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ROTATION PERIOD DETERMINATION FOR 1220 CROCUS

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R.P. Binzel (1985) described two superposed periods for 1220 Crocus on the basis of rather sparse lightcurves: 30.7 days, amplitude 0.87 magnitudes; and 7.90 hours, amplitude 0.15 magnitudes. We have looked for this behavior again with a much denser data set. We find a period of 491.4 hours, amplitude 1.0 magnitudes; a careful search with dual period software finds no evidence of a second period at a level better than 0.1 magnitudes. A color index V-R = 0.47 ± 0.03 is found, and H-G parameters are $H = 11.76 \pm 0.07$ mag, $G = 0.05 \pm 0.05$.

Binzel (1985) made the first photometric lightcurves ever obtained for 1220 Crocus. He reported somewhat sparse lightcurves from 1984 February to May that showed a large amplitude and long period lightcurve with a most likely value of 30.7 days (737 hours). He noted that periods of 20.47 and 15.35 days (491 hours and 368 hours, respectively) were also compatible with his data. His lightcurves of 1984 Feb 7-9 showed a second period of 7.90 hours with an amplitude 0.15 magnitudes. Jacobson and Scheeres (2011) describe how, following rotational spin-up and fissioning, an asteroid binary system can evolve by angular momentum transfer into a system in which the primary acquires a long rotation period and the satellite has a long orbital revolution period around the primary and short rotation period. Warner *et al*. (2015) list 1220 Crocus as one of eight systems in which a slowly rotating primary may have a satellite. The several authors of this paper agreed to collaborate in a search to confirm the existence of the short period and obtain a reliable value for the large amplitude long period.

Observers Vladimir Benishek at Sopot Observatory, Lorenzo Franco at Balzaretto Observatory, Daniel Klinglesmith III and Jesse Hanowell at Etscorn Campus Observatory, Caroline Odden and colleagues at Phillips Academy Observatory, and Frederick Pilcher at Organ Mesa Observatory all contributed lightcurves with clear filters. Table I gives the list of equipment used.

Lead Observer	**Telescope**	**CCD**
Benishek	0.35-m *f*/6.3 SCT	ST-8XME
Franco	0.20-m SCT	ST-7XME
Klinglesmith	0.35-m *f*/11 SCT	STL-1001E
Odden	0.40-m *f*/8 R-C	ikon DW436
Pilcher	0.35-m SCT	STL-1001E

Table I. Instruments used for observations. SCT: Schmidt-Cassegrain. R-C: Ritchey-Chretien. ST/STL cameras are from SBIG. The DW436 is from Andor Tech.

The observational strategy was for authors LF and FP to obtain short sessions, usually two hours or less, on as many nights as possible starting 2014 Sep 27, continuing through opposition in 2015 January, and then until late 2015 March. Each session would effectively be a single data point to define the long period but provide no information on the short period. Longer sessions in 2014 December and 2015 January, near opposition when the asteroid was brightest and most favorably placed, would be obtained by all the collaborating observers. The long sessions near minimum lightcurve brightness, when the secondary light variation would be less diluted by the primary light, were examined for a small amplitude short term variability. *MPO Canopus* software was used to measure the images and construct lightcurves; only solar colored stars were used for calibration.

For all calibration stars, the Sloan r' magnitudes as given in the CMC15 catalog (VizieR, 2014) were converted to the Cousins R system by R = r' – 0.22 (Dymock and Miles, 2009). The internal consistency of CMC15 catalog r', J, and K magnitudes is usually better than 0.05 magnitudes. Data points were binned in groups of 3 separated by no more than 5 minutes to reduce the number and make the lightcurve easier to inspect. These data provide a good fit to a lightcurve (Figure 1) phased to period 491.4 ± 0.1 hours with amplitude near 1.0 magnitudes.

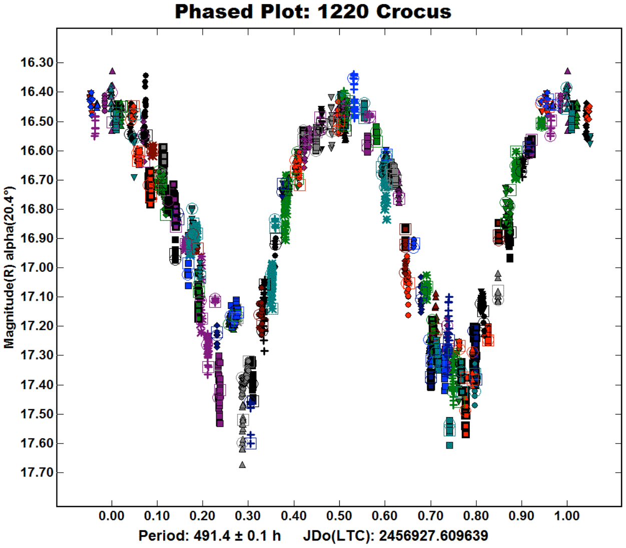

Figure 1. The lightcurve of 1220 Crocus using observations from 2014 Sep 27 - 2015 Mar 26 in R band magnitudes, corrected for changes in phase angle and geocentric and heliocentric distances.

This is exactly 2/3 of Binzel's favored period of 30.7 days (737 hours) and is consistent with his suggested possible period of 20.47 days (491 hours).

A total of 109 short sessions between 20 minutes and 2 hours were obtained between 2014 Sep 27 and 2015 Mar 26. Eleven longer sessions of 3 to 8 hours were obtained between 2014 Dec 16 and 2015 Jan 20. Dual period procedures were employed on these data and found no evidence of a second period with amplitude 0.10 magnitudes or larger. The authors agree that the purported 7.90 hour period with 0.15 magnitude amplitude, found by Binzel (1985), is spurious and the alleged variation results from noise in a sparse data set. This project finds 1220 Crocus to be especially significant as a very slow rotator with no evidence of tumbling.

On 2015 Jan 26-27, author LF obtained alternate images in V and R filters with the goal of obtaining the V-R color index. The same solar colored stars were used for magnitude calibration for both sessions. The CMC15 catalog r' magnitudes were converted to Cousins R magnitudes by R = r' – 0.22. They were converted to Johnson V magnitudes by V = 0.9947r' + 0.6278(J-K), as explained in Dymock and Miles (2009). An upward adjustment of the V magnitude session by 0.47 magnitudes produced best fit to the R magnitude session (Figure 2). Hence we conclude a color index of V-R = 0.47 ± 0.03.

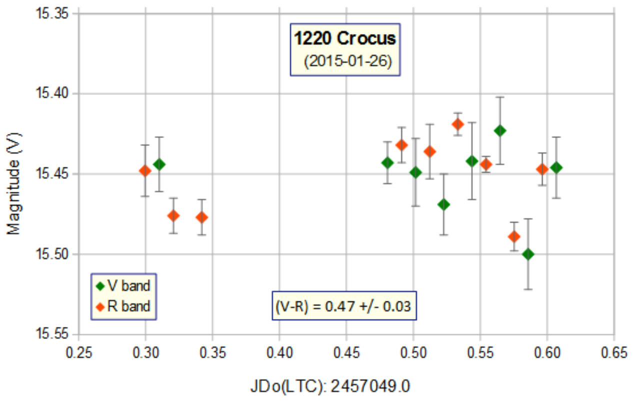

Figure 2. Observations of 1220 Crocus 2015 Jan 26-27 in V and R with R magnitudes adjusted downward by 0.47 mag for best fit.

H-G parameters

For H-G determination, the entire data set (Figure 3) was imported in *Peranso* (Vanmunster, 2014) to evaluate the amplitude variations related to the phase angle.

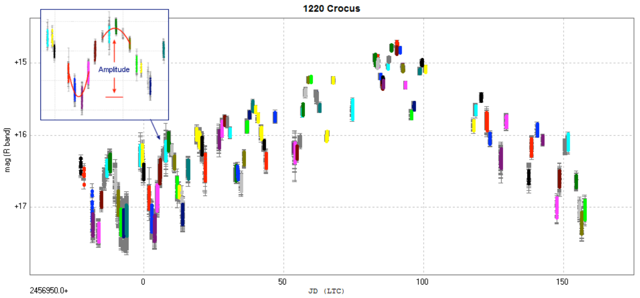

Figure 3. Raw plot of R band magnitudes of 1220 Crocus for entire six-month interval of observations 2014 Sep 27 - 2015 Mar 26.

The empirical formula by Zappala *et al.* (1990) relates the lightcurve amplitude with the phase angle: A(0°) = A(α)/(1+$m\alpha$), where α is the solar phase angle and m is the slope parameter (0.030 deg^{-1} for S-type objects). For 1220 Crocus we derive from the linear regression analysis

$$m = s/\mathrm{A}(0°) = 0.035\ \mathrm{deg}^{-1}$$

where s = 0.0216 is the slope of the linear-fit and A(0°) = 0.6155 is the intercept (Figure 4).

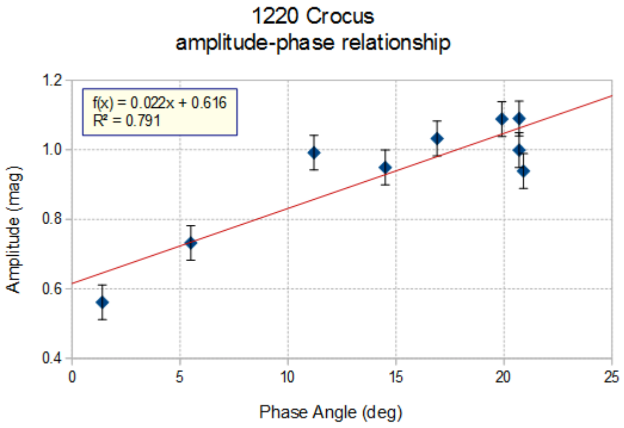

Figure 4. Amplitude-phase relationship for 1220 Crocus.

Due to the large amplitude variations related with phase angle, using, respectively, maximum, minimum and mean light points, we derive different values for H-G parameters (Figure 5).

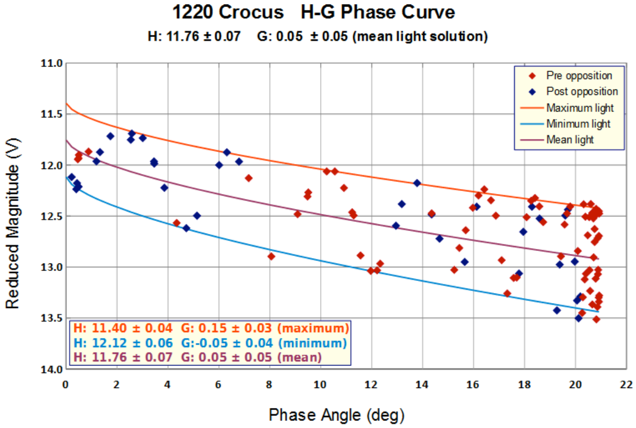

Figure 5. H-G plots for 1220 Crocus for maximum, minimum and mean light data points, respectively.

The V mag values were used by adding the color index V-R = 0.47 to the R mag. For *H-G* determination we choose the mean light values as better representing observation although the maximum light values have a more solid geometric foundation. The mean light values are used in the JPL and MPC databases. The results are *H* = 11.76 ± 0.07 mag and *G* = 0.05 ± 0.05.

Our *H* value is close to *H* = 11.72 published on the JPL Small-Body Database Browser (JPL, 2015), while our value for *G* is fairly different from the published value of *G* = 0.23. Both our color index (V-R) and *G* values are compatible with a low- to medium-albedo asteroid (Shevchenko and Lupishko, 1998).

Finally, in Figure 6 we report the fit of the observed data-points with 3rd order Fourier model with phase corrected amplitude.

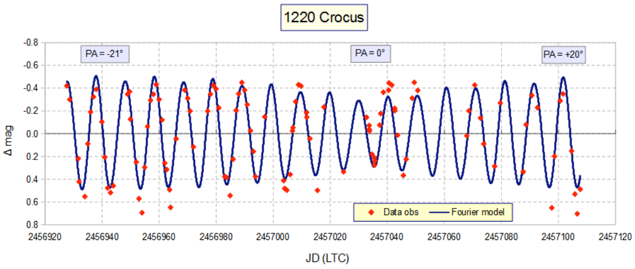

Figure 6. Raw plot of fit of observed data points for 1220 Crocus with 3rd order Fourier model applied to phase corrected amplitude.

Acknowledgments

The authors thank Petr Pravec for analyzing our data and finding no evidence of either a rotating satellite or tumbling behavior. The Etscorn Campus Observatory operations are supported by the Research and Economic Development Office of New Mexico Institute of Mining and Technology (NMIMT). Student support at NMIMT is given by NASA EPSCoR grant NNX11AQ35A, the Department of Physics, and the Title IV of the Higher Education Act from the Department of Education. Author AWH acknowledges support from NASA grant NNX13AP56G and NSF grant AST-1210099.

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[Editorial handling for this manuscript was performed by the Assistant Editor, who notes: The authors are to be congratulated for this finest of examples of a well-conceived and executed collaboration among several observers. Their careful attention to detail in data acquisition and analysis of a difficult target should serve as an inspiration and guide to all those doing asteroid photometry.]

LIGHTCURVE ANALYSIS FOR 30 URANIA

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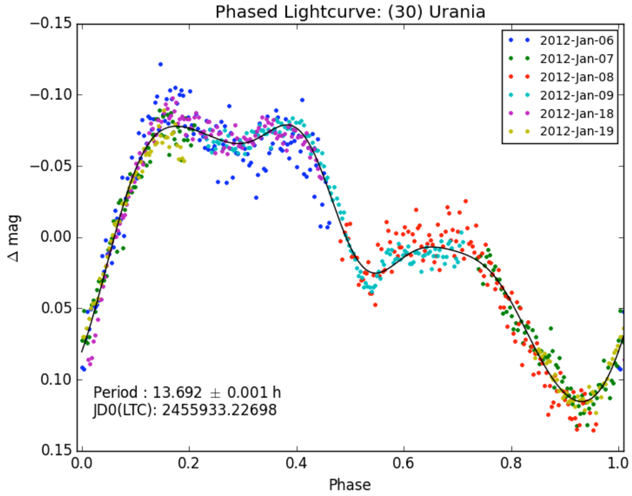
CCD photometric observations of main-belt asteroid 30 Urania were made over six nights in 2012 January. The lightcurve shows a synodic period of 13.692 ± 0.001 h with an amplitude of 0.19 mag.

Initial photometric observations of main-belt asteroid 30 Urania were made in order to support subsequent occultation observations. The asteroid was predicted to occult the star TYC2 1227-00620-1 on 2012 January 19, an event predicted to be visible from central to east Europe (Kretlow, 2011) although the circumstances were not very favorable. Unfortunately, mainly due to bad weather over Europe that time, no occultation observations was reported.

Small Automated Telescope for Internet Observations (SATINO) is a project established by the first author. SATINO 1 and SATINO 2 are remotely operated telescopes with 20-cm and 30-cm aperture, located on the Observatoire de Haute-Provence (OHP) site at Haute-Provence, France, about 100 km north-east of Marseille. Image acquisition was made with an SBIG ST-8 dual-chip CCD camera attached to the SATINO 2 telescope with focal reducer. This gave a scale of 2.1 arcsec/pixel with 2 x 2 binning. No filters were used. Exposure time was 300 seconds on the first night and 120 seconds for all subsequent nights. All images were measured using *MiraPro*. Dark and flat images were applied.



Period analysis was done with a Python/SciPy script developed by the second author. Magnitudes were reduced to unity distance and times were corrected for light-time. The period was calculated by a non-linear least squares fit of an n-order Fourier series (in this case $n = 6$) to the observations, similar to the well-known FALC algorithm developed by Harris (Harris *et al.,* 1989).

We obtained a synodic rotational period $P = 13.692 \pm 0.001$ h with an amplitude $A = 0.19$ mag from this lightcurve. The period agrees with the values given in the literature and databases (Warner, 2015).

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ETSCORN OBSERVATORY LIGHTCURVE RESULTS FOR ASTEROIDS 2245, 3759, 6388, 214088

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Four asteroids were observed at Etscorn Observatory from 2014 December to 2015 January. The results from analysis are all new determinations of synodic periods and amplitudes

Observations of four asteroids were obtained at the Etscorn Campus Obseratory (ECO, 2015) with our three Celestron 0.35-m Schmidt-Cassegrain telescopes (SCT) on Software Bisque (SB) Parmount ME mounts (SB, 2015). The telescopes were controlled with *TheSky6* (SB, 2015) and the CCDs were controlled with *CCDSoft* v5 (SB, 2015).

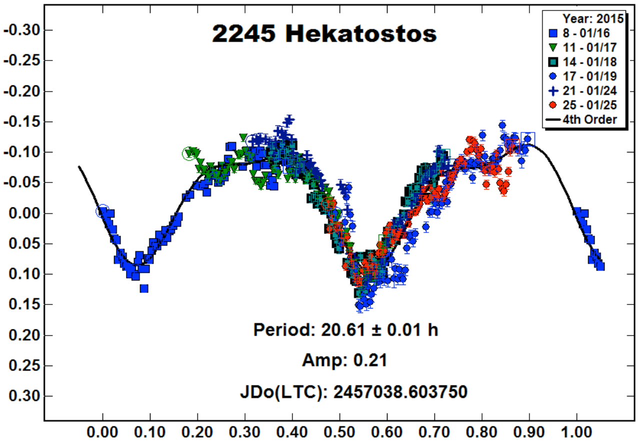
Two of the telescopes used an SBIG STL-1001E CCD camera with a pixel array of 1024x1024x24-microns. This produced a field-of-view of 22x22 arc minutes and scale of 1.25 arc sec/pixel. The third telescope used an SBIG ST10XME with an Optec 0.5x focal reducer. The ST10XME was binned 2x2 providing an image of 1092x736x13.6-micron pixels. This gave a scale of 1.28 arc sec/pixel and field-of-view of 20x16 arc minutes.

The asteroid images were obtained through a clear filter. Exposure times varied between 3 and 5 minutes depending on the brightness of the object. Each evening, a series of 11 dome flats was obtained and combined into a master flat with a median filter. The images were dark-frame and flat-field corrected using image processing tools within *MPO Canopus* v10.4.7.6 (Warner, 2015a). The multi-night data sets for each asteroid were combined with the FALC routine (Harris *et. al.*, 1989) within *MPO Canopus* to provide synodic periods for each asteroid.

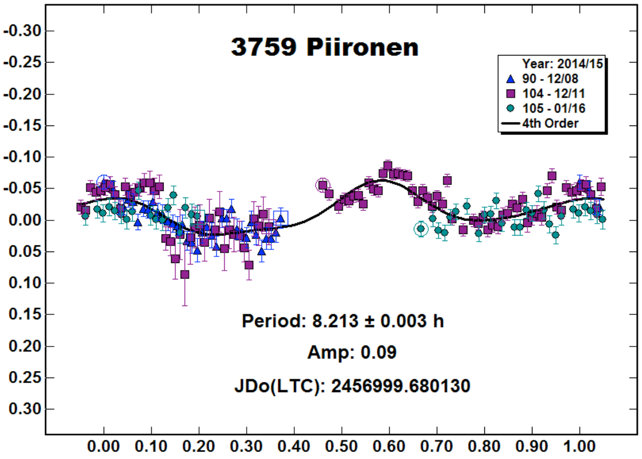
Observed Asteroids

The information about the discovery and names was obtained from the JPL Small Body Database Search Engine (JPL, 2015). 2245 Hekatostos, 3759 Piironen, and (6388) 1989 WL1 are new determinations of synodic periods and amplitudes. 214088 has also been observed by Pravec et. al. (2014) and Warner (2015b)

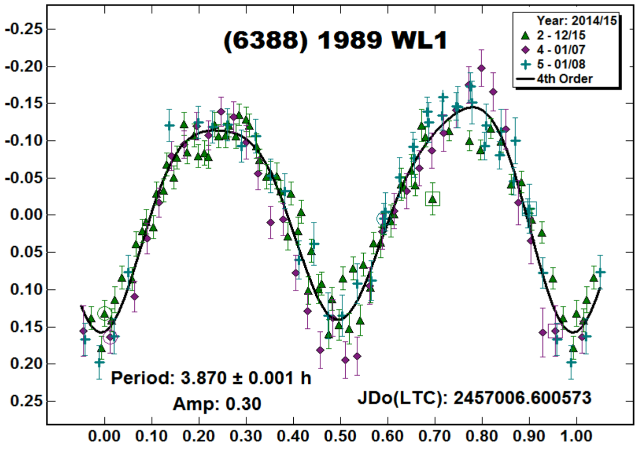
2245 Hekatostos is a main-belt asteroid discovered by L.I. Chernykh at Crimean Astrophysical Observatory on 1968 Jan 24. It is also known as 1968 BC, 1930 FA, 1958 XC, 1966 QV, and 1971 XC. We observed it on six nights between 2015 Jan 16-25. We obtained a synodic period of 20.61 h ± 0.01 h with an amplitude of 0.21 mag.



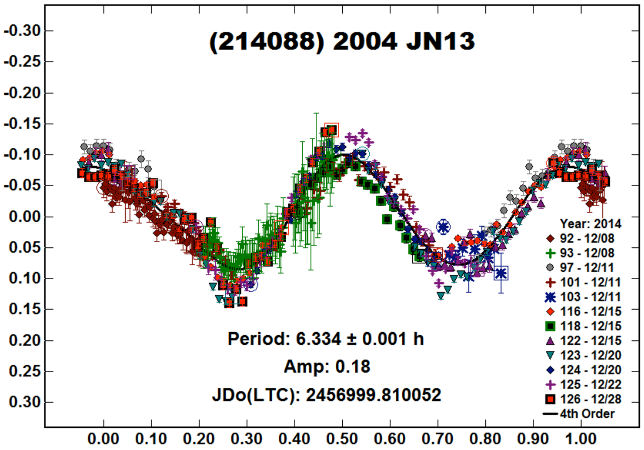
3759 Piironen is a main-belt asteroid discovered on 1984 Jan 8 by E. Bowell at the Anderson Mesa Station of Lowell Observatory, Flagstaff, AZ. It is also known as 1984 AP. We observed it on three nights between 2014 Dec 8-16. Despite the noisy data, a synodic period of 8.213 ± 0.003 h with an amplitude of 0.09 mag. was determined.



(6388) 1989 WL1 is a main-belt asteroid discovered by A. Ueda and H. Kaneda at Kushiro on 1989 Nov 24. It is also known as 1954 VW2, 1972 TZ5, and 1993 UK3. We observed it on three nights between 2014 Dec 15 and 2015 Jan 8. We obtained a synodic period of 3.870 ± 0.001 h with an amplitude of 0.30 mag.



(214088) 2004 JN13 is a main-belt asteroid discovered by Linear at Socorro, New Mexico USA. It is also known as 1975 XA. We observed it on six nights between 2014 Dec 8-28. We obtained a period of 6.334 ± 0.001 h with an amplitude of 0.18 mag. It has also been observed by Pravec *e. al.* (2014) and Warner (2015b). Pravec *et al.* determined a period of 6.342 ± 0.005 h and amplitude of 0.40 mag. Warner obtained periods of 6.336 ± 0.005 and 6.33 ± 0.01 with amplitudes of 0.20 mag. and 0.17 mag.



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PHOTOMETRIC PROPERTIES OF 12753 POVENMIRE

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(Received: 13 March)

Main-belt asteroid 12753 Povenmire has been observed for several years at the Hereford Arizona Observatory. A phase coefficient of 26 ± 2 mmag/degree is used to estimate albedo $p_V = 0.28 \pm 0.08$, which leads to a size of 5.7 ± 0.8 km. A rotation period of 17.5752 ± 0.0008 hours replaces an earlier published value.

Asteroid 12753 Povenmire (1993 HE) was discovered by Eugene and Carolyn Shoemaker, and named in honor of Hal and Katie Povenmire. It is located in the Main Belt Zone II (2.6 AU) with a high inclination (15 degrees) and high eccentricity (0.15). These orbital properties are associated with the Eunomia family. If true, then it would be an old asteroid (2.5 billion years), highly reddened and having an S taxonomy.

A previously reported period of 12.85 hours (Gary, 2004) was based on observations during the "faint" opposition of 2003, when V-mag was 17.6. Background stars required image subtraction before photometry readings could be made. This challenge accounts for the construction of a marginally significant phase-folded rotation light curve with an incorrect period. Reported V-R and R-Ic colors were also of poor quality. This publication corrects mistakes in the earlier publication and reports results from the "bright" opposition of 2010 used to estimate the asteroid's albedo and size.

Observations

Asteroid 12753 was ~1.4 AU from Earth between 2010 May 14 and June 20. Its magnitude was predicted to range from 16.0 to 16.7 during that time. A Meade 0.35-m fork-mounted Schmidt-Cassegrain telescope was used with an SBIG ST-10 XME CCD camera. Hereford Arizona Observatory (MPC code G95) is located at 1417 meter altitude near Sierra Vista, AZ. Control of the telescope, dome, focuser and camera was accomplished using *MaxIm DL* and 30-meter cabling in buried conduit. Image analysis was done with *MaxIm DL* and an *Excel* spreadsheet designed for photometry (see Gary, 2014, for spreadsheet details). All observations were made with an r' band filter and were calibrated using APASS magnitudes found in the UCAC4 catalog. CCD transformation corrections were determined using a plot of reference star instrumental magnitude minus true (APASS) magnitude versus star color (B-V). This assured that each lightcurve segment was calibrated with an accuracy estimated to be ~ 10 mmag.

Sample Lightcurves

Since the goal for this observing project was to estimate the asteroid's size using its phase function, it was necessary to establish rotation period well enough to know when to observe one of the rotation maxima on several dates. Figure 1 shows a phase-folded overlay of lightcurve segments from 11 observing dates in 2010, from which an accurate rotation period was determined: 17.5752 ± 0.0008 hours.

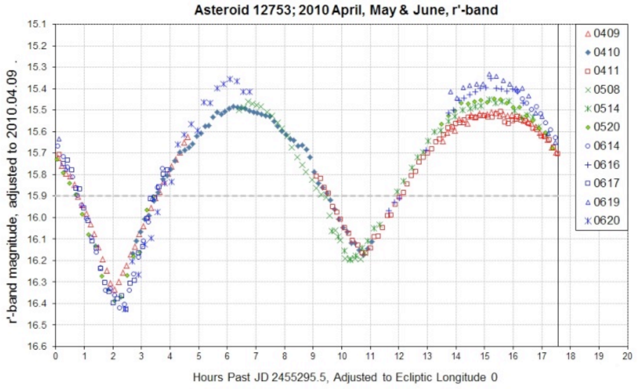

Figure 1. Phase-folded lightcurve for 2010 observations using a period of 17.5752 hours. All magnitudes have been adjusted to an ephemeris magnitude for April 9 using G = 0.15.

The minima exhibit a significant brightness difference and the maxima also vary some. Since there were more data for the second maximum, it was chosen for use in deriving a phase function.

Phase Function and Albedo

Figure 2 is a plot of r'-mag measurements that have been adjusted to the standard 1 AU for sun/asteroid and Earth/asteroid distances.

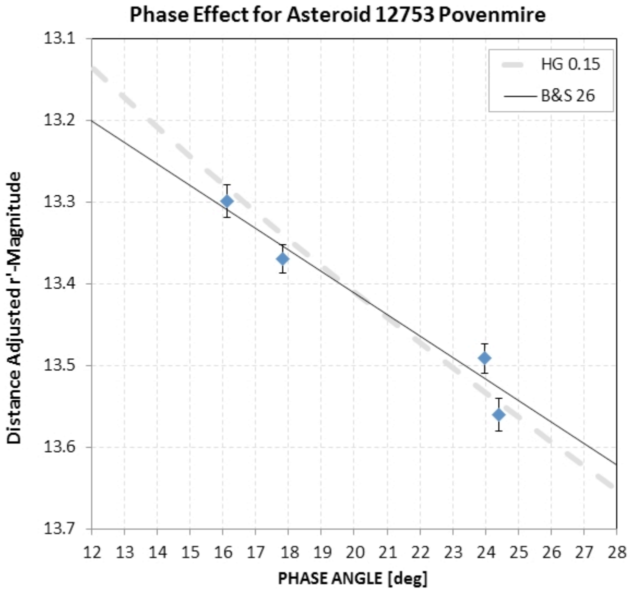

Figure 2. r' magnitudes, adjusted to standard distance, for 4 dates in 2010, with two model fits: 1) HG (G=0.15) and 2) linear B&S model with slope = 26.3 ± 1.4 mmag/degree.

Two model solutions are shown: an H-G model with the common default $G = 0.15$, and a straight line fit.

Belskaya and Schevchenko (2000), hereafter B&S, analyzed 33 well-studied main belt asteroids using a 3-term phase effect model first introduced by Schevchenko (1996, 1997):

$$V(\alpha) = Vo + b \times \alpha - a/(1+\alpha) \qquad (1)$$

where $V(\alpha)$ is V-mag at phase angle α, Vo is V-mag at zero phase, b is phase coefficient (a slope term) fitted to $V(\alpha)$ measurements and a is an "opposition effect" (OE) amplitude term. B&S found that there was a strong correlation between the phase coefficient b

and albedo, and also an inverted U-shape relationship between the OE amplitude term a and albedo. Their equation relating phase coefficient b and V-mag albedo at zero phase, p_V, is:

$$b = 0.013(2) - 0.024(2) * \log(p_V) \qquad (2)$$

where b has units of mag/degree and p_V is a fraction. (Hereafter I will use the term "albedo" to be the same as p_V.) When 26.3 ± 1.4 mmag/degree is substituted for b in the above equation, this gives albedo = 0.28 ± 0.08/0.07.

Zero Phase Brightness and Size

Since we don't have information for phase angles close to zero, we don't know the size of the "opposition effect." Fortunately, B&S also investigated the relation between OE and albedo. For an albedo of 0.28, they find that the OE term $a \sim 0.35 \pm 0.04$ magnitude. Using the B&S phase function equation and adopting their suggested OE value, a chi-square fit is achieved that is better than the H-G fit with $G = 0.15$ (delta chi-square =17), as illustrated in Figure 3.

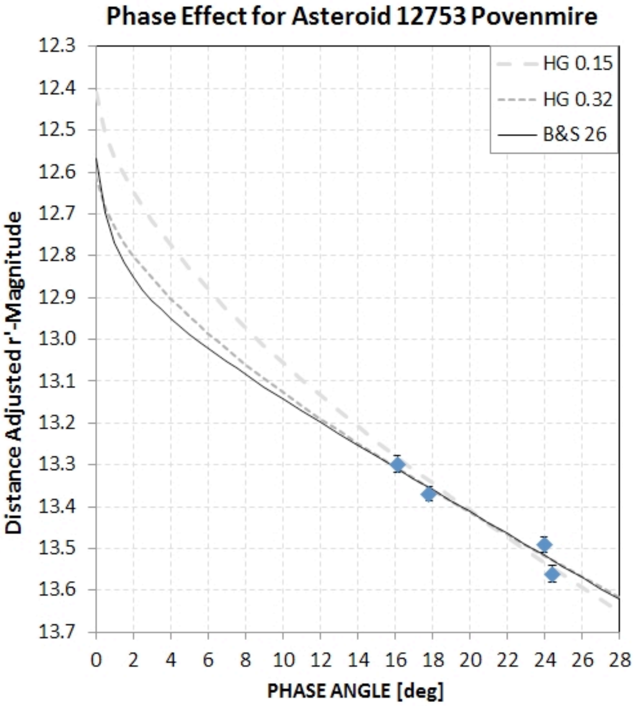

Figure 3. Phase function measurements for "second maximum" fitted with 3 models: 1) H-G ($G = 0.15$); 2) H-G ($G = 0.32$); and 3) B&S model with slope = 26 mmag/degree.

The phase curve measurements were fitted using the phase effect model of Eq. 1 with the OE amplitude term $a = 0.35$. The slope and intercept terms, b and V_0, were adjusted until chi-square was minimized. As expected, $b = 26.3 \pm 1.4$ mmag/degree; the zero phase intercept (not really V_0, since the observations were made with an r'-band filter) produced a solution r'-mag at zero phase of 12.89 ± 0.03. For an asteroid with B-V = +0.78 ± 0.08 and V-R = +0.60 (measured during the 2006 opposition), converting r'-mag to V-mag can be accomplished by adding 0.30 ± 0.10 to r'-mag. In addition, a correction of +0.35 ± 0.07 magnitude is required for the fact that the "second maximum" is on average that much brighter than the rotation average. A total correction to the zero phase r'-mag brightness for the second maximum is therefore 0.65 ± 0.13. The phase curve measurements therefore correspond to a rotation-averaged V-mag, or $V_0 = 13.26 \pm 0.13$ for the H-G ($G = 0.32$) model and 13.22 ± 0.13 for the B&S model. Forcing $G = 0.15$ for the H-G model would lead to $V_0 \sim 13.1$. All of these values are greater than the archive value of $H = 12.7$. I adopt $V_0 = 13.2 \pm 0.2$.

The asteroid's size can now be calculated using the standard equation:

$$D\,[\text{km}] = (1329 / \sqrt{\text{albedo}}) \times 10^{(-0.2H)} \qquad (3)$$

where albedo is a fraction. Setting $H = V_0 = 13.2 \pm 0.2$ yields a diameter of 5.7 ± 0.8 km.

The NEOWISE database lists a diameter and geometric albedo of 7.4 ± 0.1 km and 0.32 ± 0.04. The diameter is based on measured thermal IR flux and an assumed bond albedo used to calculate a disk-average brightness temperature. The Lightcurve Database (LCDB; Warner *et al.*, 2009) lists a diameter of 8.36 km (based on $H = 12.7$ and albedo = 0.21).

Conclusion

Asteroid 12753 rotates with a period of 17.5752 ± 0.0008 hours. The phase coefficient was used to derive an albedo of 0.28 ± 0.08. This albedo allows the opposition effect to be an estimated 0.35 mag. The phase effect measurements can be fit using either an H-G model yielding $H \sim 13.3$, or a Shevchenko model with phase coefficient = 26 ± 2 mmag/degree that yields a zero-phase V ~ 13.2. The albedo and zero-phase magnitude were used to calculate a diameter of 5.7 ± 0.8 km. Two lines of evidence support the S-type taxonomy classification for 12753 Povenmire, its orbit and albedo. Additional confirmation will require measurements for a wider range of phases and over a wider range of wavelengths.

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LONG-PERIOD LIGHTCURVE FOR ASTEROID 15552 SANDASHOUNKAN

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Photometric observations of the main-belt asteroid 15552 Sandashounkan were made from 2014 September to December. We find the data are best fit by a period of 33.62 ± 0.02 h, with an amplitude of 1.44 mag., although further observations are necessary before this result may be considered secure.

We are members of the astronomy club of Sanda Shounkan Senior High School in Japan. We participated in Asteroids Comets Meteors (ACM) 2012. 15552 Sandashounkan (2000FO26) is a main-belt asteroid that was named after our attending the ACM 2012 conference (MPC 2012). A search of the asteroid lightcurve database (LCDB; Warner *et al.*, 2009) did not find any previously reported results for 15552 Sandashounkan.

Observations of 15552 Sandashounkan were made from 2014 September 20 through December 14. We started observations on September 20 using a 0.6-m Schmidt-Cassegrain with an SBIG STL-1001E CCD Camera at Nishi-Harima Astronomical Observatory (NHAO). In order to get date for a prolonged period, we continued observations with remote internet telescopes: the University of Western Australia (UWA), SPIRIT telescope and iTelescope.net (T11, T17, T21). The details of the telescopes and cameras are shown in Table I and the observation details are given in Table II.

Name	D(m)	fl(mm)	Camera	Location
T11	0.51	2280	FLI PL11002	NewMexico(US)
T17	0.43	2912	FLI-PLI4710	SidingSpring(AU)
T21	0.43	1940	FLI-PLI6303E	NewMexico(US)
UWA	0.35	4124	Apogee-AltaU6	Perth(AU)
NHAO	0.60	7200	SBIG-STL1001E	Sayo(JPN)

Table I. Observation equipment list

UT Date	Time	Telescope	Ph	Points	Filter
Sep 20	11:36-19:43	NHAO	6.5°	112	R
Sep 24	14:13-20:16	UWA	5.1°	142	R
Oct 15	05:45-07:39	T11	3.2°	24	C
Oct 16	02:51-04:55	T21	3.5°	30	R
Oct 16	07:42-09:09	T21	3.6°	19	R
Oct 16	11:21-12:39	T17	3.7°	18	R
Oct 16	14:16-16:27	T17	3.7°	19	R
Oct 17	03:24-06:23	T21	3.9°	15	R
Oct 22	09:16-12:25	T17	5.9°	33	R
Oct 23	02:09-08:58	T21	6.1°	58	R
Dec 14	01:54-05:20	T21	18.7°	34	R

Table II. Observations List

The combined data set consists of 504 data points. Most images were unbinned with Johnson-Cousins R-band filter. Measurements were made using *MPO Canopus* (Warner, 2011), which employs differential aperture photometry to produce the raw data. Period analysis was also done using *MPO Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.*, 1989). Though it is suggested that period spectrum shows that other solutions exists, we found possible fits at 33.62 h periods. On September 20 we could make observations for the about seven hours which was the longest period, at NHAO. The longest this lightcurve runs from a minimum to a maximum. We can consider that the seven hours lightcurve showed to be about quarter of the full period, i.e., the full period is four times longer than about seven hours. Furthermore, another period analysis software, cyclocode, calculates that the period is 30.6 h from our data. Therefore, we regard that the most suitable period is 33.2 h, though the period that we have found is tentative.

The spacecraft WISE observed 15552 Sandashounkan (Masiero *et.al.,* 2011). WISE derived the optical albedo 0.3738 and absolute magnitude 12.3 mag of 15552 Sandashounkan. The diameter of 15552 Sandashounkan is estimated at 7.64 km. The rotation period of most 10 km-sized asteroids is about 10 ± 5 h. 15552 Sandashounkan has a very long rotational period for its diameter.

Fully resolving the correct lightcurve period will become possible when longer observing runs can be obtained. We note the next opportunity is when 15552 Sandashounkan reaches opposition again in 2016 January.

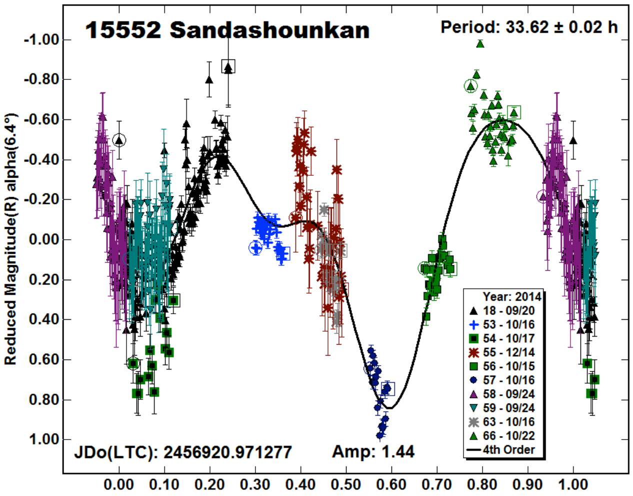

Figure 1. Our observations phased to a rotational period of 33.62h

Acknowledgement

This work was supported by Japan Science and Technology Agency (JST). We thank the staff of Nishiharima Astronomical Observatory, the University of Western Australia and Nishiwaki Earth Science Museum TERRA-DOME for their continuous support. We would like to thank Brian Warner, who has created a user friendly date reduction software (MPO Canopus) making it so much easier to work on this long period target.

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ASTEROID PHOTOMETRY FROM THE PRESTON GOTT OBSERVATORY

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Asteroid period and amplitude results obtained at the Preston Gott Observatory during the second half of 2014 are presented.

The Preston Gott Observatory is the main astronomical facility of the Texas Tech University. Located about 20km north of Lubbock, the main instrument is a 0.5-m *f*/6.8 Dall-Kirkam Cassegrain. An SBIG STL-1001E CCD was used with this telescope. Other telescopes used were 0.3-m Schmidt-Cassegrains with SBIG ST9XE CCD cameras. All images were unfiltered and were reduced with dark frames and sky flats.

Image analysis was accomplished using differential aperture photometry with *MPO Canopus*. Period analysis was also done in *MPO Canopus*, which implements the algorithm developed by Alan Harris (Harris *et al.*, 1989). Differential magnitudes were calculated using reference stars from the USNO-A 2.0 catalog and the UCAC3 catalog.

Results are summarized in Table I and the lightcurve plots are presented at the end of the paper. The data and curves are presented without additional comment except were circumstances warrant.

1708 Polit. This asteroid was observed on five nights as part of an ongoing study to model the shape of the asteroid. The derived period almost exactly matches those derived from earlier observations (Clark, 2011). However the lightcurve is noticeably different. The secondary minimum is not as deep and there appears to be a slight rise just prior to this minimum.

2036 Sheragul. This asteroid was observed on five nights as part of an ongoing study to model the shape of the asteroid. The derived period is very slightly greater than that derived previously (Clark, 2004; 2011).

3131 Mason-Dixon. Observations of this asteroid were made on two nights before clouds and work prevented further observations. The data obtained could be fitted into a single-maximum period of 10.2 hours, so a possible bimodal period would be around 20 hours.

4340 Dence. Observations of this asteroid were made on three nights. The derived period closely matches that obtained by Pravec *et al*. (2008)

8077 Hoyle. This asteroid was observed on three nights as part of an ongoing study to model the shape of the asteroid. The derived period very closely matches that previously obtained (Clark 2013; Klinglesmith *et al.*, 2012).

(9928) 1981 WE9. This asteroid was previously observed in 2007 (Clark, 2008). From those observations, a period of 5.547 hours was derived. The current observations cannot be harmonized with this result, with the new data indicating a much longer period of 18.398 hours. A re-measurement of the 2007 data does not result in a reasonable fit to an 18+ hour period. However a reasonable fit can be made to a 9.14 hour period. In view of the crowded field in 2007 and the associated difficulty in measuring the asteroid, I am inclined to rule out a 9+ hour period and put more faith in the 18.398 hour period measured most recently. However more observations are required to substantiate this result.

(12920) 1998 VM15. Observations made in 2013 (Clark, 2014) indicated a period of 12.885 hours. The current observations cannot be harmonized with such a period. The best match to the most recent observations indicates a period of 9.124 hours. A re-analysis of the 2013 data shows a fit at 9.0511 hours, which is a close match to the 2014 data. It is likely, therefore, that the earlier result was in error. However both sets of data are noisy and further observations are required. Plots of both sets of 2013 data are included here for comparison.

#	Name	Date Range	Nights	Per (h)	Error (h)	Amplitude	Error
1708	Polit	Nov 24 - Dec 25 2014	5	7.5080	0.0002	0.46	0.03
2036	Sheragul	Nov 27 - Dec 15 2014	4	5.42026	0.00015	0.90	0.05
3131	Mason-Dixon	Aug 31 - Sept 1, 2014	2	20?		0.76	0.1
4340	Dence	Nov 27 - Nov 30, 2014	3	7.546	0.005	0.58	0.1
4535	Adamcarolla	July 27 - Aug 24, 2014	4	10.211	0.001	0.35	0.05
8077	Hoyle	Dec 15 - Dec 25, 2014	3	2.7296	0.0004	0.23	0.1
8400	Tomizo	Dec 15, 2014 - Feb 9, 2015	5	3.04983	0.00007	0.14	0.05
9347	1991 RY21	Nov 27 - Nov 30, 2014	3	4.028	0.002	0.45	0.1
9732	Juchnovski	Aug 19 - Sept 1, 2014	3	7.572	0.003	0.14	0.03
9928	1981 WE9	Nov 27 - Dec 25 2014	6	18.3980	0.0034	0.41	0.1
12920	1998 VM15	Nov 27 - Dec 25 2014	6	9.1240	0.0012	0.20	0.05
41327	1999 XD217	Aug 31 2014	1	5.104	0.043	0.37	0.05

Table I. Dates of observation, number of nights, and derived periods/amplitudes.

Acknowledgments

I would like to thank Brian Warner for all of his work with the program *MPO Canopus* and for his efforts in maintaining the CALL website.

