6, 1916, by Seth Nicholson (1916) and Harlow Shapley using the 1.5 m Telescope at Mount Wilson Observatory. It was then lost for 75 years. The asteroid was named for Shapley's infant daughter "Mildred". Mildred's rotational period was determined to be 2.660 h. Mildred Shapley Matthews commented "I want to thank you… for your work on Mildred 878 that evidentially got in the way of your original goal. The same thing happened to my father!" (private communication).

2797 Teucer. Binzel (1992) reported a period of 14.8 h based upon two nights of observations separated by 44 hours. This appears to be an alias of our period of 10.145 ± 0.001 h.

3063 Makhaon. Binzel (1992) reported a period of 17.3 h based upon two consecutive nights of observations. Behrend (2010) reported a period of 2.6 h based upon a single night of observations where the amplitude was ~0.02 magnitudes. The Binzel period appears to be an alias of our 8.64 ± 0.01 h period.

3451 Mentor. Sauppe (2007) reported a period of 7.70 h. Duffard (2008) reported a period of 7.682 h. Melita (2010) reported a period of 7.68 h. Behrend (2010) reported a period of 7.699 h. Phasing our data to these periods resulted in some nights not lining up by a quarter of the phase. The Sauppe period was obtained over three 3 nights spanning 4 days in 2007. The Behrend period is from a single night in August 2010 which does not appear to complete a full rotational period. We find the best result for *P* = 7.730 ± 0.001 h.

3540 Protesilaos. No previous period has been reported. The two nights were observed at GMARS. We find *P* = 8.95 ± 0.01 h.

(4489) 1988 AK. No previous period has been reported. French and Lederer measured a period of 12.6 h in October 2009. Stephens obtained a period of 12.58 ± 0.01 h in September 2010.

4834 Thoas. No previous period has been reported. Coley and Stephens measured P = 18.192 ± 0.001 h in October 2010. French and Lederer obtained a period of 18 hours in October 2009.

4867 Polites. No previous period has been reported. French and Stephens obtained sparse data over 5 nights at CTIO to determine the low amplitude lightcurve with *P* = 9.21 ± 0.01 h.

Period Analysis

All targets were followed sufficiently to determine a period in order to minimize the likelihood of observation bias. We stress that no asteroids have been abandoned due to long period or low amplitude light curves.

Typical main-belt asteroid rotation periods are in the 3-15 hour range. Molnar *et al.* (2008) designed a study of Trojan rotation periods that would not introduce bias against slow rotators; once an asteroid was on the observing list it stayed on the list until a period was found. The median rotation period for Trojans in the 60 — 170 km size range was 18.9 hours. Molnar *et al.* (2008) found a median value of 11.5 hours for 396 MBAs in the same size range. Our new results give a somewhat different picture. The median period for our sample, which includes 23 objects reported by Stephens (2008, 2010) and French *et al.* (2010), is 9.7 hours, considerably less than that for MBAs in the same size range. A histogram showing rotation frequency for all reported Trojan asteroids of diameter greater than 70 km is shown in Figure 1. The median rotation period for all Trojans greater than 70 km in diameter reported to date, including our new data, is 17.2 hours. We note that the rotation periods of the approximately 18 Trojans larger than 100 km in diameter have been almost completely sampled, while data are available for only 21 of the 50 objects between 50 and 100 km in diameter. Trojans of diameter less than 50 km have to date been only sparsely studied. A full picture of Trojan rotation properties (and, hopefully, information about their history) will only emerge as more data become available.

Acknowledgements

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#	Name	Diam.	mm/dd 2010	Obser.	α	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
1172	Aneas	143	07/22 – 08/05	RDS, SL, DR	4.1, 3.8, 4.2	305	16	8.705	0.001	0.20	0.02
1404	Ajax	82	11/27 – 01/15/2011	RDS	4.7, 9.1	72	20	29.38	0.01	0.30	0.03
1749	Telamon	81	09/03 – 10/17	RDS	11.6, 5.7	47	5	16.975	0.001	0.10	0.02
2241	Alcathous	115	06/05 – 09/06	RDS, SL, DR	6.6, 1.2, 9.8	286	5	7.690	0.001	0.20	0.03
2357	Phereclos	95	08/13 – 08/18	LF, RDS	3.3, 4.3	305	2	7.16	0.01	0.05	0.02
2797	Teucer	111	09/11 – 10/11	DC	11.0, 8.0	55	-8	10.145	0.001	0.20	0.03
3063	Makhaon	116	12/05 – 01/09/2011	DC	1.7, 6.9	75	7	8.64	0.01	0.15	0.03
3451	Mentor	134	08/07 – 09/17	DC, RDS	4.8, 9.2	312	19	7.730	0.001	0.21	0.03
3540	Protesilaos	88	10/30 – 10/31	RDS	6.5, 6.3	65	15	8.95	0.02	0.10	0.02
3709	Polypoites	99	10/30 – 10/31	RDS	4.7, 4.5	52	-15	5.71	0.02	0.12	0.02
4489	1998 AK	93	10/17/09 – 10/19/09 09/04 – 09/12	LF, SL RDS	5.9, 6.1 10.5, 9.9	42	-18	12.6 12.58	0.1 0.01	0.21 0.20	0.03
4834	Thoas	87	10/30 – 11/14	DC, RDS	5.4, 3.2	55	-13	18.192	0.001	0.22	0.03
4867	Polites	73	08/13 – 08/19	LF, RDS	5.2, 5.9	302	-17	9.21	0.01	0.09	

Table I: Observing Results

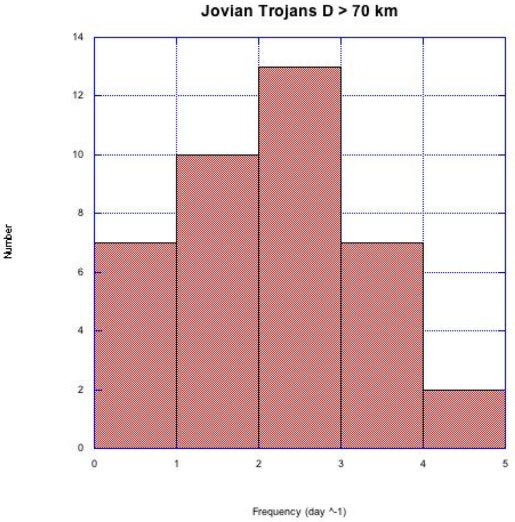
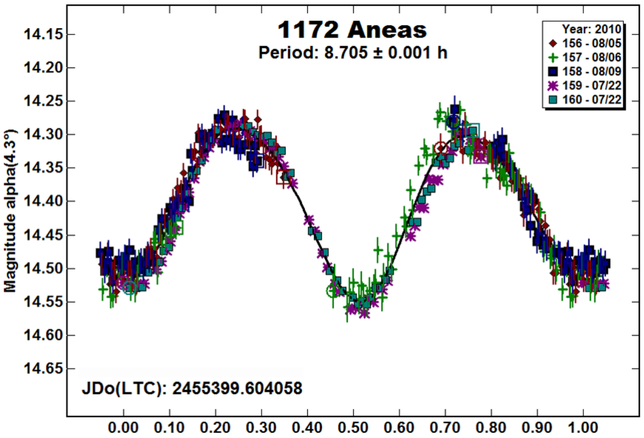
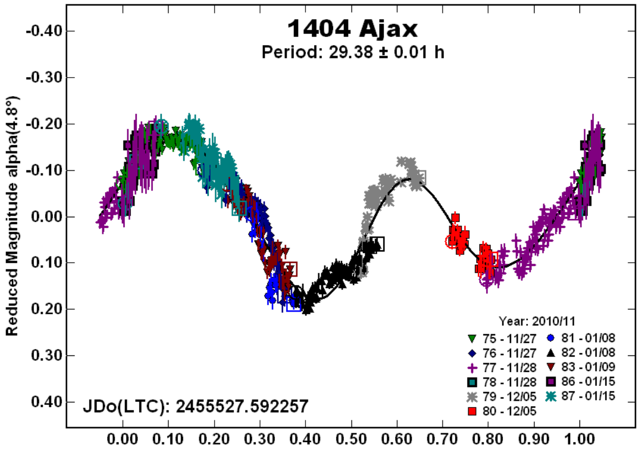
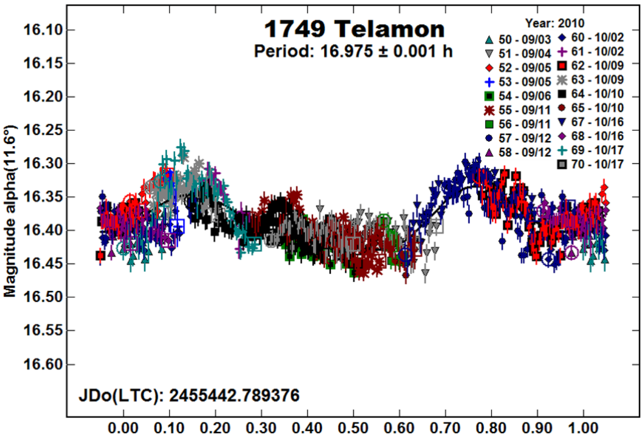
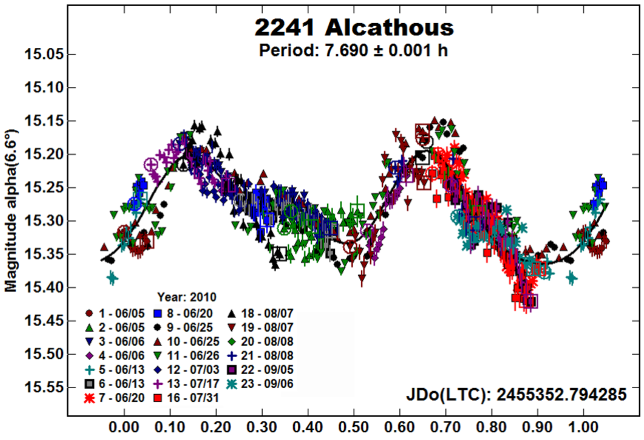


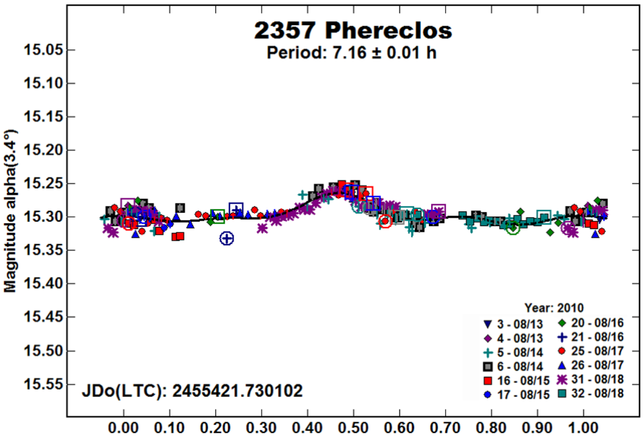
Figure 1: A histogram of rotational frequencies (rev/day) for Trojans larger than 70 km in diameter.

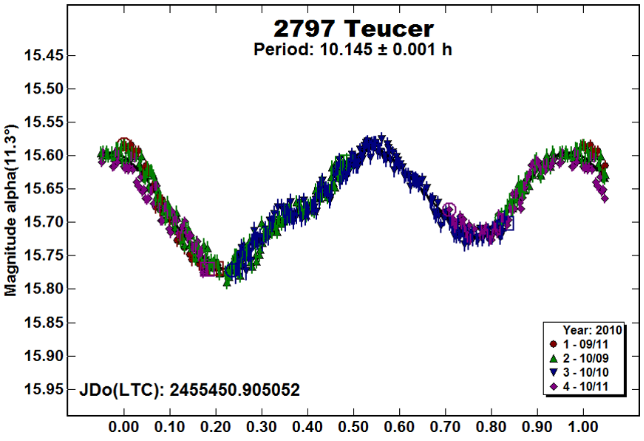


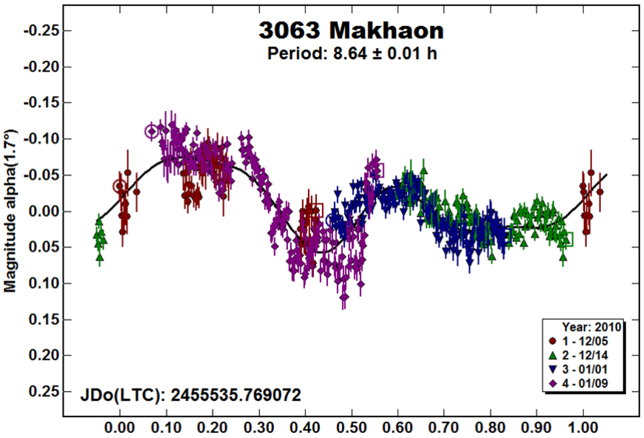








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Period: 8.64 ± 0.01 h
Magnitude alpha(1.7°)
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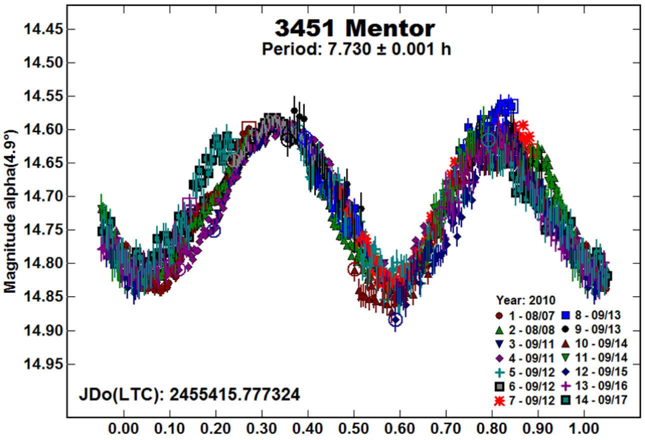
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
1 - 12/05
2 - 12/14
3 - 01/01
4 - 01/09
JDo(LTC): 2455535.769072