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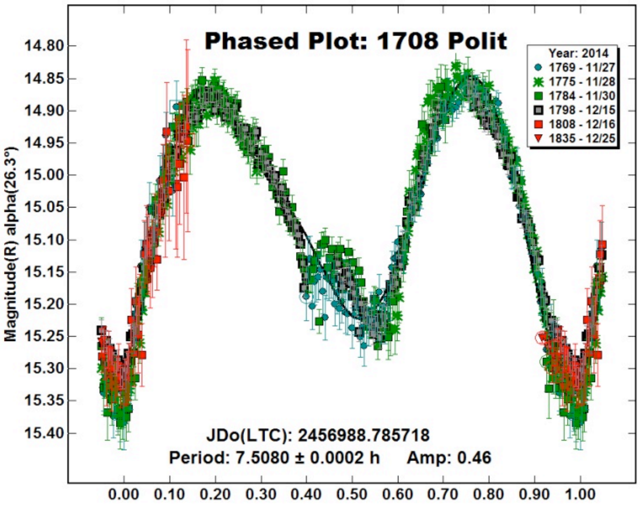
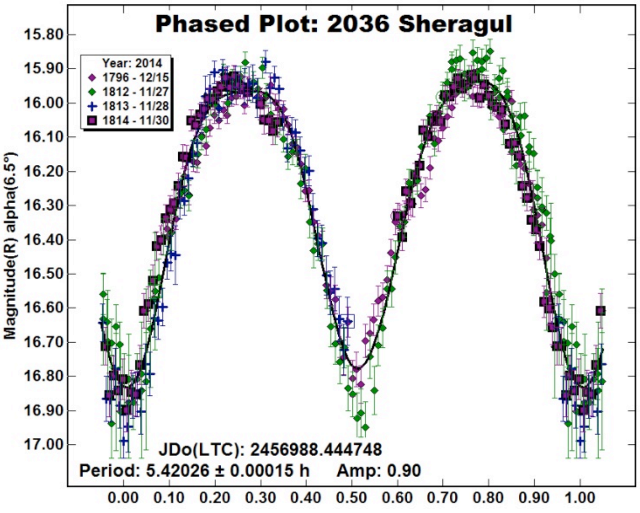
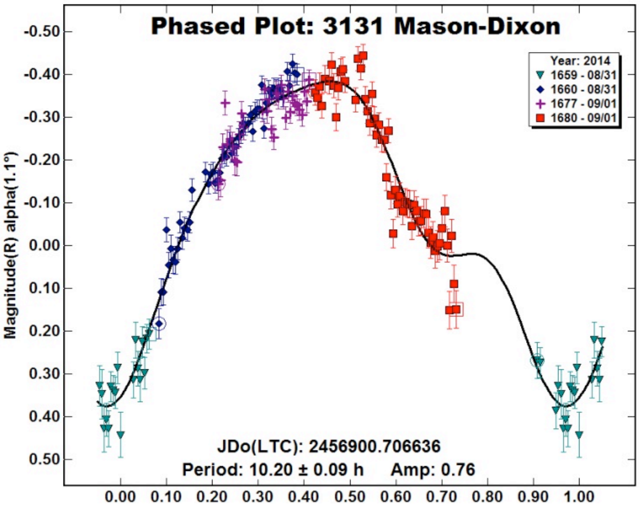
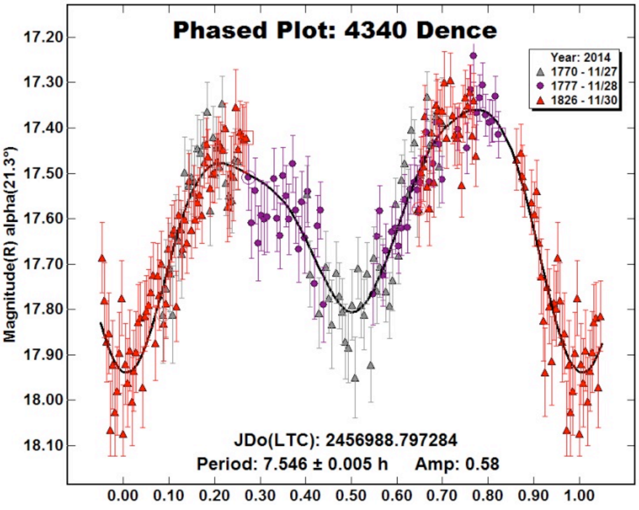
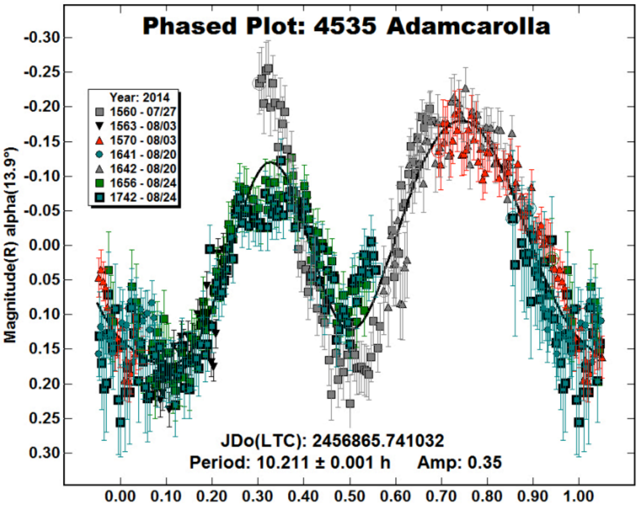
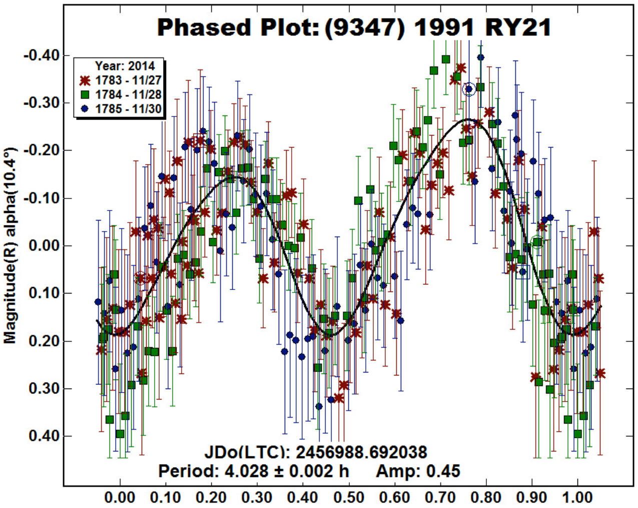


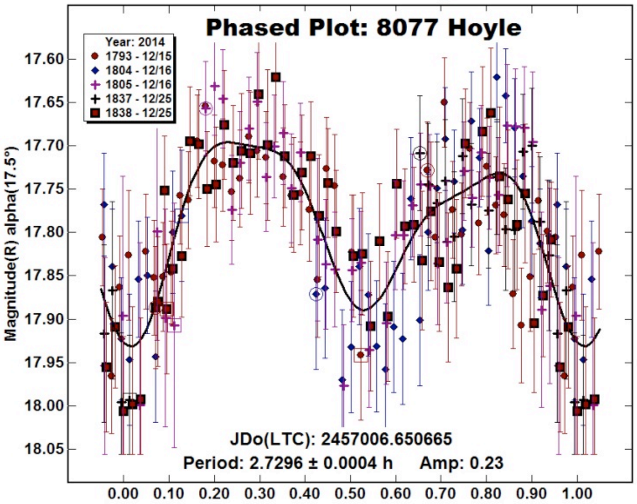


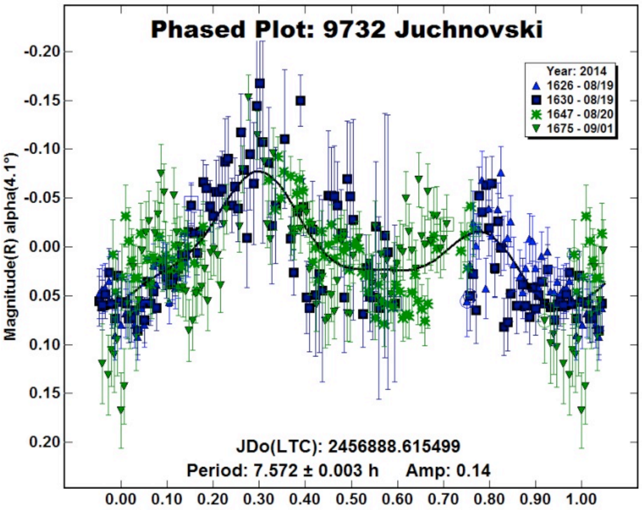


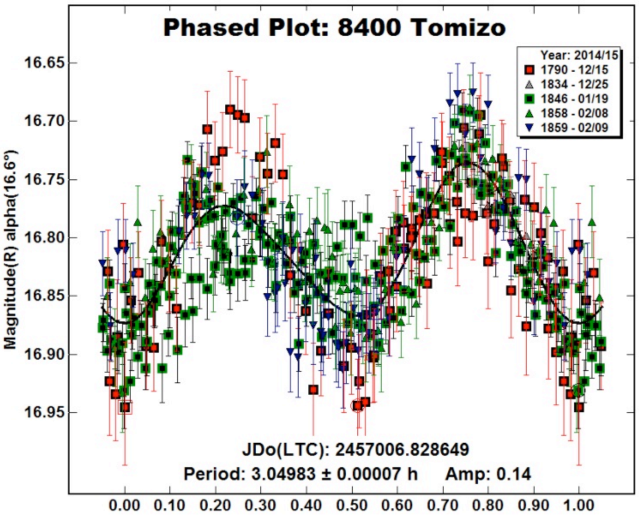



Phased Plot: 4535 Adamcarolla
Year: 2014
1560 - 07/27
1563 - 08/03
1570 - 08/03
1641 - 08/20
1642 - 08/20
1656 - 08/24
1742 - 08/24
Magnitude(R) alpha(13.9°)
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2456865.741032
Period: 10.211 ± 0.001 h Amp: 0.35


Phased Plot: (9347) 1991 RY21
Year: 2014
1783 - 11/27
1784 - 11/28
1785 - 11/30
Magnitude(R) alpha(10.4°)
-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
JDo(LTC): 2456988.692038
Period: 4.028 ± 0.002 h Amp: 0.45


Phased Plot: 8077 Hoyle
Year: 2014
1793 - 12/15
1804 - 12/16
1805 - 12/16
1837 - 12/25
1838 - 12/25
Magnitude(R) alpha(17.5°)
17.60 17.65 17.70 17.75 17.80 17.85 17.90 17.95 18.00 18.05
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2457006.650665
Period: 2.7296 ± 0.0004 h Amp: 0.23


Phased Plot: 9732 Juchnovski
Year: 2014
1626 - 08/19
1630 - 08/19
1647 - 08/20
1675 - 09/01
Magnitude(R) alpha(4.1°)
-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
JDo(LTC): 2456888.615499
Period: 7.572 ± 0.003 h Amp: 0.14


Phased Plot: 8400 Tomizo
Year: 2014/15
1790 - 12/15
1834 - 12/25
1846 - 01/19
1858 - 02/08
1859 - 02/09
Magnitude(R) alpha(16.6°)
16.65 16.70 16.75 16.80 16.85 16.90 16.95
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
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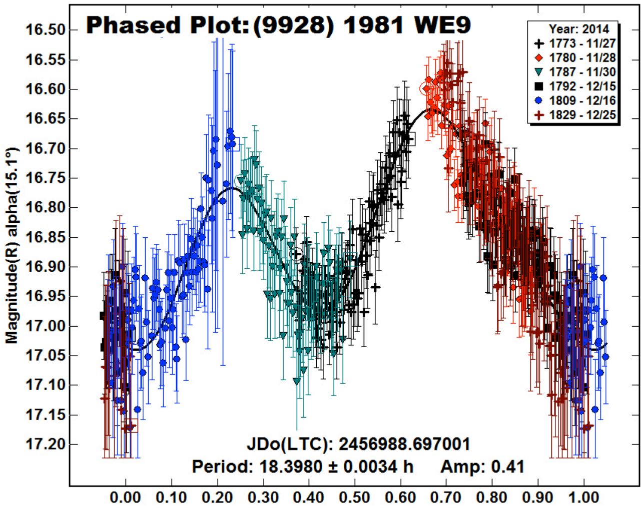
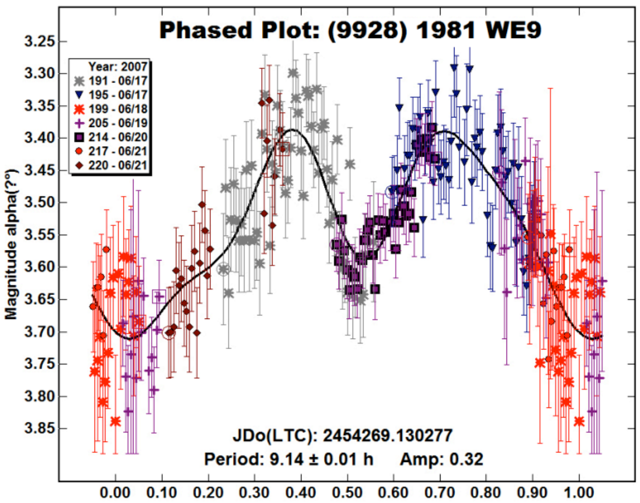
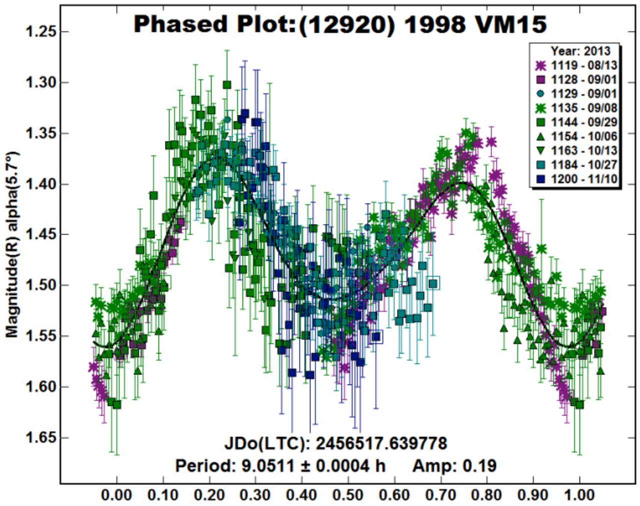
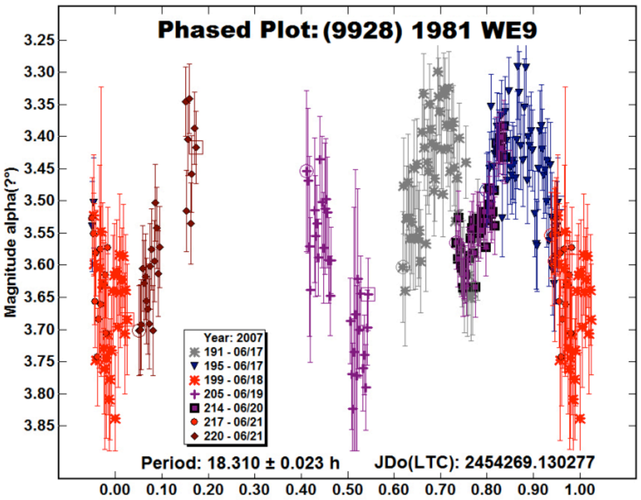

Phased Plot: (9928) 1981 WE9
Year: 2014
1773 - 11/27
1780 - 11/28
1787 - 11/30
1792 - 12/15
1809 - 12/16
1829 - 12/25
Magnitude(R) alpha(15.1°)
16.50 16.55 16.60 16.65 16.70 16.75 16.80 16.85 16.90 16.95 17.00 17.05 17.10 17.15 17.20
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2456988.697001
Period: 18.3980 ± 0.0034 h Amp: 0.41


Phased Plot: (9928) 1981 WE9
Year: 2007
191 - 06/17
195 - 06/17
199 - 06/18
205 - 06/19
214 - 06/20
217 - 06/21
220 - 06/21
Magnitude alpha(?°)
3.25
3.30
3.35
3.40
3.45
3.50
3.55
3.60
3.65
3.70
3.75
3.80
3.85
JDo(LTC): 2454269.130277
Period: 9.14 ± 0.01 h Amp: 0.32
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


Phased Plot:(12920) 1998 VM15
Year: 2013
1119 - 08/13
1128 - 09/01
1129 - 09/01
1135 - 09/08
1144 - 09/29
1154 - 10/06
1163 - 10/13
1184 - 10/27
1200 - 11/10
Magnitude(R) alpha(5.7°)
1.25
1.30
1.35
1.40
1.45
1.50
1.55
1.60
1.65
JDo(LTC): 2456517.639778
Period: 9.0511 ± 0.0004 h Amp: 0.19
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


Phased Plot:(9928) 1981 WE9
Year: 2007
191 - 06/17
195 - 06/17
199 - 06/18
205 - 06/19
214 - 06/20
217 - 06/21
220 - 06/21
Magnitude alpha(?°)
3.25
3.30
3.35
3.40
3.45
3.50
3.55
3.60
3.65
3.70
3.75
3.80
3.85
Period: 18.310 ± 0.023 h JDo(LTC): 2454269.130277
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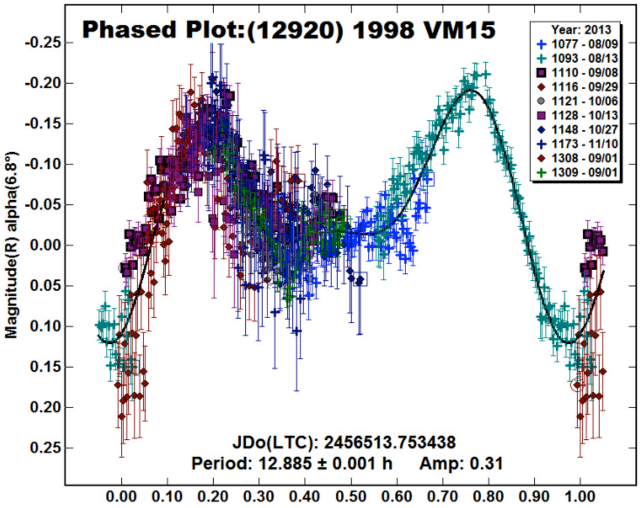
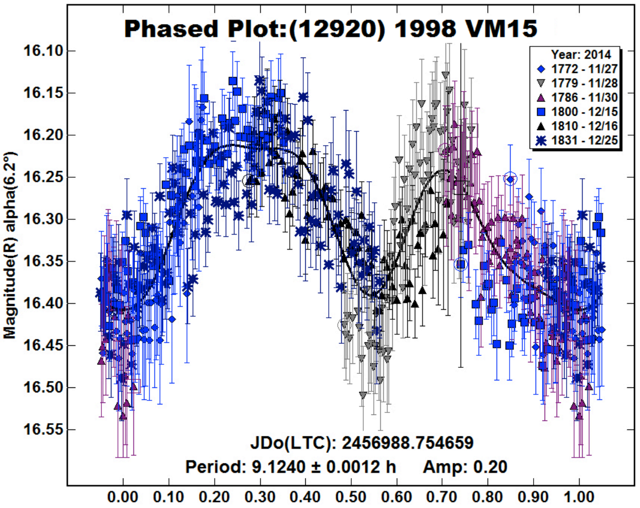
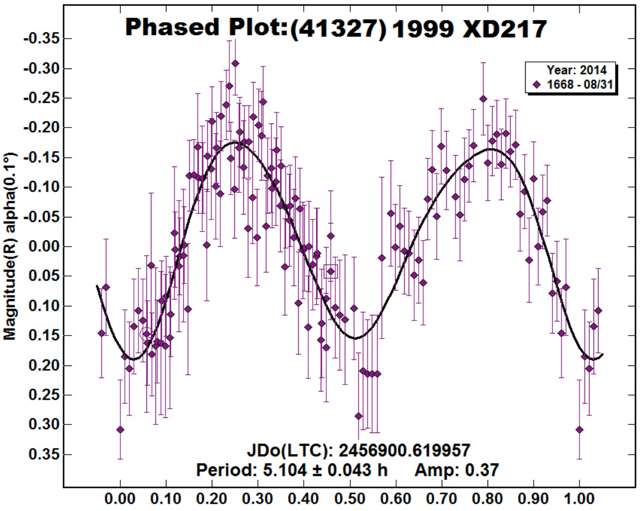
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


Phased Plot:(12920) 1998 VM15
Year: 2013
1077 - 08/09
1093 - 08/13
1110 - 09/08
1116 - 09/29
1121 - 10/06
1128 - 10/13
1148 - 10/27
1173 - 11/10
1308 - 09/01
1309 - 09/01
Magnitude(R) alpha(6.8°)
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
JDo(LTC): 2456513.753438
Period: 12.885 ± 0.001 h Amp: 0.31
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


Phased Plot:(12920) 1998 VM15
Year: 2014
1772 - 11/27
1779 - 11/28
1786 - 11/30
1800 - 12/15
1810 - 12/16
1831 - 12/25
Magnitude(R) alpha(6.2°)
16.10
16.15
16.20
16.25
16.30
16.35
16.40
16.45
16.50
16.55
JDo(LTC): 2456988.754659
Period: 9.1240 ± 0.0012 h Amp: 0.20
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


Phased Plot:(41327) 1999 XD217
Year: 2014
1668 - 08/31
Magnitude(R) alpha(0.1°)
-0.35
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
JDo(LTC): 2456900.619957
Period: 5.104 ± 0.043 h Amp: 0.37
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 CS3-PALMER DIVIDE STATION: 2014 DECEMBER – 2015 MARCH

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Lightcurves for 13 main-belt asteroids were obtained at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2014 December through 2015 March. All but two were members of the Hungaria orbital group or collisional family and observed as follow-up to previous apparitions to check for undiscovered satellites or to obtain data for spin axis and shape modeling.

CCD photometric observations of 13 main-belt asteroids were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2014 December through 2015 March. Table I lists the telescope/CCD camera combinations used for the observations. All the cameras use CCD chips from the KAF blue-enhanced family and so have essentially the same response. The pixel scales for the combinations range from 1.24-1.60 arcsec/pixel.

Desig	Telescope	Camera
Squirt	0.30-m f/6.3 Schmidt-Cass	ML-1001E
Borealis	0.35-m f/9.1 Schmidt-Cass	FLI-1001E
Eclipticalis	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Australius	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Zephyr	0.50-m f/8.1 R-C	FLI-1001E

Table I. List of CS3-PDS telescope/CCD camera combinations.

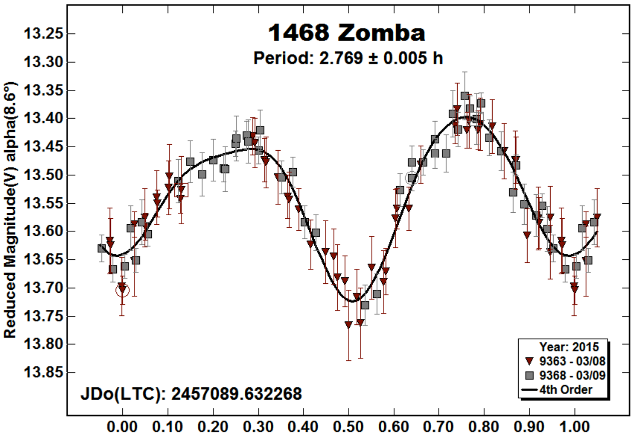
All lightcurve observations were unfiltered since a clear filter can result in a 0.1-0.3 magnitude loss. The exposure duration varied depending on the asteroid's brightness and sky motion. Guiding on a field star sometimes resulted in a trailed image for the asteroid.

Measurements were done using *MPO Canopus*. If necessary, an elliptical aperture with the long axis parallel to the asteroid's path was used. The Comp Star Selector utility in *MPO Canopus* found up to five comparison stars of near solar-color for differential photometry. Catalog magnitudes were usually taken from the MPOSC3 catalog, which is based on the 2MASS catalog (*http://www.ipac.caltech.edu/2mass*) but with magnitudes converted from J-K to BVRI using formulae developed by Warner (2007c). When possible, magnitudes are taken from the APASS catalog (Henden *et al.,* 2009) since these are derived directly from reductions based on Landolt standard fields. Using either catalog, the nightly zero points have been found to be consistent to about ± 0.05 mag or better, but on occasion are as large as 0.1 mag. This consistency is critical to analysis of long period and/or tumbling asteroids. Period analysis is also done using *MPO Canopus*, which implements the FALC algorithm developed by Harris (Harris *et al.,* 1989).

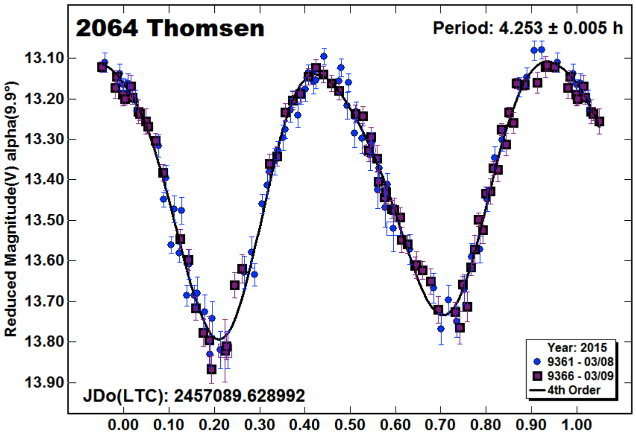
In the plots below, the "Reduced Magnitude" is Johnson V as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distance by applying $-5*\log (r\Delta)$ to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the given phase angle, e.g., alpha(6.5°), using $G = 0.15$, unless otherwise stated. The X-axis is the rotational phase ranging from –0.05 to 1.05.

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

1468 Zomba. Wisniewski *et al.* (1987) reported a period of 2.77 h for this Mars-crosser. Later results include Alkema (2014, 2.773 h) and Benishek (2014, 2.772 h). The period found here is within the stated error of those earlier results.

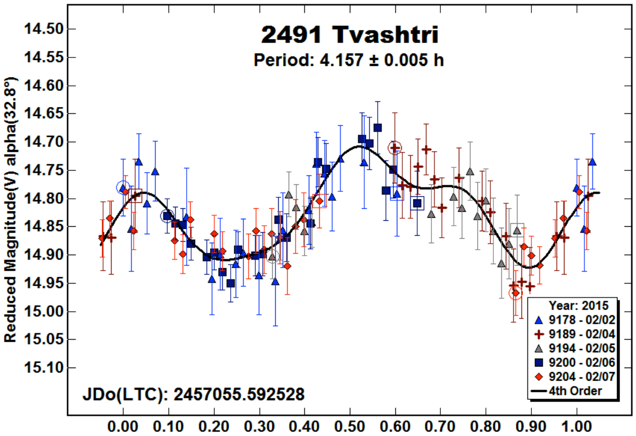


2064 Thomsen. Earlier results for this Mars-crosser include Wisniewski (1991, 4.233 h) and Behrend (2003, 4.2267 h). The amplitude for those lightcurves were also $A > 0.60$ mag, indicating an elongated object with a minimum a/b ratio of ~1.8:1 when assuming a simple triaxial ellipsoid.

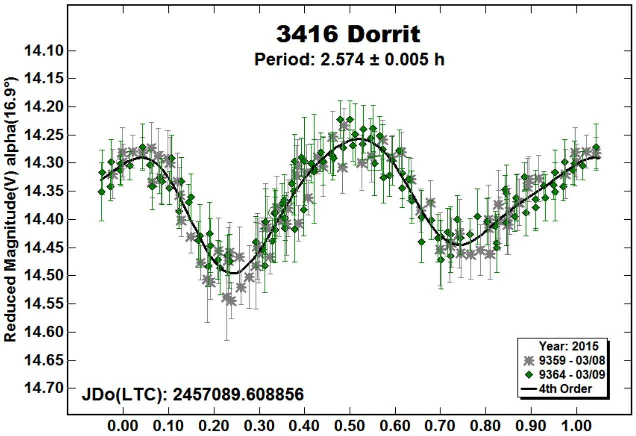


2491 Tvashtri. This Hungaria asteroid has been observed previously by the author: Warner (2008, 4.0839 h; 2013, 4.084 h). Both of those previous results were rated U = 2 in the asteroid lightcurve database (LCDB; Warner *et al*., 2009), meaning that the periods were not certain and could be in error by 30% or the result of a *rotational alias*, i.e., a miscount in the number of rotations over the span of the observations. The uncertainty was made more so by the amplitude at both apparitions being < 0.1 mag.

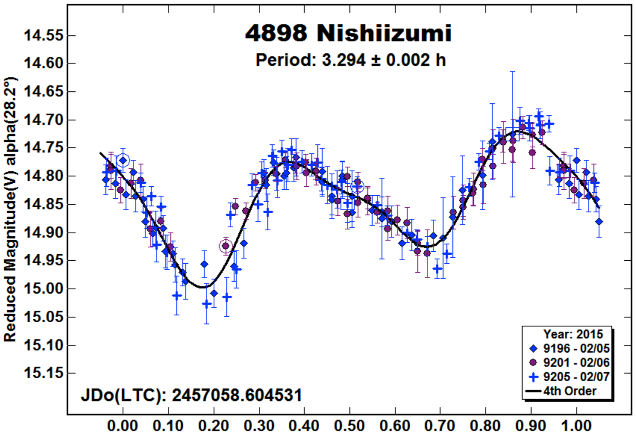
The results from the 2015 observations, even though they covered five nights with four of them consecutive and had an amplitude of 0.24 mag, did not resolve the uncertainty and – in fact – seem to make it worse since the period of 4.157 h is nearly 0.07 h (~2%) longer. Attempts to fit the data from the previous two apparitions to the longer period and those from 2015 to the shorter period were fruitless.



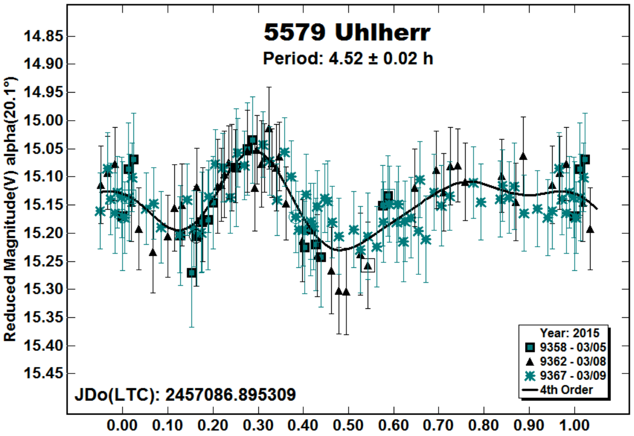
<u>3416 Dorrit</u>. Bennefeld *et al.* (2009) found a period of 2.714 h for this Mars-crosser. Warner (2010) reported 2.574 h, which is the same result found from the data obtained in 2015 March.



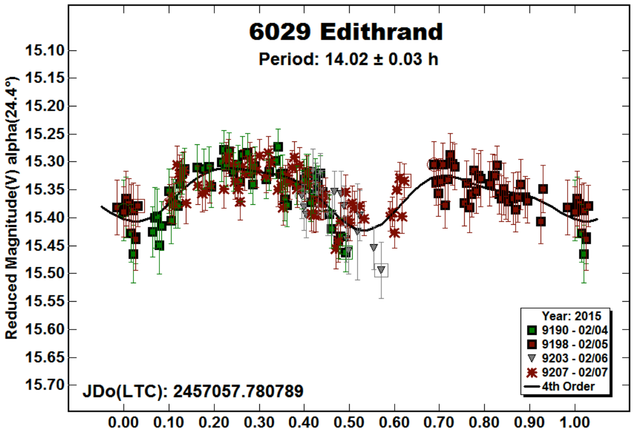
<u>4898 Nishiizumi</u>. The 2015 apparition was the third one at which the author observed this Hungaria asteroid. It appears to be a member of the collisional family based on the high albedo (p_V = 0.9938) reported by the WISE survey (Mainzer *et al.*, 2011; Masiero *et al.*, 2012). As noted in Warner (2012b and references therein), the unexpectedly high albedos reported for the Hungarias initially reported by WISE – far above the average value for type E asteroids of about 0.46 (Warner *et al.*, 2009) – was likely due to poorly-determined values for *H*, the absolute magnitude of the asteroids. Warner (2012b) used his observations to find a revised value of *H* =14.31 (versus *H* = 13.9 used by WISE), which lead to a more likely albedo of p_V = 0.5545. Even with the significant change in the two parameters, the net effect was to reduce the size of the asteroid by only 10%, from about 2.2 km to 2.0 km.



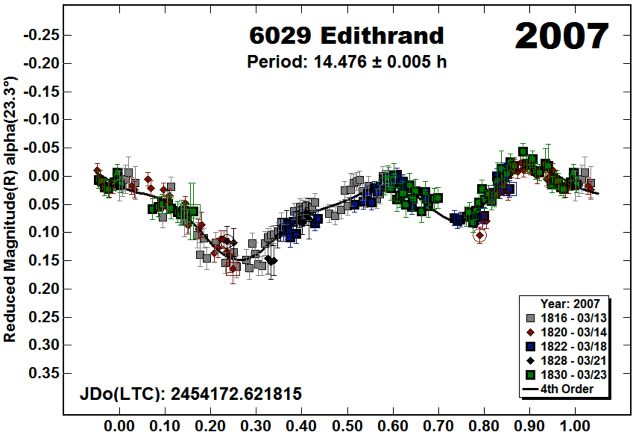
<u>5579 Uhlherr</u>. The previous results by the author (Warner, 2009, 4.754 h, U = 2; 2012, 4.774 h, U = 1) are significantly different from *P* = 4.52 h found from the 2015 observations. At least one more apparition is needed to find a definitive period.



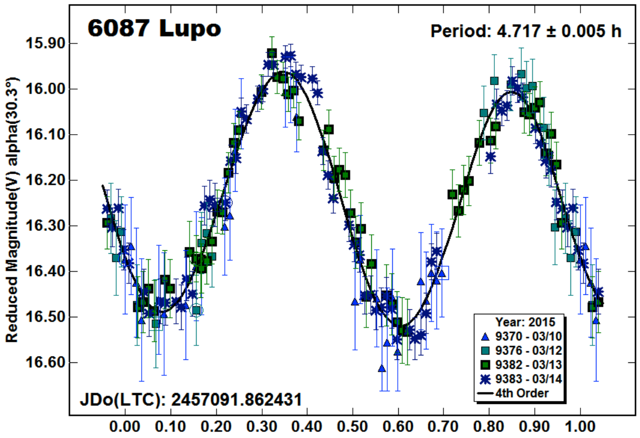
<u>6029 Edithrand</u>. The period of 14.02 h found from the 2015 observations is significantly shorter from earlier results: Warner (2007b, 14.472 h; 2012a, 14.45 h).



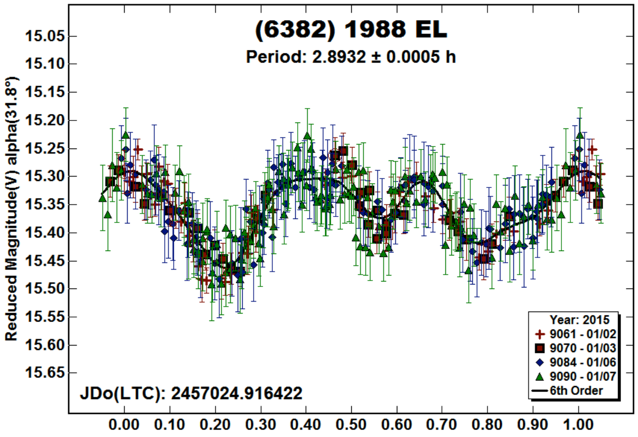
Because of the difference, the data from the earlier apparitions were checked to see if a result closer to the one from 2015 could be found. The data from 2011 were relatively sparse and so were not helpful. The 2007 data set was better and, with some very minor changes to zero points (< 0.02 mag), a slightly different period of 14.476 ± 0.005 h was found with a very strong spike in the period spectrum indicating no possibility of the shorter period fitting the data.



6087 Lupo. The results from the 2015 observations at CS3 for this Hungaria are in good agreement with past results: Warner (2011, 4.712 h; 2012b, 4.717 h).

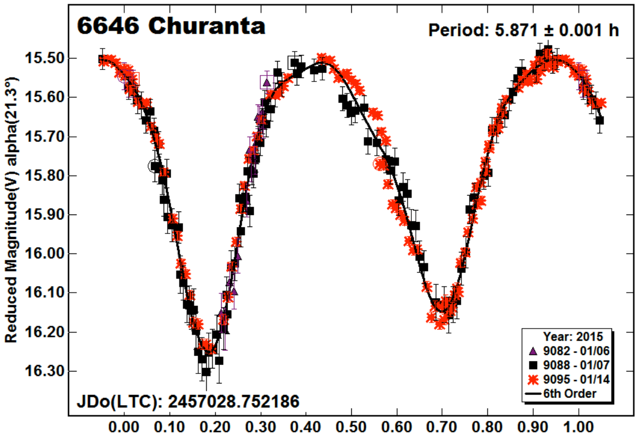


(6382) 1988 EL. The period of 2.8932 h found from 2015 observations matches earlier results from the author, e.g., Warner (2012a, 2.894 h). The amplitude at the four previous apparitions observed by the author was < 0.1 mag.

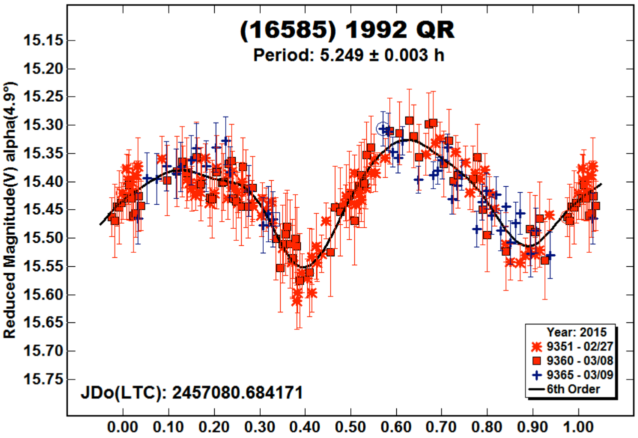


In 2015, the amplitude was 0.15 mag, which was somewhat unexpected because the phase angle bisector longitude and latitude (see Harris *et al.*, 1984) was very similar to two previous apparitions. Observations by Maisero *et al*. (2012) indicate a lower albedo that makes it likely that this asteroid is not a member of the Hungaria collisional family but an interloper in Hungaria orbital space.

6646 Churanta. Previous results include Warner (2007a, 5.8711 h; 2012a, 5.877 h). All three apparitions showed a lightcurve amplitude of $A \sim 0.75$ mag. Masiero *et al*. (2012) found an albedo compatible with a type E object, the same taxonomic type for members of the Hungaria collisional family.



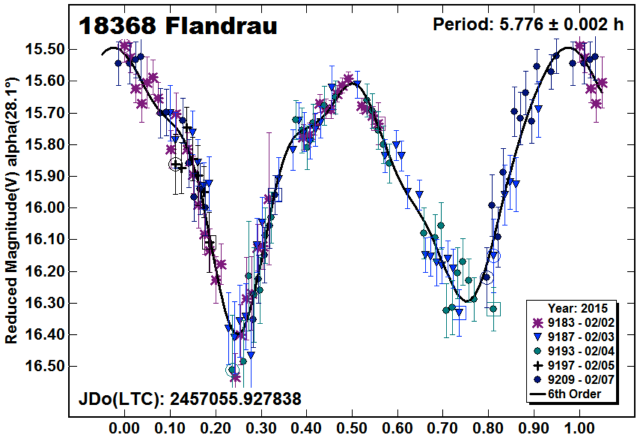
(16585) 1992 QR. The period of 5.249 ± 0.003 h found from 2015 observations is in good agreement with previous results: Warner (2007a, 5.273 h; 2012, 5.255 h). The 2012 observations by the author also found an albedo of $p_V = 0.4970$, which is compatible with a type E asteroid.



Number	Name	2015 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period	P.E.	Amp	A.E.	Group
1468	Zomba	03/08-03/09	98	26.1,26.1	89	5	2.769	0.005	0.33	0.03	MC
2064	Thomsen	03/08-03/09	141	9.9,10.3	144	-3	4.253	0.005	0.69	0.03	MC
2491	Tvashtri	02/02-02/07	97	1.3,2.3	311	-2	4.157	0.005	0.24	0.03	H
3416	Dorrit	03/08-03/09	179	17.0,17.2	142	23	2.574	0.005	0.24	0.02	MC
4898	Nishiizumi	02/05-02/07	152	28.2,28.7	94	24	3.294	0.002	0.28	0.02	H
5579	Uhlherr	03/05-03/09	126	20.1,19.5	184	32	4.52	0.02	0.18	0.03	H
6029	Edithrand	02/02-02/07	302	24.8,23.9	161	26	14.02	0.03	0.11	0.02	H
6087	Lupo	03/10-03/14	162	30.3,29.6	215	24	4.717	0.005	0.56	0.03	H
6382	1988 EL	01/02-01/07	323	31.9,31.0	156	13	2.8932	0.0005	0.15	0.02	H
6646	Churanta	01/06-01/14	234	21.3,17.5	130	17	5.871	0.001	0.75	0.03	H
16585	1992 QR	02/27-03/09	196	4.9,6.6	162	8	5.249	0.003	0.22	0.03	H
18368	Flandrau	02/02-02/07	139	28.1,27.2	170	31	5.776	0.002	0.9	0.03	H
32800	1990 QC19	[11]08/25-09/20	487	21.7,18.6,19.0	356	25	3.709	0.001	0.15	0.02	H
32800	1990 QC19	02/05-02/07	109	19.0,20.0	109	4	3.726[A]	0.006	0.14	0.02	H

Table II. Observing circumstances. [11] Observations in 2011. [A] preferred period of an ambiguous solution. 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). The Group column gives the orbital group to which the asteroid belongs. The definitions and values are those used in the LCDB (Warner *et al.*, 2009). H = Hungaria; MC = Mars-crosser.

18368 Flandrau. Warner (2012b) found a period of 5.777 h based on observations in 2012 January. The 2015 result is essentially identical in both period and amplitude. Given this and the fact that the phase angle bisector longitudes for the two apparitions differ by 82°, this would indicate a spin axis with a low obliquity, i.e., a pole near one of the ecliptic poles. The albedo from Masiero *et al.* (2012) favors this being a type E object.

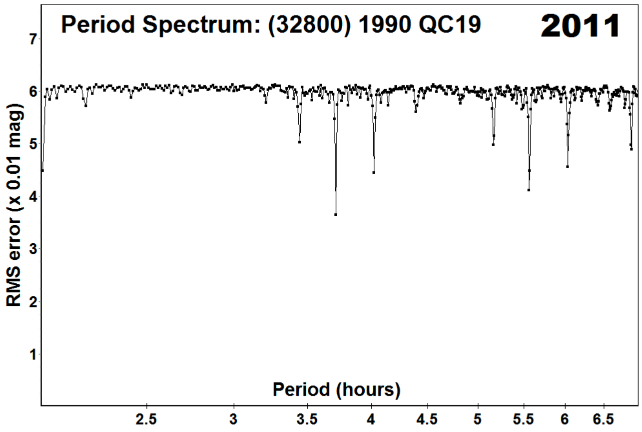


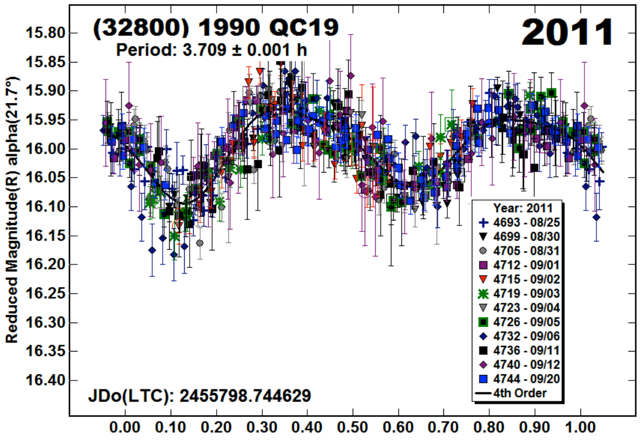
(32800) 1990 QC19. Masiero *et al.* (2012) found an albedo of 0.24 for 1990 QC19. This makes it more likely an interloper in Hungaria orbital space rather than a member of the Hungaria collisional family.

The asteroid was first observed by the author in 2011 (Warner, unpublished). At that time, one session showed what appeared to be an attenuation, possibly due to a satellite. Observations were requested from other locations. Data provided by Adrian Galad (private communications) seemed to show a second attenuation. Analysis by Petr Pravec (private communications) found several possible solutions for an orbital period, one being about 53 h. Follow-up observations in 2011 by Warner did not find any further evidence for the satellite.

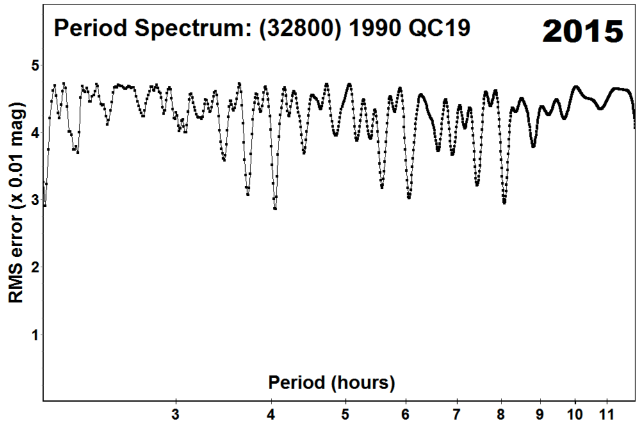
The original 2011 data from Warner alone were re-examined, where it was found that a minor shift of the zero point by 0.02 mag for the one night in question caused the attenuation to disappear into the noise, thus making it highly questionable. At this point, the likelihood of 1990 QC19 being a binary is very small, but enough so to encourage observations at future apparitions.

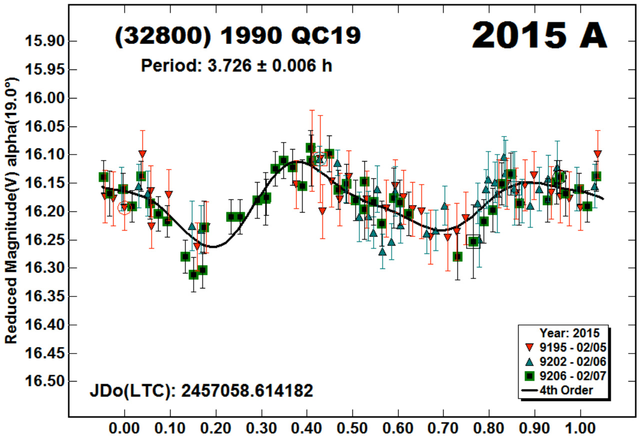
Looking at the 2011 data from the perspective of a single object, the period spectrum shows a very sharp minimum at 3.709 h. There is a "sideband" period at about 4.0 h, which represents a one-half rotation difference over a 24 hour period. The asymmetry of the lightcurve precludes the longer period, i.e., there was no miscount of the number of rotations over the span of the data set, sometimes called a *rotational alias*.

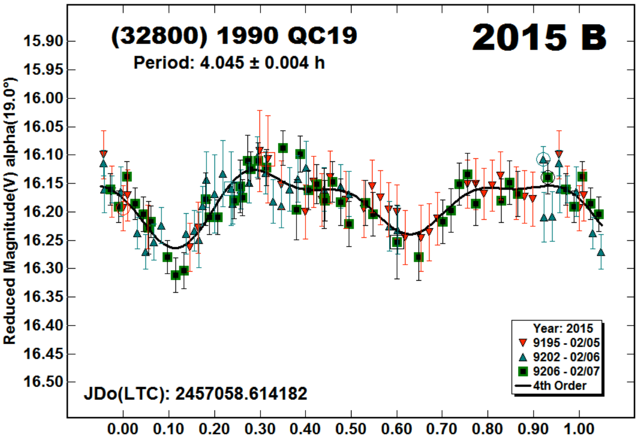




The data set for 2015 was much less extensive than in 2011. As a result, the period spectrum is not as definitive and, in fact, favors the 4-hour period over the shorter one from 2011. The plots show the 2015 data plotted to the two likely periods. All things considered, the period of 3.709 h found from 2011 is adopted for this paper.







Acknowledgements

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LIGHTCURVE ANALYSIS OF NEA (361071) 2006 AO4

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(Received: 29 January)

CCD photometric observations of Amor-type asteroid (361071) 2006 AO4 were made on 2013 September 23. From the lightcurve we obtained a synodic period of 4.09 ± 0.17 h with an amplitude of 0.13 mag.

Remote Observatory Theoretical Astrophysics Tübingen (ROTAT) is a 60-cm remotely operated telescope located on the Observatoire de Haute-Provence (OHP) site at Haute-Provence, France, about 100 km north-east of Marseille. ROTAT was formerly located and operated in Tübing by the Dept. for Theoretical Astrophysics, University of Tübingen.

Image acquisition was made with an SBIG STL-1100M CCD camera attached to the *f*/3.2 Newtonian focus of the ROTAT telescope, resulting in a pixel scale of 1.94 arcsec/pixel with 2x2 binning. No filters were used. All images were measured using *Astrometrica*, *i.e.* PSF-based all-sky photometry. Dark and flat images were applied.

Magnitudes were reduced to unity distance and times were corrected for light-time. The observations show a fair amount of scatter. Hence the period search was done with two different methods. First, a period scan using the Phase Dispersion Minimization algorithm (PDM; Stellingwerf, 1978) was done. Second, the period was determined by performing fourth-order Fourier fits to a range of possible periods. Both approaches showed a most likely period around 4 h.

The final period $P = 4.09 \pm 0.17$ h with an amplitude $A = 0.13$ mag was obtained from a fourth-order Fourier fit, similar to the FALC method developed by Harris (Harris *et al.*, 1989). The computations were done with a Python/SciPy script developed by the authors. The PDM algorithm is provided by the Python PyAstronomy package (*https://github.com/sczesla/ PyAstronomy*). Our results are consistent with those of Warner (2014) who reported another lightcurve, observed in 2013 August, from which he obtained a period $P = 4.093 \pm 0.001$ h.

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We would like to thank Dr. Dieter Husar (Hamburg) and Prof. Dr. Hanns Ruder (Tübingen), chairmen of “Stiftung Interaktive Astronomie und Astrophysik”, for granting us access to the ROTAT facilities and their friendly support.

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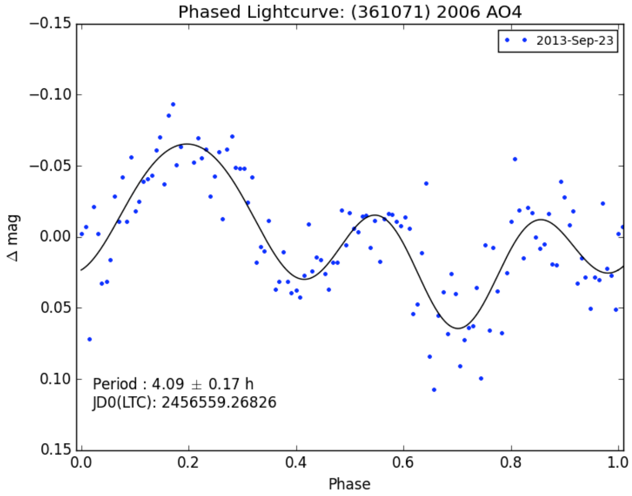

NEAR-EARTH ASTEROID LIGHTCURVE ANALYSIS AT CS3-PALMER DIVIDE STATION: 2015 JANUARY – MARCH

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Lightcurves for 35 near-Earth asteroids (NEAs) were obtained at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2014 December through 2015 March. One object, (159454) 2000 DJ8, may be a highly bifurcated body, or a close binary.

CCD photometric observations of 35 near-Earth asteroids (NEAs) were made at the Center for Solar System Studies-Palmer Divide

Station (CS3-PDS) from 2015 January – March. Table I lists the telescope/CCD camera combinations used for the observations. All the cameras use CCD chips from the KAF blue-enhanced family and so have essentially the same response. The pixel scales for the combinations range from 1.24-1.60 arcsec/pixel.

Desig	Telescope	Camera
Squirt	0.30-m f/6.3 Schmidt-Cass	ML-1001E
Borealis	0.35-m f/9.1 Schmidt-Cass	FLI-1001E
Eclipticalis	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Australius	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Zephyr	0.50-m f/8.1 R-C	FLI-1001E

Table I. List of CS3-PDS telescope/CCD camera combinations.

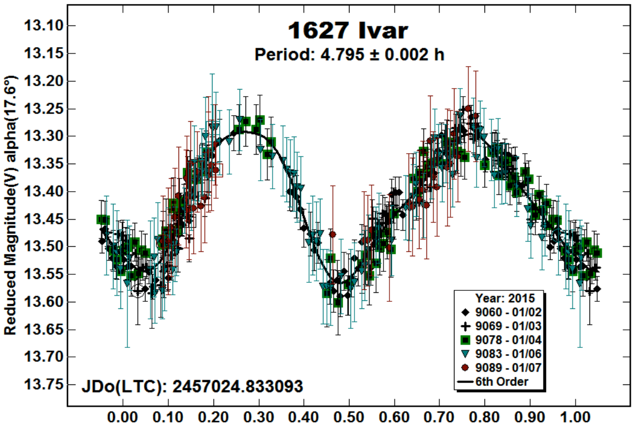
All lightcurve observations were unfiltered since a clear filter can result in a 0.1-0.3 magnitude loss. The exposure duration varied depending on the asteroid's brightness and sky motion. Guiding on a field star sometimes resulted in a trailed image for the asteroid.

Measurements were done using *MPO Canopus*. If necessary, an elliptical aperture with the long axis parallel to the asteroid's path was used. The Comp Star Selector utility in *MPO Canopus* found up to five comparison stars of near solar-color for differential photometry. Catalog magnitudes were usually taken from the MPOSC3 catalog, which is based on the 2MASS catalog (*http://www.ipac.caltech.edu/2mass*) but with magnitudes converted from J-K to BVRI using formulae developed by Warner (2007). When possible, magnitudes are taken from the APASS catalog (Henden *et al.,* 2009) since these are derived directly from reductions based on Landolt standard fields. Using either catalog, the nightly zero points have been found to be consistent to about ± 0.05 mag or better, but on occasion are as large as 0.1 mag. This consistency is critical to analysis of long period and/or tumbling asteroids. Period analysis is also done using *MPO Canopus*, which implements the FALC algorithm developed by Harris (Harris *et al.,* 1989).

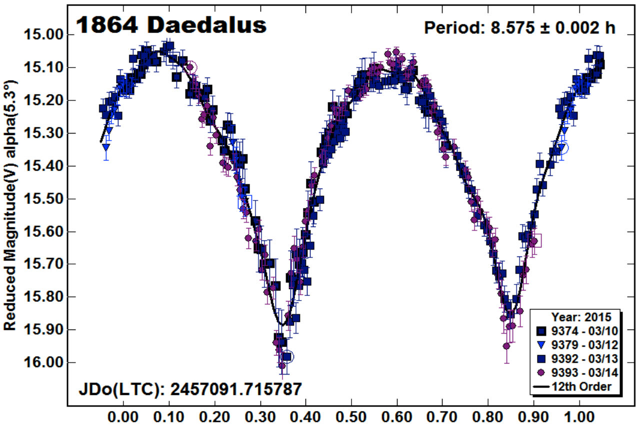
In the plots below, the "Reduced Magnitude" is Johnson V as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distance by applying –5*log (rΔ) to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the given phase angle, e.g., alpha(6.5°), using *G* = 0.15, unless otherwise stated. The X-axis is the rotational phase, ranging from –0.05 to 1.05.

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

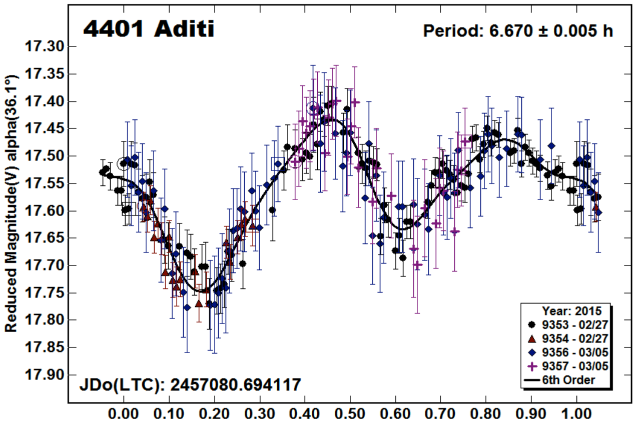
1627 Ivar. There are numerous entries in the LCDB for this near-Earth asteroid, all close to 4.8 hours, including Warner (2014a) who found *P* = 4.8003 h, *A* = 0.28 mag in early 2015 June and then *P* = 4.7961 h, *A* = 0.73 mag in mid-August. A shape model (Kassalainen *et al.*, 2004) already exists. The main benefit of additional lightcurves now is to improve on the model and see if the YORP (Yakovsky-O'Keefe-Radzievskii-Paddack) effect is slowly changing the sidereal period of the asteroid, as seen in other asteroids, e.g., 1862 Apollo (Kassalainen *et al.*, 2007).



1864 Daedalus. The period for this NEA was first determined more than 50 years ago (Gehrels *et al*., 1971; 8.57 h). Subsequent results include Pravec *et al.* (1991, 8.572 h). Thomas *et al.* (2014) determined that Daedalus is taxonomic type Sq on the SMASS system (Small Main-Belt Asteroid Spectroscopic Survey; see Bus *et al*., 2002a/b). The period of 8.575 h derived from the 2015 CS3-PDS observations is in good agreement with the earlier results.

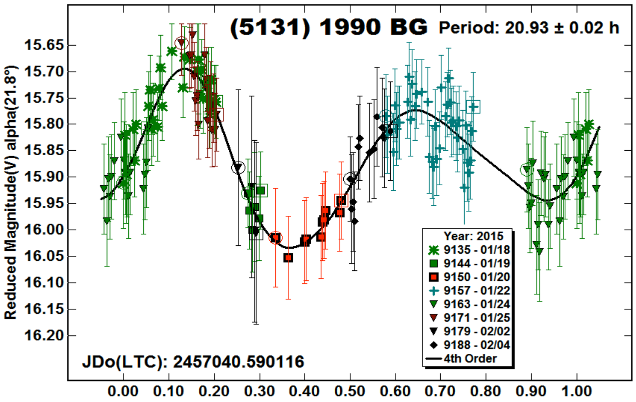


4401 Aditi. The observations in 2015 March at CS3-PDS were follow-up to those made in 2014 August-September.

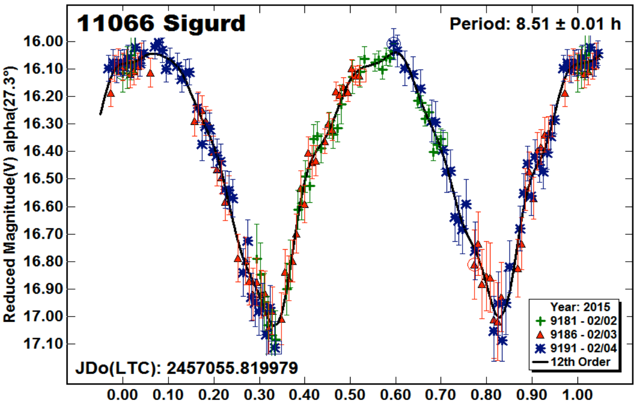


The amplitude at the earlier observations was *A* = 0.64 mag (α = 33°) and only *A* = 0.29 mag for the latter despite a similar phase angle of α = 35°. In this case, there was a significant difference in the viewing aspect as judged by the phase angle bisector longitude and latitude (L_{PAB} and B_{PAB}; see Harris *et al.*, 1984). For comparison the PAB values were: 2014 (23°, -11°) and 2015 (156°, 36°). The significant difference in amplitude and lightcurve shapes between the two data sets will be helpful when trying to model the asteroid when even more data are available.

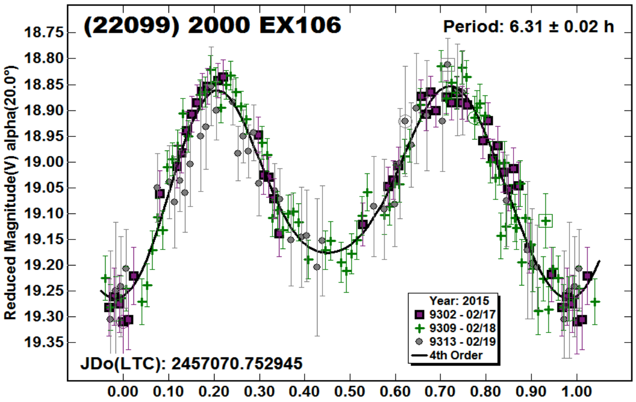
(5131) 1990 BG. No previous results were found in the LCDB for 1990 BG. The period given is the best bimodal solution in a search from 10 to 60 hours in that the slopes of the individual nights follow the Fourier model curve. A solution at about 18.5 hours produced an unlikely monomodal solution and its double period of about 37 hours an even more unlikely solution based on a highly asymmetric lightcurve with large gaps.



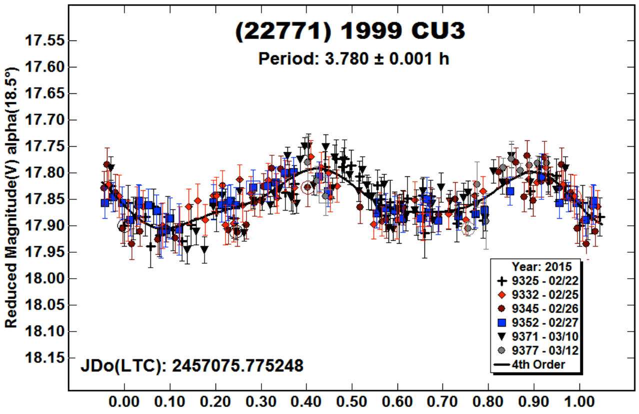
11066 Sigurd. Pravec *et al.* (1998) reported a period of 8.4958 h and Krugly *et al.* (2002) found a period of 8.496 h. The result here is in good agreement with those results. In addition, the 2015 lightcurve shows the lowest amplitude of the three, the greater difference being 0.18 mag when comparing 2015 to 2002.



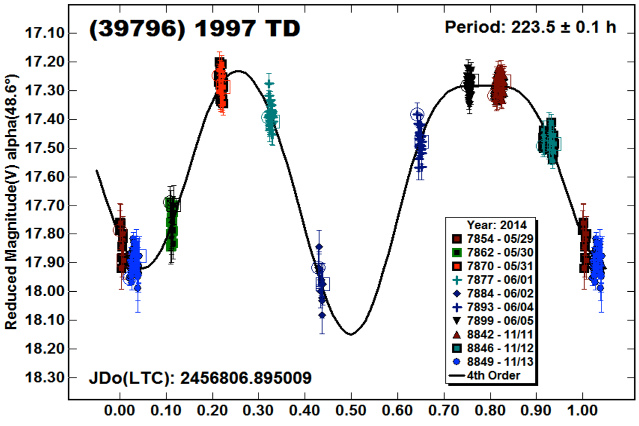
(22099) 2000 EX106. The period found from the 2015 CS3-PDS observations is in good agreement with the one of 6.334 h found by Pravec *et al.* (2002).



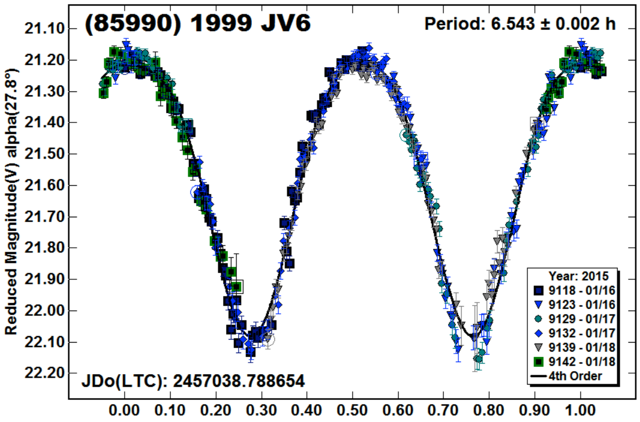
(22771) 1999 CU3. Based on observations in 2003 September-November, Pravec *et al.* (2003) found an average synodic period of 3.7822 h. The amplitude varied from 0.81-1.25 mag. The period of 3.780 h reported here is in good agreement. The lower amplitude of 0.12 mag suggests a nearly pole-on viewing aspect. If so, then the spin axis ecliptic longitude would be near the phase angle bisector longitude (L_{PAB}) of 175° (or 355°).



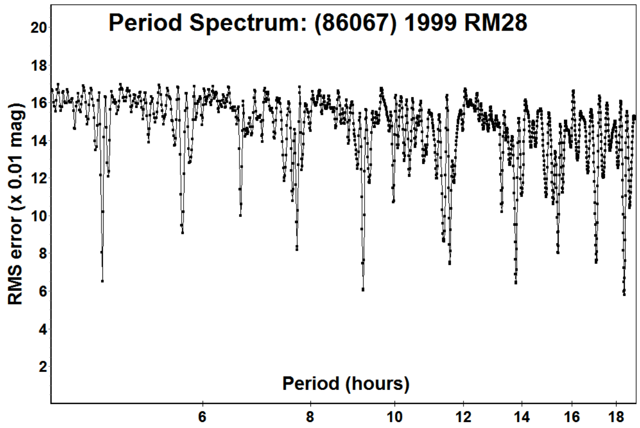
(39796) 1997 TD. Given that the slopes of individual sessions do not follow the slope of the Fourier model curve and the expected damping time for tumbling exceeds the age of the Solar System (see Pravec *et al.*, 2005; 2014), it's likely that this slow rotator is a tumbler, i.e., in non-principal axis rotation (NPAR).

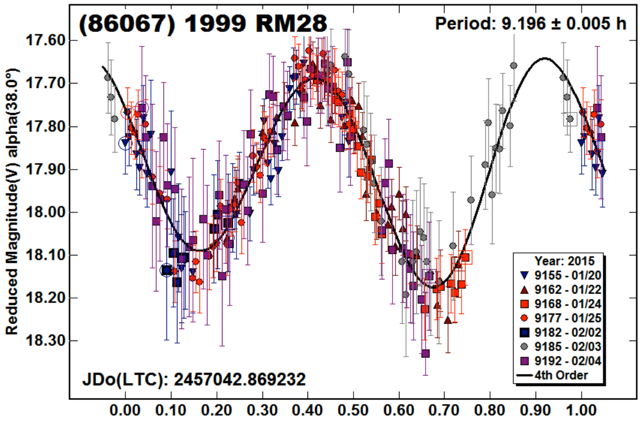


(85990) 1999 JV6. Warner (2014b) found P = 6.538 h, A = 0.87 mag ($\alpha = 12°$) based on observations in 2014 January. The 2015 January observations, A = 0.93 mag ($\alpha = 26°$), were at almost the same phase angle bisector longitude and latitude. The difference in amplitude is probably due to the difference in phase angles.

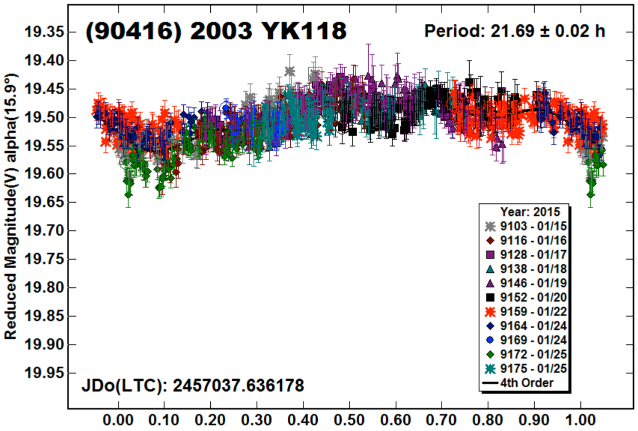


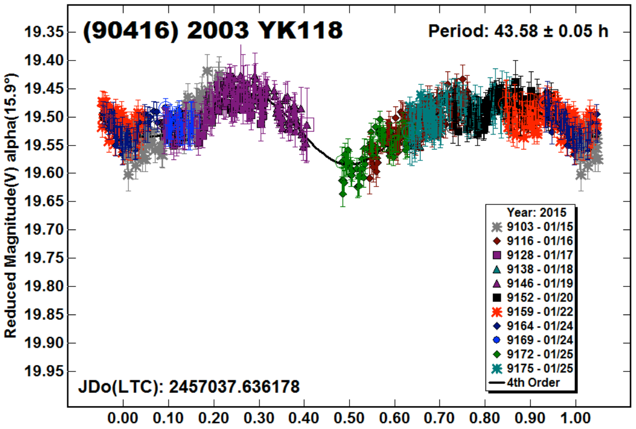
(86067) 1999 RM28. The LCDB did not have any lightcurve entries for 1999 RM28. However, it did note that Thomas *et al.* (2014) determined that this is a type Q object, which is an intermediate class between the S and V types. The period spectrum for 1999 RM28 is highly ambiguous. After reviewing half-period, double period, and double period *split halves* solutions, a period of 9.196 h is adopted for this paper. See Harris *et al.* (2014) for a discussion of a *split halves* plot and its value for eliminating ambiguous periods.



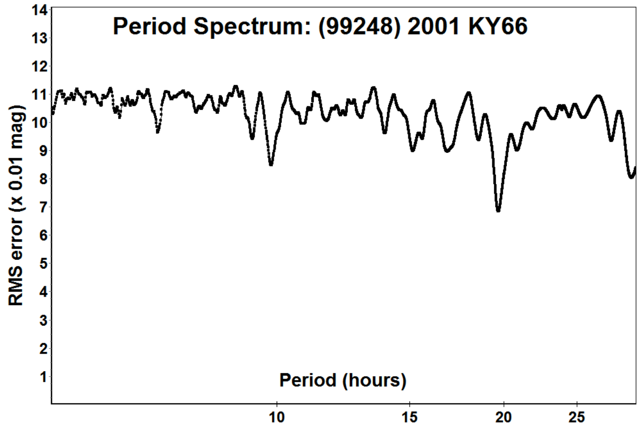


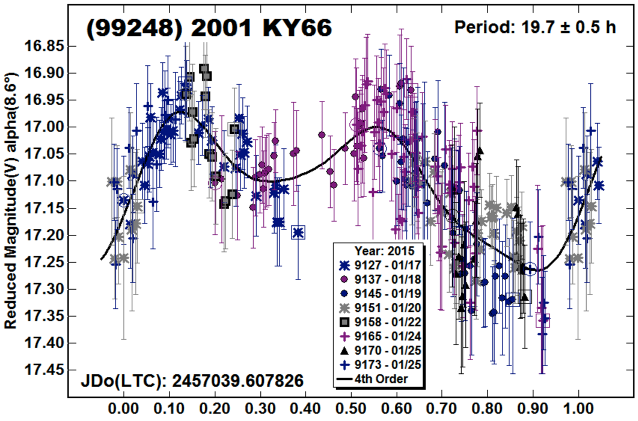
(90416) 2003 YK118. The period spectrum for 2003 YK118 shows two likely periods. Even though the amplitude is only 0.13 mag and, therefore, a bimodal solution cannot be assumed (Harris *et al.*, 2014), the longer period of 43.58 h with a bimodal lightcurve is adopted for this paper. This is based mostly on the slightly better fit to the Fourier model curve. There were no previous entries in the LCDB for this NEA.



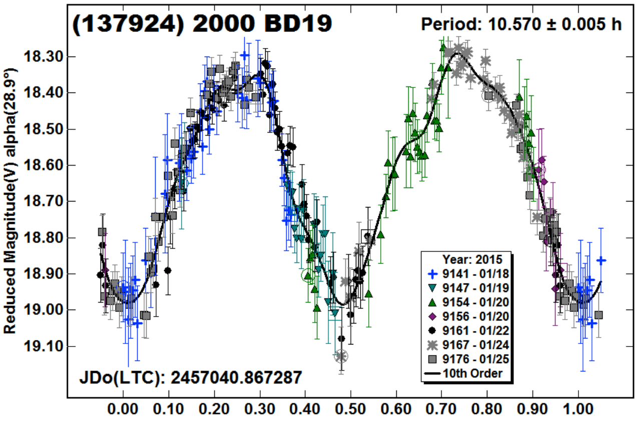


(99248) 2001 KY66. This asteroid faded from V = 18.2 to 18.6 over the course of the observations. The only telescope available was the smallest one at CS3, the 0.30-m SCT, which resulted in a noisier than preferred data set. The period spectrum shows a strong solution at 19.7 hours. However, the lightcurve for that period is far from convincing due to the irregular shape. The period reported here should not be considered definitive. In 2019, 2001 KY66 returns, reaching V ~ 15.5 at +54° declination. Perhaps a better solution will be found then.

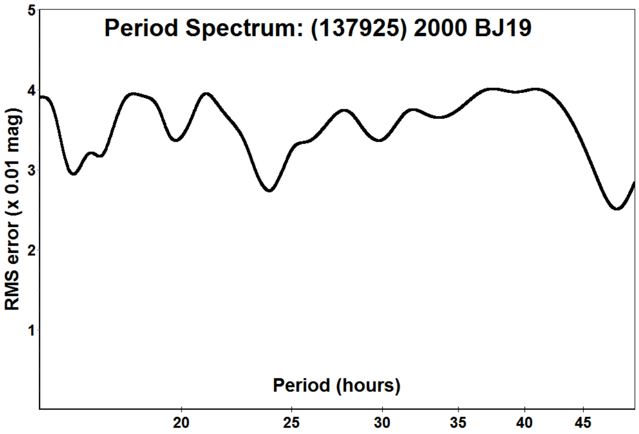


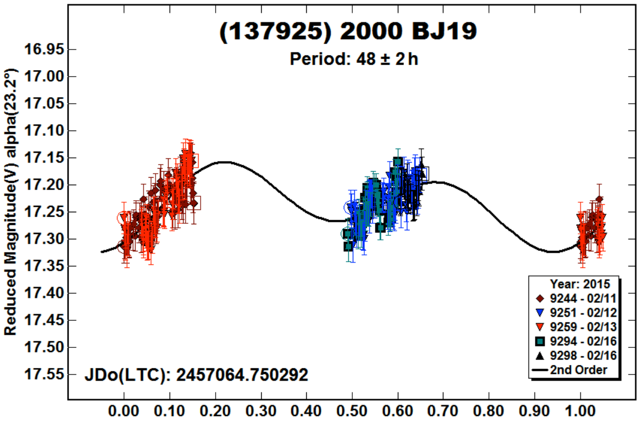


<u>(137924) 2000 BD19</u>. Thomas *et al.* (2014) report this to be a type V asteroid, making it similar spectroscopically to Vesta and raising the possibility that it might be a splinter created from the collisions that formed the impact features on Vesta. There were no other entries in the LCDB for 2000 DB19.

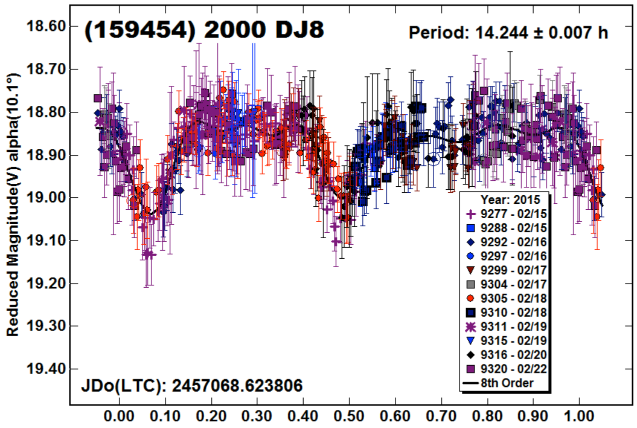


<u>(137925) 2000 BJ19</u>. The period spectrum for 2000 BJ 19 shows two solutions, both nearly commensurate with an Earth day. The longer period, 48 ± 2 h, is adopted for this paper, although the shorter period of about 24 hours cannot be excluded, nor can one of about 12 hours. The moon and weather intervened in early March. By then, the asteroid had moved too far north for the telescopes at CS3.



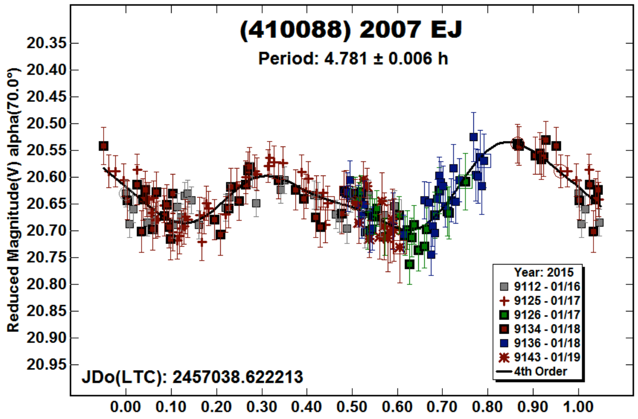


<u>(159454) 2000 DJ8</u>. The exact nature of 2000 DJ8 is a mystery. The lightcurve is similar to other objects, e.g., (69230) Hermes, which are thought to be two very close objects (sometimes misnamed *contact binaries*) that are fully synchronized, i.e., their rotation and orbital periods are the same. If true in this case, the smaller body is about half the effective size of the larger. The problem for 2008 DJ is that the two events are not evenly spaced and so imply an eccentric orbit. This is not likely given the orbital period (Alan Harris, private communications).

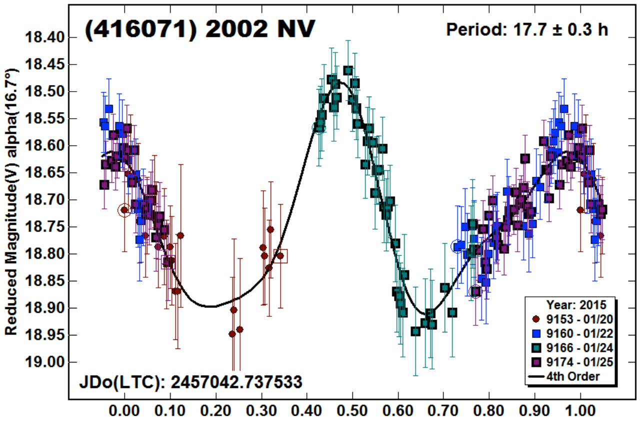


Harris suggested an alternative solution of the half-period, i.e., about 7 hours, and some large feature not viewed equatorially. This idea cannot be formally excluded. The next reasonable chance to observe this NEA is not until 2020 January-February (V ~ 17.2, Dec –4°).

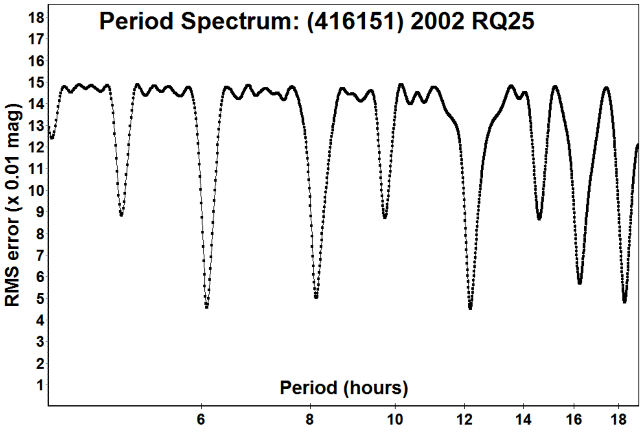
<u>(410088) 2007 EJ</u>. There were no previous entries in the LCDB for 2007 EJ. The next good opportunity for 2007 EJ is 2018 November (V ~ 16.9, Dec –49°).

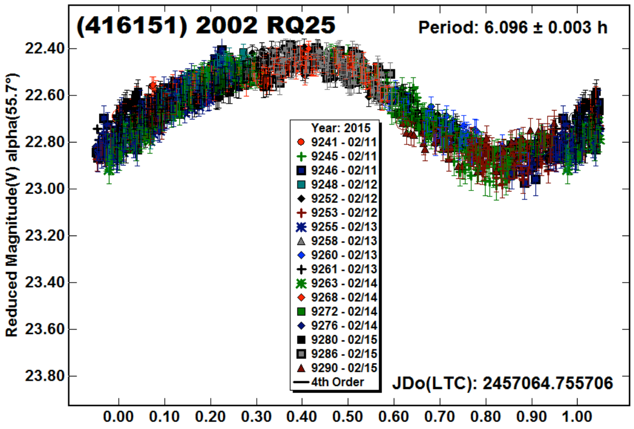


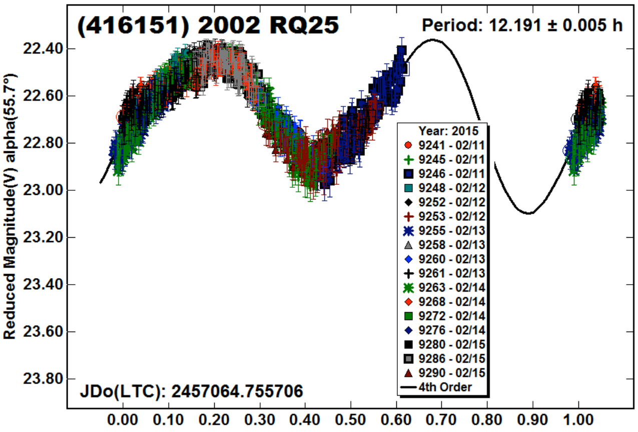
<u>(416071) 2002 NV</u>. Given the unusual shape of the lightcurve, this solution should not be considered too reliable, although it is probably correct to within about 1-2 hours and so is good enough for use in rotational statistics studies.



<u>(416151) 2002 RQ25</u>. The period spectrum for 2002 RQ25 shows a number of possibilities, the two most likely being a monomodal solution at about 6 hours and a bimodal solution at 12 hours.

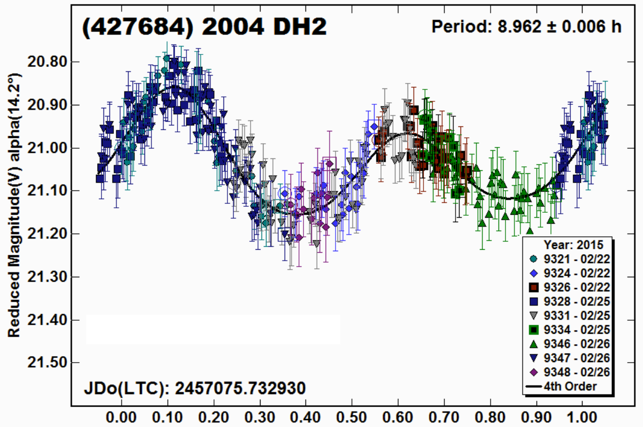






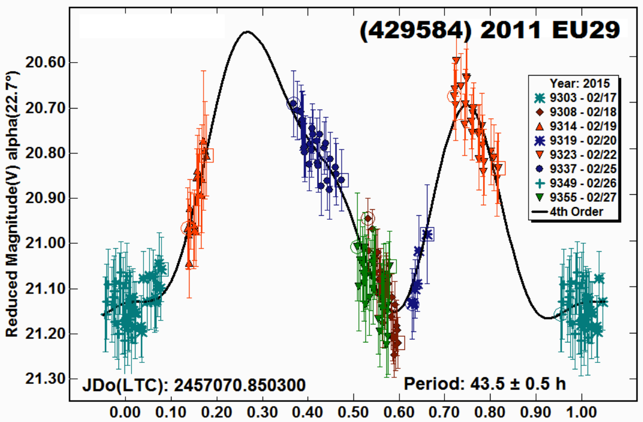
Usually, an amplitude of 0.42 mag dictates a bimodal lightcurve (Harris *et al.*, 2014). However this is mitigated by the large phase angle where, due to deep shadowing effects, even a nearly spheroidal body can have a large amplitude. The longer period is adopted for this paper, but the shorter period cannot be formally excluded.

<u>(427684) 2004 DH2</u>. There were no previous entries in the LCDB for 2004 DH2. The rounded minimums are somewhat unusual. Most elongated bodies show sharper minimums than maximums.

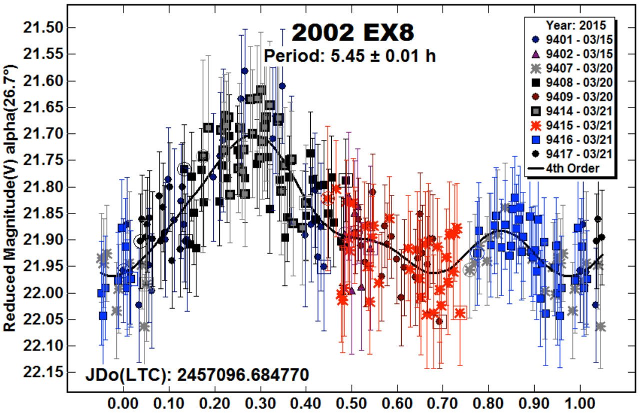


<u>(429584) 2011 EU29.</u> The large amplitude and relatively low phase angle favor a bimodal solution (Harris *et al.*, 2014). However, the large gaps in the coverage make for an uncertain period. The tumbling damping time (Pravec *et al.*, 2005; 2014) is longer than the age of the Solar System, so signs of tumbling, e.g., the slopes of individual sessions not matching the model

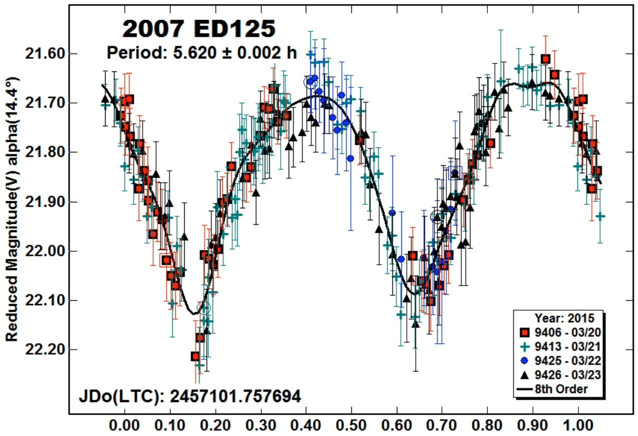
lightcurve, would not be unexpected. No such signs are obvious in this data set.



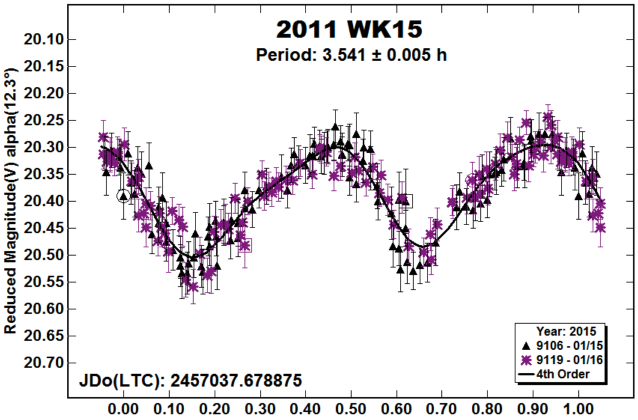
2002 EX8. The period spectrum may have a strong preference for the period of 5.45 h, but the amplitude of the lightcurve barely exceeds the error bars, meaning that the variation is likely real but the period solution is suspect. In this lightcurve, the two maximums, at 0.3 and 0.8 rotation phase, are significantly different, which might prompt a search for a period twice long, i.e., that this is a monomodal solution. A search along those lines produced very unsatisfactory results with the slopes of the data unable to follow the resulting Fourier model curve.

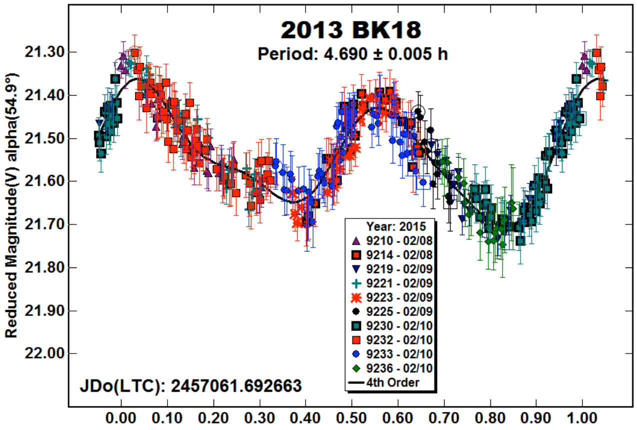


2007 ED125. This appears to be the first period reported in the literature for this NEA. The large amplitude and relatively short period make the solution secure.

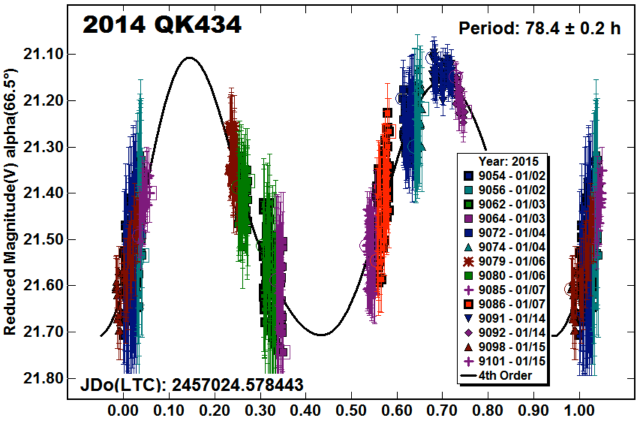


2011 WK15, 2013 BK18.. There were no previous entries in the LCDB for 2011 WK15 or 2013 BK18. Both periods are considered secure.

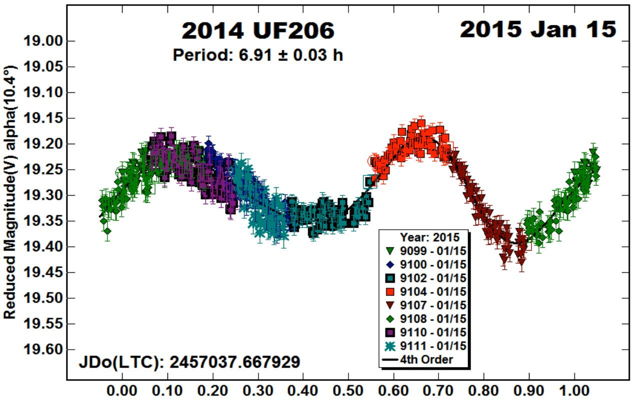


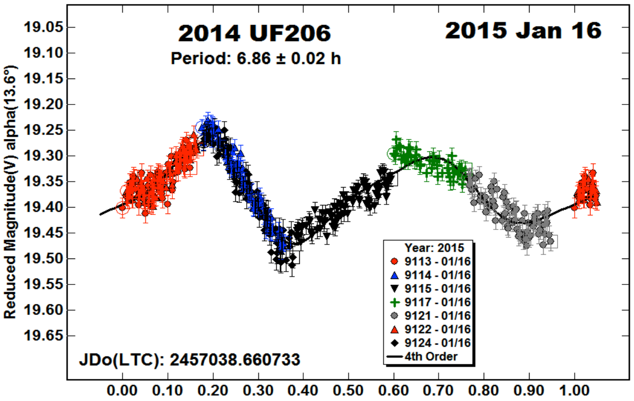


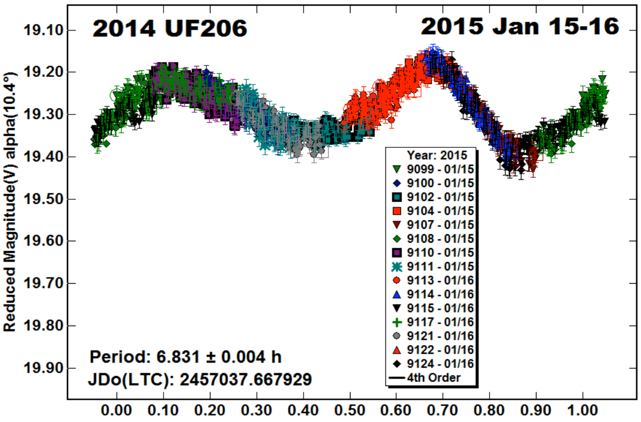
2014 QK434. This NEA is similar to 2011 EU29 in that the period and size make it a good candidate for being in non-principal axis rotation (NPAR, *tumbling*) but there are no overt signs of that being the case. 2014 QK434 won't be brighter than V = 18 again until 2033 September. Follow-up is left to the next generation of observers.



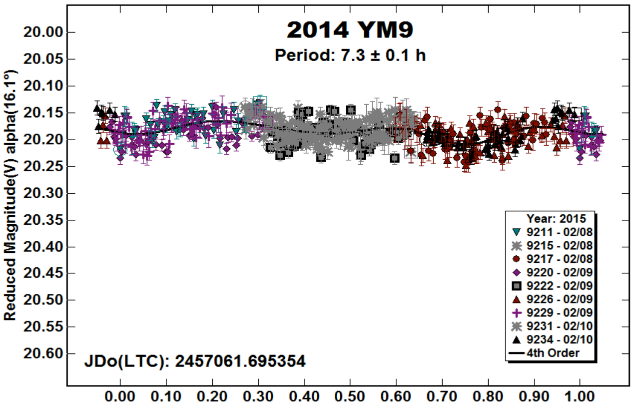
2014 UF206. From 1995 through 2050, the 2015 apparition is the only one at which the asteroid is brighter than V = 20, so it was a unique opportunity for photometry observations. The lightcurves are for 2015 Jan 15, Jan 16, and the combined data set. The result from the combined set is considered secure.



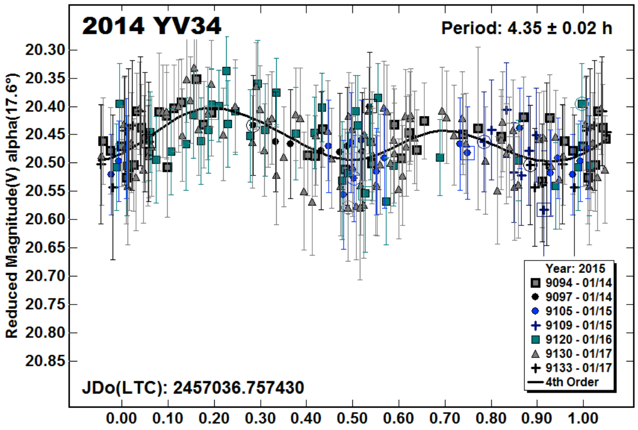




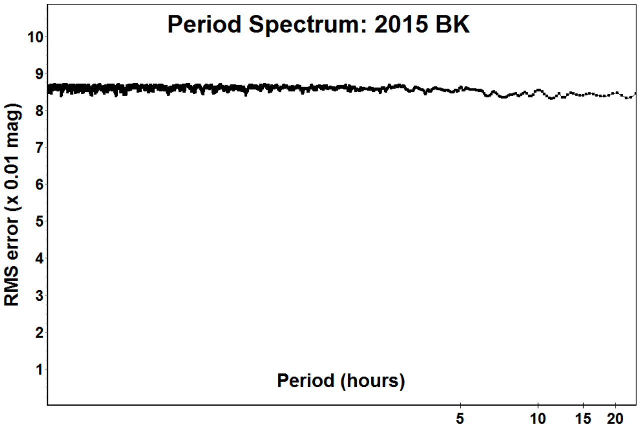
2014 YM9. Despite three nights of observations, the data set showed no discernable trend and only small variations over each night. The lightcurve shows the best fit, but unreliable, solution.

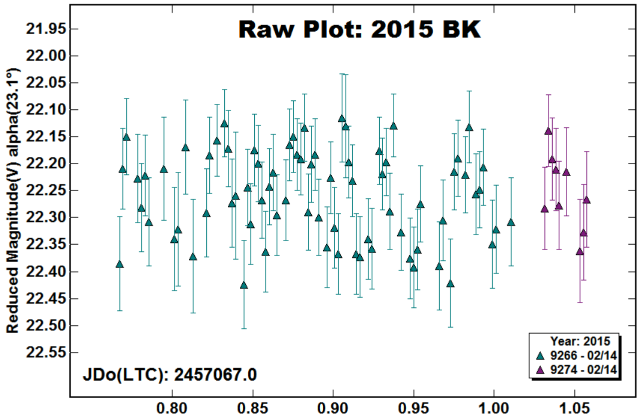


2014 YV34. Since the error bars are about equal to the lightcurve amplitude, the result of 4.35 h is not very reliable. There were no previous entries in the LCDB. The 2015 apparition is the only one from 1995-2050 when the asteroid reaches V < 20.

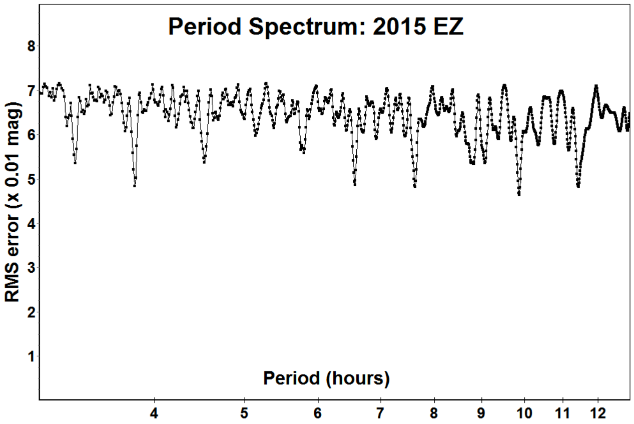


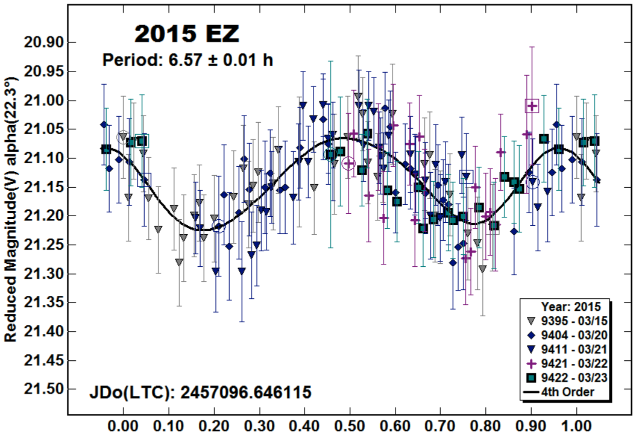
2015 BK. No solution could be found for 2015 BK, as shown by the flat line of the period spectrum. The lightcurve shows the raw data for one night. This appears to be the first reported attempt to determine the period for 2015 BK and probably the last for many years. The next time the asteroid is V < 20 is not until 2047.