3451 Mentor
Period: 7.730 ± 0.001 h
Magnitude alpha(4.9°)
14.45
14.50
14.55
14.60
14.65
14.70
14.75
14.80
14.85
14.90
14.95
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
1 - 08/07
2 - 08/08
3 - 09/11
4 - 09/11
5 - 09/12
6 - 09/12
7 - 09/12
8 - 09/13
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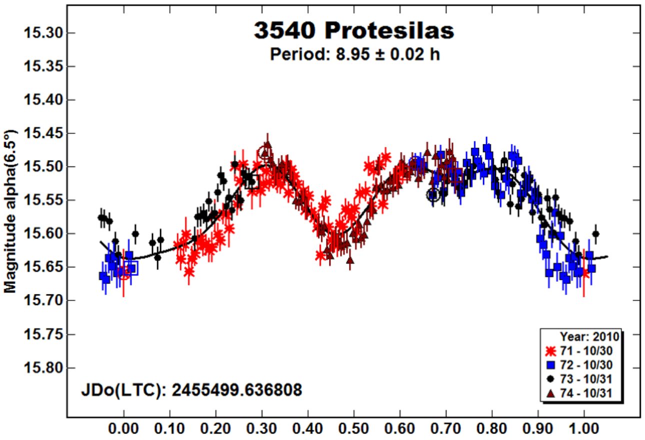
3540 Protesilas
Period: 8.95 ± 0.02 h
Magnitude alpha(6.5°)
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15.35
15.40
15.45
15.50
15.55
15.60
15.65
15.70
15.75
15.80
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
71 - 10/30
72 - 10/30
73 - 10/31
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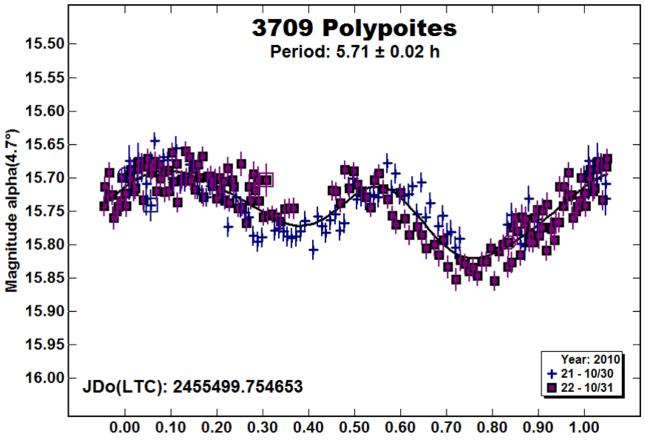
3709 Polypoites
Period: 5.71 ± 0.02 h
Magnitude alpha(4.7°)
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15.55
15.60
15.65
15.70
15.75
15.80
15.85
15.90
15.95
16.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
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0.80
0.90
1.00
Year: 2010
21 - 10/30
22 - 10/31
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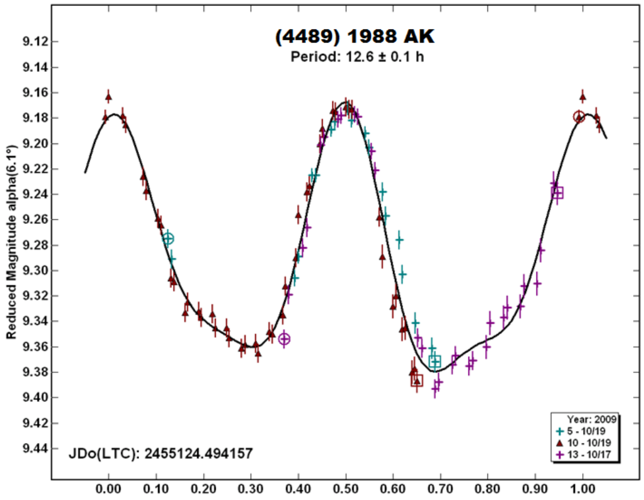
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Period: 12.6 ± 0.1 h
Reduced Magnitude alpha(6.1°)
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9.14
9.16
9.18
9.20
9.22
9.24
9.26
9.28
9.30
9.32
9.34
9.36
9.38
9.40
9.42
9.44
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2009
5 - 10/19
10 - 10/19
13 - 10/17
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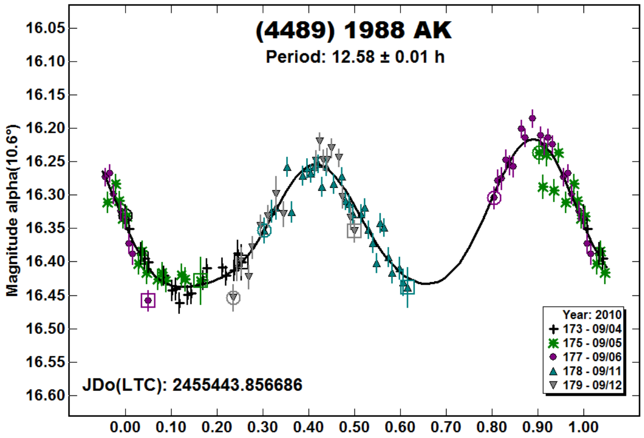
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Period: 12.58 ± 0.01 h
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16.10
16.15
16.20
16.25
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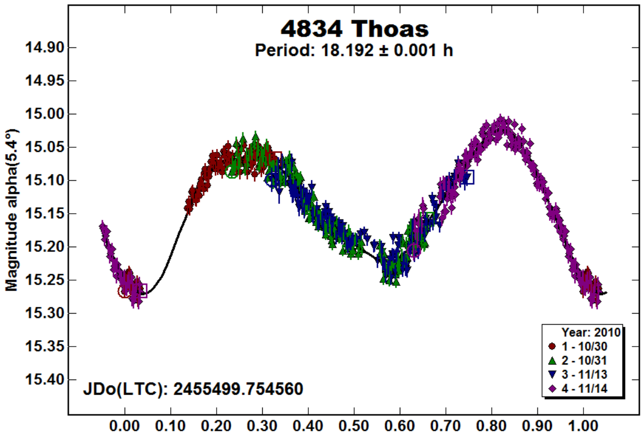
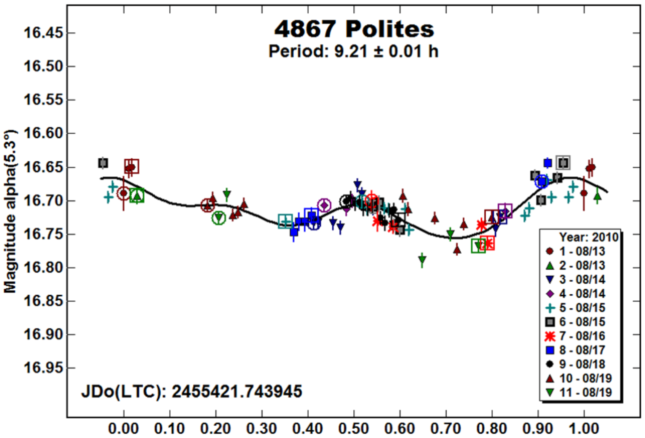
16.35
16.40
16.45
16.50
16.55
16.60
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
173 - 09/04
175 - 09/05
177 - 09/06
178 - 09/11
179 - 09/12
JDo(LTC): 2455443.856686


4834 Thoas
Period: 18.192 ± 0.001 h
Magnitude alpha(5.4°)
14.90
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
1 - 10/30
2 - 10/31
3 - 11/13
4 - 11/14
JDo(LTC): 2455499.754560



ROTATIONAL PERIOD DETERMINATION FOR 4289 BIWAKO

Luis E. Martinez
Lenomiya Observatory H13
515 E. Barrus Place
Casa Grande, AZ, USA 85122
kd7gmk@gmail.com

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Observations of main-belt minor planet 4289 Biwako were undertaken by Lenomiya Observatory in December 2010 revealing a period of 4.4185 ± 0.0005 h.

Observations at the Lenomiya Observatory were conducted with a Celestron CPC1100 0.28-m Schmidt-Cassegrain with a focal length of 1.943 m, and a ratio of f/6.3 with a focal reducer. The CCD used was a Santa Barbara Instruments Group ST8XME, unfiltered, guided, at -20 C and binned by 2 resulting in an array of 765 x 510 at 18-micron per pixels and 1.92 arcseconds per pixel. The 351 images were exposed for 140 s and calibrated using *CCDSoft* version 5.00.186 and measured using *MPO Canopus* version 10.2.0.2 (Warner, 2009).

4289 Biwako was discovered on October 29, 1989 by Japanese astronomer Atsushi Sugie, and it is named after the largest lake in Japan (MPC). The asteroid was selected from Brian Warner's Collaborative Asteroid Lightcurve Link (CALL) site's Lightcurve Targets list (Warner, 2008). A search of the Asteroid Lightcurve Database does not reveal any previously reported results for 4289 Biwako. The analysis of the data disclosed a trimodal lightcurve with a period of 4.4185 ± 0.0005 h, and an amplitude of 0.11 ± 0.03 mag. Individual sessions spanned the complex section of the curve ruling out any bimodal or monomodal fit.

Acknowledgments

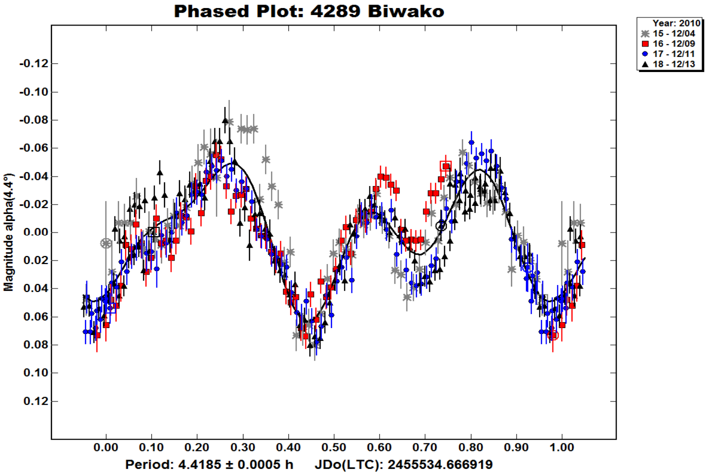
The author wishes to express gratitude to Eduardo Alvarez, Peter Caspari, David Higgins, and Brian Warner for their support and helpful suggestions on the *MPO Canopus* software, and period determination for asteroid 4289 Biwako.

References

Warner, B.D. (2008). "Potential Lightcurve Targets 2010 October 1 – December 31". http://www.minorplanetobserver.com/astlc/targets_4q_2008.htm

Warner, B.D. (2009). MPO Software, Canopus version 10.2.1.1 Bdw Publishing. http://minorplanetobserver.com

IAU Minor Planet Center. http://scully.cfa.harvard.edu/~cgi/ShowCitation.COM?num=4289



LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2011 APRIL-JUNE

Brian D. Warner
Palmer Divide Observatory/MoreData!
17995 Bakers Farm Rd.
Colorado Springs, CO 80908 USA
brian@MinorPlanetObserver.com

Alan W. Harris
MoreData!
La Canada, CA 91011-3364 USA

Petr Pravec
Astronomical Institute
CZ-25165 Ondřejov, CZECH REPUBLIC

Josef Ďurech
Astronomical Institute
Charles University in Prague
18000 Prague, CZECH REPUBLIC
durech@sirrah.troja.mff.cuni.cz

Lance A.M. Benner
Jet Propulsion Laboratory
Pasadena, CA 91109-8099 USA
lance@reason.jpl.nasa.gov

We present lists of asteroid photometry opportunities for objects reaching a favorable apparition having either no or poorly-defined lightcurve parameters, for which additional data will help with shape and spin axis modeling via lightcurve inversion. We also list objects that are planned targets for radar observations, for which lightcurves can help constrain pole solutions and/or remove rotation period ambiguities that might not come from using radar data alone.

We present four lists of "targets of opportunity" for the period 2011 April-June. For background on the program details for each of the opportunity lists, refer to previous issues, e.g., *Minor Planet Bulletin* **36**, 188. In the first three sets of tables, "Dec" is the declination, "U" is the quality code of the lightcurve, and "α" is the solar phase angle. See the asteroid lightcurve data base (LCDB) documentation for an explanation of the U code:

www.minorplanetobserver.com/astlc/LightcurveParameters.htm

Objects with U = 1 should be given higher priority when possible. *Do not overlook asteroids with* U = 2 *on the assumption that the period is sufficiently established.* Regardless, do not let the existing period influence your analysis since even high quality ratings have been proven wrong at times. Note that the lightcurve amplitude in the tables could be more or less than what's given. Use the listing only as a guide.

The first list is an *abbreviated list* of those asteroids reaching V < 14.5 at brightest during the period and have either no or poorly constrained lightcurve parameters. The goal for these asteroids is to find a well-determined rotation rate. A more complete list as well as one including objects V < 16.0 can be found on the CALL web site.

http://www.minorplanet.info/CALL/targets_2011_Q2.htm

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."

The third list is of those asteroids needing only a small number of lightcurves to allow spin axis and/or shape modeling. Those doing work for modeling should contact Josef Ďurech at the email address above and/or visit the Database of Asteroid Models from Inversion Techniques (DAMIT) web site for existing data and models: *http://astro.troja.mff.cuni.cz/projects/asteroids3D*

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

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

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

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

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

As always, we encourage observations of asteroids even if they have well-established lightcurve parameters and especially if they are lacking good spin axis and/or shape model solutions. Every lightcurve of sufficient quality supports efforts to resolve a number of questions about the evolution of individual asteroids and the general population. For example, pole directions are known for only about 30 NEAs out of a population of 6800. This is hardly sufficient to make even the most general of statements about NEA pole alignments, including whether or not the thermal YORP effect is forcing pole orientations into a limited number of preferred directions (see La Spina *et al.* 2004, *Nature* **428**, 400-401). Data from many apparitions can help determine if an asteroid's rotation rate is being affected by YORP, which can also cause the rotation rate of a smaller, irregularly-shaped asteroid to increase or decrease. See Lowry *et al.* (2007) *Science* **316**, 272-274 and Kaasalainen *et al.* (2007) *Nature* **446**, 420-422.