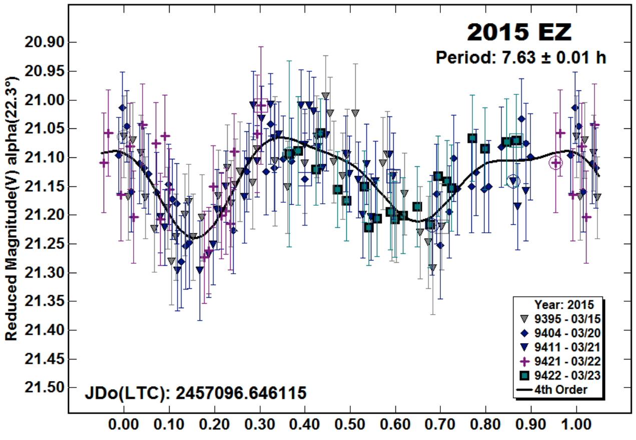




2015 EZ. The period spectrum shows several possible solutions for 2015 EZ. The lightcurves show the data phased to the two more likely periods. For this paper, the period of 6.57 h is adopted because of its more symmetrical shape. The next good opportunity (V < 19) to observe this NEA comes in 2023 April.

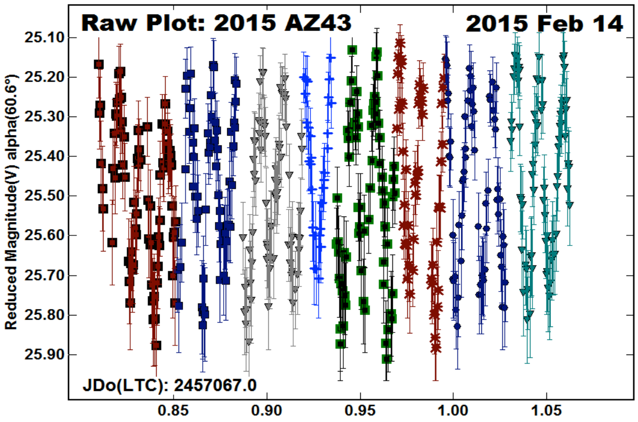


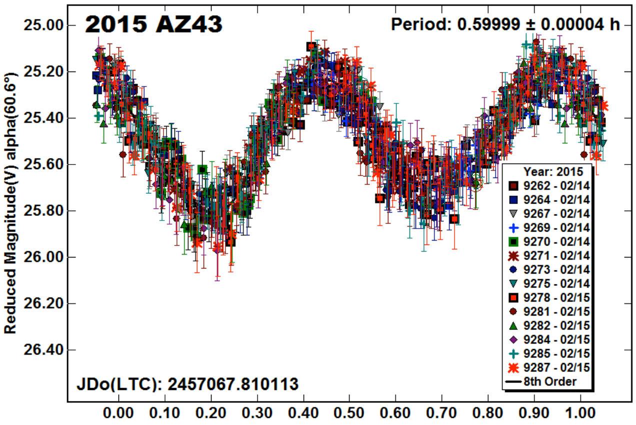




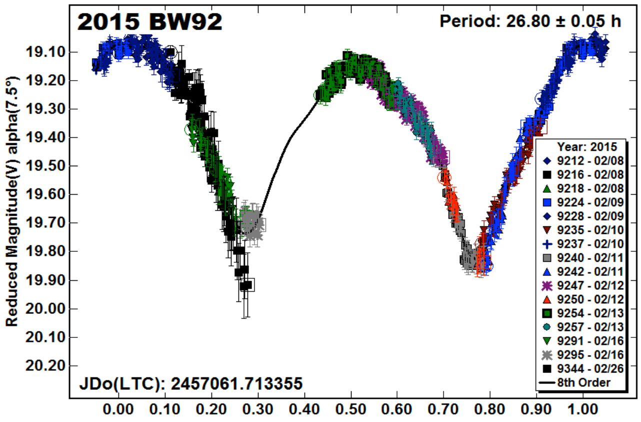
2015 AZ43. This was another "one-shot" chance to determine the rotation period of an NEA. 2015 AZ43 won't be brighter than 23.9 again through 2050. It peaked at V ~ 17.2 in 2015 mid-February but was within reach of the CS3 telescopes for only two days because of its sky position and rapid fading.

The raw plot for each night showed immediate indications that the asteroid was a super-fast rotator, i.e., $P < 1$ h. When working asteroids with estimated diameters of about $D < 200$ meters, the possibility of such short periods must be kept in mind. Most important, the exposures are not so long as to cover more than about 20% of the rotation period. In this case, the exposures were only 20 seconds, well under the limit of 6.7 minutes for a period of 36 min (see the discussion in Pravec *et al.*, 2000).

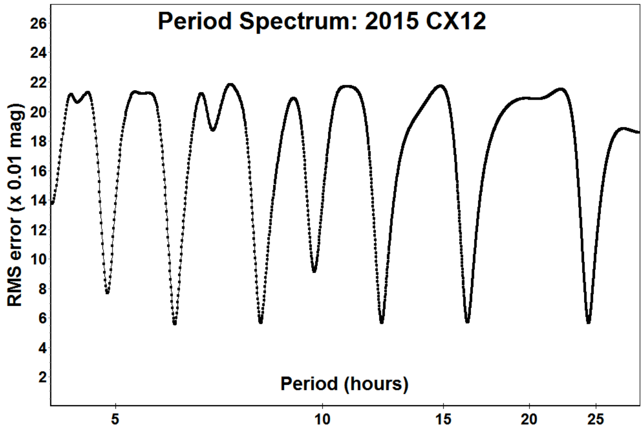


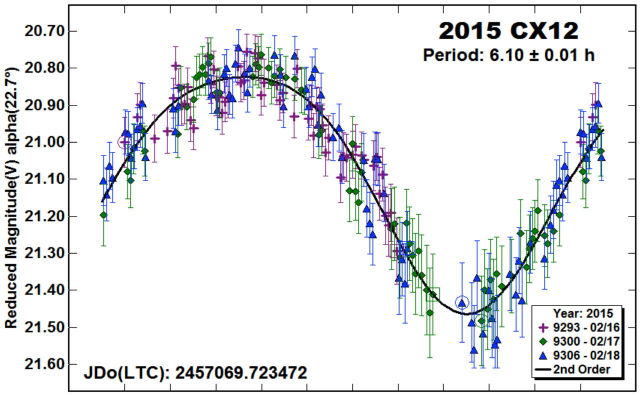


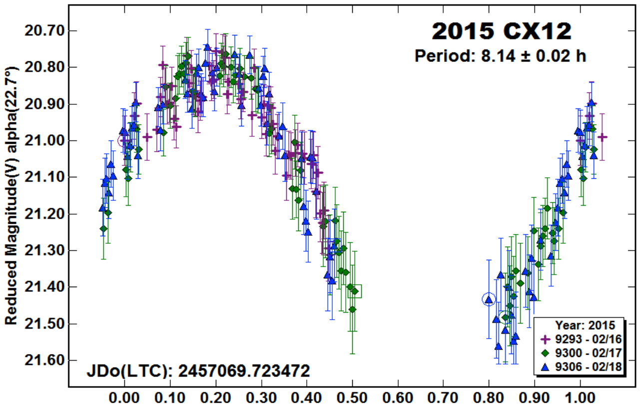
2015 BW92. 2015 BW92 has an estimated size of 500 meters, assuming an albedo of $p_V = 0.2$. Its size and measured period make it another good candidate for tumbling but there were no signs of that being the case. The asteroid has similar viewing circumstances every 17 years. The next good opportunity is in 2032 February.

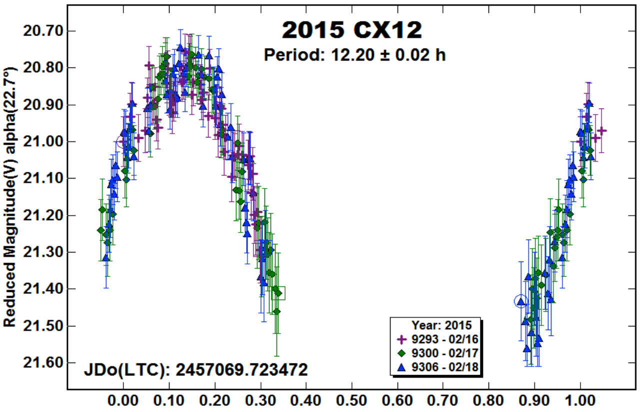


2015 CX12. The period spectrum shows several strong solutions, each commensurate with an Earth day. That makes it difficult for a single station to find a reliable period. The monomodal solution at 6.1 h leads to the bimodal solution of 12.20 h, but with a large gap. The solution for 8.14 h would require a very large amplitude to complete the curve smoothly. The shorter solution at 6.1 h doesn't make that likely. Given this and phase angle, a period of 12.20 h is adopted for this paper.

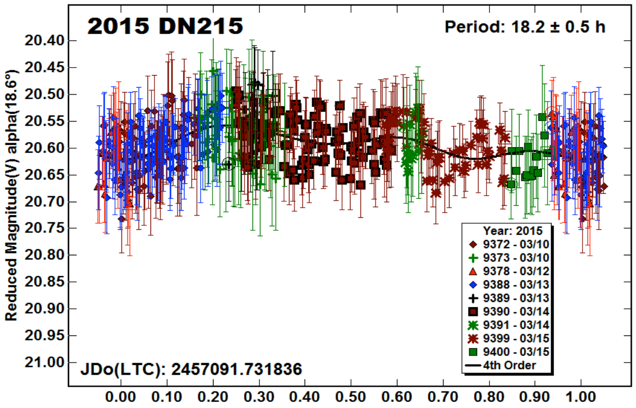




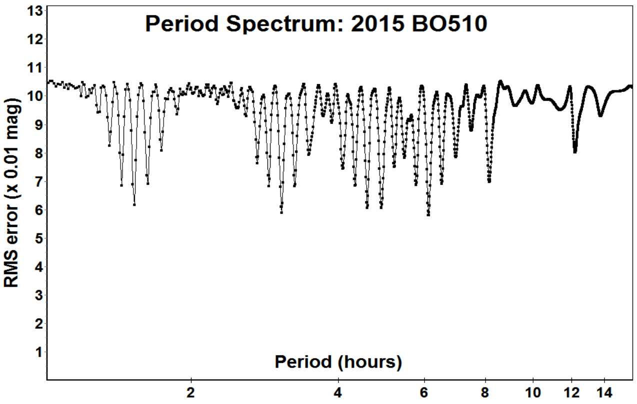


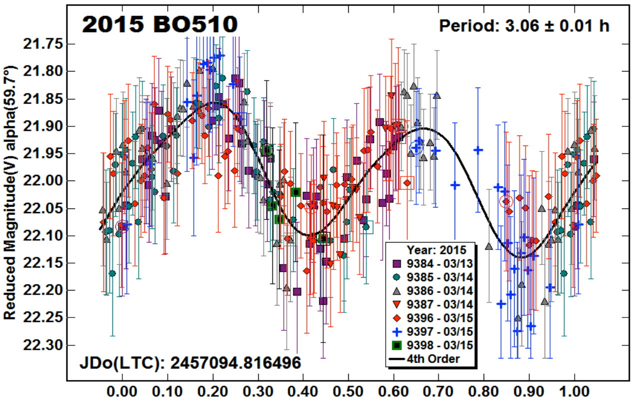


2015 DN215. A period of 18.2 h is adopted for this paper, but a solution 36.3 h cannot be formally excluded. In fact, a number of other solutions is possible and so neither of these results is more likely than any other. The next, and last time through 2050, that this asteroid is V < 20 is in 2024 March.



2015 BO510. The period spectrum for 2015 BO510 shows several strong possible solutions. Within the groups are the favored solution and then "sideband" periods that differ by one-half or one rotation over 24 hours.





A monomodal solution was rejected because it would have a period of about 1.5 h. Given the estimated size of 340 meters, this would be highly unlikely. The bimodal solution at 3.06 h seemed most likely (and is adopted for this paper). A check was also made for the double period at 6.12 hours (a trimodal solution at about 4.5 hours being rejected). A quadramodal lightcurve is not impossible at high phase angles, even with an amplitude of nearly 0.3 mag.

Despite the quadramodal lightcurve not showing a high degree of symmetry, a clue that the half-period might be valid, it was rejected because of gaps in coverage. The Fourier analysis

Number	Name	2015 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period	P.E.	Amp	A.E.	Grp
1627	Ivar	01/02-01/07	350	17.7,16.3	145	0	4.795	0.002	0.27	0.03	NEA
1864	Daedalus	03/10-03/14	280	5.3,5.0,5.1	172	8	8.575	0.002	0.95	0.03	NEA
4401	Aditi	02/27-03/05	203	36.1,33.0	156	36	6.670	0.005	0.29	0.03	NEA
5131	1990 BG	01/18-02/04	153	21.8,25.5	75	-20	37.2	0.5	0.33	0.05	NEA
11066	Sigurd	02/02-02/04	174	27.4,26.2	169	15	8.51	0.01	0.97	0.03	NEA
22099	2000 EX106	02/17-02/19	165	20.0,18.4	166	7	6.31	0.02	0.41	0.03	NEA
22771	1999 CU3	02/22-03/12	229	18.5,7.6	174	-4	3.780	0.001	0.12	0.02	NEA
39796	1997 TD	05/29-11/13	284	48.6,17.8	280	11	223	5	0.92	0.05	NEA
85990	1999 JV6	01/16-01/18	360	27.7,21.5	131	-3	6.543	0.002	0.93	0.03	NEA
86067	1999 RM28	01/20-02/04	218	38.0,32.2	171	16	9.196	0.005	0.51	0.03	NEA
90416	2003 YK118	01/15-01/25	651	15.9,23.7	112	12	43.58[A]	0.05	0.13	0.01	NEA
99248	2001 KY66	01/17-01/25	260	8.6,13.4	104	-1	19.7	0.5	0.3	0.04	NEA
137924	2000 BD19	01/18-01/25	251	28.9,25.4	141	20	10.570	0.005	0.69	0.04	NEA
137925	2000 BJ19	02/11-02/16	271	23.2,23.0	161	22	48[A]	2	0.17	0.02	NEA
159454	2000 DJ8	02/15-02/22	515	10.2,19.1	138	7	14.244	0.007	0.25	0.03	NEA
410088	2007 EJ	01/16-01/19	170	69.8,64.6	81	25	4.781	0.006	0.16	0.02	NEA
416071	2002 NV	01/20-01/25	161	16.7,16.4	134	-11	17.7	0.3	0.41	0.05	NEA
416151	2002 RQ25	02/11-02/15	1067	55.8,71.4	153	34	12.191[A]	0.005	0.72	0.05	NEA
427684	2004 DH2	02/19-02/26	206	23.0,3.9	162	-3	8.962	0.006	0.3	0.03	NEA
429584	2011 EU29	02/17-02/27	178	22.9,7.2	164	-3	43.5	0.5	0.65	0.1	NEA
	2002 EX8	03/15-03/21	228	26.8,35.4	160	-8	5.45	0.03	0.27	0.05	NEA
	2007 ED125	03/20-03/23	216	14.4,10.1	188	3	5.620	0.002	0.55	0.05	NEA
	2011 WK15	01/15-01/16	204	12.3,12.5	122	5	3.541	0.005	0.21	0.02	NEA
	2013 BK18	02/08-02/10	330	55.3,63.2	107	-8	4.690	0.005	0.34	0.03	NEA
	2014 YM9	02/08-02/10	494	16.3,20.9	130	5	7.3	0.1	0.04	0.01	NEA
	2014 YV34	01/14-01/17	196	17.6,15.4	128	2	4.35	0.02	0.09	0.02	NEA
	2014 UF206	01/15-01/16	1000	10.7,13.9	119	7	6.831	0.004	0.20	0.02	NEA
	2014 QK434	01/02-01/15	640	66.3,46.8	73	-13	78.4	0.2	0.60	0.05	NEA
	2015 BK	02/14-02/15	334	23.1,23.4	158	9	-	-	-	-	NEA
	2015 EZ	03/15-03/23	151	22.4,29.8	163	-9	6.57	0.02	0.16	0.03	NEA
	2015 CX12	02/16-02/18	192	22.7,20.8	145	-15	12.2	0.02	0.67	0.03	NEA
	2015 AZ43	02/14-02/15	767	60.5,65.1	163	28	0.59992	0.00004	0.58	0.05	NEA
	2015 BW92	02/08-02/26	716	7.5,7.2,21.2	137	-1	26.80	0.05	0.75	0.03	NEA
	2015 DN215	03/10-03/15	431	18.5,8.6	179	5	18.2	0.5	0.06	0.01	NEA
	2015 BO510	03/13-03/15	241	59.7,65.2	199	29	3.06	0.03	0.28	0.03	NEA

Table II. Observing circumstances. [A] preferred period for an ambiguous solution. Pts is the number of data points used in the analysis. 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, respectively the average phase angle bisector longitude and latitude, unless two values are given (first/last date in range). Grp is the orbital group of the asteroid. See Warner *et al.* (LCDB; 2009).

algorithm in *MPO Canopus* can find a "best" solution, one with the lowest RMS fit, by also minimizing the number of overlapping data points in the phased lightcurve. This is called a *fit by exclusion*, and can lead to accepting an incorrect solution that is longer than the correct period.

The next good photometry opportunity for this NEA is in 2031 March and again 16 years later in 2047 March.

Acknowledgements

Funding for PDS observations, analysis, and publication was provided by NASA grant NNX13AP56G. Work on the asteroid lightcurve database (LCDB) was also funded in part by National Science Foundation Grant AST-1210099. This research was made possible through the use of the AAVSO Photometric All-Sky Survey (APASS), funded by the Robert Martin Ayers Sciences Fund.

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THREE UNUSUAL HUNGARIA ASTEROIDS

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Three Hungaria asteroids observed at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) in 2015 January-March showed unusual characteristics. 2449 Kenos, a probable member of the Hungaria *collisional family*, is likely to be a binary object with period P_1 = 3.8481 h and P_2 = 15.85 h. The 2015 observations of 6901 Roybishop, a member of the Hungaria *orbital group*, showed signs of a weak secondary period, P_2 = 10.58 h. The secondary period is in contradiction with previous results. (23615) 1996 FK12 may be another example of so-called *wide binaries*, showing a strong short period, P_2 = 3.6456 h, presumably due to a widely-separated satellite that is not tidally locked to a very long orbital period. The primary in such a system has a very long period, P_1 = 368 h in this instance. The main question for 1996 FK12 is the validity of the long period.

CCD photometric observations of three Hungaria asteroids were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2015 January-March: 2449 Kenos, 6901 Roybishop, and (23615) 1996 FK12. Analysis of the data indicated that each might be a binary object.

Table I lists the telescope/CCD camera combinations used for the observations. All the cameras use CCD chips from the KAF blue-enhanced family and so have essentially the same response. The pixel scales for the combinations range from 1.24-1.60 arcsec/pixel.

Desig	Telescope	Camera
Squirt	0.30-m f/6.3 Schmidt-Cass	ML-1001E
Borealis	0.35-m f/9.1 Schmidt-Cass	FLI-1001E
Eclipticalis	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Australius	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Zephyr	0.50-m f/8.1 R-C	FLI-1001E

Table I. List of CS3-PDS telescope/CCD camera combinations.

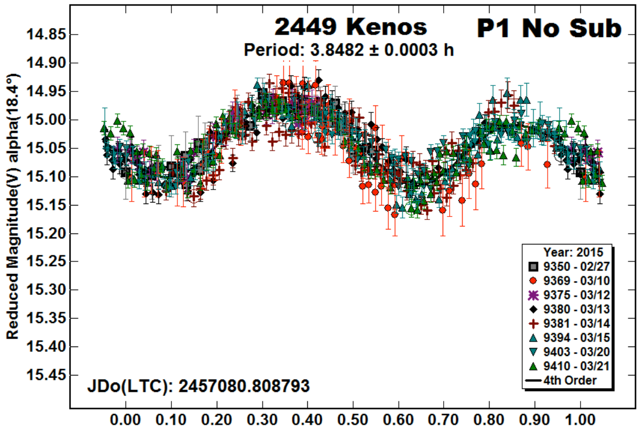
All lightcurve observations were unfiltered since a clear filter can result in a 0.1-0.3 magnitude loss. The exposure duration varied depending on the asteroid's brightness and sky motion. Guiding on a field star sometimes resulted in a trailed image for the asteroid.

Measurements were done using *MPO Canopus*. If necessary, an elliptical aperture with the long axis parallel to the asteroid's path was used. The Comp Star Selector utility in *MPO Canopus* found up to five comparison stars of near solar-color for differential photometry. Catalog magnitudes were usually taken from the MPOSC3 catalog, which is based on the 2MASS catalog (*http://www.ipac.caltech.edu/2mass*) but with magnitudes converted from J-K to BVRI using formulae developed by Warner (2007b). When possible, magnitudes are taken from the APASS catalog (Henden *et al.,* 2009) since these are derived directly from reductions based on Landolt standard fields. Using either catalog, the nightly zero points have been found to be consistent to about

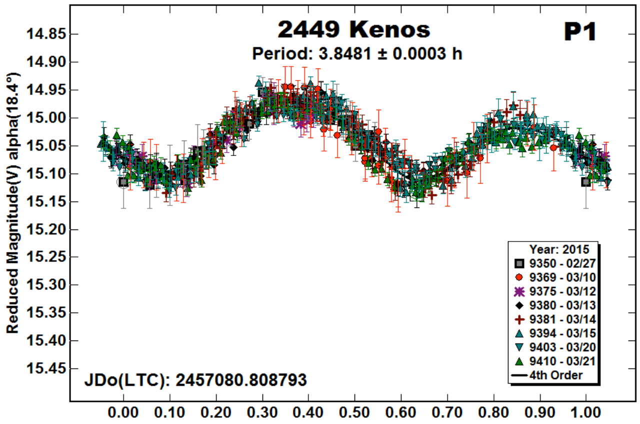
± 0.05 mag or better, but on occasion are as large as 0.1 mag. Period analysis was also done using *MPO Canopus*, which implements the FALC algorithm developed by Harris (Harris *et al.,* 1989).

In the plots below, unless stated otherwise, the "Reduced Magnitude" is Johnson V as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distance by applying –5*log (rΔ) to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the given phase angle, *e.g.*, alpha(6.5°), using $G = 0.15$. The X-axis is the rotational phase, ranging from –0.05 to 1.05.

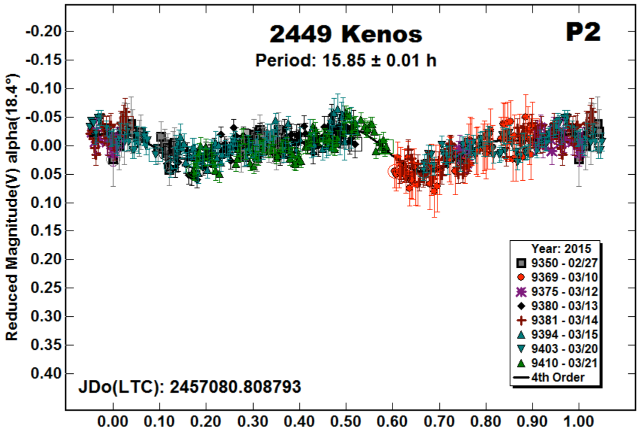
<u>2449 Kenos</u>. Wisniewski *et al*. (1997) reported a preferred period of 4.188 h for Kenos but mentioned an alternate solution of 3.862 h. Subsequent observations by Warner (2007, 3.8492 h; 2010, 3.846 h) showed that the shorter period from Wisniewski *et al.* was more likely. None of the previous papers indicated the possibility of a satellite.



The best-fit single period solution using the 2015 CS3-PDS observations ("P1 No Sub") shows several sessions with apparent attenuations. This prompted a dual-period search that found $P_1 = 3.8481 \pm 0.0003$ h, $A_1 = 0.14 \pm 0.02$ mag and $P_2 = 15.85 \pm 0.01$ h, $A_2 = 0.04\text{-}0.10$ mag. Even after this, the short period lightcurve showed some apparent deviations from the model curve, i.e., at about 0.5 rotation phase in the "P1" lightcurve. A search for a third period was fruitless and the deviations are best attributed to the evolution of the P_1 lightcurve over the nearly three weeks of observations.



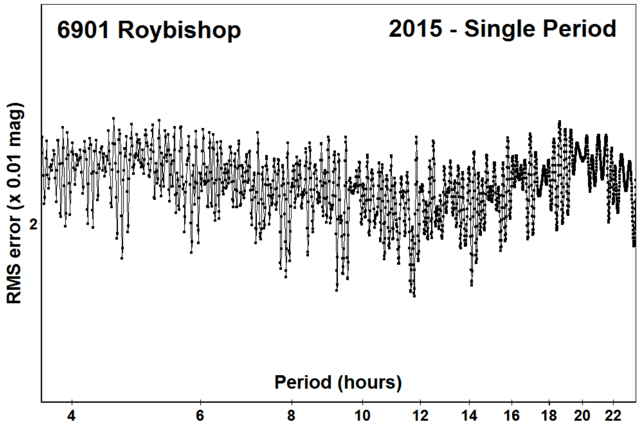
The constantly changing shape of the "P2" lightcurve seems more indicative of the rotation of a satellite, probably tidally locked to its orbital period, but with a viewing geometry that prevented seeing *mutual events*, i.e., occultations and/or eclipses.



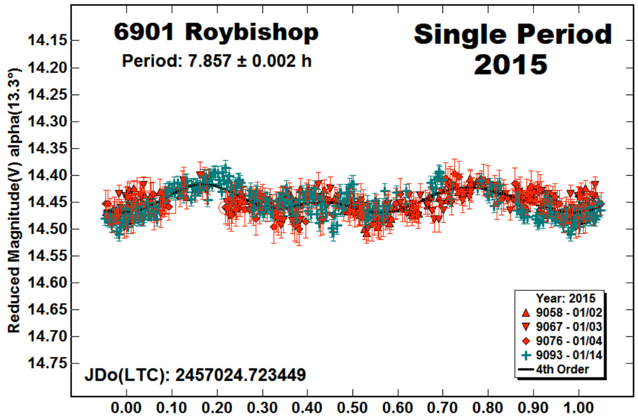
It's worth noting that the viewing aspects (phase angle bisector, PAB; see Harris *et al.*, 1984) in 2007 (L_{PAB} 172°) and 2015 (L_{PAB} 188°) were similar, with only 16° difference in longitude. Normally, this is not enough see signs of a satellite at one apparition and not at the other, especially since there were no *mutual events* seen in 2015. The 2007 data set covered only three nights from 2007 March 9-14. It's possible that the less extensive data set in 2007 didn't allow finding the subtle deviations seen in 2015.

At this time, 2449 Kenos cannot be definitely declared as a binary object, but it is likely. In either event, additional observations, especially at different viewing aspects, are strongly encouraged.

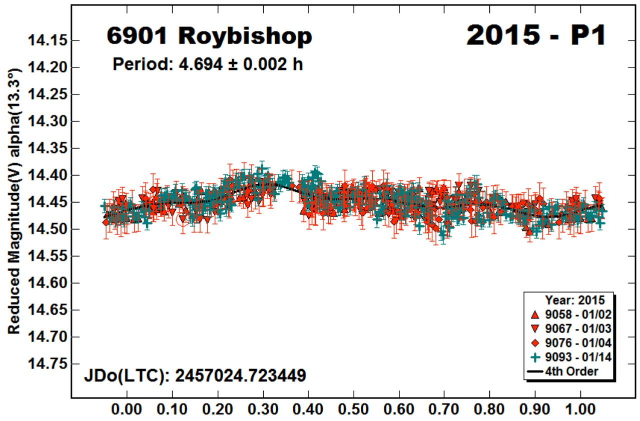
<u>6901 Roybishop</u>. This Hungaria asteroid was a known suspected binary (Warner, 2009). Analysis at that time by the author and independent work by Petr Pravec (Astronomical Institute, Czech Republic) found several possible solutions for the suspected primary and orbital period of a satellite. Updated lightcurves from that original work using the adopted values of $P_1 = 4.684$ h, $P_2 = 17.16$ h are presented below (the magnitudes in the lightcurves are relative to a zero point of R = 16.04).

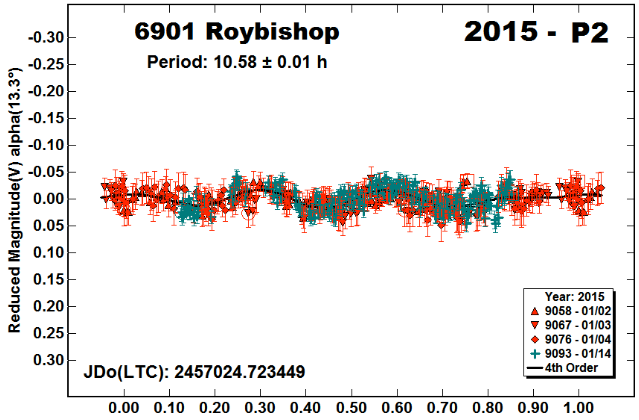


The 2015 observations from CS3-PDS led to even more ambiguity. The period spectrum when looking for a single period features several solutions, many of which have in common that of being nearly commensurate with an Earth day. Given the phase angle and low amplitude, $A = 0.07$ mag, the lightcurve for the correct solution could have one or multiple maximum-minimum pairs (Harris *et al.*, 2014). The “2015 Single Period” lightcurve shows just one example.

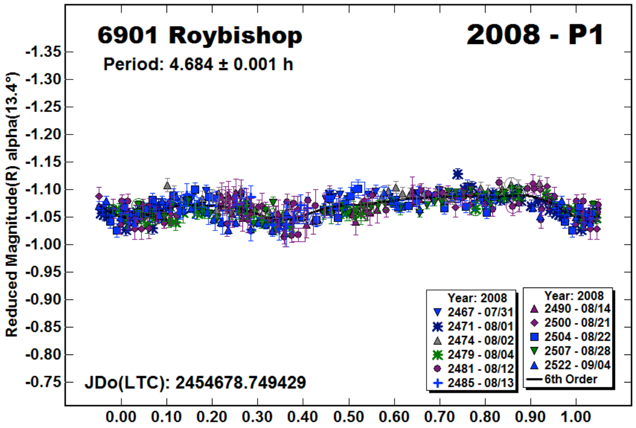


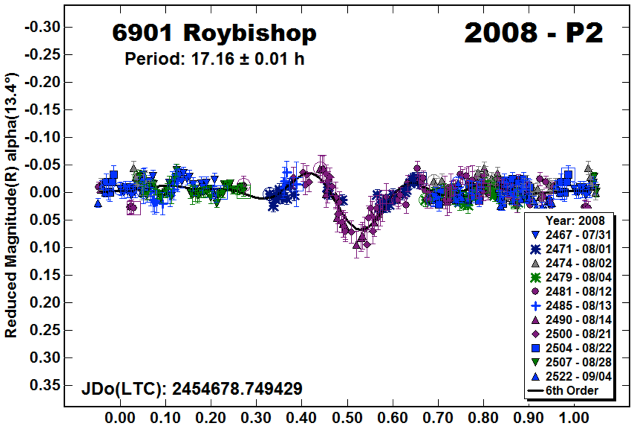
On the presumption that the previously found period of about 4.7 hours was correct, a dual-period search was performed on the 2015 data set. This produced P_1 = 4.694 ± 0.002 h, in reasonable agreement with the earlier results from 2007 and 2012 (Warner, 2012; 4.785 h). The “2015 – P1” lightcurve shows this result.





When subtracting this period from the data set, the best fit for a second period was at 10.58 h. However, this one of many possible solutions and so cannot be taken at face value. The end result is that the true nature and period(s) for this Hungaria asteroid remain undetermined. It will better-placed for southern observers in 2016 July, but close to the galactic plane. The next best chance for northern observers is not until 2019 September.



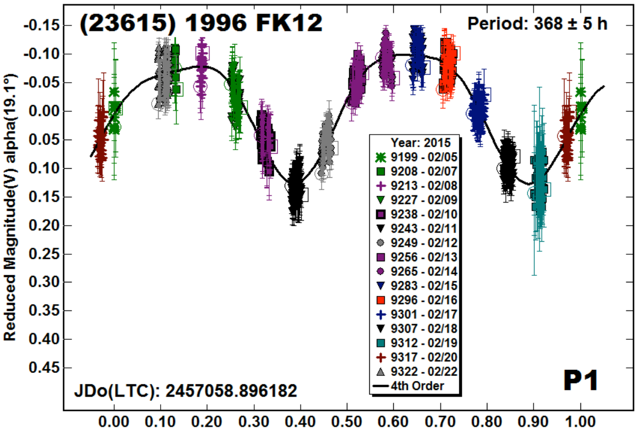


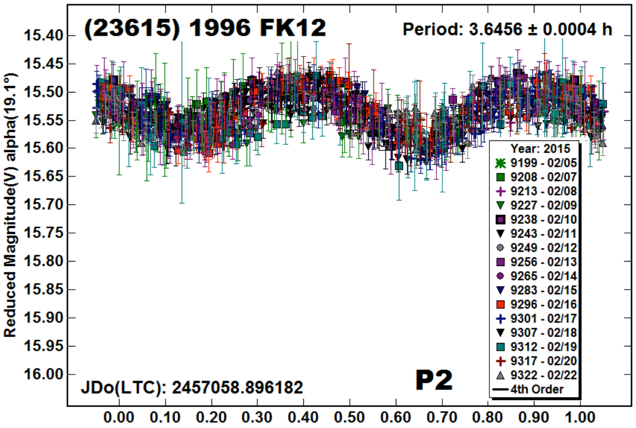
(23615) 1996 FK12. This Hungaria member may be among a small group of *wide binaries* which feature long-period, moderate-amplitude and short-period, low-amplitude components. One current theory is that the long period is due to a slowly rotating, elongated primary and the short period to a small, lesser elongated satellite that circles the primary at a relatively large distance and is not tidally-locked to the orbital period. The likelihood of seeing *mutual events* (occultations and/or eclipses), which would validate the binary nature, is extremely remote. Table II gives the current list of the suspected members of this group.

Number	Name	P_1	P_2	Ref
8026	Johnmckay	372	2.2981	MPB 38, 33-36
15778	1993 NH	113	3.320	MPB 42, 60-66
23615	**1996 FK12**	**368**	**3.6456**	**This work**
67175	2000 BA19	275	2.7157	MPB 40, 36-42
119744	2001 YN42	624	7.24	MPB 41, 102-112
190208	2006 AQ	182	2.621	MPB 42, 79-83
218144	2002 RL66	588	2.49	MPB 37, 109-111
	2014 PL51	205	5.384	MPB 42, 134-136

Table II. List of suspected wide binary asteroids. P_1 is the primary’s period (hours). P_2 is the satellite’s, which is not tidally-locked to its orbital period. All references are Warner (*et al.*).

The primary concern about the legitimacy of these objects lies with the long period, *i.e.*, whether it is real or the result of systematic errors in catalog magnitudes, the reduction process, a combination of these, or other errors. On the other hand, there has been little or no doubt about the reliability of the solution for the purported satellite in most cases, as seen in the “P2” lightcurve for 1996 FK12.





In the case of 1996 FK12, two of the sessions required zero point adjustments on the order of 0.1 mag to get a smooth fitting lightcurve. Given that the amplitude of the long period is only 0.20 mag, this is a significant adjustment. However, the remaining sessions required zero point changes of < 0.05 mag to obtain the best-fit solution shown in "P1". These were similar, if not more extreme, to the adjustments required when fitting the data in many of the previous results shown in Table II. Since observing *mutual events* is virtually unlikely, the best way to establish the validity of the results given in Table II will be to observe the asteroid at subsequent apparitions and, if possible, use data calibrated to at least an internal, if not standard, system with an accuracy and precision of 0.02 mag or better.

Acknowledgements

Funding for PDS observations, analysis, and publication was provided by NASA grant NNX13AP56G. Work on the asteroid lightcurve database (LCDB) was also funded in part by National Science Foundation Grant AST-1210099. This research was made possible through the use of the AAVSO Photometric All-Sky Survey (APASS), funded by the Robert Martin Ayers Sciences Fund.

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LOW RESOLUTION VISIBLE REFLECTANCE SPECTRUM FOR NEA (357439) 2004 BL86

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Low resolution spectroscopic observations of the near-Earth asteroid (357439) 2004 BL86 were acquired during the flyby of 2015 January 26. The spectrum analysis shows that its taxonomic class is very close to that of 4 Vesta in the visible wavelength.

The near-Earth asteroid (357439) 2004 BL86 was observed in the visible spectrum during the flyby of 2015 January 26 at Balzaretto Observatory (A81) in Rome, Italy, using a 0.20-m Schmidt-Cassegrain (SCT) reduced to *f*/5.5 and an SBIG ST7-XME CCD camera equipped with a diffraction grating SA-200 (Paton Hawksley Education) mounted inside the filter wheel. With this simple slit-less configuration, it's possible to acquire low resolution spectra in the visible wavelength region of the relatively faint objects (up to 12-13 mag) with a spectral resolution R~100.

Due to the fast movement of the asteroid in the sky (147 arcsec/min), a sequence of 62 images, each with a 5 second exposure time, was acquired. The images were stacked with sigma-clip to increase the final signal-to-noise ratio and remove the weak spectra of faint field stars (Figure 1).

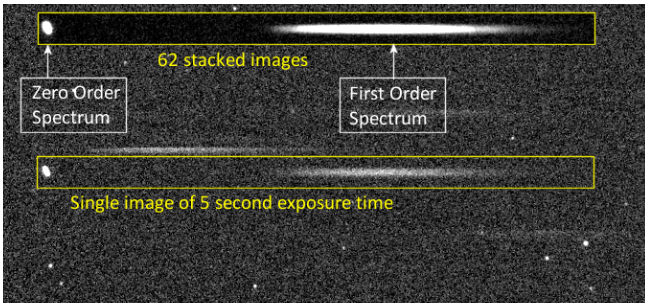

Figure 1. A single image of 5 second exposure compared with the stacked images, from which we can see the zero order and the first order spectra.

During the observations, the asteroid had a magnitude of V~9.7. For calibrating purposes, reference spectra of Sirius (A1V type) and HD 76151 (G2V type; solar analog) were acquired. Six images (0.1 sec) were taken of Sirius and three images (30 sec) of HD 76151. The spectrum of the G2V calibration star was acquired at about the same airmass of the asteroid. All CCD images were calibrated with dark and flat-field frames. Spectra reduction was done using *RSpec* (Field, 2013).

Linear wavelength calibration was performed using the A1V type star (Sirius), taking as reference two points: the zero order image (0 Å) and the H-beta Hydrogen Balmer absorption line (4861 Å), from which a dispersion of 17.0 Å/pixel was found. For low resolution work, the non-linearity effects in the wavelength calibration are negligible. In fact, in this case, the deviation from linearity was below the dispersion value. The wavelength calibration of the other spectra (HD 76151) was done using the zero order image as reference and the previously determined dispersion factor.

The reflectance spectrum of 2004 BL96 was obtained by dividing its calibrated spectrum in wavelength with the one for HD 76151 and then normalized to unity at the standard wavelength of 0.55 µm (center of the photometric V band). The acquired spectrum was in the spectral range from 0.4 µm to 0.85 µm. Errors are estimated to be lower than 0.05 in the range 0.45-0.70 µm, but significantly greater in the outer regions.

For taxonomy determination, the reflectance spectrum of 2004 BL86 was fitted with a 4th order polynomial and then compared with the typical relative reflectance spectra of single-letter taxonomy classes in the SMASS II catalog (Bus and Binzel, 2002) by computing the standard deviation of differences at the discrete wavelengths of 0.44, 0.50, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85 µm. Lower standard deviation values were found for the taxonomy classes O, Q, T, V, and, in particular, for 4 Vesta (Figures 2, 3).

Data analysis shows that the taxonomy class of NEA (357439) 2004 BL86 is very close to that of 4 Vesta in the visible wavelength as judged by the lowest standard deviation as well as the tight-fitting overlap of the reflectance spectrum shown in Figure 4. This result is consistent with results reported on the JPL web site (2015).

This work shows the potential of low resolution spectroscopic observations made with small telescopes applied to the preliminary taxonomic classification of NEA during their close approaches to the Earth.

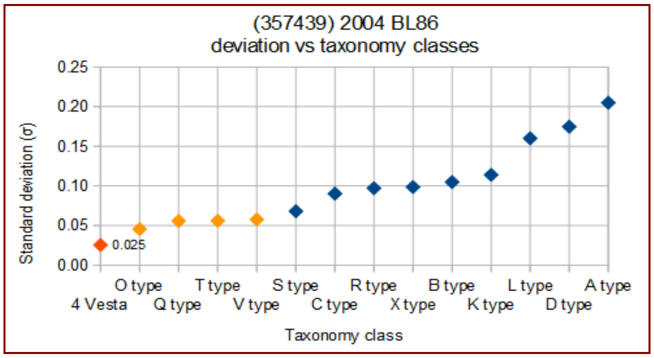

Figure 2. The standard deviation of 2004 BL86 with respect to the single-letter Bus taxonomy classes.

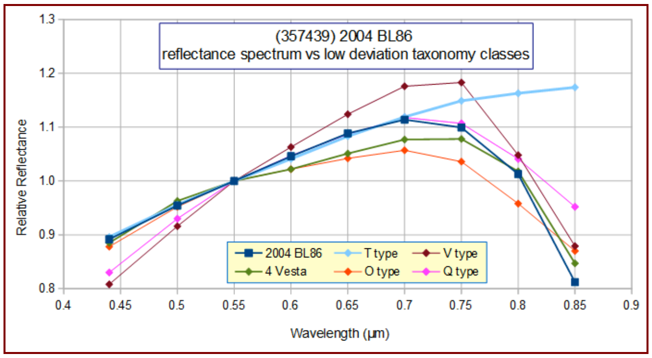

Figure 3. The reflectance spectrum of 2004 BL86 compared with the taxonomic classes with lower standard deviation.

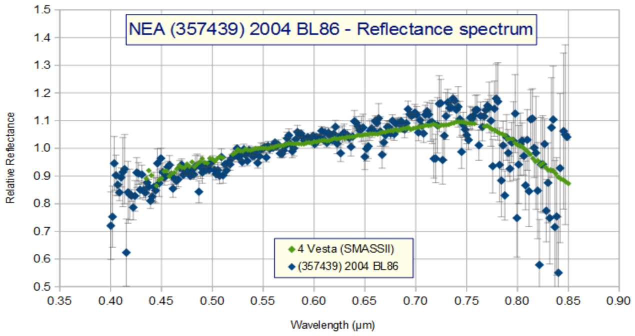

Figure 4. The reflectance spectrum of 2004 BL86 overlapped with that of 4 Vesta (SMASS II).

Acknowledgments

I would like to thank Frederick Pilcher for his helpful suggestions.

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THE HUNGARIA ASTEROID 4868 KNUSHEVIA: A POSSIBLE BINARY

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(Received: 31 March)

CCD photometry observations of the Hungaria asteroid 4868 Knushevia were made in 2013 April-June at the Center for Solar System Studies. Analysis of the data indicates that the asteroid may be a binary with a primary period P_1 = 3.4122 ± 0.0001 h, A_1 = 0.05 ± 0.01 mag and a secondary period of P_2 = 11.922 ± 0.003 h with possible *mutual events, i.e.,* occultations and/or eclipses, of about 0.02 mag depth. On that assumption, this leads to an estimated effective size ratio of $D_S/D_P \geq 0.13 \pm 0.03$, which fits well within a model of binary asteroids developed by Pravec *et al.* (2010).

CCD photometric observations of the Hungaria asteroid 4868 Knushevia were made at the Center for Solar System Studies observatories in Landers, CA, from 2013 April through June. Based on a very high albedo reported from Masiero *et al.* (2011), it is likely that Knushevia is a member of the Hungaria *collisional family*, *i.e.*, a remnant of the parent body.

The 2013 observations were made by Stephens as follow-up to previous work by Warner. Those earlier results include Warner (2009, 4.45 h; 2010, 4.54 h) and Warner *et al.* (2012, 4.717 h). In the last work, an alternate solution of 3.143 h was considered, being almost an equally good fit (RMS error) to the longer period. The shorter period was a bimodal solution while the longer period featured a trimodal lightcurve. Given the low amplitude and phase angle, α = 11°), either solution was possible (Harris *et al.*, 2014). Additional analysis of the 2011 data at the time did not find signs of tumbler or a satellite.

Stephens used a 0.4-m Schmidt-Cassegrain (SCT) for imaging. All but three sessions used an SBIG STL-1001E CCD camera. The last session in May and two in June used an FLI ProLine-1001E. Both cameras used the same KAF-1001E blue-enhanced chip with a 1024x1024x24-μ array. The exposures were 300 s and unfiltered.

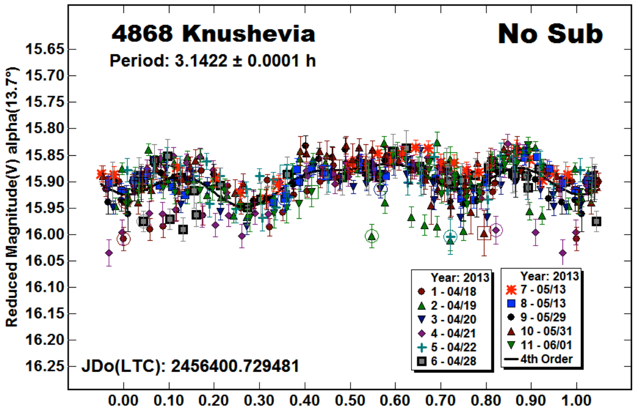
Date (2013/mm/dd)	Phase (α)	L_{PAB} °	B_{PAB} °
04/18	13.7	219.3	16.3
04/19	13.5	219.4	16.5
04/20	13.4	219.4	16.7
04/21	13.2	219.5	16.9
04/22	13.1	219.5	17.2
04/28	13.1	219.7	18.4
05/13	16.7	220.3	21.1
05/29	22.9	221.7	22.9
05/31	23.6	222.0	23.1
06/01	23.9	222.1	23.2

Table I. Observing circumstances. PAB is the phase angle bisector (see Harris *et al.*, 1984).

Table I gives the observing circumstances.

Stephens measured the images using *MPO Canopus* using the Comp Star Selector utility to find up to five comparison stars of near solar-color for differential photometry. Catalog magnitudes were taken from the MPOSC3 catalog, which is based on the 2MASS catalog (*http://www.ipac.caltech.edu/2mass*) but with magnitudes converted from J-K to BVRI using formulae developed by Warner (2007). When using this catalog, the nightly zero points have been found to be consistent to about ± 0.05 mag or better, but on occasion are as large as 0.1 mag. The resulting data files were sent to Warner, who did the period analysis with *MPO Canopus*, which implements the FALC algorithm developed by Harris (Harris *et al.,* 1989), and modified by Warner to allow subtracting a Fourier model curve from the data set to search for a second period.

In the plots below for the suspected primary body, the "Reduced Magnitude" is Johnson V. These are values that have been converted from sky magnitudes to unity distance by applying –5*log (rΔ) to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized phase angle α = 13.7° using G = 0.43, the default value for type E asteroids in the asteroid lightcurve database (LCDB; Warner *et al.*, 2009). The X-axis is the rotational phase, ranging from –0.05 to 1.05.

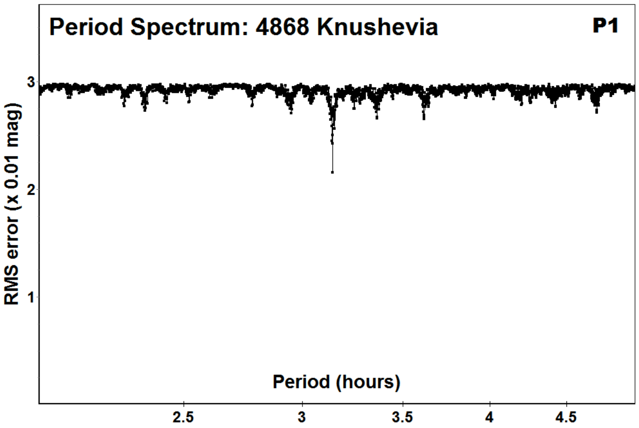


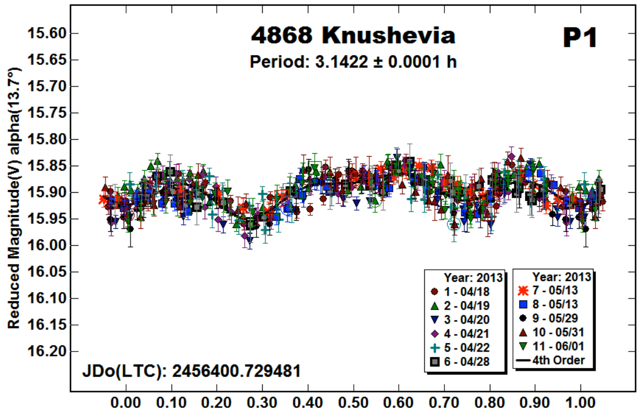
The "No Sub" lightcurve shows the best fit to the data in a single period search. Several of the sessions show apparent attenuations, possibly due to a satellite. While this was a best-fit solution, the period spectrum (not included) showed the period barely stood out from the noise.

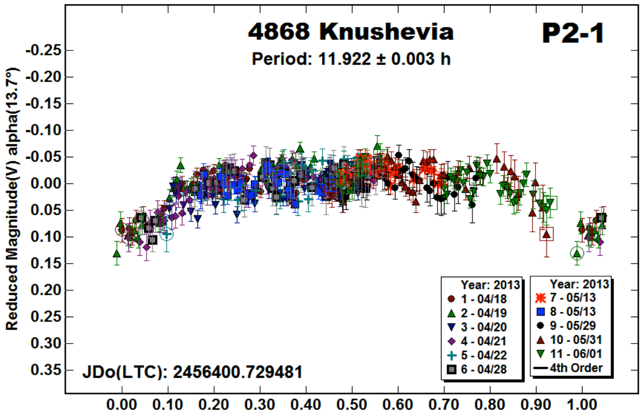
The dual period analysis proceeded by starting with the best-fit unsubtracted solution and searching for possible secondary periods. The best-fit secondary period was subtracted from the data set and a new search for the primary period was begun. The new primary result was then used to look for a secondary period. The process was continued until both periods stabilized. This approach can be self-fulfilling in that the initial secondary period result is based on what could be an incorrect primary period. As a check, the initial primary period search was forced to a range of 4-5 hours, which included the earlier results. This still lead to the same two possible values for P_2 of about 12 and 24 hours, with the shorter one slightly favored. The 12-hour secondary period was used to search a range of 2-5 hours for the primary period, with a result again find one near 3.14 hours.

As a result of the above, and the period spectrum included here, we contend that a primary period of 3.1422 h should be adopted for

Knushevia, whether or not there is a satellite, and that the longer solutions near 4.5 hours should be rejected.







The "P2-1" lightcurve shows the lightcurve for the suggested secondary period P_2 = 11.922 h. The scatter in the data hides the Fourier model curve but there appears to be a slight attenuation at about 0.45 rotation phase. Assuming this is the case, this leads to an effective size ratio between the satellite and primary of $D_S/D_P \geq 0.13 \pm 0.03$. The primary period and size ratio put the asteroid almost exactly on the center line of the model shown in Figure 1 of Pravec *et al.* (2010). This model shows the correlation between primary period and mass ratio of known binary systems. While fitting the model may be another case of self-fulfillment (it assumes the model is correct), this does lend support to results presented here and to the asteroid being binary.

Conclusion

While the evidence for a satellite seems strong, we admit that it is not fully conclusive, especially the values for the secondary period and size ratio. For example, if a value of P_2 = 23.8 h is used, leads to mutual events on the order of 0.05 mag and $D_S/D_P \geq 0.21 \pm 0.03$. This value and primary period still fit well within the error envelope of the Pravec *et al*. model.

The best solution at this point is to observe the asteroid at future apparitions, incorporating help from observers at well-separated longitudes and better calibrated data. This is another good example of why our research group's name is "MoreData!"

Acknowledgements

Funding for PDS observations, analysis, and publication was provided by NASA grant NNX13AP56G. Work on the asteroid lightcurve database (LCDB) was also funded in part by National Science Foundation Grant AST-1210099. The purchase of the FLI-1001E CCD camera used for some observations by Stephens at the CS3 site was made possible by a 2013 Gene Shoemaker NEO Grant from the Planetary Society. This research was made possible through the use of the AAVSO Photometric All-Sky Survey (APASS), funded by the Robert Martin Ayers Sciences Fund.

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FOUR COLOR OBSERVATIONS OF 2501 LOHJA

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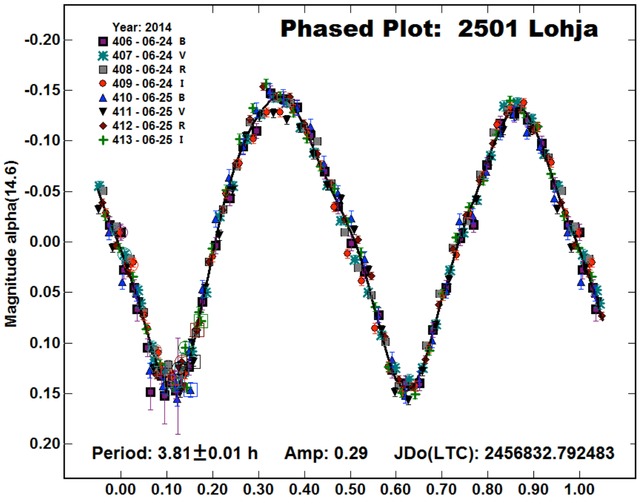
Photometric studies of asteroid 2501 Lohja were made between 2014 June 24 and 25 using the Southeastern Association for Research in Astronomy (SARA) Kitt Peak telescope with Bessell B, V, R and I filters. We obtained a synodic period of 3.81 ± 0.01h, which is consistent with previous values.

All observational data reported here were obtained with the Southeastern Association for Research in Astronomy (SARA) Kitt Peak telescope. This telescope has an aperture of 0.91 m and is located at the Kitt Peak National Observatory near Tucson, Arizona. It has an effective focal ratio of *f*/7.5. When coupled to an Astronomical Research Cameras, Inc, (ARC) CCD camera, the resulting resolution is 0.86 arcsec/pixel (binned 2×2) and the field-of-view (FOV) = 14.6'×14.6'. Bessell BVRI filters were used in turn when taking images. The camera temperature was cooled to –109°C. Image acquisition was done with *DS9*. All images were reduced with master bias, dark, and flat frames. All calibration frames were created using *IDL*. Period analysis was performed using *MPO Canopus,* which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.,* 1989).

We selected 2501 Lohja to accumulate lightcurve data for shape modeling. We also carried out the photometric studies using B, V, R, I filters to detect possible color variations over the surface of the asteroid. Previously reported synodic periods include Higgins (2006, 3.804 h; 2011, 3.80865 h). Husarik (2014) used lightcurve inversion to find the shape, pole, and sidereal period ($P_{Sidereal}$ = 3.808348 h).



We observed the asteroid on 2014 June 24 and 25 and found color indexes of B-V = 0.94 ± 0.02, V-R = 0.54 ± 0.01, and R-I = 0.382 ± 0.004 mag. No significant differences can be seen among these four color lightcurves. We obtained a synodic period P = 3.81 ± 0.01 h, which agrees with the previously determined values.

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NEW PHOTOMETRIC OBSERVATIONS OF 128 NEMESIS, 249 ILSE, AND 279 THULE

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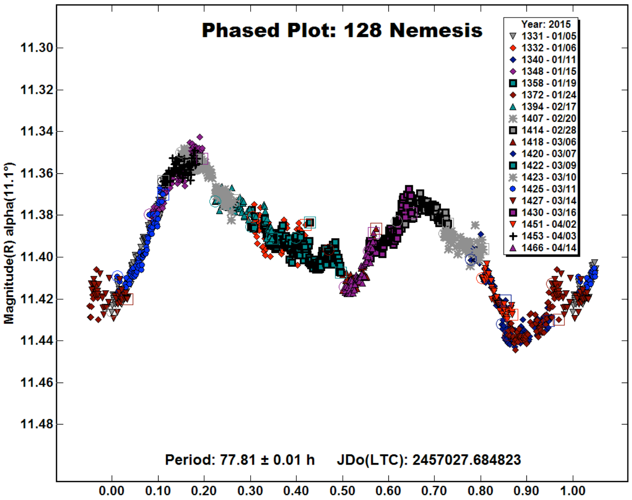
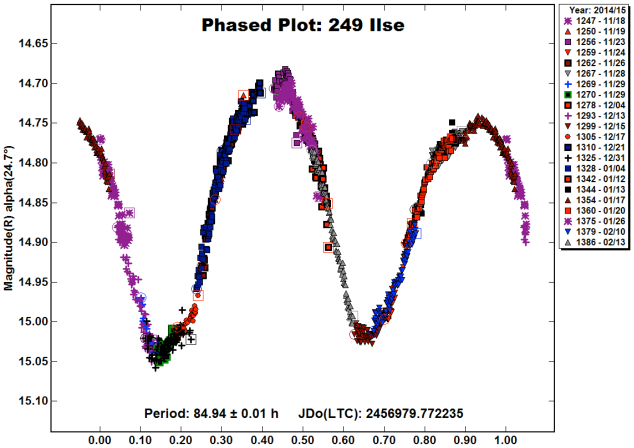
Synodic rotation periods and amplitudes are reported for 128 Nemesis 77.81 ± 0.01 hours, 0.08 ± 0.01 magnitudes; 249 Ilse 84.94 ± 0.01 hours, 0.34 ± 0.02 magnitudes; and 279 Thule, 15.931 ± 0.001 hours, 0.08 ± 0.02 magnitudes.

All observations reported here were made at the Organ Mesa Observatory with a 35 cm Meade LX200 GPS S-C and SBIG STL-1001E CCD, 60 second exposures, unguided. A clear filter was used for 249 Ilse and 279 Thule and R filter for brighter 128 Nemesis. To reduce the large number of data points they have been binned in sets of 3 with maximum time difference 5 minutes for 279 Thule, and in sets of 5 with maximum time difference 10 minutes for 128 Nemesis and 249 Ilse for each of which a total of more than 5000 data points was obtained.

<u>128 Nemesis.</u> Previous photometric observations are by Debehogne et al. (1977) who found a rise of about 0.03 magnitudes on 1976 Sept. 10 0:30 - 7:00 UT and could only infer a fairly long period. Scaltriti et al. (1979) obtained observations on 5 consecutive nights 1977 Dec. 16-20 and obtained a dense unsymmetric bimodal lightcurve with full phase coverage and a good fit to a 39 hour period, 0.1 magnitude amplitude. Although their lightcurve and period look convincing, they estimate an error of ± 0.5 hours due to the short interval of observations. New observations over a much longer time interval were undertaken to confirm the 39 hour period and reduce its error. The pursuit of the next decimal place sometimes yields entirely unexpected behavior that requires us to revise our previously perceived description of nature. The new observations on 19 nights 2015 Jan. 5 – Apr. 14 provide a good fit only to a lightcurve with period 77.81 ± 0.01 hours and amplitude 0.08 ± 0.01 magnitudes. The asymmetry of this lightcurve definitively rules out the 39 hour period by Scaltriti et al. (1979) in favor of a period twice as great.



<u>249 Ilse.</u> Previous photometric observations and derived periods have been published by Binzel (1983), 42.62 hours; Binzel (1987), 85.24 hours; and Angeli et al. (2001), 42.6 hours. All these are based on very sparse data and considered to have low reliability. New observations have been made on 21 nights 2014 Nov. 19 - 2015 Feb. 13 and provide a good fit to an unsymmetric bimodal lightcurve with period 84.94 ± 0.01 hours, amplitude 0.34 ± 0.02 magnitudes.

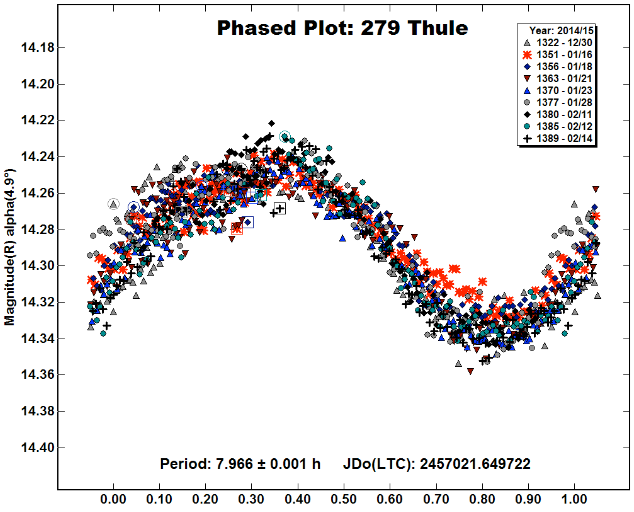


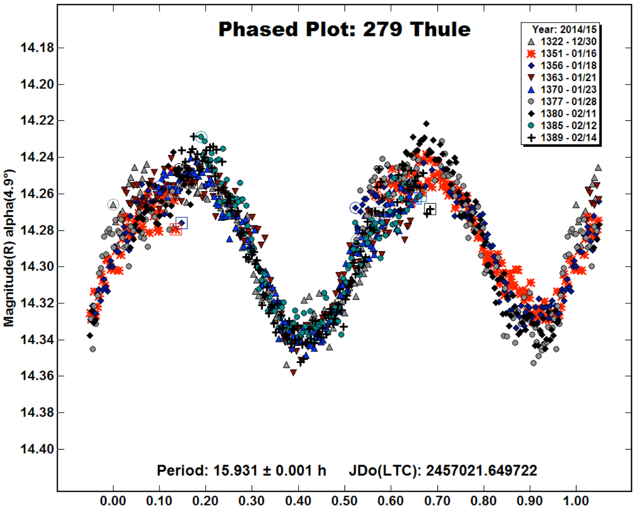
<u>279 Thule.</u> Minor planet 279 Thule is the only large asteroid in a stable 4:3 resonance with Jupiter with a small eccentricity small inclination orbit. Oppositions occur at nearly uniform intervals separated by about 13.5 months and celestial longitudes of about 45 degrees. The magnitude at opposition is always near 14.5. The minimum possible distance from Earth is about 3.24 AU. This makes disk resolved imagery by adaptive optics or radar studies especially difficult, and the only practical means to study its properties is by photometry.

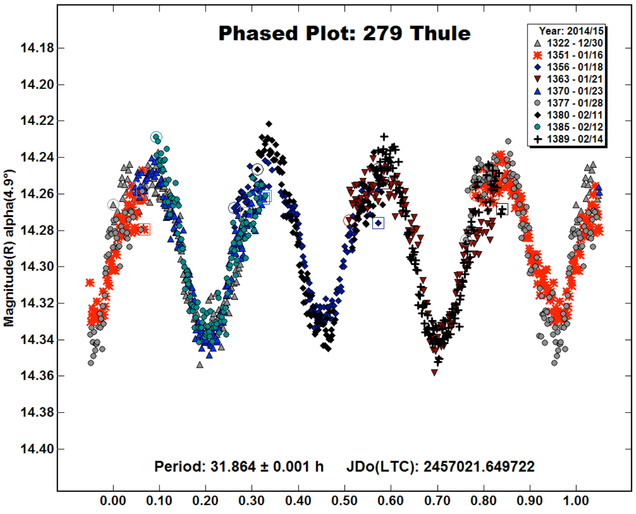
Observations near several previous oppositions have all yielded inconclusive results. The period, amplitude, and celestial longitude of each of these follow, listed in chronological sequence. Zappala et al. (1989) 7.44 h, 0.06 mag, 5 deg; Sauppe et al. (2007), no period found, 0.14 mag, 157 deg; Behrend (2008), 5.75 h, 0.06 mag, 200 deg; Pravec (2008), 11.942 h, 0.04 mag, 200 deg. Warner et al. (2010) published lightcurves phased to both 7.979 h and 15.962 h with amplitude 0.10 mag at celestial longitude 245 deg. The 15.962 hour bimodal lightcurve with a slight asymmetry has a somewhat better fit than the 7.979 hour monomodal lightcurve.

Pilcher (2014) reported additional observations and used the amplitude-aspect method to find an approximate pole orientation. Observations in year 2008 near celestial longitude 200 degrees could be equally well fitted to ambiguous periods of 7.970 hours with monomodal lightcurve and 15.960 hours with bimodal lightcurve and amplitude 0.06 ± 0.02 magnitudes. Observations in 2013 at celestial longitude 70 degrees showed very small amplitude 0.02 magnitudes, and a distinctly monomodal lightcurve phased to 15.85 ± 0.1 hours. In this reference Pilcher also noted the wide range of celestial longitudes of the several investigations, with minimum amplitude at celestial longitude 70 degrees and maximum at celestial longitude 157 degrees. Application of the amplitude-aspect method to determine a rotational pole position suggests it lies within 15 degrees of celestial longitude 70 degrees, latitude 0 degrees, or alternately longitude 250 degrees, latitude 0 degrees. The Asteroid Lightcurve Data File (Warner et al., 2014) states 15.962 hours as the most likely, but not secure, period. Half and twice the most likely period of 15.962 hours are still possible, but all other periods can now be confidently ruled out.

Additional observations were made near the 2014/2015 opposition to provide more data to resolve this ambiguity. It is noted that the possible periods are very nearly Earth commensurate, being 1/3, 2/3, or 4/3 of Earth period. For full lightcurve coverage it necessary to have one-night sessions greater than 8 hours. Nine sufficiently long sessions were obtained 2014 Dec. 30 - 2015 Feb. 14 and spaced so that each segment of the possible 31.864 hour double period was included twice. Lightcurves phased to 7.966 hours, 15.931 hours, 31.864 hours, all ± 0.001 hours, with one, two, and four maxima and minima, respectively, are presented to facilitate discussion. The 15.931 hour lightcurve shows a slight asymmetry between the two maxima and minima, and a slightly smaller scatter of data points than the 7.966 hour lightcurve. The two sides of the 31.864 hour lightcurve are almost identical, and also show the small distinction between adjacent maxima and minima. These all favor the 15.931 hour period with the usual 2 maxima and minima per cycle. The 2013 very small amplitude 15.85 hour monomodal lightcurve is believed to be at near polar aspect, at which circumstance monomodal lightcurves are commonly observed. All the available evidence favors the 15.931 hour period, but not strongly, and this period still cannot be considered reliable.







Future work. The next opposition in 2016 February/March is expected to occur at near equatorial aspect with nearly the maximum amplitude possible, likely near the 0.14 magnitudes reported by Sauppe et al. (2007) at almost the same position in the sky. Observers take note, and please place 279 Thule on your schedule for 2016 February/March. These months represent the best opportunity for many years to come to resolve definitively the rotation period of 279 Thule.

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GENERAL REPORT OF POSITION OBSERVATIONS BY THE ALPO MINOR PLANETS SECTION FOR THE YEAR 2014

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Observations of positions of minor planets by members of the Minor Planets Section in calendar year 2014 are summarized.

During the year 2014 a total of 533 positions of 160 different minor planets were reported by members of the Minor Planets Section. All are approximate visual positions.

The summary lists minor planets in numerical order, the observer and telescope aperture (in cm), UT dates of the observations, and the total number of observations in that period. The year is 2014 in each case.

Positional observations were contributed by the following observers:

Observer, Instrument	Location	Planets	Positions
Faure, Gerard 5 cm binoculars 45 cm Dobsonian 40 cm Meade LX200	Observations of Vesta from Rajasthan, India Others from Valdrome, France with Jean-michel Rayon	3	47(42CCD)
Harvey, G. Roger 73 cm Newtonian 60 cm reflector at Scout Key, Florida, USA	Concord, North Carolina, USA	128	444
Pryal, Jim 20 cm f/10 S-C 12 cm refractor	Ellensburg, WA USA	30	72
Watson, William W. 20 cm Celestron	Tonawanda, NY USA	4	14

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2014)	NO. OBS.
1 Ceres	Pryal, 12, 20	Mar 30-Jul 1	5
2 Pallas	Pryal, 12	Mar 20-23	4
4 Vesta	Faure, 5 Pryal, 12, 20	Mar 3-6 Mar 30-Jul 1	2 4
5 Astraea	Pryal, 20	Sep 26-27	2
23 Thalia	Pryal, 20	Nov 28	2
26 Proserpina	Pryal, 20	Aug 18-20	2
37 Fides	Pryal, 20	Oct 20	2
55 Pandora	Pryal, 20	Oct 20	2
63 Ausonia	Pryal, 20	Aug 21	2
66 Maja	Pryal, 20	Nov 23	2
80 Sappho	Pryal, 20	Aug 18-20	2
84 Klio	Pryal, 20	Sep 29	2
97 Klotho	Pryal, 20	Aug 18-20	2
104 Klymene	Pryal, 20	Nov 28	2
114 Kassandra	Watson, 20	Mar 7-8	2
146 Lucina	Pryal, 20	Jun 2-3	2
165 Loreley	Watson, 20	Jul 6	2
190 Ismene	Pryal, 20	Jan 1-5	5
233 Asterope	Pryal, 20	Aug 18-20	2
253 Mathilde	Pryal, 20	Sep 20-21	2
259 Aletheia	Pryal, 20	Jun 2-3	2
283 Emma	Pryal, 20	Sep 29	2
313 Chaldaea	Watson, 20	Mar 7-Apr 3	5
373 Melusina	Pryal, 20	Sep 20-21	2
379 Huenna	Pryal, 20	Sep 20-21	2
393 Lampetia	Pryal, 20	Sep 20-21	2
481 Emita	Pryal, 20	Nov 28	2
584 Semiramis	Pryal, 20 Watson, 20	Aug 6-7 Sep 24-28	3 5
598 Octavia	Pryal, 20	Dec 14	2
606 Brangäne	Pryal, 20	Aug 21	2
952 Caia	Pryal, 20	Sep 26-27	2
1093 Freda	Pryal, 20	Jun 6	2
1931 Čapek	Harvey, 73	Nov 22	3
1957 Angara	Harvey, 73	Nov 22	3
2225 Serkowski	Harvey, 73	Dec 27	3
2340 Hathor	Harvey, 73	Oct 25	6
2400 Derevskaya	Harvey, 73	Jul 27	3
2440 Educatio	Harvey, 73	Oct 18 0.5m fainter@15.6	3
2472 Bradman	Harvey, 73	Mar 8	3
2481 Bürgi	Harvey, 73	Sep 28	3
2528 Mohler	Harvey, 73	Aug 26	3
2558 Viv	Harvey, 73	Oct 1	3
2683 Brian	Harvey, 73	Nov 22	3
2812 Scaltriti	Harvey, 73	Mar 8	3
3026 Sarastro	Harvey, 73	Oct 23	3
3100 Zimmerman	Harvey, 73	Jan 25	3
3144 Brosche	Harvey, 73	Oct 1	3
3383 Koyama	Harvey, 73	Jul 27 0.5m fainter@15.6	3
3405 Diawensai	Harvey, 73	Jul 24	6
3656 Hemingway	Harvey, 73	Aug 30	3
3681 Boyan	Harvey, 73	Oct 1	3
3710 Bogoslovskij	Harvey, 73	Aug 30	3
3755 Lecointe	Harvey, 73	Sep 28	3
3771 Alexejtolstoj	Harvey, 73	Nov 16	3
3965 Konopleva	Harvey, 73	Nov 22	3
3991 Basilevsky	Harvey, 73	Oct 1	3
4059 Balder	Harvey, 73	Nov 28	3
4083 Jody	Harvey, 73	Jan 25	3
4225 Hobart	Harvey, 73	Oct 19	3
4245 Nairc	Harvey, 73	Nov 28	3
4319 Jackierobinson	Harvey, 73	Aug 30	3
4359 Berlage	Harvey, 73	Sep 28	3
4401 Aditi	Harvey, 73	Oct 23	6
4402 Tsunemor	Harvey, 73	Oct 25	3

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2014)	NO. OBS.
4583 Lugo	Harvey, 73	Jul 5	6
4652 Iannini	Harvey, 73	Oct 1	3
		0.5m fainter@15.6	
4909 Couteau	Harvey, 73	Aug 26	3
4921 Volonté	Harvey, 73	Nov 22	3
5134 Ebilson	Harvey, 73	Dec 14	3
5182 Bray	Harvey, 73	Jul 24	3
5235 Jean-Loup	Harvey, 73	Jul 26-27	3
5268 Chernohorsky	Harvey, 73	Oct 25	3
5385 Kamenka	Harvey, 73	Oct 25	3
5546 Salavat	Harvey, 73	Jan 25	3
5576 Albanese	Harvey, 73	Nov 22	3
5595 Roth	Harvey, 73	Oct 26	3
5617 Emelyanenko	Harvey, 73	Dec 27	3
5670 Rosstaylor	Harvey, 73	Dec 26	3
5703 Hevelius	Harvey, 73	Nov 22	3
5803 Ötzi	Harvey, 73	Jul 5	6
5852 Nanette	Harvey, 73	Jun 1	3
5945 Roachapproach	Harvey, 73	Oct 26	3
6038 1989 EQ	Harvey, 73	Dec 13	3
6050 Miwablock	Harvey, 73	Dec 13	3
6095 1991 UU	Harvey, 73	Jul 24	6
6098 Mutojunkyu	Harvey, 73	Aug 25	3
6115 Martinduncan	Harvey, 73	Oct 18	3
		0.5m fainter@15.8	
6164 Gerhardmüller	Harvey, 73	Aug 25	3
		0.7m fainter@15.6	
6171 Uttorp	Harvey, 73	Oct 26	3
6182 Katygord	Harvey, 73	Aug 25	3
6341 1993 UN3	Harvey, 73	Nov 16	3
6735 Madhatter	Harvey, 73	Oct 26	3
6737 Okabayashi	Harvey, 73	Jan 25	3
6754 Burdenko	Harvey, 73	Oct 18	3
6969 Santaro	Harvey, 73	Dec 14	3
7075 Sadovnichij	Harvey, 73	Sep 28	3
7124 Glinos	Harvey, 73	Dec 27	3
		0.5m fainter@16.0	
7196 Baroni	Harvey, 73	Dec 13	3
7240 Hasebe	Harvey, 73	Oct 26	3
7330 Annelemaître	Harvey, 73	Oct 1	3
7783 1994 JD	Harvey, 73	Dec 26	3
7860 Zahnle	Harvey, 73	Aug 25	3
8147 Colemanhawkins	Harvey, 73	Sep 28	3
8274 Soejima	Harvey, 73	Oct 25	3
8350 1989 AG	Harvey, 73	Dec 26	3
8355 Masuo	Harvey, 73	Sep 28	3
8730 Iidesan	Harvey, 73	Oct 1	3
8917 1996 EU2	Harvey, 73	Dec 27	3
9120 1998 DR8	Harvey, 73	Oct 25	3
9156 Malanin	Harvey, 73	Aug 25	3
9190 Masako	Harvey, 73	Oct 25	3
9192 1992 AR1	Harvey, 73	Jan 31	3
9387 Tweedledee	Harvey, 73	Aug 26	3
		0.5m fainter@15.5	
9729 1981 RQ	Harvey, 73	Aug 25	3
10076 1989 PK	Harvey, 73	Aug 25	3
10141 Gotenba	Harvey, 73	Oct 25	3
10483 Tomburns	Harvey, 73	Oct 19	3
11017 Billputnam	Harvey, 73	Dec 27	3
11065 1991 XE2	Harvey, 73	Oct 19	3
14095 1997 PE2	Harvey, 73	Jul 27	3
14497 1995 DD	Harvey, 73	Sep 28	3
15166 2000 GX90	Harvey, 73	Aug 25	3
		0.5m fainter@15.6	
15199 Rodnyanskaya	Harvey, 73	Nov 22	3
19133 1988 PC2	Harvey, 73	Jul 27	3
19140 Jansmit	Harvey, 73	Nov 28	3
19144 1989 UP1	Harvey, 73	Dec 13	3
19243 Bunting	Harvey, 73	Sep 28	3
19318 Somanah	Harvey, 73	Dec 27	3
20470 1999 NS5	Harvey, 73	Jul 24	3
20562 1999 RV120	Harvey, 73	Aug 25	3
21023 1989 DK	Harvey, 73	Jan 25-26	3
21028 1989 TO	Harvey, 73	Oct 17	3
		0.6m fainter@15.7	
21035 Iwabu	Harvey, 73	Dec 27	3
23766 1998 MZ23	Harvey, 73	Oct 25	3
		0.5m fainter@16.1	
25916 2011 CP44	Harvey, 73	Jun 1	6
26632 2000 HS30	Harvey, 73	Dec 14	3
27176 1993 BR3	Harvey, 73	Jan 25	3
27221 1999 FA27	Harvey, 73	Nov 28	3
31843 2000 CQ80	Harvey, 73	Aug 14	3
32555 2001 QZ29	Harvey, 73	Oct 25	3
		0.5m fainter@15.8	
32570 Peruindiana	Harvey, 73	Dec 27	3
32575 2001 QY78	Harvey, 73	Aug 25	3
		0.5m fainter@15.4	
34459 2000 SC91	Harvey, 73	Jan 25	3
37306 2001 KW46	Harvey, 73	Nov 22	3
		0.5m fainter@15.5	
39525 1989 TR2	Harvey, 73	Nov 22	3
43815 1991 VD4	Harvey, 73	Nov 22	3
68267 2001 EA16	Harvey, 73	Oct 17	6
69971 Tanzi	Harvey, 73	Jan 25	3
162566 2000 RJ34	Harvey, 60	Feb 24	6
163132 2002 CU11	Harvey, 73	Aug 27-29	6
214088 2004 JN13	Harvey, 73	Nov 28	6
275677 2000 RS11	Harvey, 73	Mar 23	6
285944 2011 RZ11	Faure, 45	Aug 24	3
	Faure and Rayon, 40	Aug 24	19C
	Harvey, 73	Aug 24	6
387733 2003 GS	Harvey, 73	Apr 21	6
398188 2010 LE15	Harvey, 73	Aug 5	6

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2014)	NO. OBS.
1995 CR	Harvey, 73	Feb 21	6
2006 DP16	Harvey, 73	Feb 16	6
2013 WT67	Faure and Rayon, 40	Aug 23	23C
	Harvey, 73	Aug 19	6
2014 SC324	Harvey, 73	Oct 23	6
2014 WZ120	Harvey, 73	Nov 28	6

LIGHTCURVE ANALYSIS OF THE HUNAGARIA ASTEROID 30935 DAVASOBEL

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After a single night of observations at the Sopot Astronomical Observatory on 2014 Dec 31, there were possible indications of an attenuation that would indicate that the asteroid was binary. A collaboration was formed by the authors to obtain data from well-separated locations in case the potential satellite had an orbital period commensurate with an Earth day. The final data set contained no significant secondary period and led to a single period solution of $P = 3.9769 \pm 0.0005$ h, $A = 0.60 \pm 0.03$ mag.

Observations of the Hungaria asteroid 30935 Davesobel were started on 2014 Dec 31 by Benishek at the Sopot Astronomical Observatory (SAO). A preliminary analysis appeared to show an attenuation and the possibility of something other than a single period solution. Benishek contacted Warner to obtain additional data while continuing his observations. The advantage would be two stations well-separated in longitude, which could help resolve ambiguities should a secondary period be commensurate with an Earth day. Also, if conditions allowed, observations ending in Serbia would almost overlap those starting in California, thus providing a very long set of nearly continuous observations. Unfortunately, the moon and weather did not cooperate in this regard.

OBS	Telescope	Camera
Warner	0.35-m *f*/9.1 Schmidt-Cass	STL-1001E
Benishek	0.35-m *f*/10 Schmidt-Cass	ST-8XME

Table I. List of observers and equipment.

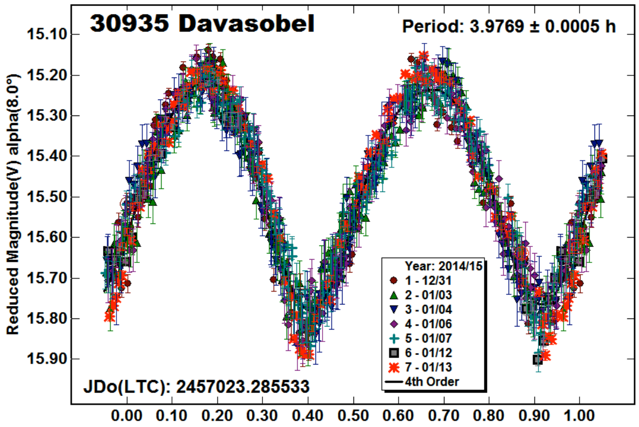
Obs	Dates (2014/2015)	Sessions
Warner (CS3-PDS)	12/31 01/12 13	1 6 7
Benishek (SAO)	01/03 04 06 07	2-5

Table II. Dates of observation for each observer. The Sessions column gives the session numbers shown in the lightcurve legend.

Tables I and II give the equipment used and the dates of observations for each observer. Over the range of observations, the asteroid's phase angle started at $\alpha = 8.0°$, dropped to 6.8°, and increased back to 9.1°. The phase angle bisector longitude was nearly constant at $L_{PAB} = 103°$ while the latitude went from $B_{PAB} = 10°$ to 6° (see Harris *et al.*, 1984, for the derivation of the phase angle bisector).

Both observers used *MPO Canopus* to measure the images. The Comp Star Selector utility found up to five solar-colored stars for each session. The magnitudes for the comparisons were taken from the MPOSC3 catalog, which is based on the 2MASS catalog converted to the BVRcIc system using formulae developed by Warner (2007). Benishek sent his *MPO Canopus* export data sets to Warner for period analysis, which was also done in *MPO Canopus,* which incorporates the FALC Fourier analysis algorithm developed by Harris (Harris *et al.,* 1989) and modified by Warner to allow subtracting a Fourier model lightcurve from a data set to search for a secondary period.

The search for a second period found nothing that rose above the noise in the period spectrum covering 5 to 30 hours. Instead, a unique single period solution was found with $P = 3.9769 \pm 0.0005$ h, $A = 0.60 \pm 0.03$ mag. It should be noted that the observations on 2014 Dec 31 were hampered by moonlight and weather conditions. It's possible that the deviation was the result of a systematic error.



Acknowledgements

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LIGHTCURVE ANALYSIS OF THE NEAR-EARTH ASTEROID 2015 CN13

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The near-Earth asteroid 2015 CN13 made a fly-by of Earth in late 2015 February. We observed the asteroid on Feb 25, 26, and 28. Analysis of the data set found two possible periods, the most likely being $P = 22.7 \pm 0.3$ h. Given the estimated diameter of 70 meters and long period, this puts 2015 CN13 in a small group of NEAs with $D \leq 140$ meters and periods well below the spin barrier, *i.e.*, approximately $P \geq 2.2$ hours.

The near-Earth asteroid (NEA) 2015 CN13 made a fly-by of Earth in late 2015 February. It was $V < 18.0$ from about Feb 22- March 5, reaching a minimum of $V \sim 16.9$ on Feb 28. Given its sky motion and the size of telescopes available and, combined with a waxing moon beyond first quarter, there was only a small window of opportunity for making CCD photometry observations. With an estimated size of about 70 meters, the chances that the asteroid was a super-fast rotator, $P \ll 1$ hour, were high and so exposures had to be kept short in order to avoid *rotational smearing*, which is when exposures are a significant portion of the rotation period and so details about features within the lightcurve are lost (see Pravec *et al.*, 2000).

Tables I and II give the equipment used and the dates of observations for each observer. Exposures were 60 sec on Feb 25-26 and 30 sec on Feb 28. To keep the signal-to-noise as high as possible, no filters were used.

OBS	Telescope	Camera
Warner	0.30-m *f*/9.6 Schmidt-Cass	FLI ML-1001E
Oey	0.61-m *f*/6.8 CDK	Apogee U42

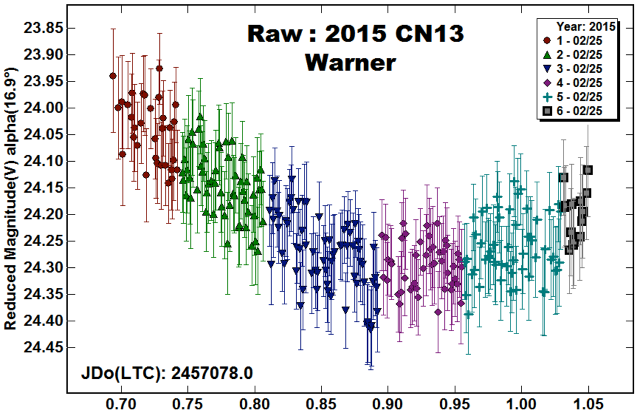
Table I. List of observers and equipment.

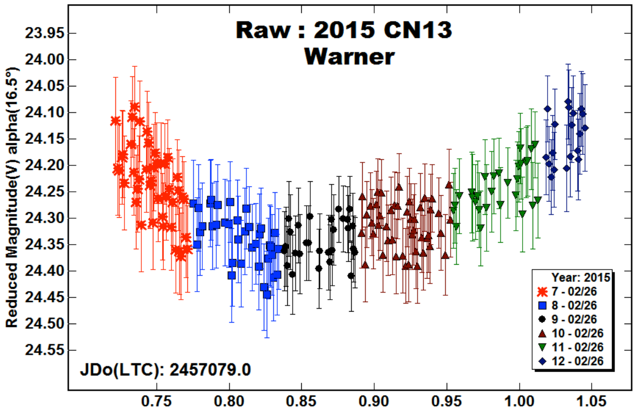
Obs	2015 mm/dd	Sess	α	L_{PAB}	B_{PAB}
Warner	02/25 26	1-12	17.1,16.4	160,163	8,6
Oey	02/28	13-15	20.2	170	1

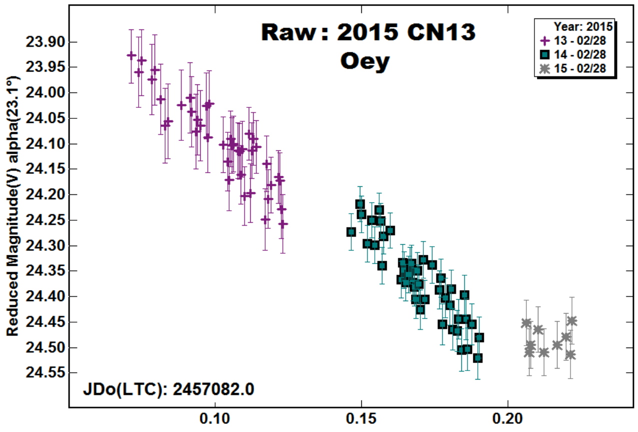
Table II. Dates of observation for each observer. a is the solar phase angle. The last two columns are the phase angle bisector longitude and latitude (see Harris *et al.*, 1984).

Both observers used *MPO Canopus* to measure the images. The Comp Star Selector utility in *MPO Canopus* found up to five solar-colored stars for each session. The magnitudes for the comparisons were taken from the MPOSC3 catalog, which is based on the 2MASS catalog converted to the BVRcIc system using formulae developed by Warner (2007). Oey sent his data to Warner for period analysis using *MPO Canopus,* which incorporates the FALC Fourier analysis algorithm developed by Harris (Harris *et al.,* 1989).

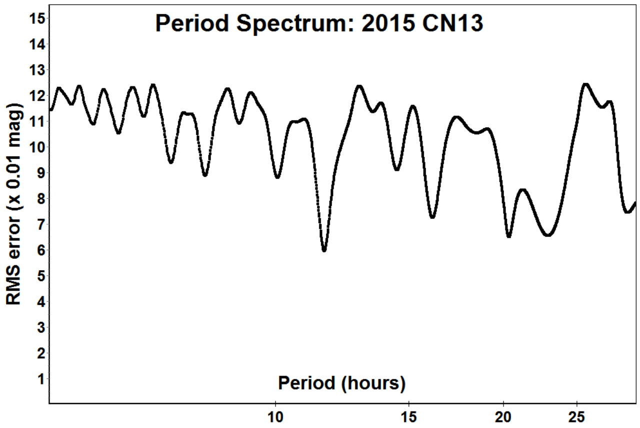
The raw plots for Feb 25 and 26 each show an apparent minimum in the lightcurve. Since the Feb 26 shifted the minimum to the left, a first estimate for the period was that it was a little less than being exactly commensurate with an Earth day, *e.g.*, between 11-12 or 23-24 hours. Given the shape of the raw curves, shorter periods near 6 and 8 hours were considered unlikely, but leaving the possibility for a period near 16 hours. Since the asteroid was within range for only a short period, there was no chance for a single station to get sufficient coverage of the total lightcurve to find a reasonably accurate period. This is where the observations from Oey, located about 110 degrees in longitude to the west of Warner's location, became critical.

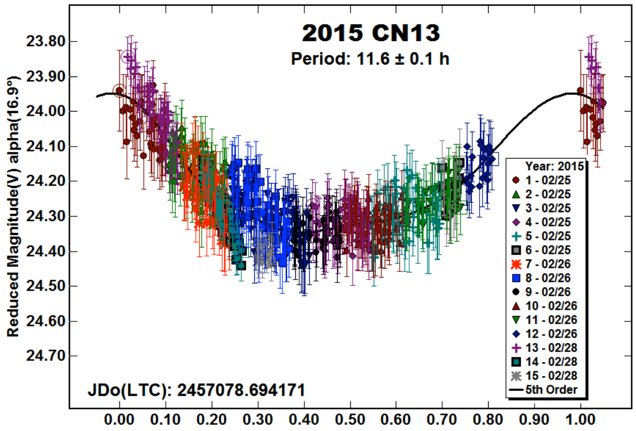


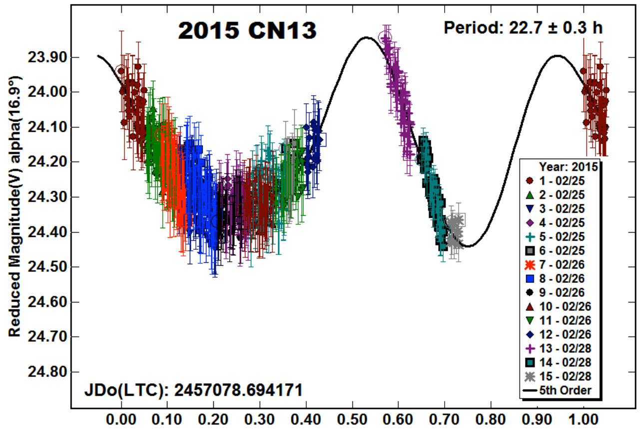




The data from Oey were obtained when the asteroid had an even larger sky motion and the moon was 3 days past first quarter, therefore there was some uncertainty about how well they would fit in with the other data. Fortunately, when combined with the data from the two previous sessions, they led to solutions that, as expected, were nearly commensurate with an Earth day, as seen in the period spectrum.





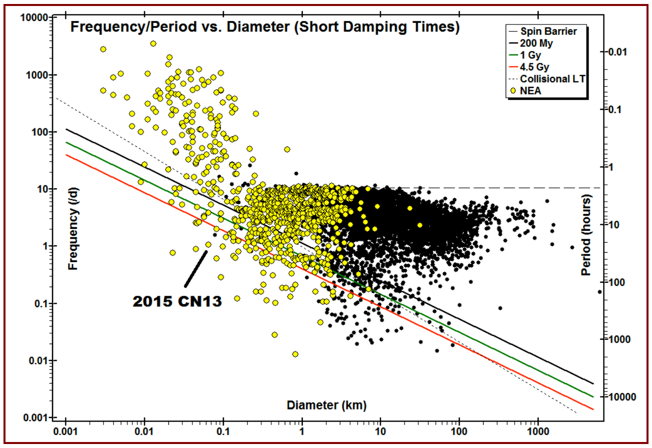


The two more likely periods were $P = 11.6 \pm 0.1$ h, $A = 0.40 \pm 0.05$ mag and $P = 22.7 \pm 0.3$ h, $A = 0.60 \pm 0.05$ mag. Given the moderate phase angle and large amplitude, the longer period is adopted for this paper (see Harris *et al.*, 2104).

Unfortunately, this was the only good chance for time-series photometry on 2015 CN13 for many years. From 1995-2050, this was the only apparition when then asteroid was V < 22.0. Radar observations for 2015 CN13 were canceled due to electronic problems (Lance Benner, private communications) so, unless there are other optical data of which we are unaware, verification of these results may be a long time coming.

The period makes the asteroid a little unusual but not particularly rare. A scan of the asteroid lightcurve database (LCDB; Warner *et al.*, 2009) found 37 NEAs with $D \leq 140$ meters and $P \geq 2.2$ hours, or below the so-called *spin barrier* that roughly separates rubble pile from strength-bound asteroids. When setting $P \geq 10$ hours, the count drops to 11 NEAs. These numbers should be viewed with some caution. Since many NEAs are available for only short periods and often only once within a period of many years, there is likely a bias against slow rotating NEAs, *i.e.*, there may be (many) more objects with moderate to long periods.

The frequency-diameter plot based on the LCDB as of 2015 March 31 shows the location of 2015 CN13. NEAs are highlighted by yellow circles. The dotted horizontal line at about 2.2 hours is the *spin barrier*. The diagonal solid lines give the frequency vs. diameter for specific damping times, *i.e.*, the estimated time for a tumbling asteroid to return to single axis rotation.



Acknowledgements

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2455 SOMVILLE: LIGHTCURVE ANALYSIS AND PRELIMINARY INVERSION MODEL

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2455 Somville was observed on 24 nights between 2015 Jan 16 and Mar 15, which covered a solar phase angle range from –1.1° to +19.5°. This allowed the determination of a synodic period $P = 2.8287 \pm 0.0001$ h with an amplitude that varied from $A = 0.12$ to 0.18 mag. We were also able to determine a color index of V-R = 0.43 ± 0.04 and H-G parameters of $H = 12.03 \pm 0.02$ mag and $G = 0.16 \pm 0.03$. By combining our dense lightcurves with sparse photometric data, we obtained a preliminary shape and spin axis model of ($\lambda = 224°$, $\beta = -68°$) or ($\lambda = 39°$, $\beta = -49°$) with a sidereal period $P_S = 2.82868 \pm 0.00024$ h.

Observations of 2455 Somville were obtained at both Etscorn Campus Observatory (ECO, 2015) and Balzaretto Observatory. The observations at Etscorn covered the entire period while the Balzaretto observations were used to obtain the color index for the asteroid. The Balzaretto observations were obtained using a 0.20-m Schmidt-Cassegrain (SCT), reduced to *f*/5.5, equipped with an SBIG ST7-XME CCD camera. The Etscorn observations were obtained with three Celestron 0.35-m SCTs. Two of the telescopes used SBIG STL-1001E CCD cameras. The third telescope used an SBIG ST-10XME with an Optec 0.5x focal reducer. The Balzaretto observations were obtained in both Cousins V and a Cousins R filters while the Etscorn observations were all obtained with a clear filter. All observations were reduced with *MPO Canopus,* flat-field corrected using image processing tools within *MPO Canopus* version 10.4.3.17 (Warner, 2013). The V and R magnitudes were calibrated using the method described by Dymock and Miles (2009) and CMC-15 stars with near-solar color indexes selected by using Vizier (2015). The same method was also applied to the clear filter observations after converting to R magnitudes. The observations of 2015 February 19 were a sequence of V and R filters. From these we find a color index of V-R = 0.43 ± 0.04 (mean of 12 pairs of values).

Period analysis was done using the FALC analysis algorithm developed by Alan Harris (Harris *et al.*, 1989) and implemented in *MPO Canopus*. Some minor adjustments in the lightcurve offsets were done via the CompAdjust function. We find a synodic period of $P = 2.8287 \pm 0.0001$ h with an amplitude of 0.13 magnitudes (Figure 1), characterized by a quadramodal shape lightcurve that is asymmetric with respect to the left-right axis at 0.5 phase.

The amplitude of the lightcurve increased from 0.12 mag at low phase angles to 0.18 mag at higher phase angles (Figure 2). This trend of the amplitude is described by the empirical formula of Zappala *et al.* (1990) that relates the lightcurve amplitude with the phase angle as $A(0°) = A(\alpha)/(1+m\alpha)$, where α is the solar phase angle and m is the slope parameter (typically, 0.030 deg^{-1} for S-type, 0.015 deg^{-1} for C-type and 0.013 deg^{-1} for M-type objects).