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

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Lightcurve Opportunities

		Brightest				LCDB Data	
#	Name	Date	Mag	Dec	U	Period	Amp
3156	Ellington	04 01.5	14.5	- 7	2	8.33	0.08-0.15
6511	Furmanov	04 04.0	15.0	-18			
2356	Hirons	04 08.4	14.9	- 4			
1466	Mundleria	04 10.1	14.1	+ 9			
3385	Bronnina	04 14.9	14.3	- 8			
531	Zerlina	04 19.0	14.7	+ 1	2	16.71	0.12-0.41

Lightcurve Opportunities (continued)

		Brightest				LCDB Data	
#	Name	Date	Mag	Dec	U	Period	Amp
3181	Ahnert	04 22.5	14.7	-13			
3033	Holbaek	04 23.7	14.9	- 6			
2008	Konstitutsiya	04 23.4	14.2	-22			
4362	Carlisle	04 25.8	14.8	-13			
3031	Houston	04 25.0	14.9	-21			
2438	Oleshko	04 27.8	14.3	-11			
2592	Hunan	04 28.9	15.0	-14			
2410	Morrison	04 28.0	14.5	-10			
7191	1993 MA1	04 29.5	14.9	-10			
2573	Hannu Olavi	04 30.2	14.9	- 9			
1238	Predappia	05 01.5	15.0	-11	2-	8.94	0.03
27708	1987 WP	05 03.6	14.5	-24			
983	Gunila	05 06.7	13.5	-26	1	long	0.25
1305	Pongola	05 06.1	14.2	-15	2	8.03	0.18
425	Cornelia	05 10.2	13.4	-16	2	17.56	0.19
2812	Scaltriti	05 12.2	14.9	-14			
1859	Kovalevskaya	05 13.2	14.6	-29			
2692	Chkalov	05 15.0	14.6	-19			
1775	Zimmerwald	05 16.6	14.7	- 5	?		
27064	1998 SY63	05 22.0	14.8	-22			
1455	Mitchella	05 23.1	14.7	- 6			
1167	Dubiago	05 25.8	14.2	-18	2	14.3	0.23
3313	Mendel	05 25.4	15.0	-31			
1706	Dieckvoss	05 25.1	14.0	-23			
2411	Zellner	05 26.9	14.5	-18			
896	Sphinx	05 29.2	13.1	-24	1	26.27	0.08
6975	Hiroaki	05 29.1	14.6	-30			
4666	Dietz	05 29.5	14.5	- 3			
3690	Larson	05 31.8	15.0	-19			
5978	Kaminokuni	06 04.1	14.5	-26			
3230	Vampilov	06 06.9	15.0	-23			
3803	Tuchkova	06 06.2	15.0	-21			
3492	Petra-Pepi	06 07.7	14.7	- 1	1	9.	0.40
3796	Lene	06 07.0	14.4	-25			
6018	1991 PS16	06 08.5	15.0	-12			
29292	Conniewalker	06 09.1	15.0	- 8			
2926	Caldeira	06 10.7	15.0	-19			
86401	2000 AF143	06 13.6	15.0	-25			
4090	Risehvezd	06 13.5	14.4	-23			
1938	Lausanna	06 14.9	14.5	-16			
1064	Aethusa	06 16.7	12.7	-28	2	8.62	0.18
15633	2000 JZ1	06 16.9	15.0	-11			
231	Vindobona	06 16.0	12.3	-32	2+	14.24	0.29
15318	Innsbruck	06 16.1	14.6	-12			
6764	Kirillavrov	06 17.5	14.8	-37			
5146	Moiwa	06 18.6	15.0	-46			
27757	1991 PO18	06 19.4	14.9	-36			
465	Alekto	06 20.5	12.9	-27	2		
3807	Pagels	06 20.7	14.4	-15	2	3.3	0.13
217	Eudora	06 20.6	12.5	- 5	2+	25.25	0.16-0.26
5069	Tokeidai	06 21.7	14.6	-13			
57754	2001 VW12	06 24.3	15.0	-28			
1618	Dawn	06 24.2	15.0	-22	2+	43.19	0.38
6952	Niccolo	06 25.1	15.0	-10			
5496	1973 NA	06 26.4	14.3	-34			
9739	Powell	06 28.4	15.0	-34	2	16.7	0.09-0.11
897	Lysistrata	06 28.9	13.0	-15	2	11.26	0.11
6028	1994 ER1	06 28.8	14.6	-29			
1166	Sakuntala	06 29.6	12.3	-16	2	6.30	0.40
2249	Yamamoto	06 30.3	14.9	-18			
1085	Amaryllis	06 30.4	13.8	-17	2	18.2	0.20
1688	Wilkens	06 30.2	14.6	-10			

Low Phase Angle Opportunities

#	Name	Date	α	V	Dec	Period	Amp	U
19	Fortuna	04 07.0	0.22	10.7	-07	7.4432	0.14-0.35	3
361	Bononia	04 08.6	0.11	13.8	-07	13.83	0.25	3
431	Nephele	04 15.2	0.77	13.4	-07	21.43	0.02-0.30	1
104	Klymene	04 19.6	0.27	13.0	-10	8.984	0.3	3
50	Virginia	04 21.9	0.74	13.8	-10	14.315	0.07-0.20	3
216	Kleopatra	04 22.1	0.38	12.1	-13	5.385	0.12-1.2	3
189	Phthia	04 22.7	0.51	12.4	-11	22.346	0.06-0.28	3
368	Haidea	04 28.9	0.62	14.0	-16	9.823	0.15-0.23	3
770	Bali	04 29.9	0.29	13.9	-14	5.9513	0.40-0.55	3
798	Ruth	04 30.0	0.40	13.3	-13	8.53	0.36	3
151	Abundantia	05 03.1	0.25	12.2	-16	9.864	0.03-0.19	3
528	Rezia	05 03.9	0.64	13.9	-14	7.337	0.39	3
425	Cornelia	05 10.2	0.49	13.4	-16	17.56	0.19	2
1044	Teutonia	05 16.3	0.32	13.4	-18	3.153	0.27	3
264	Libussa	05 18.9	0.68	12.6	-22	9.2276	0.03-0.33	3
352	Gisela	05 23.4	0.28	12.9	-21	7.490	0.31-0.58	3
293	Brasilia	05 23.9	0.14	13.6	-21	8.17	0.20	3-
566	Stereoskopia	05 27.8	0.48	13.0	-20	12.103	0.08-0.25	3
277	Elvira	05 28.1	0.15	13.8	-21	29.69	0.34-0.59	3
447	Valentine	05 31.8	0.13	13.1	-22	9.651	0.18	3
64	Angelina	06 02.8	0.62	11.3	-24	8.752	0.04-0.42	3
492	Gismonda	06 06.0	0.39	13.8	-24	6.488	0.10	3
782	Montefiore	06 16.0	0.31	13.6	-24	4.08	0.43	3
178	Belisana	06 18.1	0.83	12.0	-25	12.323	0.12-0.26	3
462	Eriphyla	06 22.7	0.46	12.9	-22	8.64	0.14-0.25	3
241	Germania	06 26.4	0.23	11.4	-23	15.51	0.05-0.17	3
43	Ariadne	06 27.7	0.80	9.0	-22	5.762	0.08-0.66	3

Shape/Spin Modeling Opportunities

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

Occultation Profiles Available

		Brightest			LCDB DATA		
#	Name	Date	Mag	Dec	Period	Amp	U
345	Tercidina	04 09.6	11.5	-11	12.371	0.12-0.23	3
51	Nemausa	04 11.5	9.8	-01	7.783	0.10-0.25	3
134	Sophrosyne	04 15.3	12.5	-21	17.196	0.19	3
431	Nephele	04 15.3	13.3	-07	18.821	0.02-0.30	2
828	Lindemannia	04 22.1	14.5	-13			
568	Cheruskia	04 24.1	13.8	-28	13.209	0.10-0.44	3
94	Aurora	05 04.4	12.4	-23	7.22	0.12	3
141	Lumen	05 04.9	12.8	-32	19.87	0.12-0.2	3
638	Moira	05 12.7	12.5	-07	9.875	0.31	3
914	Palisana	05 14.8	11.7	-37	15.922	0.04-0.18	3
566	Stereoskopia	05 27.8	12.9	-20	12.103	0.08-0.25	3
350	Ornamenta	06 16.4	13.3	-20	9.178	0.10-0.20	3
366	Vincentina	06 21.3	12.8	-39	15.5	0.08	1

Inversion Modeling Candidates

		Brightest			LCDB Data		
#	Name	Date	Mag	Dec	Period	Amp	U
390	Alma	04 12.4	13.8	-28	3.74	0.42	3
787	Moskva	04 12.4	13.2	-02	6.056	0.47-0.60	3
104	Klymene	04 19.6	12.9	-10	8.984	0.3	3
1368	Numidia	04 19.6	13.9	-16	3.64	0.35	3
355	Gabriella	04 19.9	13.4	-15	4.830	0.42	3
1419	Danzig	04 24.7	14.1	-13	8.1202	0.81-0.92	3
550	Senta	04 26.7	12.8	-25	20.555	0.3	3
770	Bali	04 29.9	13.9	-14	5.9513	0.40-0.55	3
408	Fama	05 02.4	14.7	-27	202.10	0.05-0.58	3
899	Jokaste	05 02.4	15.0	-24	6.245	0.28	3
809	Lundia	05 03.0	15.0	-05	15.4142	0.18-1.12	3
1088	Mitaka	05 05.2	14.5	-14	3.049	0.23-0.40	3
226	Weringia	05 06.5	13.0	+11	11.240	0.08-0.15	3-
484	Pittsburghia	05 06.5	13.6	+03	10.63	0.37	3
2841	Puijo	05 07.4	14.8	-10	3.545	0.03	1+
163	Erigone	05 21.3	13.1	-13	16.136	0.37	3
854	Frostia	05 23.4	14.0	-11	37.56	0.33	3
277	Elvira	05 28.1	13.7	-21	29.69	0.34-0.59	3
2001	Einstein	05 29.7	15.0	-68	5.487	0.66-1.02	3
601	Nerthus	05 31.6	14.1	+02	13.59	0.29	3
292	Ludovica	06 01.4	12.7	-34	8.93	0.45	3
900	Rosalinde	06 03.9	14.4	-02	16.5	0.52	2
889	Erynia	06 09.6	15.0	-13	9.89	0.67	3
590	Tomyris	06 09.7	14.4	-15	5.562	0.21-0.93	3
782	Montefiore	06 16.0	13.6	-24	4.08	0.43	3
313	Chaldaea	06 18.1	12.6	-05	8.392	0.08-0.24	3
1002	Olbersia	06 22.0	14.7	-40	10.244	0.38	3
1245	Calvinia	06 28.1	13.6	-20	4.84	0.37-0.63	3

Radar-Optical Opportunities

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

MPC: *http://cfa-www.harvard.edu/iau/mpc.html*
JPL: *http://ssd.jpl.nasa.gov/?horizons*

In the ephemerides below, E.D. and S.D. are, respectively, the Earth and Sun distances (AU), V is the estimated Johnson V magnitude, and α is the phase angle. "PHA" in the header indicates that the object is a "potentially hazardous asteroid", meaning that at some (long distant) time, its orbit might take it very close to Earth.

(141484) 2002 DB4 (2011 March-April, H = 16.4)
There are no known lightcurve parameters for this near-Earth asteroid that is circumpolar for Southern Hemisphere observers in March and April. The estimated diameter is 1.5 km.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/15	13 25.56	-77 00.7	0.289	1.079	16.29	65.5
03/20	13 26.15	-82 18.8	0.261	1.058	16.14	69.2
03/25	13 14.21	-88 35.7	0.234	1.036	16.01	74.1
03/30	1 34.94	-83 44.9	0.209	1.011	15.94	80.6
04/04	1 33.09	-74 14.9	0.187	0.985	15.98	89.3
04/09	1 32.41	-62 27.2	0.170	0.956	16.21	100.5
04/14	1 31.81	-48 21.8	0.161	0.926	16.79	114.0

(85953) 1999 FK21 (2011 March/April, H = 18.1)
The estimated diameter for this NEA is 0.7 km. There are no known lightcurve parameters.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/15	13 36.92	-09 59.8	0.270	1.232	16.88	25.5
03/20	13 12.56	-05 06.1	0.232	1.217	16.23	16.2
03/25	12 39.17	+01 38.0	0.202	1.198	15.48	5.8
03/30	11 55.87	+10 03.6	0.184	1.176	15.56	13.8
04/04	11 04.67	+18 55.7	0.179	1.150	15.98	30.5
04/09	10 11.24	+26 23.0	0.188	1.121	16.49	46.8
04/14	9 22.05	+31 29.9	0.207	1.087	17.04	60.8

2001 AD2 (2011 March-April, H = 19.3, PHA)
This 0.4 km NEA favors southerly observers in March and April. Note the ephemeris interval is only 2 days.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/15	15 17.41	-21 40.7	0.253	1.146	18.41	47.9
03/17	15 30.49	-22 38.0	0.227	1.126	18.20	50.0
03/19	15 46.74	-23 42.7	0.202	1.105	17.98	52.6
03/21	16 07.42	-24 54.5	0.178	1.084	17.77	56.2
03/23	16 34.38	-26 10.4	0.156	1.062	17.58	61.1
03/25	17 10.14	-27 20.1	0.136	1.040	17.44	67.8
03/27	17 57.38	-27 58.6	0.120	1.018	17.41	76.9

2004 XN50 (2011 March-April, H = 18.8, PHA)
This 0.5 km NEA will require larger telescopes, preferably at more southerly latitudes. There are no known lightcurve parameters. This is one asteroid where astrometry prior to the radar observations would be particularly useful.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/21	15 55.32	-09 44.2	0.292	1.171	18.25	47.1
03/23	16 12.23	-09 48.9	0.261	1.144	18.04	50.1
03/25	16 33.09	-09 49.9	0.233	1.116	17.85	54.0
03/27	16 59.14	-09 44.1	0.207	1.088	17.68	59.1
03/29	17 31.88	-09 26.2	0.183	1.059	17.57	65.8
03/31	18 12.61	-08 47.8	0.165	1.030	17.55	74.5
04/02	19 01.42	-07 40.1	0.152	1.001	17.70	85.1

3554 Amun (2011 April, H = 15.8)
Since this asteroid is observable this quarter, we include it for a second time. The period is 2.53 h. Given the size (2.5 km) and rotation period, it is a good candidate for being a binary, although there are no previous reports of such. Detecting a satellite by lightcurve photometry requires that it have a minimum size in relation to its parent, > 0.2 $D_{primary}$, and that the orbital orientation allows mutual events (occultations and eclipses). If a satellite is not tidally-locked to its orbital period, it's possible that its rotation might be seen as a second period within the data event if there are no mutual events, although the amplitude may be very small. High-precision observations are strongly encouraged.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
04/01	10 30.03	-02 23.1	0.279	1.243	14.69	25.5
04/06	10 08.95	-04 50.4	0.300	1.240	15.05	32.7
04/11	9 52.47	-06 56.6	0.325	1.235	15.38	38.7
04/16	9 40.10	-08 44.5	0.353	1.228	15.69	43.7
04/21	9 31.19	-10 18.1	0.382	1.221	15.96	47.8
04/26	9 25.10	-11 40.9	0.412	1.212	16.20	51.2
05/01	9 21.31	-12 56.2	0.441	1.201	16.42	54.0