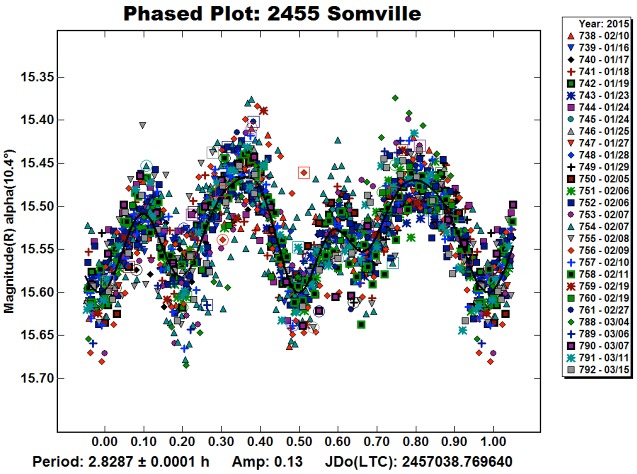

Figure 1. The lightcurve of 2455 Somville with a synodic period of 2.8287 ± 0.0001 h and amplitude of 0.13 mag.

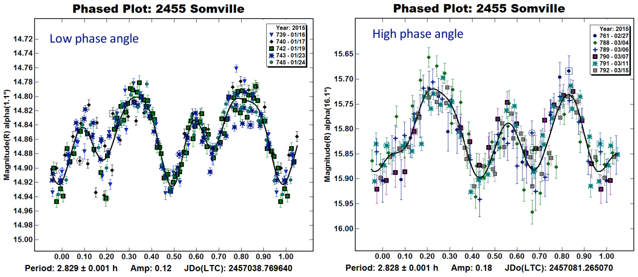

Figure 2. Two lightcurves of 2455 at low and high phase angles.

For 2455 Somville, we derive a linear regression analysis $m = s/A(0°) = 0.039 \text{ deg}^{-1}$, where $s = 0.0043$ is the slope of the linear-fit and $A(0°) = 0.1126$ is the intercept (Figure 3).

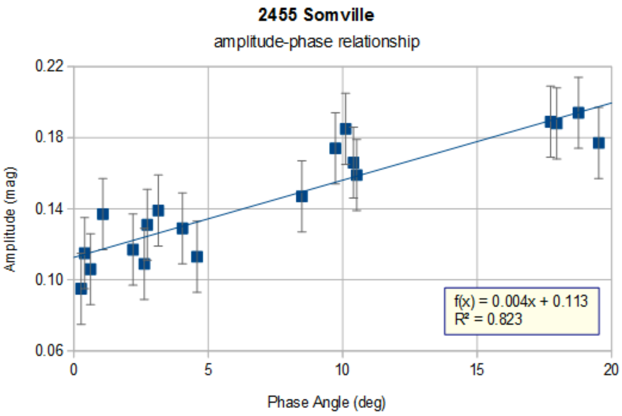

Figure 3. Amplitude-phase relationship for 2455 Somville.

The H-G parameters were found using the H-G Calculator function of *MPO Canopus*. For each lightcurve, the R mag was measured using half peak-to-peak amplitude with *Peranso* (Vanmunster, 2014) via polynomial fit and the V mag was obtained by adding the color index (V-R = 0.43) to the previously determined R mag. From this, we derived $H = 12.03 \pm 0.02$ mag and $G = 0.16 \pm 0.03$ (Figure 4). This H value is quite different from $H = 11.70$ published on the JPL Small-Body Database Browser (JPL, 2015). Both the obtained color index (V-R) and G value are compatible with a low- to medium-albedo asteroid (Shevchenko and Lupishko, 1998).

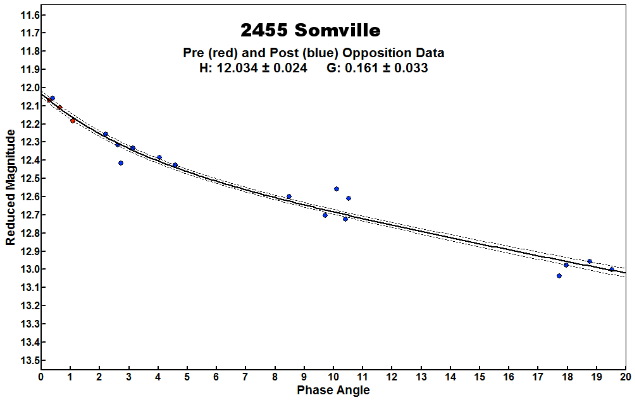

Figure 4. Visual reduced magnitude vs phase angle.

Lightcurve Inversion

Typically, dense data from three or four apparitions are needed for a main-belt asteroid to attempt the lightcurve inversion process (Kaasalainen *et al.*, 2002). We can combine, however, sparse and dense data to derive model as shown by Kaasalainen (2004) and Ďurech *et al.* (2009). In our case, the wide range of phase angle bisector longitude/latitude distribution (Figure 5) covered by sparse data from (689) USNO Flagstaff station and (703) Catalina Sky Survey made us hopeful when attempting the lightcurve inversion process to derive a preliminary shape and spin axis model. In addition, the sparse data, covering more apparitions, contain considerable information about the brightness variations at different geometries (Figure 6).

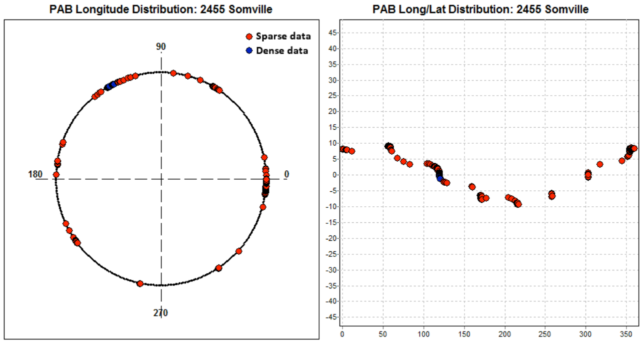

Figure 5. Phase angle bisector (PAB) longitude/latitude distribution of the data used for the lightcurve inversion model. Dense data are in blue and sparse data are in red.

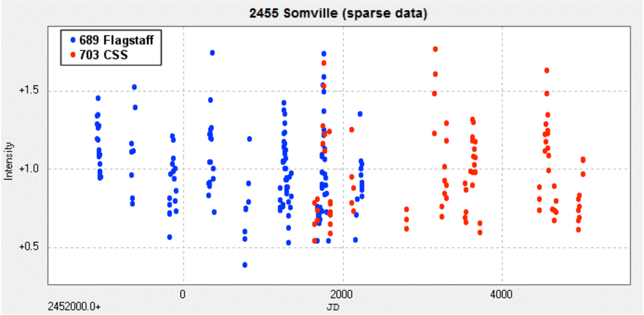

Figure 6. Sparse data photometry from 689 USNO Flagstaff station and 703 Catalina Sky Survey.

Lightcurve inversion was performed using *MPO LCInvert* v.11.1.0.2 (Bdw Publishing). For the analysis, the eleven most significant dense lightcurves were imported as well as the sparse data from 689 Flagstaff and 703 CSS, assigning them respectively a different weighting factor of 1.0, 0.3 and 0.15. For the inversion process, the "dark facet" weighting factor was set to 0.7 to keep the dark facet area below 1% of total area and the number of iterations was set to 50 (default).

The search for sidereal period, started around the synodic period value. We found an isolated solution with lowest chi-square value (Figure 7). For the pole search we used the "medium" search option (312 fixed pole positions with 15° longitude-latitude steps) and the previously found sidereal period was allowed to "float."

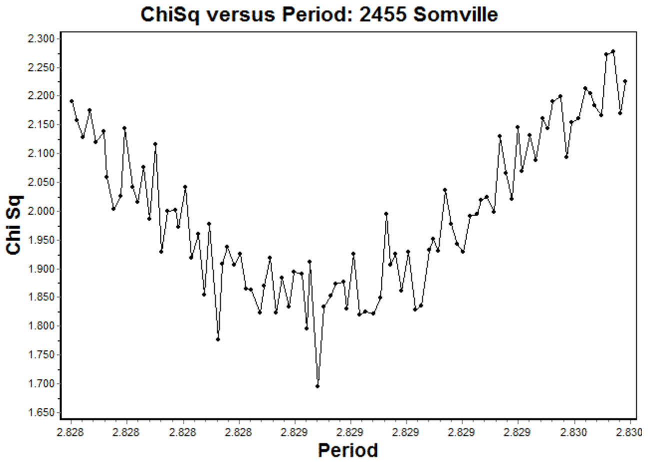

Figure 7. The period search plot from MPO LCInvert shows an isolated minimum.

Data analysis shows two lower chi-square solutions with a possible ambiguity for λ ± 180° at (λ = 224°, β = –68°) and (λ = 39°, β = –49°) with a sidereal period *Ps* = 2.82868 ± 0.00024 h; see Figure 8 for log(chi-square) values distribution. Typical errors in the pole solution are ±15 degrees and the uncertainty in period has been evaluated as a rotational error of 15° over the total time-span of the dense observations.

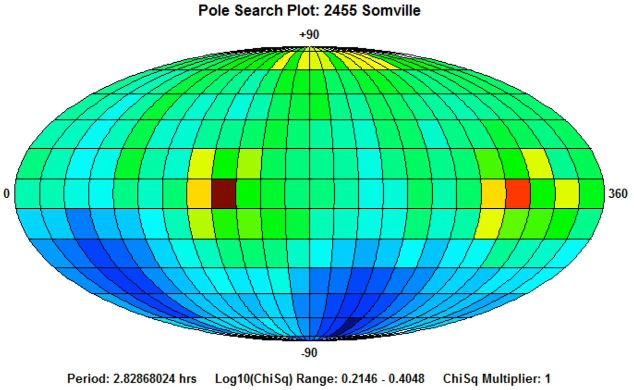

Figure 8. The pole search plot, where dark blue identifies the best solution and the dark red the worst solution.

Figure 9 shows the shape model (first solution). Figure 10 shows the fit between the model (black line) and observed dense lightcurves (red points) at low and high phase angles.

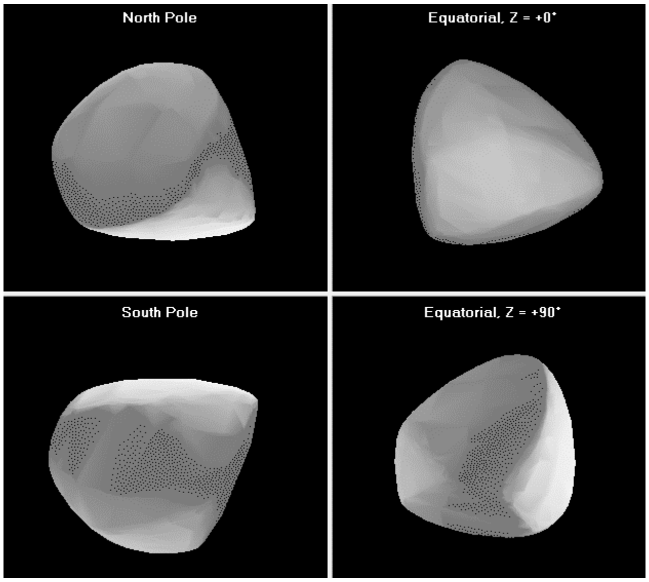

Figure 9. The shape model for 2455 Somville with λ = 224°, β = –68°, and *Ps* = 2.82868 h.

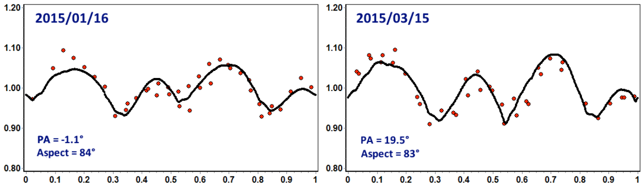

Figure 10. Model fit (black line) versus observed lightcurves (red points).

Acknowledgments

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ASTEROIDS OBSERVED FROM CS3: 2015 JANUARY - MARCH

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(Received: 13 April)

CCD photometric observations of 9 Hungaria asteroids and one NEA were obtained from the Center for Solar System Studies from 2015 January to March.

During this calendar quarter, the Center for Solar System Studies (CS3, MPC U81) was mostly focused on studying Hungaria family asteroids. Some of these Hungarias had previously determined rotational periods and further observations were acquired so that over time pole positions and shape models can be determined.

All images were made with a 0.4-m or a 0.35-m SCT using an FLI-1001E or a SBIG STL-1001E CCD camera. Images were unbinned with no filter and had master flats and darks applied to the science frames prior to measurement. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *MPO Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al*., 1989). Night-to-night calibration of the data (generally < ±0.05 mag) was done using field stars converted to approximate Cousins V magnitudes based on 2MASS J-K colors (Warner 2007). The Comp Star Selector feature in *MPO Canopus* was used to limit the comparison stars to near solar color.

Number	Name	2015 mm\dd	Pts	Phase	L_{PAB}	B_{PAB}	Period	P.E.	Amp	A.E.	Grp
6870	Pauldavies	02/02-02/03	152	16.2,15.7	159	3	4.487	0.004	0.68	0.02	H
7829	Jaroff	02/04-02/05	140	14.9,15.2	125	-19	4.391	0.003	0.67	0.03	H
17083	1999 JB4	02/17-02/21	408	23.3,24.0	127	29	6.147	0.007	0.07	0.02	H
25318	1999 CH12	02/21-02/26	231	0.6,3.9	152	0	15.80	0.03	0.09	0.02	H
34817	2001 SE116	02/02-02/03	135	9.7,9.8	133	-15	6.393	0.005	0.78	0.03	H
39791	Jameshesser	02/22-02/25	228	4.2,6.2	147	0	4.829	0.002	0.71	0.02	H
71765	2000 SU4	02/27-03/22	799	21.4,26.7	140	23	70.72	0.05	0.23	0.03	H
76841	2000 TC33	02/26-02/27	231	3.9,4.6	152	-2	4.895	0.002	0.54	0.03	H
79316	Huangshan	03/04-03/28	199	10.5,7.8,1	171	10	493.00	0.02	0.62	0.03	H
311554	2006 BQ147	02/16-02/18	109	47.1,49.6	116	-12	9.15	0.03	0.31	0.05	NEA

6870 Pauldavies. Pauldavies was previously observed by Warner (Warner 2007) reporting a rotational period of 4.487 h. This result agrees with that period and was obtained at a similar phase angle bisector longitude (L_{PAB}; see Harris *et al*., 1984).

7829 Jaroff. Jaroff has had results published twice before (Warner *et* al 2009, Warner 2012a). This result is in good agreement with those previously published rotational periods.

(17083) 1999 JB4. No previously reported rotational periods could be found in the Lightcurve Database (LCDB; Warner et al., 2009). With an amplitude of only 0.07 mag., it is possible that the lightcurve could have only a single extrema, or three or more extrema (Harris *et al* 2014). However, the extrema on this high quality lightcurve are not symmetrical favoring the 6.147 h period.

(25318) 1999 CH12. This Hungaria also does not have a previously reported rotational period. Its 0.09 amplitude suffers from the same uncertainties as those of (17083) 1999 JB4. In this case, the lightcurve is symmetrical. The 15.80 h solution is favored because it results in a bimodal solution. A possible 7.93 h solution is also presented for comparison purposes along with a period spectrum.

(34817) 2001 SE116. Warner observed this Hungaria four times in the past (Warner 2012a) finding a rotational period each time of 6.38 h. Since there was a favorable opposition in 2014, more observations were obtained to improve the shape model. This period is in good agreement with the previous results.

(39791) Jameshesser. No previously reported results could be found in the Lightcurve Database (LCDB; Warner et al., 2009).

(71765) 2000 SU4. No previously reported results could be found in the Lightcurve Database (LCDB; Warner et al., 2009). A complete lightcurve could not be obtained because the rotational period appears to be nearly 3 times that of the Earth's rotation.

(76841) 2000 TC33. No previously reported results could be found in the Lightcurve Database (LCDB; Warner et al., 2009).

(79316) Huangshan. Warner (Warner 2012b) previously found a period of 11.7 h. However, He observed it on three consecutive nights showing an amplitude of 0.1 magnitude and an asymmetric lightcurve. At the time, it was assumed that the asymmetry was because the lightcurve was dominated by surface features. Now, with a substantially different L_{PAB}, it was immediately apparent at this opposition that the lightcurve has a much larger amplitude. Over the course of the 3 week observing campaign, a distinct repeating pattern is seen. A raw plot is also presented to better show the repeating feature at the first minimum. Another test of a long rotational period is if nightly trends can be seen. When presenting any lightcurve over ~ 250 h, the nightly trends get squashed on the horizontal scale and can no longer be seen. Here, a raw plot spanning 6 nights is also presented to better illustrate the nightly trends. With a rotational period so long, it is expected that the damping time approaches the age of the solar system and that the asteroid has a strong chance of having non-principle axis rotation (tumbling). It is equally expected that even for a private observatory, an observing campaign cannot be sustained long enough to prove that fact. Eventually, resources were allocated to other targets.

(311554) 2006 BQ147. No previously reported rotational periods for this NEA could be found in the Lightcurve Database (LCDB; Warner et al., 2009).

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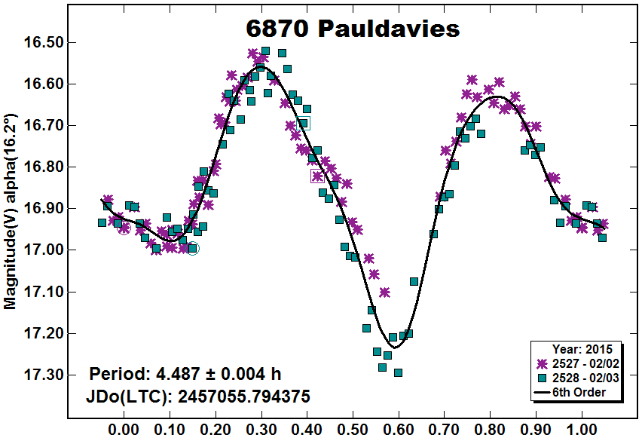
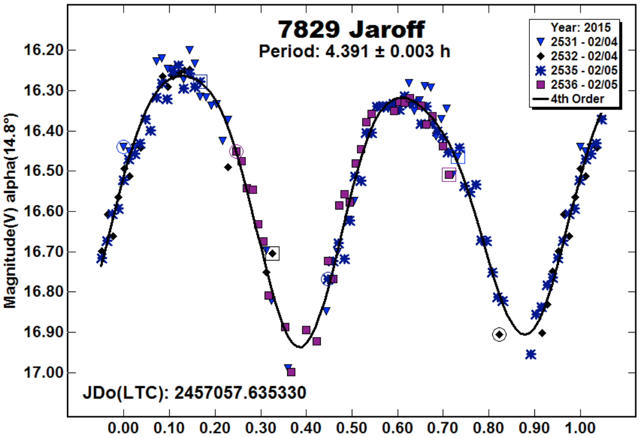
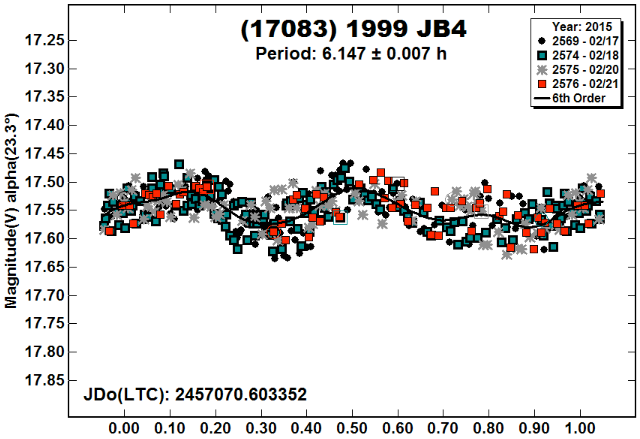
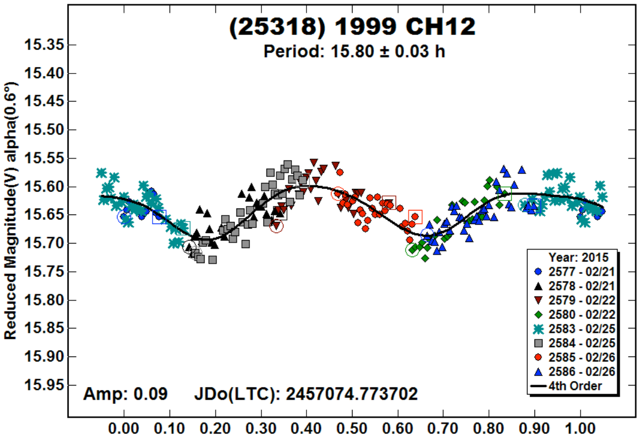
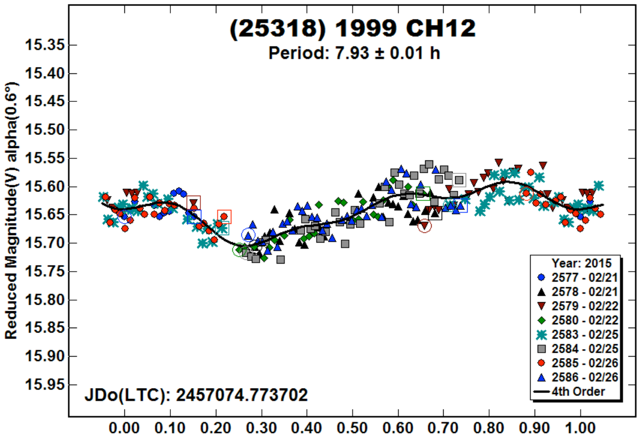
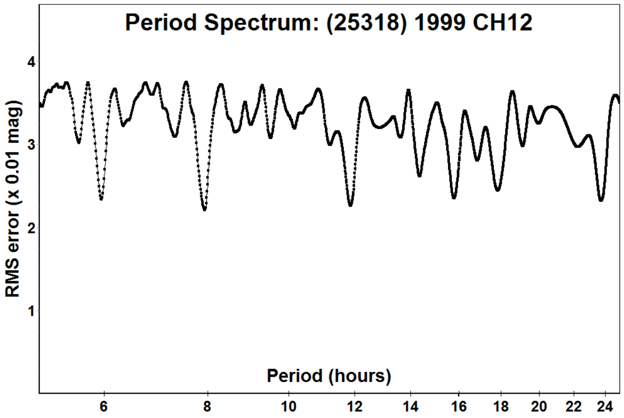

6870 Pauldavies

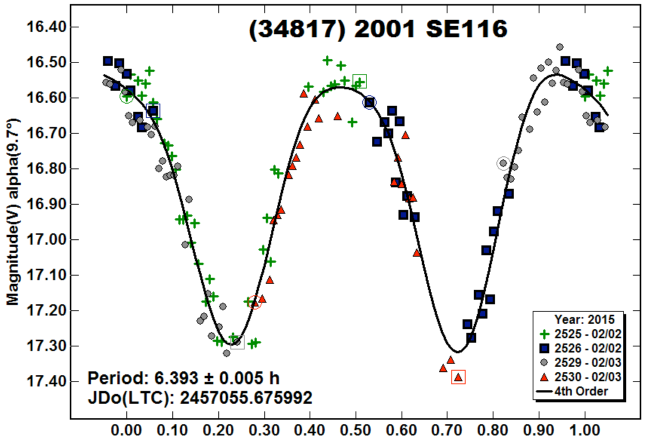

7829 Jaroff
Period: 4.391 ± 0.003 h

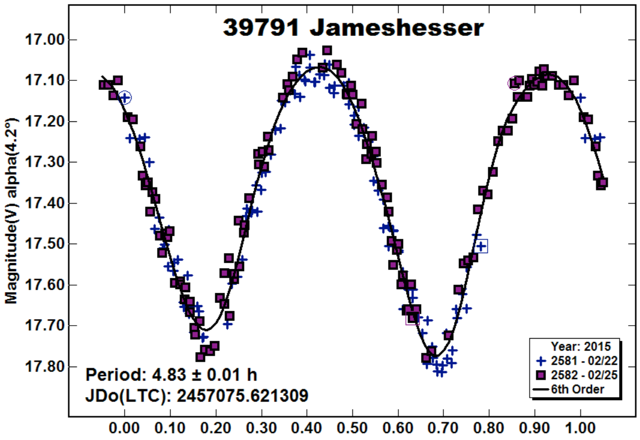

(17083) 1999 JB4
Period: 6.147 ± 0.007 h

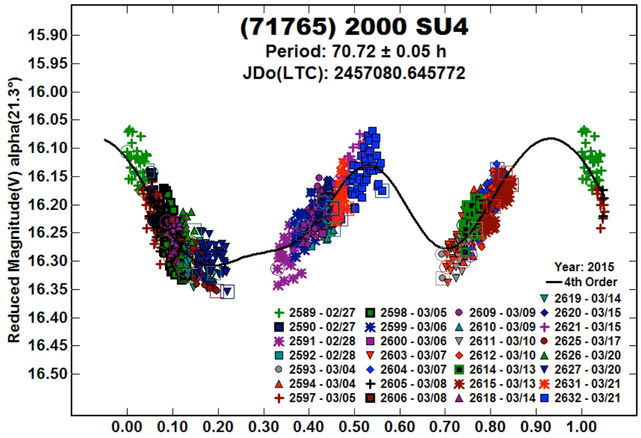

(25318) 1999 CH12
Period: 15.80 ± 0.03 h


(25318) 1999 CH12
Period: 7.93 ± 0.01 h


Period Spectrum: (25318) 1999 CH12


(34817) 2001 SE116


39791 Jameshesser
Magnitude(V) alpha(4.2°)
Period: 4.83 ± 0.01 h
JDo(LTC): 2457075.621309
Year: 2015
2581 - 02/22
2582 - 02/25
6th Order


(71765) 2000 SU4
Period: 70.72 ± 0.05 h
JDo(LTC): 2457080.645772
Reduced Magnitude(V) alpha(21.3°)
Year: 2015
4th Order
2619 - 03/14
2589 - 02/27
2590 - 02/27
2591 - 02/28
2592 - 02/28
2593 - 03/04
2594 - 03/04
2597 - 03/05
2598 - 03/05
2599 - 03/06
2600 - 03/06
2603 - 03/07
2604 - 03/07
2605 - 03/08
2606 - 03/08
2609 - 03/09
2610 - 03/09
2611 - 03/10
2612 - 03/10
2614 - 03/13
2615 - 03/13
2618 - 03/14
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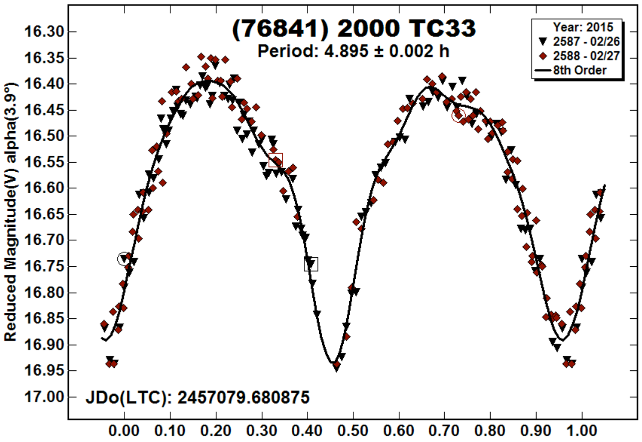
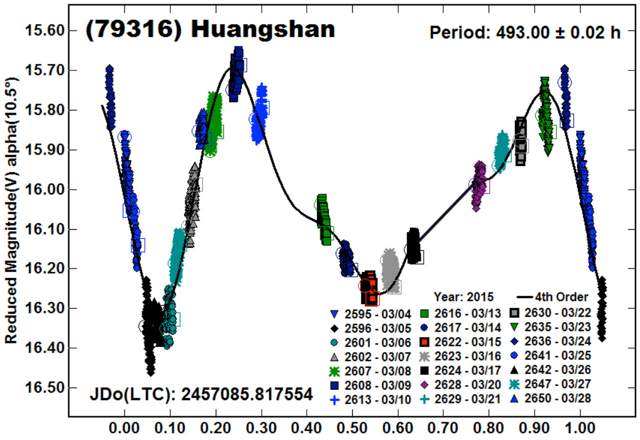
2631 - 03/21
2632 - 03/21


(76841) 2000 TC33
Period: 4.895 ± 0.002 h
Reduced Magnitude(V) alpha(3.9°)
JDo(LTC): 2457079.680875
Year: 2015
2587 - 02/26
2588 - 02/27
8th Order


(79316) Huangshan
Period: 493.00 ± 0.02 h
Reduced Magnitude(V) alpha(10.5°)
JDo(LTC): 2457085.817554
Year: 2015
4th Order
2595 - 03/04
2596 - 03/05
2601 - 03/06
2602 - 03/07
2607 - 03/08
2608 - 03/09
2613 - 03/10
2616 - 03/13
2617 - 03/14
2622 - 03/15
2623 - 03/16
2624 - 03/17
2628 - 03/20
2629 - 03/21
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2635 - 03/23
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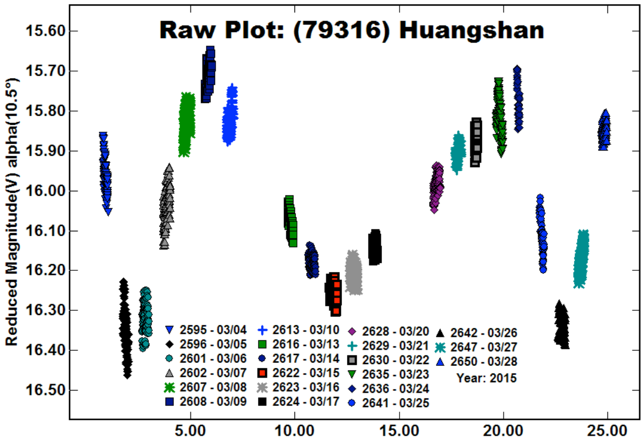
2641 - 03/25
2642 - 03/26
2647 - 03/27
2650 - 03/28


Raw Plot: (79316) Huangshan
Reduced Magnitude(V) alpha(10.5°)
2595 - 03/04
2596 - 03/05
2601 - 03/06
2602 - 03/07
2607 - 03/08
2608 - 03/09
2613 - 03/10
2616 - 03/13
2617 - 03/14
2622 - 03/15
2623 - 03/16
2624 - 03/17
2628 - 03/20
2629 - 03/21
2630 - 03/22
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2636 - 03/24
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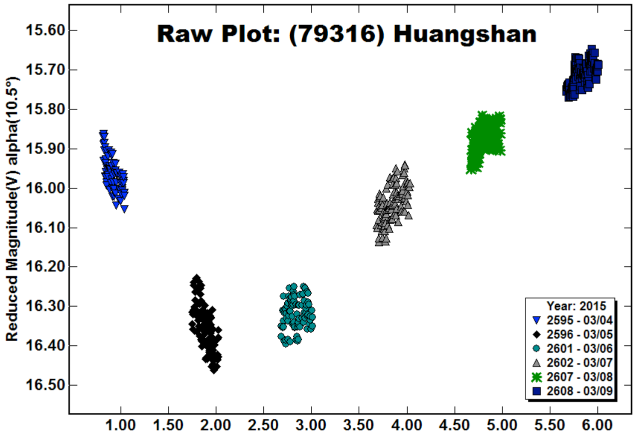
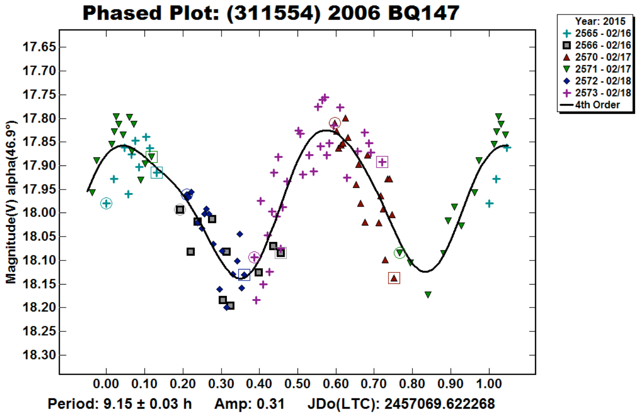
2647 - 03/27
2650 - 03/28
Year: 2015


Raw Plot: (79316) Huangshan
Reduced Magnitude(V) alpha(10.5°)
Year: 2015
2595 - 03/04
2596 - 03/05
2601 - 03/06
2602 - 03/07
2607 - 03/08
2608 - 03/09


Phased Plot: (311554) 2006 BQ147
Magnitude(V) alpha(46.9°)
Year: 2015
2565 - 02/16
2566 - 02/16
2570 - 02/17
2571 - 02/17
2572 - 02/18
2573 - 02/18
4th Order
Period: 9.15 ± 0.03 h
Amp: 0.31
JDo(LTC): 2457069.622268

LIGHTCURVE INVERSION FOR 65 CYBELE

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We present a shape and spin axis model for main-belt asteroid 65 Cybele. The model was obtained with lightcurve inversion process, using combined dense photometric data obtained during fifteen apparitions from 1977 to 2014 and sparse data from USNO Flagstaff. Analysis of the resulting data found a sidereal period P = 6.081434 ± 0.000005 hours and two possible pole solutions: (λ = 208°, β = –7°) and (λ = 27°, β = –14°) with an error of ±15 degrees.

The main-belt asteroid 65 Cybele has been observed for fifteen apparitions from 1977 to 2014 with a variety of phase angles and phase angle bisectors. Dense photometric data were downloaded from the Asteroid Photometric Catalogue (APC) by Lagerkvist *et al.* (2001) and from the Asteroid Light Curve Database (ALCDEF, 2014). The observational circumstances for the fifteen apparitions are reported in Table I.

Year	#LCs	Data Points	PA°	PABL°	PABB°	Ref.
1977	3	150	2/3	332	0	(1)
1978	1	9	-3	38	-4	(1)
1982	11	92	17/16	213/219	3/4	(2)
1983	11	119	18	299/314	3/1	(2)
1984	2	29	17/12	10/16	2/3	(2)
1985/6	3	91	11/12	73	-4	(2)
1987	1	44	4	126	-2	(3)
1988	1	63	3	189	2	(3)
1989	1	28	4	272	4	(4)
1994	2	44	7/5	165	0	(5)
2007	2	56	5	182	2	(6)
2009	7	1590	12/2	345	-1	(7)
2010/1	5	1234	12/15	46/49	-4	(6)(8)
2011/2	6	1841	11/1	99	-4	(9)
2014	5	1030	2/8	264	4	(10)

Table I. Observational circumstances for 65 Cybele over fifteen apparitions. A total of 61 lightcurves were used for lightcurve inversion analysis. PA, PABL and PABB are, respectively, the phase angle, phase angle bisector longitude and latitude. References: (1) Schober *et al.* (1980); (2) Weidenschilling *et al.* (1987); (3) Weidenschilling *et al.* (1990); (4) Gil Hutton (1990); (5) Shevchenko *et al.* (1996); (6) Behrend web; (7) Pilcher and Stephens (2010); (8) Pilcher (2011); (9) Pilcher (2012); (10) Pilcher (2014)

In order to improve the solution, we also used sparse data from USNO Flagstaff Station, as has been shown by Kaasalainen (2004) and Ďurech *et al.* (2009). Sparse data were taken from the Asteroids Dynamic Site (AstDyS-2, 2014) for a total of 484 data points (Figure 2). Figure 1 (left) shows the phase angle bisector (PAB) longitude distribution for dense and sparse data points from 689 USNO Flagstaff station. Figure 1 (right) shows the PAB latitude distribution.

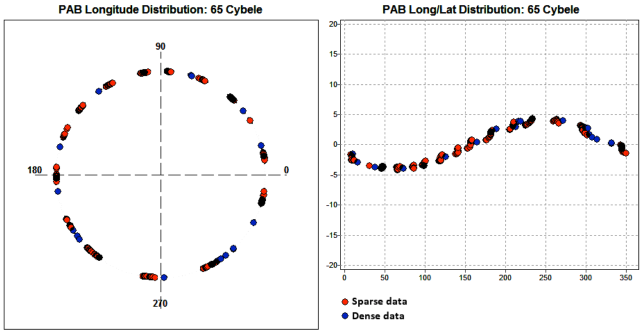

Figure 1. PAB longitude and latitude distribution of the data used for lightcurve inversion model. Dense data are in blue and sparse data are in red.

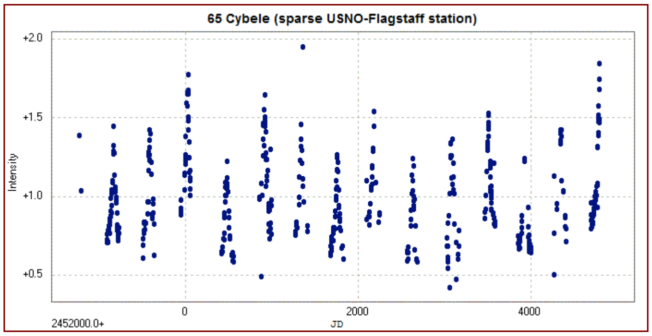

Figure 2. Sparse photometry data points from 689 USNO Flagstaff station.

Lightcurve inversion was performed using *MPO LCInvert* v.11.1.0.2 (Bdw Publishing), which implements algorithms and code provided by Mikko Kaasalainen and Josef Ďurech. For guidelines and a description of the modeling process see the *MPO LCInvert* operating instructions manual and Warner *et al.* (2008).

All data from the sixty-one dense lightcurves and one sparse dataset were imported in *MPO LCInvert* for analysis, assigning them a different weighting factor, from 1.0 for the dense data to 0.3 for sparse data. The period search was started around the average of the synodic periods previously published in the literature. The search process found an isolated sidereal period with lowest chi-square value (Figure 3).

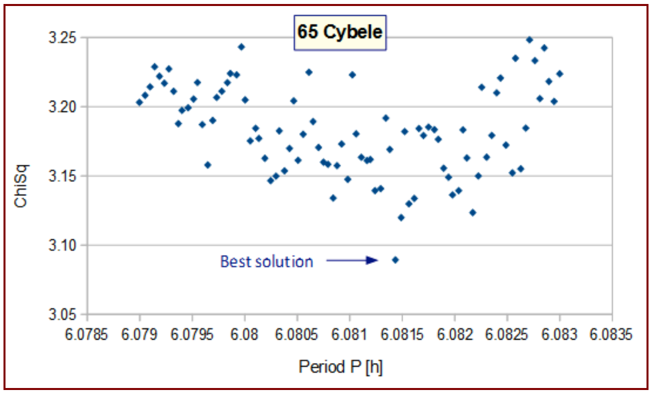

Figure 3. The period search for 65 Cybele shows an isolated minimum.

The pole search was started using the "medium" search option (312 fixed pole positions with 15° longitude-latitude steps) and the previously found sidereal period allowed to "float." The "dark facet" weighting factor was set to 1.8 to keep the dark facet area below 1% of total area and the number of iterations of processing was set to 75.

Data analysis shows the two lower chi-square solutions with a possible ambiguity for λ ± 180° at (λ = 208°, β = –7°) and (λ = 27°, β = –14°) with a sidereal period $P = 6.081434 \pm 0.000005$ h; see Figure 4 for log(chi-square) values distribution.

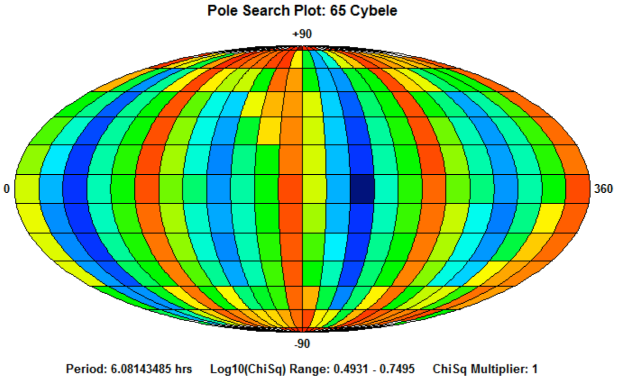

Figure 4. The pole search plot. Darker blue indicates the better solutions while red indicates the least-favorable solutions.

Typical errors in the pole solution are ±15 degrees and the uncertainty in period has been evaluated as a rotational error of 15° over the total time-span of the dense observations. This pole solution agrees with those reported by Pilcher (2011) using the simple amplitude-aspect method and found by Durech (private communication) using lightcurve inversion method with a similar dataset.

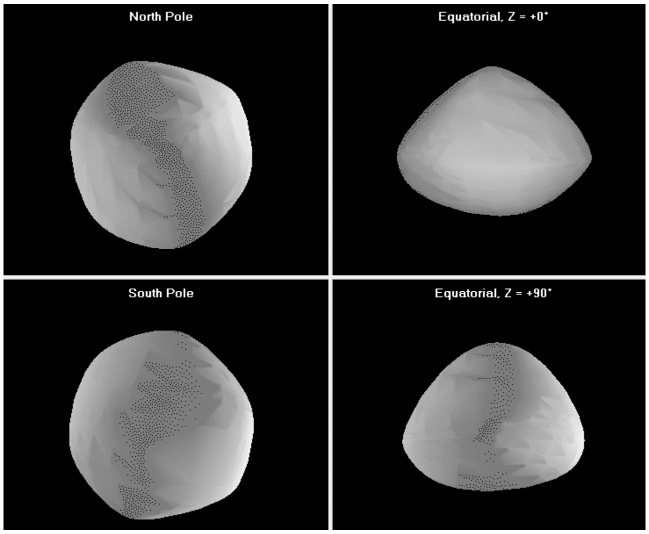

Figure 5. The shape model for 65 Cybele (λ = 208°, β = –7°).

Figure 5 shows the shape model (first solution) while Figure 6 shows the fit between the model (black line) and observed lightcurves (red points).

The model and the data will be stored in Database of Asteroid Models from Inversion Techniques (DAMIT; Ďurech 2015).

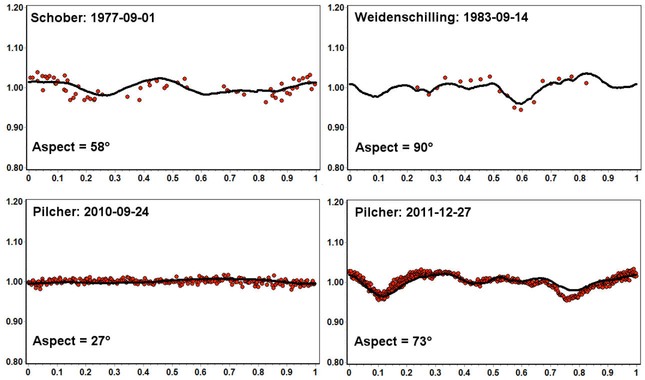

Figure 6. Model fit (black line) versus observed lightcurves (red points)

Acknowledgement

The authors thank Dr. Josef Durech for his advice.

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5426 SHARP: A PROBABLE HUNGARIA BINARY

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Initial CCD photometry observations of the Hungaria asteroid 5426 Sharp in 2014 December and 2015 January at the Center of Solar System Studies-Palmer Divide Station in Landers, CA, showed attenuations from the general lightcurve, indicating the possibility of the asteroid being a binary system. The secondary period was almost exactly an Earth day, prompting a collaboration to be formed with observers in Europe, which eventually allowed establishing two periods: P_1 = 4.5609 ± 0.0003 h, A_1 = 0.18 ± 0.01 mag and P_2 = 24.22 ± 0.02 h, A_2 = 0.08 ± 0.01 mag. No *mutual events, i.e.,* occultations and/or eclipses, were seen, therefore the asteroid is considered a *probable* and not *confirmed* binary.

Observations of the Hungaria asteroid 5426 Sharp were made by Warner at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) starting on 2014 December 29. These were follow-up to earlier work by Warner (2012) which found P = 4.56 h and A = 0.25 mag. The lightcurve was rated U = 2 on the asteroid lightcurve database rating system (LCDB; Warner *et al.*, 2009). Based on a high albedo derived from WISE observations (Masiero, 2011), Sharp is a member of the Hungaria *collisional family*, meaning it is a remnant of the parent body and probably of taxonomic type E.

The initial data from CS3-PDS showed attenuations from the general lightcurve that might be attributed to a satellite. A preliminary dual-period analysis by Warner using *MPO Canopus* found a secondary period of about 24 hours, making it nearly impossible to resolve the period with some certainty without observations from stations well removed in longitude.

OBS	Telescope	Camera
Warner	0.35-m *f*/9.1 Schmidt-Cass	STL-1001E
Benishek	0.35-m *f*/10 Schmidt-Cass	ST-8XME
Ferrero	0.30-m *f*/8.0 Ritchey-Chretien	ST-9

Table I. List of observers and equipment.

Obs	Dates (2014/2015)	Sessions
Warner (CS3-PDS)	12/29-01/02 14 19	1-5 8
Benishek (SAO)	01/15 16	6 7
Ferrero (BO)	01/24 26	10 11

Table II. Dates of observation for each observer. The Sessions column gives the session numbers shown in the lightcurve legend.

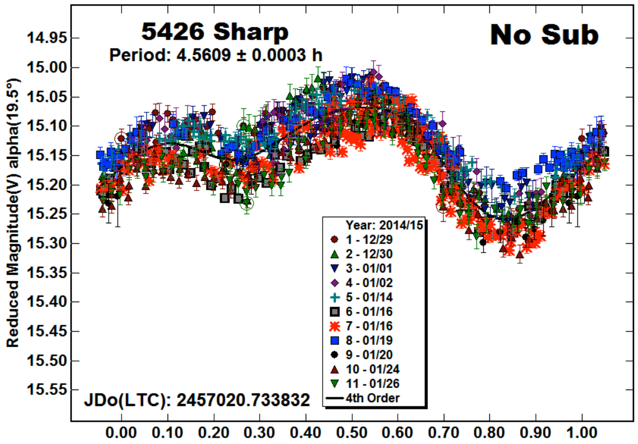
A collaboration was formed with Benishek (working at Sopot Astronomical Observatory) and Ferrero, which eventually allowed resolving the system parameters. Tables I and II list the observers, equipment used, and the dates that each person made observations. All exposures were unfiltered and ranged from 180 to 300 sec.

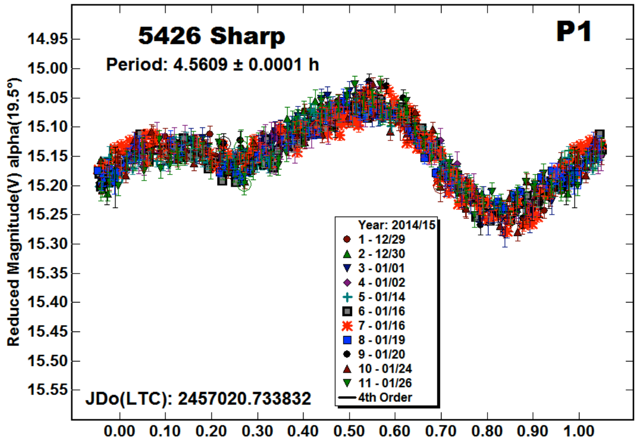
All three observers used *MPO Canopus* to measure the images. The Comp Star Selector utility found up to five solar-colored stars for each session. The magnitudes for the comparisons were taken from the MPOSC3 catalog, which is based on the 2MASS catalog converted to the BVRcIc system using formulae developed by Warner (2007). Benishek and Ferrero sent *MPO Canopus* export data sets to Warner for period analysis. This was also done in in *MPO Canopus,* which incorporates the FALC Fourier analysis algorithm developed by Harris (Harris *et al.,* 1989) and modified by Warner to allow subtracting a Fourier model lightcurve from a data set to search for a secondary period.

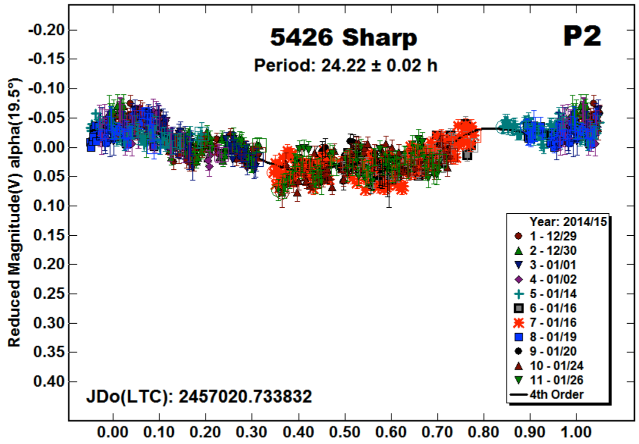
In the "No Sub" and "P1" lightcurves presented here, the "Reduced Magnitude" is Johnson V corrected to unity distance by applying $-5*\log(r\Delta)$ to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes in the "P2" are relative to the average magnitude of the "P1" lightcurve, or V = 15.15. The magnitudes were normalized to a phase angle of $\alpha = 19.5°$ using G = 0.43, which is the default for type E asteroids in the asteroid lightcurve database (LCDB; Warner *et al.*, 2009). The horizontal axis is the rotation phase, ranging from –0.05 to 1.05.

The "No Sub" lightcurve shows the entire data set when searching for a single period. The deviations from the average lightcurve exceed the general noise and so prompted the dual period search, which involves finding a single period, primary solution and subtracting that to find a secondary period. The resulting secondary period is subtracted to find a revised primary period. That is used to find a revised secondary period. The process continues until both periods stabilize.

In cases where the initial primary period is not well constrained, some of the alternative periods are used to find the first guess for the secondary period. If this leads to a significantly different result than with the first results, it's an indication that the data set may not be sufficient to find a secure solution. If all initial primary periods lead to about the same secondary period, which then leads to a single primary period, the result is considered as secure as the data set allows.







The "P2" lightcurve shows only a slowly varying amplitude with no significant deviations, which would indicate *mutual events, i.e.,* occultations and/or eclipses. Lacking these, it is not possible to give a size estimate of the satellite and to suggest only that the long period lightcurve represents a satellite that is tidally locked to it orbital period of about 24 hours.

Perhaps future observations will find definitive proof of a satellite. If nothing else, these results strongly recommend a collaboration involving stations located at two widely-separated longitudes. A third station, also well removed from the other two would be better. For example, in this case, having observations from India or Japan would have been a considerable help. Unfortunately, the asteroid was too far north for observers in, for example, Australia or Chile.

Acknowledgements

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ROTATIONAL PERIOD OF 5685 SANENOBUFUKUI

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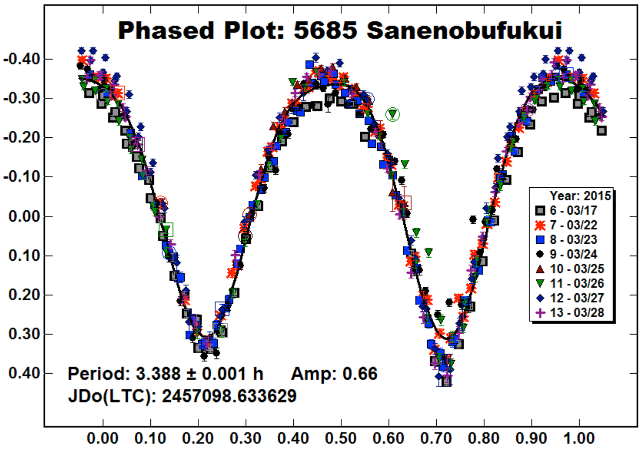
The asteroid 5685 Sanenobufukui was observed over eight nights in 2015 March in order to determine its previously unknown rotational period. Lightcurve analysis yielded a bimodal trend with a period of 3.388 ± 0.001 hours.

The main-belt asteroid 5685 Sanenobufukui, also called 1990 XA, was discovered by T. Nomura and K. Kawanishi at Minami-Oda. It is named after the astronomer Sanenobu Fukui. The orbit of 5685 is characterized by a 4.69 year period, an eccentricity of about

0.09, and a semi-major axis of 2.8 AU (Minor Planet Center, 2015). Additionally, the asteroid has an absolute magnitude of H = 11.6 and currently does not have a measured diameter.

The observations were made at the Etscorn Campus Observatory (ECO, 2015) from 2015 March 17-28. Data were collected using a 0.35-m Schmidt-Cassegrain telescope with an SBIG STL-1001E CCD camera. Image resolution was 1024x1024 with 24-micron pixels, yielding a 22x22 arc minute field-of-view. The telescope was controlled with Software Bisque's *TheSky6* (SB, 2014) and the camera with *CCDsoft* V5 (SB, 2014).

The images were taken with a 5-minute exposure time and were adjusted using a series of darks and flats. The flats were taken using the sky as a background about a half-hour after sunset. These images were then combined into a master flat by using a normalized median tool within *MPO Canopus* version 10.4.1.0 (Warner, 2012). The multiple nights of data were then combined with the FALC algorithm (Harris *et al.*, 1989) within *MPO Canopus* in order to calculate the synodic period.



The resultant lightcurve displays a well-defined, bimodal trend with a period of 3.388 ± 0.001 hours and an amplitude of 0.66 ± 0.07 mag.

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SHAPE MODELS OF ASTEROIDS AS A MISSING INPUT FOR BULK DENSITY DETERMINATIONS

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To determine a meaningful bulk density of an asteroid, both accurate volume and mass estimates are necessary. The volume can be computed by scaling the size of the 3D shape model to fit the disk-resolved images or stellar occultation profiles, which are available in the literature or through collaborations. This work provides a list of asteroids, for which (i) there are already mass estimates with reported uncertainties better than 20% or their mass will be most likely determined in the future from Gaia astrometric observations, and (ii) their 3D shape models are currently unknown. Additional optical lightcurves are necessary to determine the convex shape models of these asteroids. The main aim of this article is to motivate the observers to obtain lightcurves of these asteroids, and thus contribute to their shape model determinations. Moreover, a web page *https://asteroid-obs.oca.eu*, which maintains an up-to-date list of these objects to assure efficiency and to avoid any overlapping efforts, was created.

The motivation for studying density of asteroids is the fact that it belongs to the most important characteristics of asteroids, which is also one of the least constrained. By comparing with densities of meteorites, which can be considered as remnants of collisionally disrupted asteroids that survive entry through the Earth's atmosphere, we can deduce also the nature of asteroid interiors. These physical properties of asteroids reflect the accretional and collisional environment of the early solar system. Moreover, because some asteroids are analogs to the ancient material that formed the terrestrial planets 4.56 Gyr ago, the density and internal structures of minor bodies inform us about the formation conditions and evolution processes of planets and the solar system as a whole.

To determine the bulk density, we need both the mass and the volume of the object. In the following, we briefly describe several methods for asteroid volume estimates, summarize the current knowledge of asteroid densities and masses, and provide a list of asteroids, for which new photometric data need to be obtained in order to derive their shape models.

The most frequent method to determine the size (and volume) of an asteroid is fitting the thermal data observations (typically from IRAS, WISE, and AKARI satellites) by simple thermal models that assume a spherical shape model (e.g., the Near-Earth Asteroid Thermal Model; Harris, 1998). The reported size uncertainties for individual asteroids are usually very small (few percent), however, they are not realistic. Indeed, the uncertainties are dominated by the model systematics – the spherical shape assumption is too crude and also the role of the geometry is neglected (e.g., the spin axis orientation). In the statistical sense, the sizes determined by thermal models are reliable, but could be easily off for individual objects by 10–30%. This implies a volume uncertainty of 30–90%!

Obviously, more complex shape models (instead of spheres and ellipsoids) have to be used for more accurate size and volume determinations. Currently, the leading method is the convex inversion (Kaasalainen and Torppa, 2001; Kaasalainen et al., 2001), which makes use of only disk-integrated photometry and provides a convex shape model with the sidereal rotational period and the pole orientation. A more advanced KOALA method of Carry et al. (2012), which is build on the lightcurve inversion basis, allows a non-convex shape model determination. This method uses among the disk-integrated photometry also stellar occultation measurements and/or disk-resolved images (2D contours) obtained by the 8-10m class telescopes equipped with adaptive optics systems. Moreover, recent inversion method of Viikinkoski et al. (2015) called ADAM can handle, among the already mentioned types of data, also disk-resolved thermal data, interferometry and radar observations.

The disk-integrated photometric data itself are not sufficient to constrain the dimensions of these asteroids. However, there are three methods commonly used to determine the size of the shape model: (i) scaling the asteroid shape projections by disk-resolved images obtained by adaptive optics systems; (ii) scaling the asteroid shape projections to fit the stellar occultation measurements; and (ii) fitting the thermal measurements by the thermophysical model. The shape model can be either an input (typically computed by the convex inversion) or derived simultaneously with the size (KOALA, ADAM).

The method for comparing the AO contours with the asteroid's projections was developed and already used for size determinations of ~40 asteroids in Hanus et al. (2013). Conceptually similar method can be applied when constraining the asteroid sizes with stellar occultation measurements (see Durech et al. 2011). These two methods as well as the KOALA and ADAM methods will be used to scale the sizes of studied asteroids.

With available thermal data (WISE, IRAS, AKARI), it is possible to constrain sizes of asteroids by the means of thermophysical modeling (see, e.g., Delbo 2004; Delbo et al. 2007). By this method, which uses the convex shape model as a fixed input, surface properties such as albedo, surface roughness or thermal inertia can be determined.

The currently available mass and volume estimates allowed the determination of densities with accuracy formally better than 20% for less than hundred asteroids (Carry, 2012). A significant number of the density estimates with uncertainties better than 20% reported in Carry (2012) are determined from sizes based on spherical shape models (i.e., determined by thermal models), and thus the uncertainties are most likely strongly underestimated. This means that our knowledge of accurate densities (<20%) is probably limited too only a few dozens of asteroids, which sizes/volume were determined by more sophisticated techniques.

Recent mass determinations were reported from the astrometric observations, namely based on the planetary ephemeris or orbit deflection methods, and promise a significant improvement of the poor knowledge of the mass. Goffin (2014) published more than one hundred mass estimates with a typical uncertainty of 5–20% (planetary ephemeris). The astrometric observations of the Gaia satellite should also provide masses, namely for ~150 asteroids (for ~50 with an accuracy better than 10%, Mouret et al., 2007, 2008) by the orbit deflection method. The advantage of Gaia masses is in the uniqueness of the mission, which should result in a comprehensive sample with well-described biases (e.g., the current mass estimates are strongly biased towards the inner main belt).

The main limiting factor for meaningful bulk density determinations is the lack of shape models for many asteroids with accurate mass estimates. These shape models can be derived only with the help of additional optical data, because the currently available photometry is not sufficient. Our Table 1 lists observational opportunities until the end of year 2016 for all asteroids with accurate mass estimates we compiled from above mentioned studies, and for which shape models have not yet been determined. Any observational support would be greatly appreciated. This work follows the legacy and even uses the optical data obtained within the framework of a principally similar project "Photometric geodesy of main-belt asteroids" from late 80's (see, e.g., Weidenschilling et al., 1987).

An up-to-date status of this project dedicated to shape model determination of asteroids with accurate mass estimates is maintained on a web page *https://asteroid-obs.oca.eu*. The list of asteroids, for which new photometric data are still needed as well as additional information and tools useful for observers willing to support our project will be provided and regularly updated. The general policy is to include observers as co-authors of publications, where the shape model is presented for the first time. We do not require an embargo on the data, thus the observers can publish their observations independently at any time.

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Table 1. Observational opportunities until the end of year 2016 for all asteroids with accurate mass estimates (compiled from the literature), and for which shape models have not yet been determined. The date when the asteroid is in the opposition, the predicted V magnitude (MPC), the declination, the rotation period in hours and the quality code U (Warner et al. 2009) are shown.

Ast	Date	V	Dec	Period	U
117 Lomia	2015 07 04	12.4	-43.3	9.127	3
308 Polyxo	2015 07 04	11.6	-16.0	12.029	3-
31 Euphrosyne	2015 07 08	12.6	-56.1	5.530	3
488 Kreusa	2015 07 22	12.9	-29.4	32.666	2+
60 Echo	2015 07 22	11.9	-15.2	25.208	3
772 Tanete	2015 08 03	13.2	-53.4	17.258	3
442 Eichsfeldia	2015 08 09	12.6	-16.2	11.871	3
65 Cybele	2015 08 13	11.0	-13.4	6.0814	3
200 Dynamene	2015 08 25	11.5	-9.8	37.394	3
790 Pretoria	2015 08 29	12.6	18.9	10.37	3
334 Chicago	2015 09 13	13.0	-7.7	7.361	3
328 Gudrun	2015 09 15	13.0	-3.2	10.992	3
259 Aletheia	2015 09 18	12.4	-16.0	8.143	3
206 Hersilia	2015 09 26	12.2	-2.3	11.128	3
356 Liguria	2015 10 13	10.8	13.6	31.82	3-
96 Aegle	2015 10 18	12.7	28.8	13.82	3
212 Medea	2015 10 20	12.1	15.9	10.283	3
705 Erminia	2015 10 22	12.6	28.4	53.96	2
203 Pompeja	2015 10 23	12.0	14.6	24.052	3
106 Dione	2015 10 31	10.8	11.1	16.26	3
375 Ursula	2015 11 01	11.9	33.9	16.83	2
49 Pales	2015 11 26	10.7	24.3	10.42	3
762 Pulcova	2015 12 05	12.6	37.8	5.839	3
268 Adorea	2015 12 08	12.7	20.1	7.80	3
379 Huenna	2016 01 03	13.3	20.7	14.141	3
202 Chryseis	2016 01 07	11.2	15.5	23.670	3
150 Nuwa	2016 01 12	12.5	18.6	8.1347	3
12 Victoria	2016 01 13	11.2	10.8	8.6599	3
654 Zelinda	2016 01 28	10.1	-4.3	31.735	3
702 Alauda	2016 01 28	11.9	9.2	8.3531	2+
144 Vibilia	2016 02 04	11.9	22.3	13.819	3
419 Aurelia	2016 02 16	12.3	7.1	16.784	3
46 Hestia	2016 02 23	12.2	8.8	21.040	3
173 Ino	2016 03 14	12.3	10.6	6.163	3
455 Bruchsalia	2016 03 15	13.9	17.4	11.838	2+
566 Stereoskopia	2016 03 19	13.3	6.3	12.103	3
238 Hypatia	2016 03 25	12.3	-1.6	8.8749	3
81 Terpsichore	2016 03 29	12.8	-4.8	10.943	3
324 Bamberga	2016 04 12	12.0	-20.5	29.43	3
128 Nemesis	2016 04 21	11.8	-5.7	39.	3
78 Diana	2016 04 21	11.3	-23.6	7.2991	3
139 Juewa	2016 05 04	11.0	-28.1	20.991	3
381 Myrrha	2016 05 25	12.5	-4.5	6.572	3
241 Germania	2016 05 26	11.8	-24.6	15.51	3
50 Virginia	2016 06 10	12.9	-18.6	14.315	3
554 Peraga	2016 06 10	12.5	-25.8	13.7128	3
120 Lachesis	2016 06 18	12.0	-33.5	46.551	3
704 Interamnia	2016 06 18	10.4	-29.5	8.727	3
758 Mancunia	2016 07 28	12.7	-21.5	12.7253	3
59 Elpis	2016 07 30	11.4	-9.1	13.69	3
159 Aemilia	2016 08 09	12.7	-16.2	24.476	3
48 Doris	2016 08 14	11.4	-8.3	11.89	3
211 Isolda	2016 08 15	12.3	-9.4	18.365	3
56 Melete	2016 08 15	10.3	-2.2	18.147	3
24 Themis	2016 08 16	11.9	-14.7	8.374	3
751 Faina	2016 08 17	11.8	-36.0	23.678	3
154 Bertha	2016 08 27	12.7	-34.3	25.224	3
451 Patientia	2016 09 05	11.1	-26.5	9.727	3
388 Charybdis	2016 09 11	12.2	-5.2	9.516	3
31 Euphrosyne	2016 09 12	11.6	-28.2	5.530	3
488 Kreusa	2016 09 17	13.1	-16.4	32.666	2+
405 Thia	2016 09 22	13.0	15.0	10.08	3
92 Undina	2016 09 22	10.7	-13.6	15.941	3
117 Lomia	2016 10 01	12.0	10.3	9.127	3
51 Nemausa	2016 10 13	10.6	1.7	7.783	3
65 Cybele	2016 10 20	11.7	6.8	6.0814	3
18 Melpomene	2016 10 23	8.0	-6.3	11.570	3
308 Polyxo	2016 10 24	11.8	8.5	12.029	3-
772 Tanete	2016 10 27	13.2	-8.1	17.258	3
334 Chicago	2016 11 05	13.1	10.0	7.361	3
790 Pretoria	2016 11 14	13.2	28.0	10.37	3
194 Prokne	2016 11 19	11.4	-8.7	15.679	3
259 Aletheia	2016 11 24	12.7	14.3	8.143	3
60 Echo	2016 11 27	10.1	15.6	25.208	3
442 Eichsfeldia	2016 12 09	13.2	14.3	11.871	3
328 Gudrun	2016 12 16	13.0	47.8	10.992	3

NEW LIGHTCURVES OF 1027 AESCULAPIA AND 3395 JITKA

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We present measurements for the rotation periods of two near-Earth asteroids: 1027 Aesculapia and 3395 Jitka. Our measured period for 1027 Aesculapia is 9.791 ± 0.002 h and amplitude of 0.09 mag, which is inconsistent with the previously published measurement of 6.83 ± 0.10 h. We measure the period of 3395 Jitka to be 18.276 ± 0.005 h with an amplitude of *A*= 0.41 mag.

Observations of the near-Earth asteroids 1027 Aesculapia and 3395 Jitka were taken with the 0.5-m telescope owned by the NASA Meteoroid Environment Office (MEO) located at the New Mexico Skies observatory in Mayhill, New Mexico. This telescope was equipped with an Apogee U42 CCD camera. The Johnson V band filter was used for all observations. On a given night, the telescope had dedicated imaging of a single target for as long as the weather allowed, resulting in up to ~8 hours of continuous imaging of each asteroid. Individual image exposures were set to 60 sec.

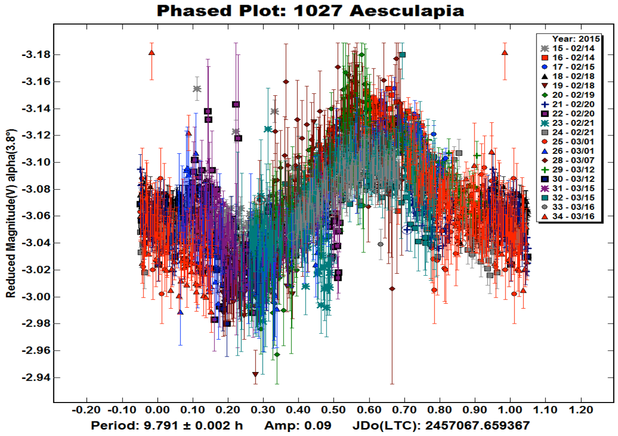
Images were corrected for bias noise, dark current, and flat-fielding using the MEO's telescope image analysis pipeline software. All lightcurve photometry and period measurements were performed using *MPO Canopus* version 10.4.3.17 (Warner, 2006; Warner 2012), using the standard Fourier series based fitting algorithm (Harris *et al.*, 1989) provided by *MPO Canopus.* All of our data were fit to this model using six orders.

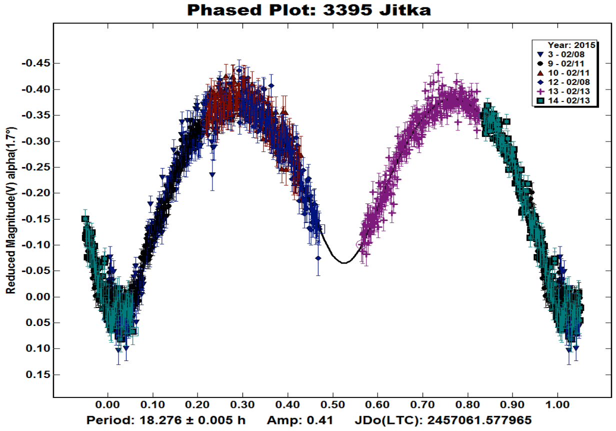
<u>1027 Aesculapia.</u> Observations of the asteroid 1027 Aesculapia were taken starting the night of 2015 February 14 and went through the night of March 16. In total, 5034 images were analyzed from observations taken on eleven separate nights.

Photometric conditions between nights and over the course of each individual night varied greatly, but all of these data are consistent with a rotation period of 9.791 ± 0.002 h, as shown in the figure below. The amplitude of variation was measured at *A* = 0.09 mag. These measurements are in strong tension with a previously measured period for this asteroid made by Maleszewski and Clark (2004) of 6.83 ± 0.1 h and amplitude of *A* = 0.15 mag. Attempts to fit our data with a model that assumes a 6.83 h period were shown to provide a poorer fit. Differences between the analysis procedures of this work and the previous measurement are likely responsible for this disagreement, and further observations will be needed to resolve these discrepancies.

<u>3395 Jitka.</u> Observations of the asteroid 3395 Jitka were taken between the nights of 2015 February 8-13. In total, 2636 images were analyzed from observations taken over three separate nights. Photometric conditions for the three nights of observations were more stable than those for 1027 Aesculapia.

The best-fit period for these data is measured to be 18.276 ± 0.005 h, with amplitude of *A* = 0.41 mag. The phase-folded lightcurve is shown in the figure below. Marchini and Salvaggio (2015) report a period of 18.293 ± 0.006 h, in excellent agreement with this measurement.





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PERIOD DETERMINATION FOR THE SLOW ROTATOR 930 WESTPHALIA

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Lightcurve analysis for 930 Westphalia was performed using observations during its 2015 opposition. The synodic rotation period was found to be 100.66 ± 0.12 h and the lightcurve amplitude was 0.15 ± 0.02 mag.

Minor planet 930 Westphalia is a main-belt object discovered in 1920 by Walter Baade at Bergedorf (Germany) prior to moving to USA where his most known and notable research was done; it was named in honor of the region where the discoverer had been born 27 years earlier. It appeared on the CALL web site as an asteroid photometry opportunity due to it reaching a favorable apparition in 2015 and in the appealing short list of 3-digit asteroids still having no defined lightcurve parameters (Alvarez, 2015).

Unfiltered CCD photometric images were taken at Observatorio Los Algarrobos, Salto, Uruguay (OLASU; MPC Code I38) in 2015 from March 27 to April 14. The telescope was a 0.3-m Meade LX-200R reduced to *f*/6.9. The imager was a QSI 516wsg NABG (non-antiblooming gate) with a 1536x1024 array of 9-micron pixels and 23x16 arcminutes field-of-view. The exposure time was 120 seconds. 2x2 binning was used, yielding an image scale of 1.77 arcseconds per pixel. The camera was set to –10°C and off-axis guided by means of an SX Lodestar camera and *PHD2 Guiding* (Stark Labs) software. Image acquisition was done with *MaxIm DL5* (Diffraction Limited). The computer was synchronized with atomic clock time via Internet NTP servers at the beginning of each session.

All images were dark and flat-field corrected and then measured using *MPO Canopus* version 10.4.3.16 (Bdw Publishing) with a differential photometry technique. The data were light-time corrected. Night-to-night zero point calibration was accomplished by selecting up to five comparison stars with near solar colors according to recommendations by Warner (2007) and Stephens (2008). Period analysis was also done with *MPO Canopus*, which incorporates the Fourier analysis algorithm developed by Harris (Harris *et al*., 1989).

A total of 14 nights were devoted to observe this asteroid exclusively over a total span of 19 days. More than 75 hours of effective observation and about 2,200 data points were required in order to solve the essentially flat lightcurve (Figure 1). Over the span of observations, the phase angle varied from 7.6º to 6.0º to 6.8º, the phase angle bisector ecliptic longitude from 197.9º to 197.7º, and the phase angle bisector ecliptic latitude from –11.5º to –12.7º. The rotation period for 930 Westphalia was determined to be 100.66 ± 0.12 h with a lightcurve peak-to-peak amplitude of 0.15 ± 0.02 mag. No clear evidence of tumbling was seen in the lightcurve.

At the time of this study, 930 Westphalia was one of only 18 three-digit numbered asteroids for which no rotation parameters were found in the literature. However, not all of the already measured 982 rotation periods for the first 1000 asteroids are reliable (i.e., many still have U < 3; see Warner *et al*., 2009), so that ongoing investigations to verify, refine, or revise their values remains an important and pending endeavor.

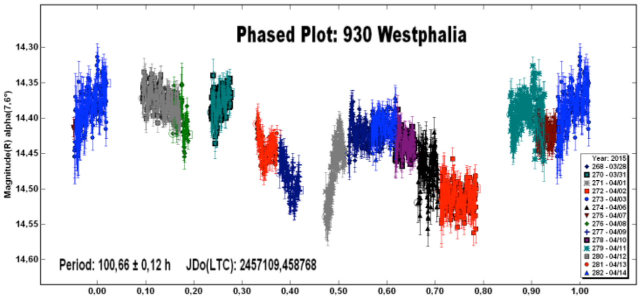

Figure 1. Composite lightcurve of 930 Westphalia.

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TARGET ASTEROIDS! OBSERVING CAMPAIGNS FOR JULY THROUGH SEPTEMBER 2015

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Asteroids campaigns to be conducted by the *Target Asteroids!* program during the July through September 2015 quarter are described. In addition to asteroids on the original *Target Asteroids!* list of easily accessible spacecraft targets, an effort has been made to identify other asteroids that are 1) brighter and easier to observe for small telescope users and 2) analogous to (101955) Bennu and (162173) 1999 JU3, targets of the OSIRIS-REx and Hayabusa-2 sample return missions.

Introduction

The *Target Asteroids!* program strives to engage telescope users of all skill levels and telescope apertures to observe asteroids that are viable targets for robotic sample return. The program also focuses on the study of asteroids that are analogous to (101955) Bennu and (162173) 1999 JU3, the target asteroids of the NASA OSIRIS-REx and JAXA Hayabusa-2 sample return missions respectively. Most target asteroids are near-Earth asteroids (NEA) though observations of relevant Main Belt asteroids (MBA) are also requested.

Even though many of the observable objects in this program are faint, acquiring a large number of low S/N observations allows many important parameters to be determined. For example, an asteroid's phase function can be measured by obtaining photometry taken over a wide range of phase angles. The albedo can be constrained from the phase angle observations, as there is a direct correlation between phase function and albedo (Belskaya and Shevchenko (2000). The absolute magnitude can be estimated by extrapolating the phase function to a phase angle of 0°. By combining the albedo and absolute magnitude, the size of the object can be estimated.

An overview of the *Target Asteroids!* program can be found at Hergenrother and Hill (2013).

Current Campaigns

Target Asteroids! plans to conduct a number of dedicated campaigns on select NEAs and analog carbonaceous MBAs during the quarter. These campaigns have a primary goal of conducting photometric measurements over a large range of phase angles.

Target Asteroids! objects brighter than V = 17.0 are presented in detail. A short summary of our knowledge of each asteroid and 10-day (shorter intervals for objects that warrant it) ephemerides are presented. The ephemerides include rough RA and Dec positions, distance from the Sun in AU (r), distance from Earth in AU (Δ), V magnitude, phase angle in degrees (PH) and elongation from the Sun in degrees (Elong).

We ask observers with access to large telescopes to attempt observations of spacecraft accessible asteroids that are between V magnitude ~17.0 and ~20.0 during the quarter (contained in the table below).

Asteroid Number	Name	Peak V Mag	Time of Peak Brightness
(7350)	1993 VA	17.4	late Aug
(52381)	1993 HA	18.2	late Nov
(65717)	1993 BX3	19.9	mid Sep
(89136)	2001 US16	19.6	late Jul
(163000)	2001 SW169	16.6	early Oct
(164221)	2004 QE20	19.0	early Jul
(341050)	2007 HZ	19.8	mid Sep
(350713)	2001 XP88	17.9	late Jul

The campaign targets are split up into two sections: carbonaceous MBAs that are analogous to Bennu and 1999 JU3; and NEAs analogous to the Bennu and 1999 JU3 or provide an opportunity to fill some of the gaps in our knowledge of spacecraft targets (examples include very low and high phase angle observations, phase functions in different filters and color changes with phase angle).

The ephemerides listed below are just for planning purposes. In order to produce ephemerides for your observing location, date and time, please use the Minor Planet Center's Minor Planet and Comet Ephemeris Service:

http://www.minorplanetcenter.net/iau/MPEph/MPEph.html

or the *Target Asteroids!* specific site created by Tomas Vorobjov and Sergio Foglia of the International Astronomical Search Collaboration (IASC) at

http://iasc.scibuff.com/osiris-rex.php

Analog Carbonaceous Main Belt Asteroid Campaigns

(442) Eichsfeldia (a=2.35 AU, e=0.07, i=6.1°, H = 10.0)
Not an obvious member of any of the major inner Main Belt carbonaceous asteroid families, (442) Eichsfeldia is an example of a carbonaceous (Ch-type) background object. Past studies suggested that it was a member of the Vesta family but its type and very low albedo (0.04) make that very unlikely.

This quarter Eichsfeldia covers a range of phase angles from 20° to an extremely low 0.2° at opposition on August 9. It is also at its brightest that day at V = 12.6. Lightcurve photometry found a period of 11.88 h and amplitude of 0.24-0.38 magnitudes. Filter photometry is especially requested to detect color changes at different phase angles.

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	21 40	-12 15	1.49	2.32	13.6	18	135
07/11	21 37	-12 56	1.42	2.33	13.4	14	146
07/21	21 31	-13 54	1.37	2.34	13.2	10	157
07/31	21 23	-15 04	1.34	2.35	12.9	5	169
08/10	21 14	-16 18	1.34	2.35	12.6	0	179
08/20	21 04	-17 29	1.36	2.36	13.0	6	167
08/30	20 57	-18 29	1.41	2.37	13.3	10	155
09/09	20 51	-19 16	1.49	2.38	13.6	14	144
09/19	20 49	-19 47	1.58	2.38	13.8	18	134
09/29	20 49	-20 02	1.68	2.39	14.1	20	124

Near-Earth Asteroid Campaign Targets

(4055) Magellan (a=1.82 AU, e=0.33, i=23.3°, H = 14.5)

Over 12,000 NEAs are known today with ~1000 being discovered every year. The vast majority of discoveries are by semi-automated wide-field surveys employing CCD cameras and banks of computers. When Magellan was discovered back in 1985 things were very different. Back then only ~85 NEAs were known and none had been discovered with a CCD. Photographic film scanned visually with a stereomicroscope was the detection method of choice at the time.

Typical of early NEA discoveries, Magellan is a large object (2.8 km diameter and albedo of 0.33) that routinely gets bright. This quarter Magellan ranges in brightness from V = 15.4 to 12.2 and covers a range of phase angles from 49° to 3°. Spectrally it is a V-type suggesting it may be a piece of the large Main Belt asteroid Vesta. It rotates once every 6.38 h with a lightcurve amplitude of ~0.6 magnitudes.

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	20 48	+41 43	0.51	1.27	15.4	49	108
07/11	21 04	+42 40	0.46	1.25	15.1	49	111
07/21	21 21	+42 06	0.40	1.24	14.8	48	115
07/31	21 38	+39 23	0.35	1.23	14.4	45	121
08/10	21 57	+33 33	0.30	1.23	13.9	40	130
08/20	22 15	+23 24	0.26	1.23	13.3	29	144
08/30	22 33	+08 46	0.24	1.24	12.7	15	162
09/09	22 50	-07 26	0.25	1.26	12.3	4	176
09/19	23 07	-20 45	0.29	1.28	13.2	16	159
09/29	23 22	-29 21	0.35	1.31	14.0	26	146

(68278) 2001 FC7 (a=1.44 AU, e=0.11, i=2.6°, H = 18.3)

2001 FC7 may not get as bright as some of the other NEA campaign objects this quarter but as a low delta-V carbonaceous asteroid it is worthy of special attention. Low delta-V means it is requires less energy to sortie to and return from the asteroid.

Little is known about 2001 FC7 other than a spectral C-type classification. Phase function photometry will help constrain its albedo and any phase angle dependent color changes. Minimum phase angle of 5.2° occurs on August 3. Peak brightness also happens at that time (V = 16.4).

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	21 05	-18 07	0.34	1.31	17.8	26	145
07/11	21 09	-19 22	0.31	1.30	17.3	20	154
07/21	21 07	-21 08	0.28	1.29	16.9	13	164
07/31	21 02	-23 09	0.27	1.28	16.5	6	173
08/10	20 55	-25 03	0.27	1.28	16.5	8	170
08/20	20 49	-26 24	0.28	1.27	16.9	16	160
08/30	20 47	-27 01	0.29	1.27	17.3	24	150
09/09	20 51	-26 53	0.32	1.27	17.6	30	141
09/19	20 59	-26 04	0.35	1.27	18.0	35	134
09/29	21 12	-24 41	0.39	1.28	18.3	39	127

(85989) 1999 JD6 (a=0.88 AU, e=0.63, i=17.1°, H = 17.1)

1999 JD6 passes within 0.016 AU of Earth on July 20. During its flyby the asteroid will peak at magnitude V = 14.6 and cover a range of phase angles from 109° to 16°.

Taxonomic classification is all over the place with K, L and Cg types being assigned to it. Its albedo is rather dark at 0.075. Lightcurve observations show a 7.7 hr rotation period and large amplitude ~1.2 magnitudes.

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	21 26	+14 59	0.29	1.20	16.5	45	124
07/05	21 27	+17 18	0.24	1.17	16.1	45	125
07/09	21 28	+20 27	0.20	1.14	15.6	46	126
07/13	21 27	+25 12	0.15	1.11	15.0	49	125
07/17	21 24	+33 30	0.11	1.07	14.4	55	120
07/21	21 13	+51 21	0.07	1.07	13.8	70	106
07/25	12 48	+83 31	0.05	1.00	14.7	110	68
07/29	09 52	+39 56	0.07	0.96	19.7	151	27

(206378) 2003 RB (a=1.79 AU, e=0.44, i=6.7°, H = 18.7)

Broadband filter photometry suggests 2003 RB is a carbonaceous NEA. Other than that little else is known of its physical characteristics. This quarter 2003 RB peaks at a rather bright V = 13.8 in mid-August. Minimum phase angle is reached a week earlier at 8°. A maximum phase angle of 88° occurs in mid-September.

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	20 39	-33 52	0.33	1.31	17.9	22	151
07/11	20 51	-32 58	0.25	1.25	17.1	19	157
07/21	21 04	-30 44	0.19	1.19	16.3	15	162
07/31	21 22	-25 24	0.13	1.14	15.2	11	168
08/10	21 55	-12 11	0.08	1.09	14.1	9	170
08/20	23 04	+21 07	0.05	1.06	14.0	36	142
08/30	01 46	+57 18	0.07	1.03	15.4	74	103
09/09	04 45	+63 05	0.10	1.01	16.8	87	88
09/19	06 10	+60 19	0.14	1.00	17.5	87	85
09/29	06 50	+57 27	0.18	1.01	17.8	82	88

2011 UW158 (a=1.62 AU, e=0.38, i=4.6°, H = 19.5)

2011 UW158 will brighten to magnitude 14.7 on July 21 as it passes within 0.016 AU of Earth. A large range of phase angles can be observed this quarter (from 110° to 18°). Little is known of about this object so all types of photometry is welcome.

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	12 36	-19 29	0.07	1.03	16.4	79	97
07/11	12 44	-04 50	0.03	1.01	15.5	94	84
07/21	14 13	+71 45	0.02	1.01	14.7	108	72
07/31	00 10	+54 58	0.04	1.02	15.6	84	94
08/10	00 21	+44 38	0.08	1.04	16.4	70	107
08/20	00 20	+39 47	0.11	1.07	16.8	57	118
08/30	00 15	+35 58	0.14	1.10	17.2	46	129
09/09	00 08	+32 10	0.17	1.14	17.4	35	140
09/19	00 00	+28 09	0.21	1.19	17.6	25	150
09/29	23 55	+24 08	0.26	1.24	17.9	18	157

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LIGHTCURVE AND ROTATION PERIOD DETERMINATION FOR 4678 NINIAN

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Photometric observations of the main-belt asteroid 4678 Ninian performed by the authors in Italy and Ireland in 2014 October and November revealed the bimodal light curve phased to 56.72 ± 0.01 hours as the most likely solution representing the synodic rotation rate for this asteroid.

Asteroid 4678 Ninian (1990 SS4) is a typical member of the main-belt that was discovered on 1990 September 24 by R. H. MacNaught. The orbit has a semi-major axis of about 2.26 AU, eccentricity 0.21, and period of about 3.41 years (JPL, 2014). It was selected from the "Potential Lightcurve Targets" web site (Warner, 2014).

At the Astronomical Observatory of the University of Siena, data were obtained with a 0.30-m *f*/5.6 Maksutov-Cassegrain telescope, SBIG STL-6303E NABG CCD camera (binned 2x2), and clear filter; the scale was 2.20 arcsec/pixel. Exposures were 180 seconds. At Saronno Observatory, data were obtained with a 0.235-m *f*/10 (SCT) telescope and SBIG ST8-XME NABG CCD camera with 2x2 binning; the scale was 1.6 arcsec/pixel. The unfiltered exposures were 150-300 seconds.

Observations from Cherryvalley Observatory were conducted with a 0.2-m *f*/7.6 SCT using an SBIG STL-1301E CCD camera and R-band Bessel photometric filter. The scale was 2.15 arcsec/pixel, unbinned. Carpione Observatory employed a 0.25-m *f*/10 SCT. The camera was an SBIG ST9 CCD camera with a 512x512 array of 20-micron pixels. The unfiltered exposures were 300 seconds.

The collaborative observations resulted in 25 sessions over a span of 22 days and a total of 843 data points. The phase angle ranged from 6.1° before to 25.4° after the opposition.

All data images were calibrated with bias, flats, and darks. Data processing, including reduction to R band, and period analysis, were performed using *MPO Canopus* (BDW Publishing, 2012). Differential photometry measurements were performed using the Comp Star Selector (CSS) procedure in *MPO Canopus* that allows selecting of up to five comparison stars of near solar color. Subsequently, the additional adjustments of the magnitude zero-points for the particular data sets were carried out in order to achieve the best alignment between them i.e. to reach the minimum RMS value from the Fourier analysis.

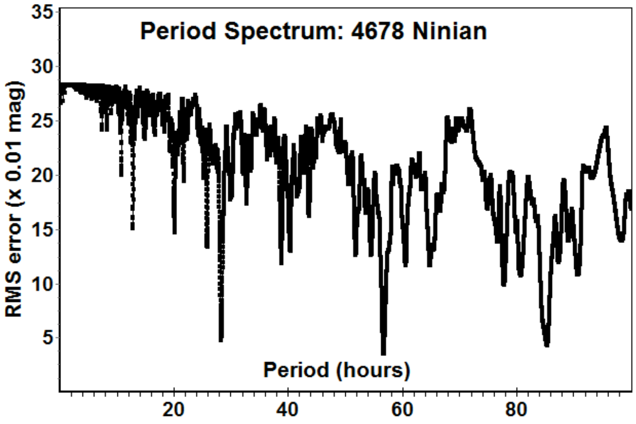

Figure 1. The period spectrum for 4678 covering 1 to 100 hours.

The period analysis found a few possible solutions with nearly comparable RMS errors. These clearly stand out in the period spectrum that plots RMS vs. period (Fig. 1). We concluded that the most likely value of the synodic period for 4678 Ninian is associated with a bimodal lightcurve phased to 56.72 ± 0.01 hours with an amplitude of 1.04 ± 0.03 mag (Fig. 2).

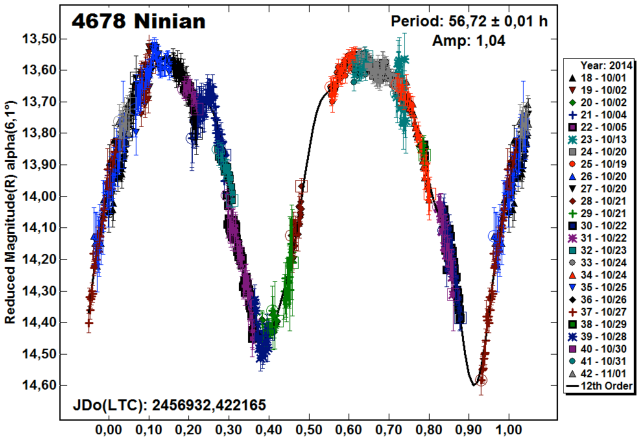

Fig. 2. The lightcurve for 4678 Ninian phased to the adopted period of 56.72 hours.

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ROTATIONAL PERIOD OF 1511 DALERA

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Photometric observations of the asteroid 1511 Dalera were made on three nights in 2015 February and March. Analysis of the data has allowed to draw a lightcurve with a synodic period P = 3.880 ± 0.001 h with amplitude A = 0.18 mag.

The main-belt asteroid 1511 Dalera was selected from the "Potential Lightcurve Targets" web site (Warner, 2015) and observed on three nights: 2015 Feb 27, Mar 6, and Mar 10. Observations were carried out from Franceschini Observatory in Rome (Italy), using a 9.25 in. Schmidt-Cassegrain *f*/6.2 equipped with an ATIK 314L CCD camera. The exposures were unfiltered. All images were calibrated with dark and flat-field frames. Differential photometry and period analysis was done using *MPO Canopus* (Warner, 2012).

The derived synodic period was *P* = 3.880 ± 0.001 h (Fig.1) with an amplitude of *A* = 0.18 mag.

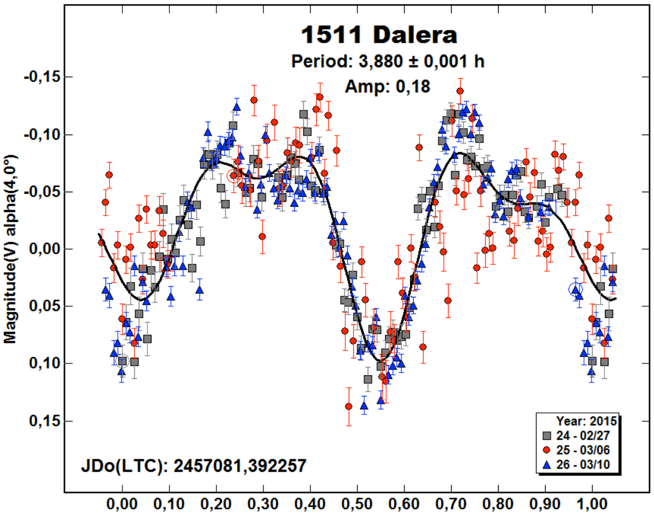

Figure 1.The lightcurve of 1511 Dalera with a period of 3.880 ± 0.001 h and amplitude of 0.18 mag.

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DISPATCHES FROM THE TROJAN CAMP – JOVIAN TROJAN L5 ASTERIODS OBSERVED FROM CS3: 2014 OCTOBER – 2015 JANUARY

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Rotational periods were determined for 35 members of the Jovian L5 Trojan group. Data were obtained by the Center for Solar System Studies from 2014 October to 2015 January.

During this calendar quarter, the Center for Solar System Studies (CS3, MPC U81) focused on studying Jovian Trojan asteroids. The Jovian Trojan asteroids are found in orbits librating around the stable L4 and L5 Lagrange points of Jupiter's orbit. They are believed to have formed further from the Sun than main belt asteroids and their composition and collisional history appears to be different. In a study of small Jovian Trojans, we show they could incorporate bulk ice and resemble the nuclei of short-period comets (French *et al* 2015). A recent study (Fernandez *et al* 2009) found there were fewer Trojans in the L4 and L5 swarms as previously calculated because the average albedo for smaller Trojans was found to be brighter resulting in an overestimation of the population of smaller Trojans. As yet, the rotation properties of Trojan asteroids are poorly known relative to those of main-belt asteroids, due to the lower albedo and greater distance of the Trojans. During this calendar quarter, the L5 (Trojan Camp) region was well placed for observing. Here we report lightcurve data for 35 Trojans. Most are in the 30 – 50 km diameter size range.

All images were made with a 0.4-m or a 0.35-m SCT using an FLI-1001E, a SBIG STL-1001E, or a SBIG ST-9e CCD camera. Images were unbinned with no filter and had master flats and darks applied to the science frames prior to measurement. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *MPO Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al*., 1989). Night-to-night calibration of the data (generally < ±0.05 mag) was done using field stars converted to approximate Cousins V magnitudes based on 2MASS J-K colors (Warner 2007). The Comp Star Selector feature in *MPO Canopus* was used to limit the comparison stars to near solar color. The results are summarized in Table 1. Diameters (Dia) are from the WISE/NEOWISE database (Grav 2012).

884 Priamus. Priamus has been well observed over the years. We observed it (French *et al* 2011b) finding a period of 6.8605 h. Mottola observed it twice (Mottola *et al* 2011) finding periods of 6.866 h and 6.894 h. Shevchenko (Shevchenko *et al* 2011) found a period of 6.815 h. We observed Priamus again to attempt to get

Number	Name	2014\15 mm\dd	Pts	Phase	L_{PAB}	B_{PAB}	Period	P.E.	Amp	A.E.	WISE Dia.
884	Priamus	01/14-01/18	279	6.0,6.6	79	6	6.854	0.002	0.4	0.02	101
1172	Aneas	12/31-12/31	327	7.1,5.5	83	-6	8.701	0.001	0.62	0.02	118
2241	Alcathous	10/08-10/22	994	6.7,4.6	49	12	7.689	0.001	0.22	0.02	114
2895	Memnon	01/03-01/05	220	7.0,7.2	78	-25	7.55	0.01	0.33	0.05	57
4348	Poulydamas	01/04-01/06	259	6.8,7.2	71	-5	9.88	0.01	0.19	0.02	82
4707	Khryses	10/24-10/24	97	10.4,10.	87	6	6.861	0.006	0.41	0.41	38
4708	Polydoros	10/26-11/25	1020	4.4,1.3,	52	6	20.24	0.02	0.12	0.02	55
4715	1989 TS1	01/01-01/03	313	7.2,7.5	69	19	8.799	0.001	0.54	0.03	62
4791	Iphidamas	11/09-11/11	202	3.8,3.5	58	13	9.65	0.002	0.12	0.02	50
4832	Palinurus	01/01-01/07	347	3.6,4.3	90	-15	5.85	0.01	0.16	0.03	52
4867	Polites	10/27-11/02	188	8.6,8.1	73	29	11.26	0.01	0.22	0.02	57
5144	Achates	01/07-01/09	202	5.6,5.9	73	9	5.951	0.004	0.35	0.03	81
9030	1989 UX5	12/28-12/30	156	0.9,1.4	92	1	6.3	0.01	0.60	0.03	32
11089	1994 CS8	10/19-10/20	118	2.4,2.2	34	-8	7.72	0.01	0.38	0.02	37
11488	1988 RM11	12/27-01/09	125	2.8,5.4	82	-3	15.92	0.02	0.16	0.03	22
11509	Thersilochos	12/23-12/30	531	3.8,4.8	80	-15	17.329	0.006	0.28	0.02	50
11552	Boucolion	01/14-01/20	369	3.3,4.3	98	-10	32.44	0.05	0.21	0.03	51
15502	1999 NV27	10/09-10/22	469	7.8,5.9	52	18	15.19	0.005	0.18	0.02	53
16070	1999 RB101	12/19-01/07	640	2.3,4.8	82	11	20.27	0.03	0.09	0.02	63
17172	1999 NZ41	01/14-02/16	168	6.4,9.8	89	-22	47.02	0.02	0.83	0.05	34
17314	Aisakos	10/21-10/23	135	6.2,5.9	55	10	9.67	0.02	0.34	0.02	36
18137	2000 OU30	10/13-10/17	168	3.2,2.4	35	1	16.20	0.03	0.20	0.03	34
18493	Demoleon	11/12-11/22	101	3.6,2.2	66	-9	14.43	0.01	0.18	0.03	33
24446	2000 PR25	10/23-10/28	251	7.6,6.9	62	22	10.74	0.01	0.29	0.02	31
24454	2000 QF198	11/23-11/29	223	2.9,1.6	74	-2	> 600		> 0.4		28
30705	Idaios	10/13-10/17	194	6.9,6.2	52	9	15.69	0.02	0.26	0.02	45
30942	Helicaon	01/21-02/15	316	7.8,10.6	88	-20	44.77	0.05	0.18	0.04	33
32482	2000 ST354	11/23-11/25	158	1.2,0.8	65	3	5.67	0.02	0.16	0.02	28
34642	2000 WN2	11/12-11/22	217	4.2,2.6	69	9	7.374	0.005	0.13	0.02	33
37519	Amphios	11/23-12/24	213	3.9,3.7,	68	18	50.93	0.03	0.30	0.05	33
51364	2000 SU333	12/19-12/27	257	2.3,4.1	77	-2	30.56	0.03	0.55	0.03	28
51365	2000 TA42	10/19-11/11	300	6.4,4.1	54	20	58.76	0.01	0.26	0.03	41
54656	2000 SX362	01/19-02/10	92	5.3,8.1	94	-16	11.937	0.006	0.29	0.03	38
76857	2000 WE132	11/26-12/14	298	2.4,1.4,	74	6	37.69	0.03	0.43	0.03	33
76867	2000 YM5	10/29-11/08	302	5.2,3.5	59	11	9.112	0.003	0.29	0.02	43

data to determine a pole position in the future. Our period this year is in good agreement with previous results.