2004 QT24 (2011 April, H = 18.3, PHA)
There are no known lightcurve parameters for this NEA. The estimated diameter is 0.7 km. It will be circumpolar for Northern observers in early to mid-April.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
04/01	3 35.05	+81 32.7	0.184	0.983	17.75	89.7
04/06	7 49.97	+79 38.9	0.164	1.003	17.33	84.4
04/11	9 40.09	+69 16.9	0.149	1.024	16.91	77.4
04/16	10 20.25	+55 21.2	0.141	1.045	16.57	69.2
04/21	10 40.82	+40 12.7	0.143	1.066	16.39	61.2
04/26	10 54.10	+25 59.2	0.154	1.087	16.42	54.9
05/01	11 04.18	+14 02.3	0.174	1.108	16.61	51.0

2008 FU6 (2011 April, H = 17.9)
This is another NEA (*D* ~ 0.8 km) for which no lightcurve parameters are known.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
04/01	13 25.66	-07 58.9	0.383	1.376	17.10	8.7
04/06	13 15.67	-04 26.7	0.334	1.334	16.49	3.6
04/11	13 02.44	+00 10.5	0.292	1.291	16.30	6.9
04/16	12 45.36	+06 05.1	0.256	1.247	16.29	16.1
04/21	12 23.61	+13 22.8	0.228	1.201	16.31	27.4
04/26	11 56.14	+21 53.1	0.208	1.154	16.40	40.7
05/01	11 21.77	+30 59.7	0.197	1.106	16.60	55.3

1866 Sisyphus (2011 April-May, H = 13.0, NEA)
This is largest of the Earth-crossing asteroids (based on H). Radar observations in 1985 gave indications of a satellite but little about it. If a satellite does exist, it will be very small and may not be

detectable with photometry. Very high precision data will be needed to have any chance for detecting a satellite.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
04/20	16 19.34	+02 32.2	1.285	2.155	16.13	17.3
04/30	16 05.20	+02 04.5	1.161	2.097	15.72	13.7
05/10	15 45.82	+01 06.5	1.061	2.036	15.33	10.2
05/20	15 22.19	-00 30.2	0.992	1.973	15.11	10.2
05/30	14 56.44	-02 46.7	0.955	1.907	15.13	14.8
06/09	14 31.49	-05 36.3	0.949	1.839	15.25	21.3
06/19	14 09.97	-08 46.8	0.969	1.769	15.40	27.7

(164121) 2003 YT1 (2011 May, H = 16.1, Binary, PHA)

Nolan *et al.* (2003, IAUC 8336) used radar observations to determine that this is a binary with sizes of approximately 1 and 0.2 km and primary rotation period of $P < 2.6$ h. Pravec *et al.* (2006, *Icarus* **181**, 63-93) reported $P = 2.343$ h and an orbital period of $P \sim 30$ h. The latter was determined by observing mutual events. Dense lightcurves with 0.01-0.02 mag precision are preferred. A collaboration among observers widely-separated in longitude will be even more valuable.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
05/01	7 50.28	+56 45.4	0.180	0.967	15.92	97.8
05/06	8 42.96	+33 50.7	0.168	0.992	15.52	90.9
05/11	9 10.61	+11 12.7	0.187	1.017	15.49	82.5
05/16	9 27.65	-05 17.8	0.229	1.042	15.74	75.9
05/21	9 39.64	-16 09.8	0.283	1.066	16.10	71.3
05/26	9 49.03	-23 25.9	0.343	1.091	16.45	67.9
05/31	9 57.08	-28 33.2	0.405	1.115	16.78	65.2

(141432) 2002 CQ11 (2011 May, H = 19.8, PHA)

Polishook *et al.* (2005, *Abst. IAU Symp.* **229**, 60-61) reported a period of $P > 8$ h for this 0.3 km NEA. If the period is on the long side, data placed onto at least an internal system and, if possible, from widely-separated observers may be needed to find the period.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
05/01	14 23.63	-00 04.7	0.142	1.145	16.72	13.1
05/03	14 10.51	+01 41.2	0.131	1.133	16.65	16.4
05/05	13 55.27	+03 41.4	0.122	1.121	16.61	20.9
05/07	13 37.62	+05 56.4	0.113	1.109	16.59	26.5
05/09	13 17.28	+08 25.9	0.106	1.096	16.60	33.1
05/11	12 54.05	+11 07.6	0.099	1.083	16.65	40.5
05/13	12 27.87	+13 56.9	0.094	1.070	16.75	48.7

(137170) 1999 HF1 (2011 May-July, H = 14.4, Binary)

This is another known binary NEA system (Pravec *et al.*, 2006, *Icarus* **181**, 63-93). In this case, the primary has a period of 2.3193 h and the secondary has one of 14.03 h. It is assumed that the satellite is tidally-locked and so the orbital period is also 14.03 h. Once scheduled for radar observations but no longer, we include it in this list because it's a known binary that is not yet well-modeled and is a BYORP (Binary YORP) candidate. Those planning to observe this asteroid should contact Petr Pravec via the email listed above to coordinate efforts.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
05/01	19 03.06	+43 00.5	0.558	1.195	15.69	57.1
05/11	19 04.88	+50 03.7	0.536	1.182	15.61	58.3
05/21	19 00.32	+57 01.6	0.513	1.160	15.54	60.6
05/31	18 45.89	+63 49.4	0.489	1.128	15.48	64.0
06/10	18 13.72	+70 18.7	0.462	1.086	15.42	68.8
06/20	17 03.02	+76 07.2	0.431	1.034	15.39	75.6
06/30	14 24.87	+79 16.4	0.398	0.971	15.41	85.0

(188174) 2002 JC (2011 May, H = 17.3)

The estimated diameter of this NEA is about 1 km. Polishook *et al.* (2008, *Icarus* **194**, 111-124) reported a period of 2.49 h with an amplitude of 0.35 mag. The size and period again make this a good binary candidate.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
05/15	17 33.30	+68 35.1	0.249	1.040	17.03	76.4
05/17	17 04.03	+71 03.1	0.231	1.031	16.93	78.6
05/19	16 20.23	+73 26.2	0.214	1.022	16.84	81.2
05/21	15 14.51	+75 15.6	0.198	1.013	16.76	84.2
05/23	13 45.54	+75 36.5	0.183	1.003	16.71	87.8
05/25	12 12.61	+73 31.7	0.171	0.993	16.70	91.9
05/27	10 59.73	+68 53.8	0.160	0.982	16.75	96.6

(242450) 2004 QY2 (2011 May-July, H = 14.7, PHA)

There are no known lightcurve parameters this 3.5 km NEA. The size does make it a potential binary candidate, so high-precision observations are encouraged.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
05/15	22 39.98	-41 47.9	0.812	1.288	16.71	51.7
05/25	23 09.52	-37 08.4	0.680	1.224	16.33	55.8
06/04	23 41.71	-30 14.3	0.551	1.154	15.91	61.5
06/14	00 19.64	-19 12.6	0.434	1.077	15.51	70.1
06/24	01 09.08	-01 06.3	0.348	0.995	15.32	83.5
07/04	02 18.88	+23 33.8	0.326	0.909	15.68	99.9
07/14	03 54.49	+43 23.1	0.388	0.819	16.35	109.4

2002 JB9 (2011 May-July, H = 15.7, PHA)

Pravec *et al.* (2002, *http://www.asu.cas.cz/~ppravec/neo.htm*) report a period of 2.426 h for this 2 km NEA. This makes this another good candidate to be binary. While fainter in mid-May, sky motion will be much slower and so getting good photometry will be a little easier in some regards. Note the ephemeris interval is 10 days. Accurate astrometry prior to the radar observations would reduce the radar pointing uncertainties to more acceptable levels.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
05/15	17 11.70	+06 06.6	0.530	1.473	16.48	23.9
05/25	16 37.67	+02 46.9	0.360	1.348	15.28	18.4
06/04	15 13.48	-07 00.6	0.225	1.219	14.16	22.2
06/14	12 07.48	-23 59.5	0.188	1.088	14.68	62.6
06/24	09 26.97	-27 11.8	0.275	0.956	16.38	94.7
07/04	08 14.98	-24 19.7	0.407	0.827	17.46	105.8
07/14	07 38.09	-20 14.9	0.552	0.711	17.84	106.5

2009 BD (2011 June, H = 28.3)

This is another object wanting good astrometry prior to radar observations. There are no known lightcurve parameters for this very small (5 meter) NEA. This is definitely one for telescopes of 1-m or greater size. Given its size, it could easily be a rapid rotator and/or tumbler. There is also speculation that it might be some kind of "space junk". Spectroscopy could help eliminate (or confirm) that possibility.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
06/01	09 06.50	-36 12.7	0.002	1.014	19.09	92.2
06/02	11 09.42	-49 15.4	0.002	1.015	18.02	67.2
06/03	13 55.15	-50 32.8	0.002	1.016	17.44	42.1
06/04	15 46.25	-41 58.9	0.003	1.017	17.25	22.6
06/05	16 43.93	-32 56.2	0.004	1.018	17.23	10.1
06/06	17 16.73	-25 53.8	0.004	1.019	17.44	5.9
06/07	17 37.64	-20 38.9	0.005	1.020	17.94	9.3

1998 KM3 (2011 June, H = 19.4, PHA)

Here is another NEA favoring larger telescopes. There are no known lightcurve parameters for the 0.4 km asteroid. Accurate astrometry prior to the radar observations would be particularly useful.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
06/01	15 00.26	-25 46.6	0.189	1.192	17.21	18.3
06/03	14 46.95	-24 43.0	0.173	1.171	17.11	22.6
06/05	14 31.55	-23 20.9	0.157	1.151	17.02	27.7
06/07	14 13.69	-21 34.9	0.143	1.131	16.94	33.5
06/09	13 52.97	-19 18.0	0.130	1.110	16.88	40.3
06/11	13 29.01	-16 22.2	0.118	1.090	16.85	48.3
06/13	13 01.48	-12 39.4	0.108	1.069	16.88	57.5

2003 AL73 (2011 June, H = 19.2)

Surprise! There are no known lightcurve parameters for this NEA. The estimated diameter is 0.4 km. The daily motion will be on the order of 6-10 arminutes/hr. Given the faintness of the target, larger telescopes will be in order for good photometry.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
06/05	21 26.74	+39 50.3	0.148	1.026	18.15	81.3
06/07	21 04.20	+37 00.6	0.158	1.045	18.09	74.5
06/09	20 45.67	+34 17.9	0.169	1.065	18.08	68.4
06/11	20 30.26	+31 45.3	0.180	1.085	18.09	62.9
06/13	20 17.28	+29 23.7	0.192	1.104	18.13	58.0
06/15	20 06.20	+27 12.9	0.205	1.124	18.18	53.5
06/17	19 56.62	+25 12.1	0.219	1.145	18.24	49.4

(65909) 1998 FH12 (2011 June, H = 19.1, PHA)

Benner reports on the Goldstone targets page that radar data indicate an upper bound for the period of about 3 h for this 0.4 km NEA.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
06/10	21 44.10	-06 48.7	0.211	1.113	18.13	57.4
06/12	22 02.35	-05 10.4	0.194	1.096	18.01	60.8
06/14	22 23.64	-03 13.0	0.178	1.078	17.91	65.0
06/16	22 48.49	-00 53.6	0.164	1.060	17.86	70.1
06/18	23 17.29	+01 48.7	0.153	1.041	17.87	76.2
06/20	23 50.12	+04 50.8	0.144	1.023	17.96	83.4
06/22	00 26.47	+08 03.5	0.139	1.004	18.15	91.2

(5496) 1973 NA (2011 June-July, H = 15.3)

This *D* ~ 2.6 km NEA will be moving quite rapidly at the end of June when it is also brightest.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
06/15	22 58.93	+12 15.7	0.303	1.072	15.35	71.1
06/20	22 55.31	-05 54.5	0.255	1.111	14.77	61.8
06/25	22 48.61	-29 07.6	0.241	1.152	14.40	50.6
06/30	22 35.82	-51 14.9	0.268	1.195	14.50	43.4
07/05	22 10.41	-67 13.2	0.326	1.238	14.95	41.4
07/10	21 16.87	-77 07.0	0.403	1.282	15.49	41.5
07/15	19 26.77	-82 08.7	0.489	1.327	15.99	41.8

IN THIS ISSUE

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

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Nonmembers are invited to join ALPO by communicating with: Matthew L. Will, A.L.P.O. Membership Secretary, P.O. Box 13456, Springfield, IL 62791-3456 (will008@attglobal.net). The Minor Planets Section is directed by its Coordinator, Prof. Frederick Pilcher, 4438 Organ Mesa Loop, Las Cruces, NM 88011 USA (pilcher@ic.edu), assisted by Lawrence Garrett, 206 River Rd., Fairfax, VT 05454 USA (LSGasteroid@msn.com). Dr. Alan W. Harris (Space Science Institute; awharris@spacescience.org), and Dr. Petr Pravec (Ondrejov Observatory; ppravec@asu.cas.cz) serve as Scientific Advisors. The Asteroid Photometry Coordinator is Brian D. Warner, Palmer Divide Observatory, 17995 Bakers Farm Rd., Colorado Springs, CO 80908 USA (brian@MinorPlanetObserver.com).

The Minor Planet Bulletin is edited by Professor Richard P. Binzel, MIT 54-410, Cambridge, MA 02139 USA (rpb@mit.edu). Brian D. Warner (address above) is Assistant Editor. The *MPB* is produced by Dr. Robert A. Werner, JPL MS 301-121, 4800 Oak Grove Drive, Pasadena, CA 91109 USA (robert.a.werner@jpl.nasa.gov) and distributed by Derald D. Nye. Direct all subscriptions, contributions, address changes, etc. to:

Mr. Derald D. Nye - Minor Planet Bulletin
10385 East Observatory Drive
Corona de Tucson, AZ 85641-2309 USA
(nye@kw-obsv.org) (Telephone: 520-762-5504)

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* * * * *

The deadline for the next issue (38-3) is April 15, 2011. The deadline for issue 38-4 is July 15, 2011.