1172 Aneas. We studied this Trojan asteroid before (French *et* al 2011a) finding a rotational period of 8.705 h. Mottola (Mottola *et al* 2011) found a similar period of 8.708 h. We observed it at this opposition in hope of someday finding a pole position.

2241 Alcathous. We observed Alcathous twice before (French *et al* 2011b and Stephens *et al* 2014) finding rotational periods of 7.695 h and 7.690 h. Mottola (Mottola *et al* 2011) found a similar period of 7.687 h. The result we found at this year's opposition is in good agreement with those previous findings.

2895 Memnon. Mottola (Mottola *et al* 2011) found a rotational period of 7.502 h. Our result this year of 7.55 agrees with that result.

4348 Poulydamas. Mottola (Mottola *et al* 2011) previously found a rotational period of 9.908 h. This denser lightcurve is in good agreement with that result.

4707 Khryses. We observed Khryses before (Stephens *et al* 2014) finding a rotational period of 6.87 h. This year's result is in good agreement.

4708 Polydoros. We observed Polydoros in 2011 (French *et al* 2012) finding a rotational period of 20.03 h. The 2011 observations were only over 3 nights spanning 6 nights, resulting in a partial lightcurve. The year we were able to get observations spanning a month resulting in a much denser lightcurve. The resulting 20.24 h period is similar to the 2011 result.

(4715) 1989 TS1. Mottola (Mottola *et al* 2011) previously found a rotational period of 8.8129 h. This denser lightcurve improves on that result.

4791 Iphidamas. Mottola (Mottola *et al* 2011) previously found a rotational period of 9.727 h. This lightcurve with a smaller amplitude agrees with that result.

4832 Palinurus. Mottola (Mottola *et al* 2011) previously found a rotational period of 5.319 h. The lightcurve we obtained this year could barely be extracted from the noise. We found a weak signal of a rotational period that is consistent with the Mottola result.

4867 Polites. We observed Polites twice before (French *et al* 2011a and Stephens *et al* 2014) initially finding a rotational period of 9.21 h which we later corrected to 11.24 h. The period found at this opposition of 11.26 h is in good agreement with our corrected finding.

5144 Achates. Molnar (Molnar *et al* 2008) previously found a period of 5.958 h. (Mottola *et al* 2011) previously found a rotational period of 5.949 h. Our result agrees with those previous findings.

(9030) 1989 UX5. There is no previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009).

(11089) 1994 CS8. We observed this Trojan before (Stephens *et al* 2014) finding a rotational period of 7.72 h. This year's result is in agreement.

(11488) 1988 RM11. There is no previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009).

(11509) Thersilochos. Mottola (Mottola *et al* 2011) previously found a rotational period of 17.367 h. This denser lightcurve improves that result.

11552 Boucolion. There is no previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009).

(15502) 1999 NV27. We observed this Trojan twice before (French *et al* 2013 and Stephens *et al* 2014) finding rotational periods of 15.03 and 15.09 h. This year's result is in good agreement.

(16070) 1999 RB101. We observed this asteroid before (French *et al* 2012) finding a rotational period of 31.74 h. We could not get the 2014 data to match that period. A Period spectrum shows several possibilities, but 20 and 40 h solutions (aliases of the 2011 period) have the strongest signal producing single and bimodal lightcurves. We reprocessed the 2011 data looking for solutions around 20 and 40 h, finding that a 20.24 h period produces a fairly normal bimodal lightcurve. The 40 h solution results in a lightcurve with 4 extremas. With an amplitude of around 0.10 mag., it is possible that the lightcurve could have only a single extremum, or three or more extrema (Harris *et al* 2014). With both amplitudes around 0.1 mag. (spheroidal), all of these solutions are possible. However, we prefer the 20.2 h solution resulting in single (2014) and bimodal (2011) lightcurves.

(17172) 1999 NZ41. The Asteroid lightcurve database (LCDB; Warner *et al*., 2009) contains no record for this asteroid.

(17314) Aisakos. There is no previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009).

(18137) 2000 OU30. We observed this Trojan before (Stephens *et al* 2014) finding a rotational period of 49.36 h which resulted in a lightcurve where the sessions did not quite line up and each individual session covering no more than about 15% of the lightcurve. The amplitude was 0.35 mag. This year the amplitude was only 0.20 magnitude but each nightly session covered over half of the high-quality lightcurve resulting in a rotational period of 16.20 h. We rephrased the 2013 results and found that with some small nightly zero point adjustments a reasonable 16.175 h solution could be obtained. Therefore we now favor the 16.20 h period.

18493 Demoleon. We cannot find a previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009).

(24446) 2000 PR25. There is no previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009).

(24454) 2000 QF198. There is no previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009). We observed it on seven consecutive nights in November 2014 with the asteroid brightening every night. There is a hint of a minimum on the first night and a maximum on the last night suggesting that the period is at least 600 h. It will take a substantial observing campaign to find the rotational period for this unusual object.

(30705) Idaios. We observed Idaios once before (Stephens *et al* 2014) finding a rotational period of 15.736 h. This year's result is in agreement.

(30942) Helicaon. The Asteroid lightcurve database (LCDB; Warner *et al*., 2009) does not contain a previously reported period for this asteroid.

(32482) 2000 ST354. There is no previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009).

(34642) 2000 WN2. We could not find a previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009). With an amplitude of only 0.13 mag., it is possible that the lightcurve could have only a single extremum, or three or more extrema (Harris *et al* 2014).

(37519) Amphios. There is no previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009).

(51364) 2000 SU333. The Asteroid lightcurve database (LCDB; Warner *et al*., 2009) does not have a record for this asteroid.

(51365) 2000 TA42. There is no previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009).

(54656) 2000 SX362. The Asteroid lightcurve database (LCDB; Warner *et al*., 2009) does not contain a record for this asteroid. With a rotational period nearly commensurate with one half of the Earth's rotation, it was not possible to get a complete lightcurve. However, assuming a bimodal shape, we favor the 11.937 h solution.

(76857) 2000 WE132. There is no previously reported period for this asteroid in the Asteroid lightcurve database (LCDB; Warner *et al*., 2009).

(76867) 2000 YM5. We observed this asteroid before (Stephens *et al* 2014) finding a rotational period of 9.13 h. This year's result is in agreement.

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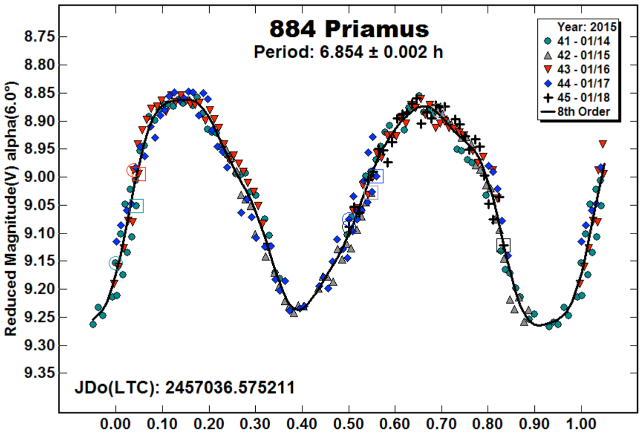

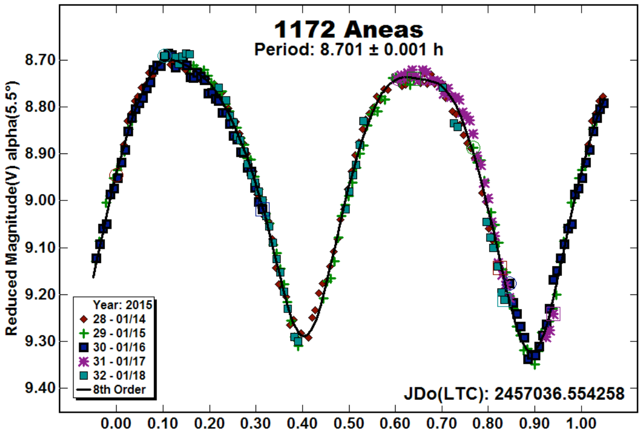

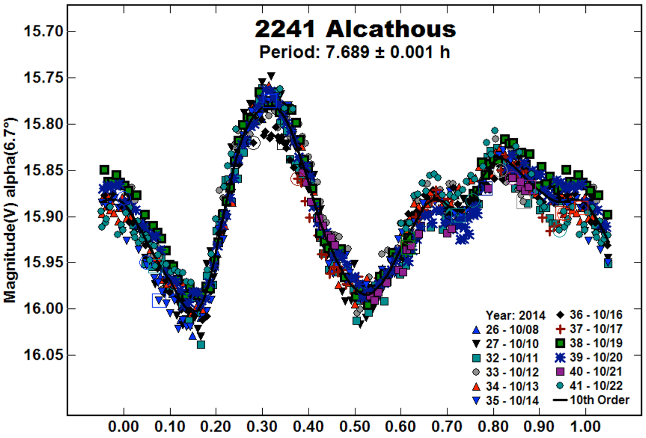

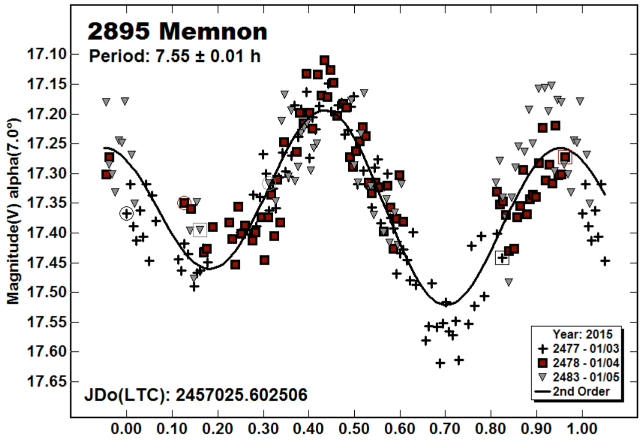

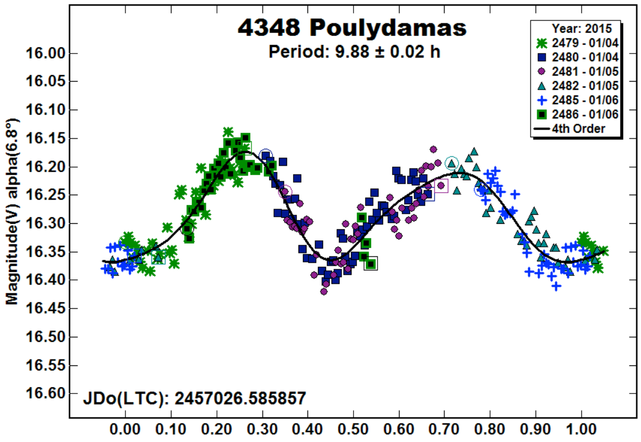
4348 Poulydamas
Period: 9.88 ± 0.02 h
Year: 2015
2479 - 01/04
2480 - 01/04
2481 - 01/05
2482 - 01/05
2485 - 01/06
2486 - 01/06
4th Order
Magnitude(V) alpha(6.8°)
16.00
16.05
16.10
16.15
16.20
16.25
16.30
16.35
16.40
16.45
16.50
16.55
16.60
JDo(LTC): 2457026.585857
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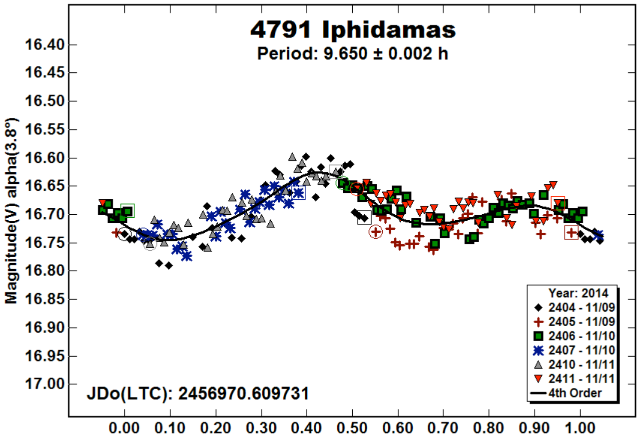
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


4791 Iphidamas
Period: 9.650 ± 0.002 h
Year: 2014
2404 - 11/09
2405 - 11/09
2406 - 11/10
2407 - 11/10
2410 - 11/11
2411 - 11/11
4th Order
Magnitude(V) alpha(3.8°)
16.40
16.45
16.50
16.55
16.60
16.65
16.70
16.75
16.80
16.85
16.90
16.95
17.00
JDo(LTC): 2456970.609731
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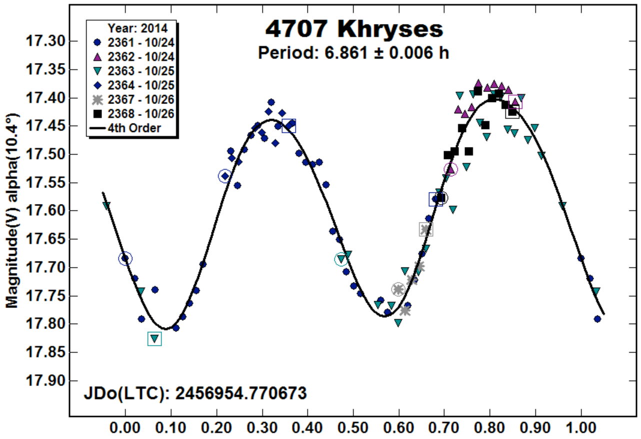
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


4707 Khryses
Period: 6.861 ± 0.006 h
Year: 2014
2361 - 10/24
2362 - 10/24
2363 - 10/25
2364 - 10/25
2367 - 10/26
2368 - 10/26
4th Order
Magnitude(V) alpha(10.4°)
17.30
17.35
17.40
17.45
17.50
17.55
17.60
17.65
17.70
17.75
17.80
17.85
17.90
JDo(LTC): 2456954.770673
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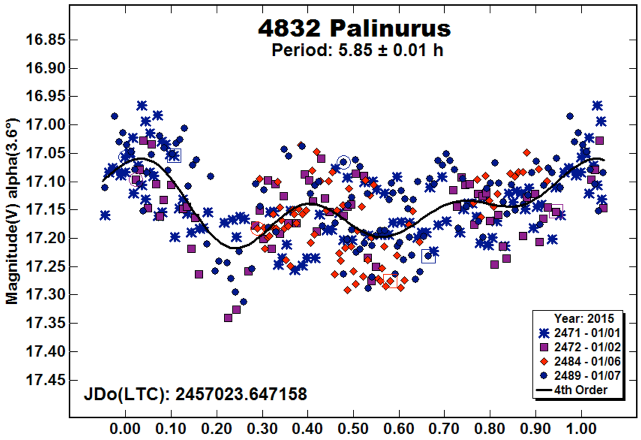
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


4832 Palinurus
Period: 5.85 ± 0.01 h
Year: 2015
2471 - 01/01
2472 - 01/02
2484 - 01/06
2489 - 01/07
4th Order
Magnitude(V) alpha(3.6°)
16.85
16.90
16.95
17.00
17.05
17.10
17.15
17.20
17.25
17.30
17.35
17.40
17.45
JDo(LTC): 2457023.647158
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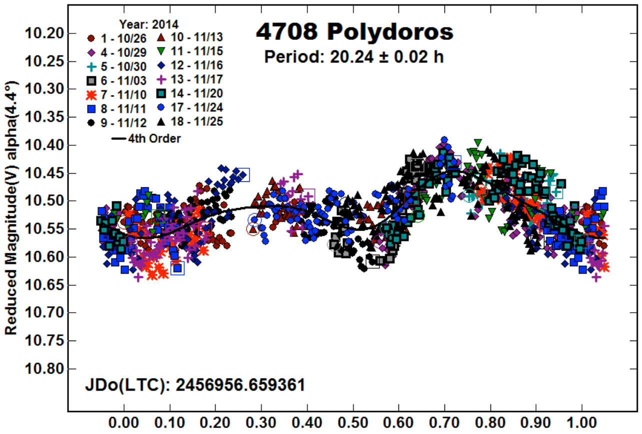
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


4708 Polydoros
Period: 20.24 ± 0.02 h
Year: 2014
1 - 10/26
4 - 10/29
5 - 10/30
6 - 11/03
7 - 11/10
8 - 11/11
9 - 11/12
10 - 11/13
11 - 11/15
12 - 11/16
13 - 11/17
14 - 11/20
17 - 11/24
18 - 11/25
4th Order
Reduced Magnitude(V) alpha(4.4°)
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
JDo(LTC): 2456956.659361
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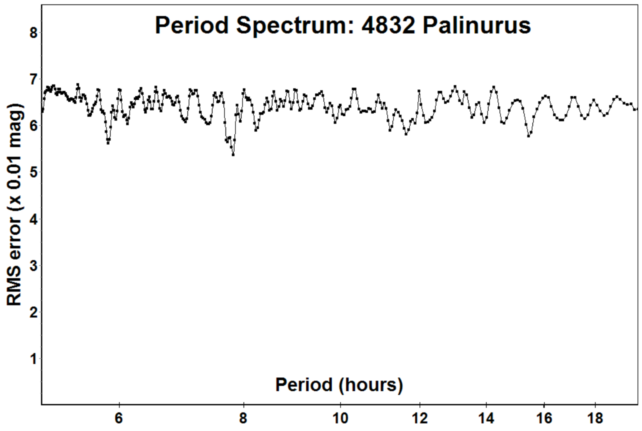
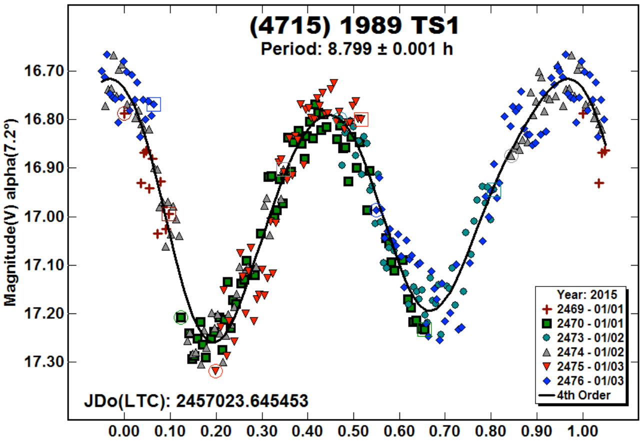
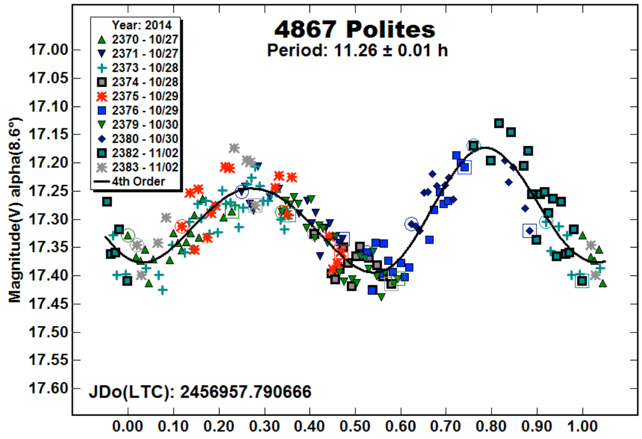
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


Period Spectrum: 4832 Palinurus
RMS error (x 0.01 mag)
8
7
6
5
4
3
2
1
Period (hours)
6
8
10
12
14
16
18


(4715) 1989 TS1
Period: 8.799 ± 0.001 h
Year: 2015
2469 - 01/01
2470 - 01/01
2473 - 01/02
2474 - 01/02
2475 - 01/03
2476 - 01/03
4th Order
Magnitude(V) alpha(7.2°)
16.70
16.80
16.90
17.00
17.10
17.20
17.30
JDo(LTC): 2457023.645453
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


4867 Polites
Period: 11.26 ± 0.01 h
Year: 2014
2370 - 10/27
2371 - 10/27
2373 - 10/28
2374 - 10/28
2375 - 10/29
2376 - 10/29
2379 - 10/30
2380 - 10/30
2382 - 11/02
2383 - 11/02
4th Order
Magnitude(V) alpha(8.6°)
17.00
17.05
17.10
17.15
17.20
17.25
17.30
17.35
17.40
17.45
17.50
17.55
17.60
JDo(LTC): 2456957.790666
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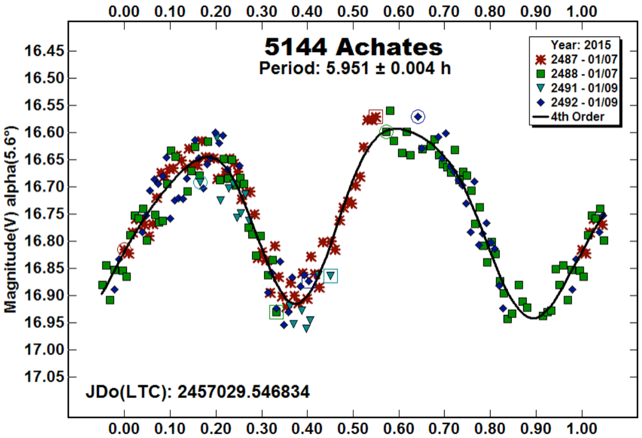
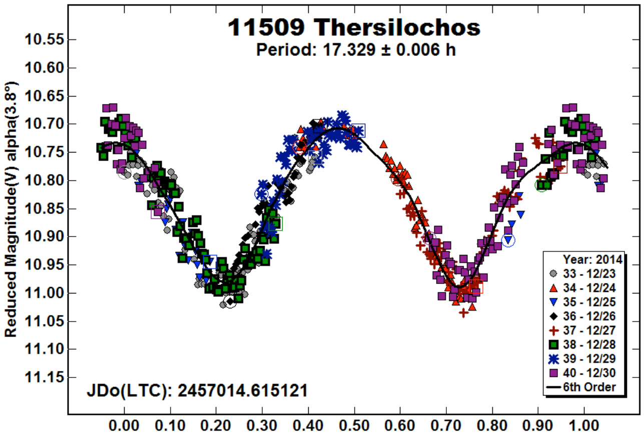
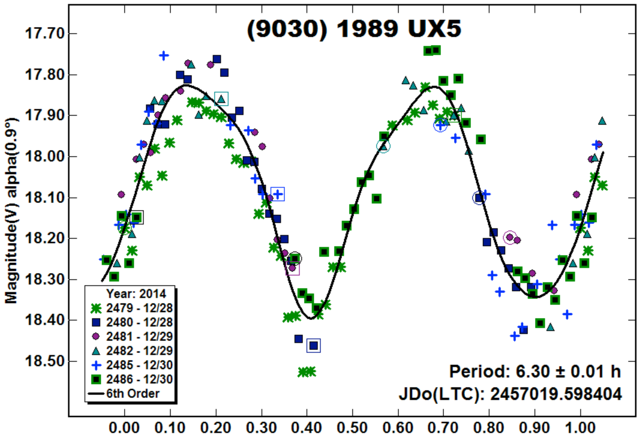
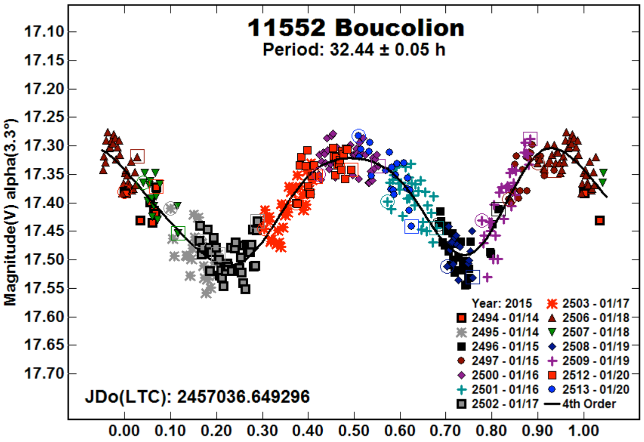
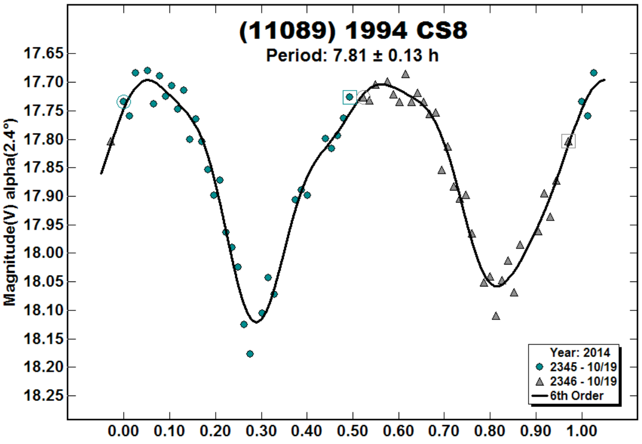
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

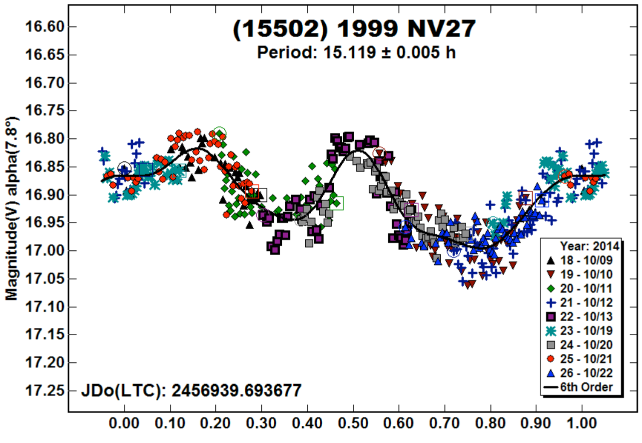

5144 Achates
Period: 5.951 ± 0.004 h
Year: 2015
2487 - 01/07
2488 - 01/07
2491 - 01/09
2492 - 01/09
4th Order
Magnitude(V) alpha(5.6°)
JDo(LTC): 2457029.546834
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
16.45 16.50 16.55 16.60 16.65 16.70 16.75 16.80 16.85 16.90 16.95 17.00 17.05

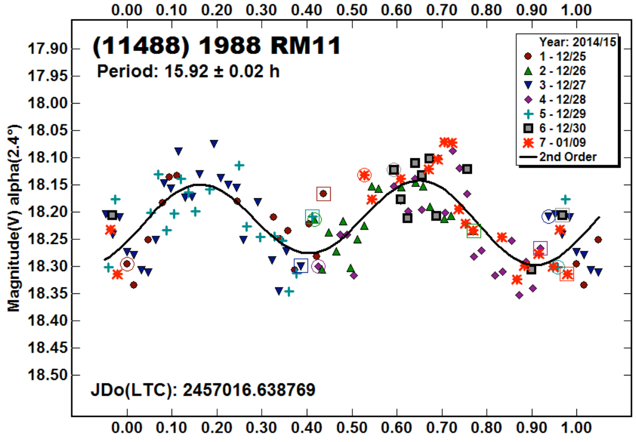

11509 Thersilochos
Period: 17.329 ± 0.006 h
Reduced Magnitude(V) alpha(3.8°)
JDo(LTC): 2457014.615121
Year: 2014
33 - 12/23
34 - 12/24
35 - 12/25
36 - 12/26
37 - 12/27
38 - 12/28
39 - 12/29
40 - 12/30
6th Order
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
10.55 10.60 10.65 10.70 10.75 10.80 10.85 10.90 10.95 11.00 11.05 11.10 11.15

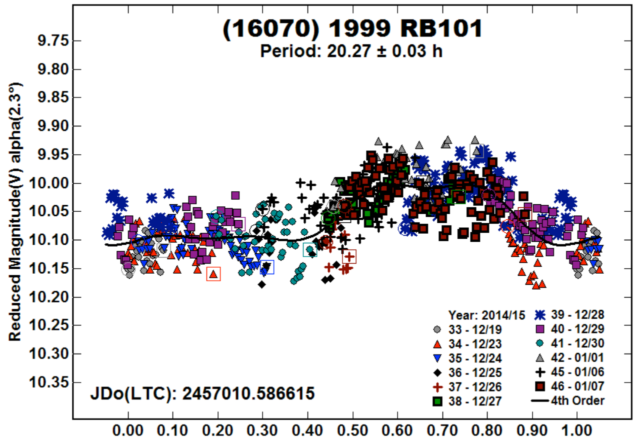

(9030) 1989 UX5
Period: 6.30 ± 0.01 h
JDo(LTC): 2457019.598404
Magnitude(V) alpha(0.9°)
Year: 2014
2479 - 12/28
2480 - 12/28
2481 - 12/29
2482 - 12/29
2485 - 12/30
2486 - 12/30
6th Order
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
17.70 17.80 17.90 18.00 18.10 18.20 18.30 18.40 18.50

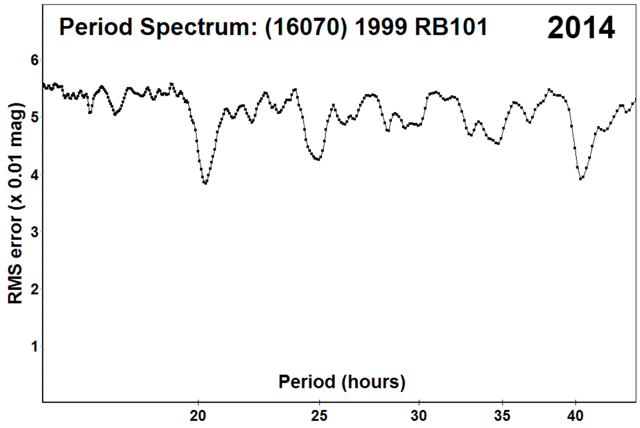

11552 Boucolion
Period: 32.44 ± 0.05 h
Magnitude(V) alpha(3.3°)
JDo(LTC): 2457036.649296
Year: 2015
2494 - 01/14
2495 - 01/14
2496 - 01/15
2497 - 01/15
2500 - 01/16
2501 - 01/16
2502 - 01/17
2503 - 01/17
2506 - 01/18
2507 - 01/18
2508 - 01/19
2509 - 01/19
2512 - 01/20
2513 - 01/20
4th Order
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
17.10 17.15 17.20 17.25 17.30 17.35 17.40 17.45 17.50 17.55 17.60 17.65 17.70

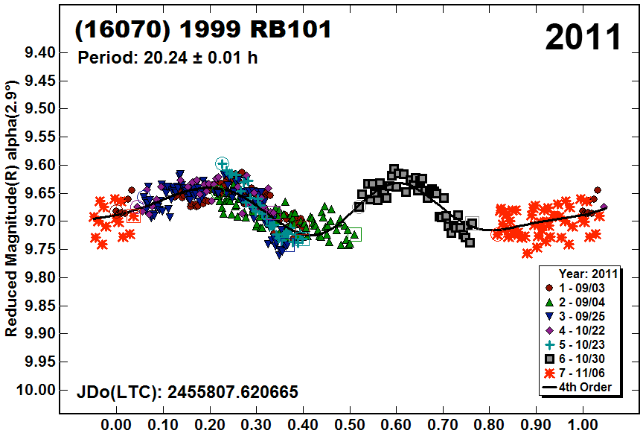

(11089) 1994 CS8
Period: 7.81 ± 0.13 h
Magnitude(V) alpha(2.4°)
Year: 2014
2345 - 10/19
2346 - 10/19
6th Order
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
17.65 17.70 17.75 17.80 17.85 17.90 17.95 18.00 18.05 18.10 18.15 18.20 18.25

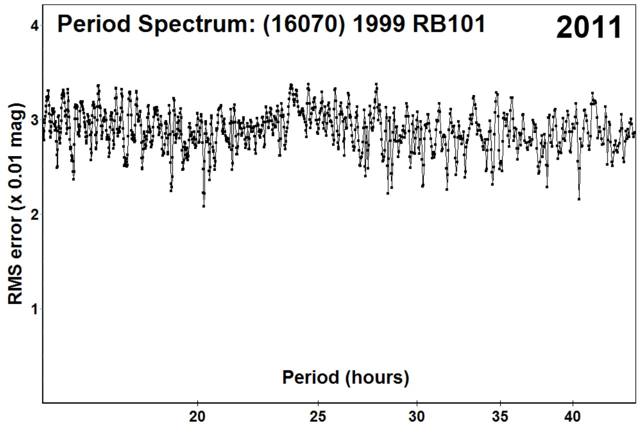

(15502) 1999 NV27
Period: 15.119 ± 0.005 h
Magnitude(V) alpha(7.8°)
JDo(LTC): 2456939.693677
Year: 2014
18 - 10/09
19 - 10/10
20 - 10/11
21 - 10/12
22 - 10/13
23 - 10/19
24 - 10/20
25 - 10/21
26 - 10/22
6th Order
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
16.60 16.65 16.70 16.75 16.80 16.85 16.90 16.95 17.00 17.05 17.10 17.15 17.20 17.25

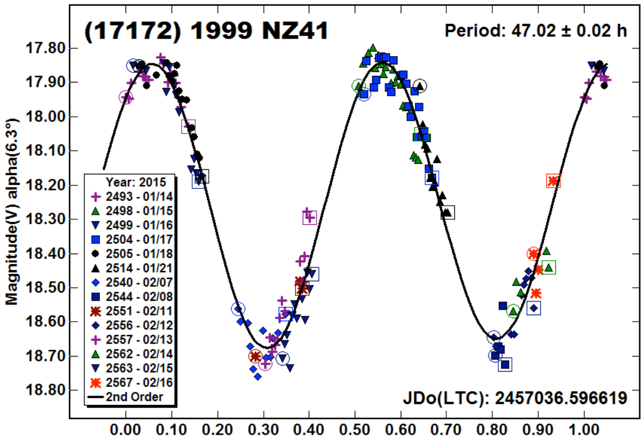

(11488) 1988 RM11
Period: 15.92 ± 0.02 h
Magnitude(V) alpha(2.4°)
JDo(LTC): 2457016.638769
Year: 2014/15
1 - 12/25
2 - 12/26
3 - 12/27
4 - 12/28
5 - 12/29
6 - 12/30
7 - 01/09
2nd Order
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
17.90 17.95 18.00 18.05 18.10 18.15 18.20 18.25 18.30 18.35 18.40 18.45 18.50

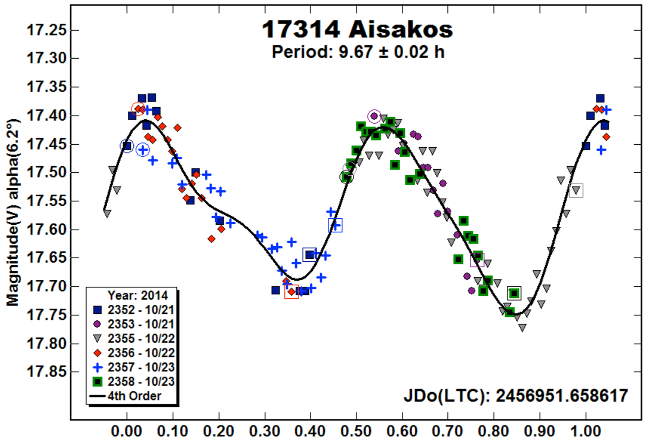

(16070) 1999 RB101
Period: 20.27 ± 0.03 h
Reduced Magnitude(V) alpha(2.3°)
JDo(LTC): 2457010.586615
Year: 2014/15
33 - 12/19
34 - 12/23
35 - 12/24
36 - 12/25
37 - 12/26
38 - 12/27
39 - 12/28
40 - 12/29
41 - 12/30
42 - 01/01
45 - 01/06
46 - 01/07
4th Order
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
9.75 9.80 9.85 9.90 9.95 10.00 10.05 10.10 10.15 10.20 10.25 10.30 10.35

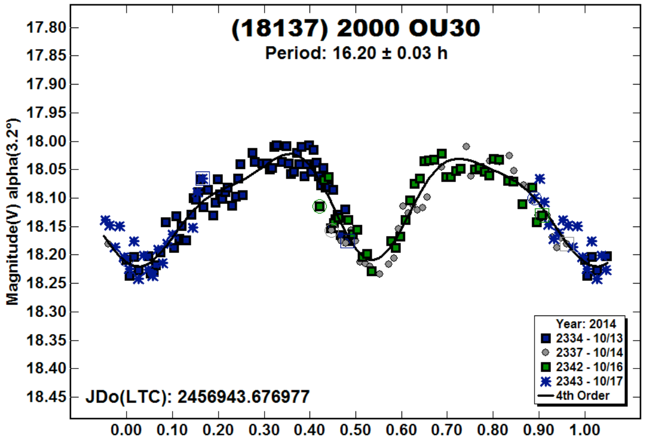

Period Spectrum: (16070) 1999 RB101
2014
RMS error (x 0.01 mag)
Period (hours)
1
2
3
4
5
6
20
25
30
35
40

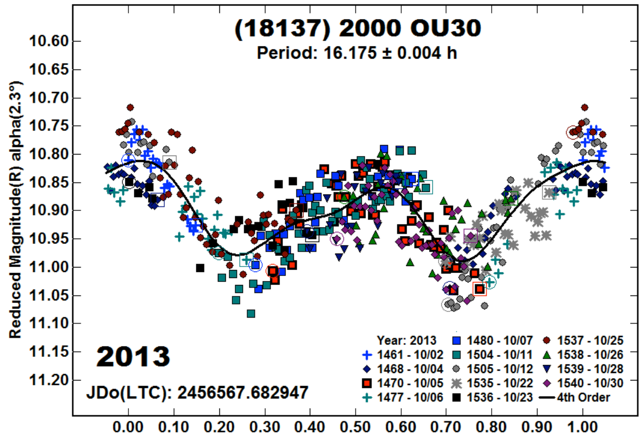

(16070) 1999 RB101
2011
Period: 20.24 ± 0.01 h
Reduced Magnitude(R) alpha(2.9°)
Year: 2011
1 - 09/03
2 - 09/04
3 - 09/25
4 - 10/22
5 - 10/23
6 - 10/30
7 - 11/06
4th Order
JDo(LTC): 2455807.620665
9.40
9.45
9.50
9.55
9.60
9.65
9.70
9.75
9.80
9.85
9.90
9.95
10.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

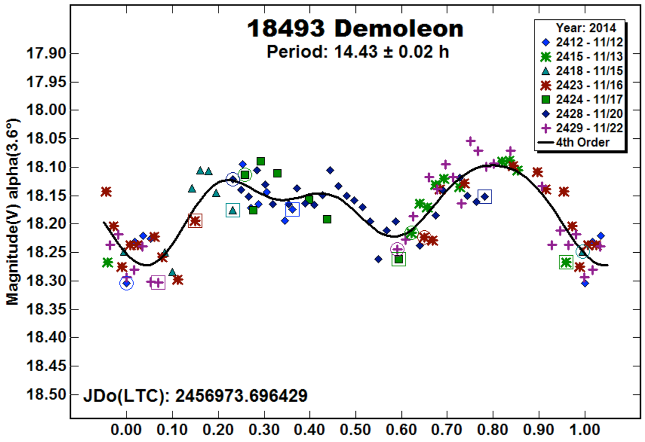

Period Spectrum: (16070) 1999 RB101
2011
RMS error (x 0.01 mag)
Period (hours)
1
2
3
4
20
25
30
35
40

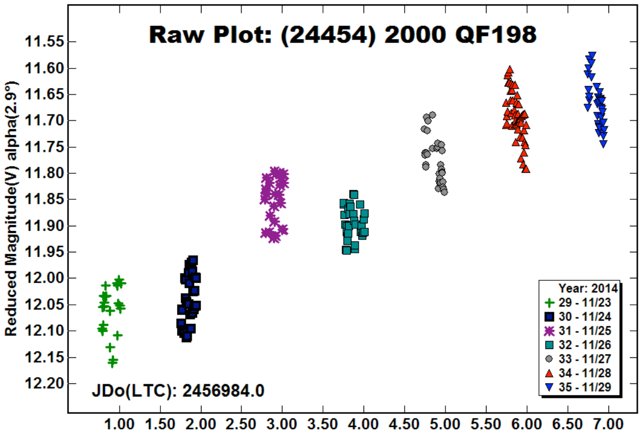

(17172) 1999 NZ41
Period: 47.02 ± 0.02 h
Magnitude(V) alpha(6.3°)
Year: 2015
2493 - 01/14
2498 - 01/15
2499 - 01/16
2504 - 01/17
2505 - 01/18
2514 - 01/21
2540 - 02/07
2544 - 02/08
2551 - 02/11
2556 - 02/12
2557 - 02/13
2562 - 02/14
2563 - 02/15
2567 - 02/16
2nd Order
JDo(LTC): 2457036.596619
17.80
17.90
18.00
18.10
18.20
18.30
18.40
18.50
18.60
18.70
18.80
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

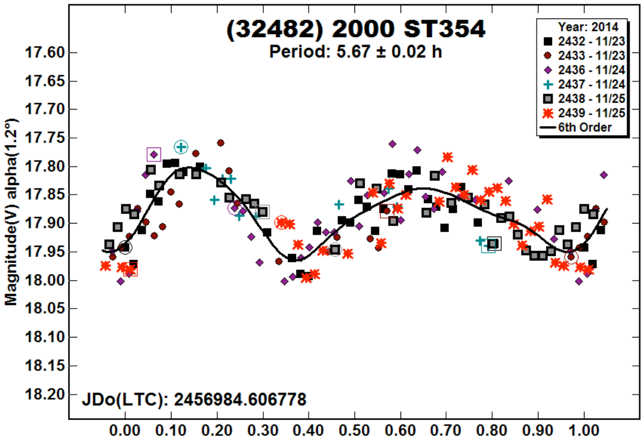

17314 Aisakos
Period: 9.67 ± 0.02 h
Magnitude(V) alpha(6.2°)
Year: 2014
2352 - 10/21
2353 - 10/21
2355 - 10/22
2356 - 10/22
2357 - 10/23
2358 - 10/23
4th Order
JDo(LTC): 2456951.658617
17.25
17.30
17.35
17.40
17.45
17.50
17.55
17.60
17.65
17.70
17.75
17.80
17.85
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

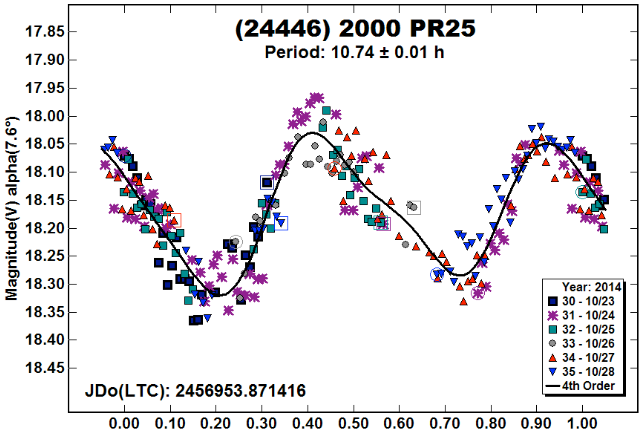

(18137) 2000 OU30
Period: 16.20 ± 0.03 h
Magnitude(V) alpha(3.2°)
Year: 2014
2334 - 10/13
2337 - 10/14
2342 - 10/16
2343 - 10/17
4th Order
JDo(LTC): 2456943.676977
17.80
17.85
17.90
17.95
18.00
18.05
18.10
18.15
18.20
18.25
18.30
18.35
18.40
18.45
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

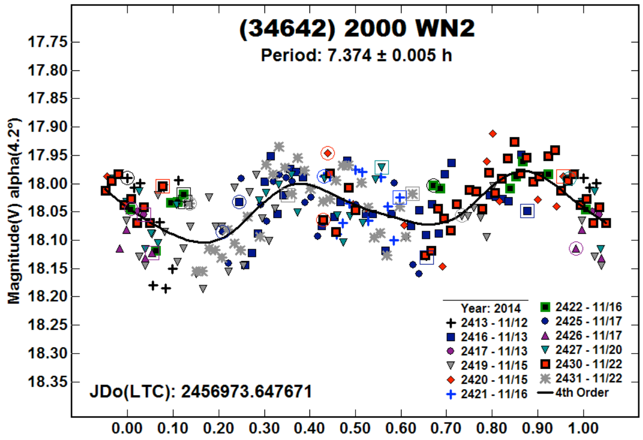

(18137) 2000 OU30
Period: 16.175 ± 0.004 h
Reduced Magnitude(R) alpha(2.3°)
2013
Year: 2013
1461 - 10/02
1468 - 10/04
1470 - 10/05
1477 - 10/06
1480 - 10/07
1504 - 10/11
1505 - 10/12
1535 - 10/22
1536 - 10/23
1537 - 10/25
1538 - 10/26
1539 - 10/28
1540 - 10/30
4th Order
JDo(LTC): 2456567.682947
10.60
10.65
10.70
10.75
10.80
10.85
10.90
10.95
11.00
11.05
11.10
11.15
11.20
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

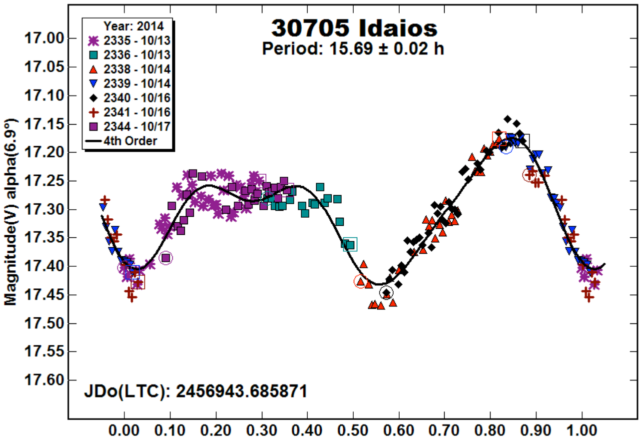

18493 Demoleon
Period: 14.43 ± 0.02 h
Magnitude(V) alpha(3.6°)
Year: 2014
2412 - 11/12
2415 - 11/13
2418 - 11/15
2423 - 11/16
2424 - 11/17
2428 - 11/20
2429 - 11/22
4th Order
JDo(LTC): 2456973.696429
17.90
17.95
18.00
18.05
18.10
18.15
18.20
18.25
18.30
18.35
18.40
18.45
18.50
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

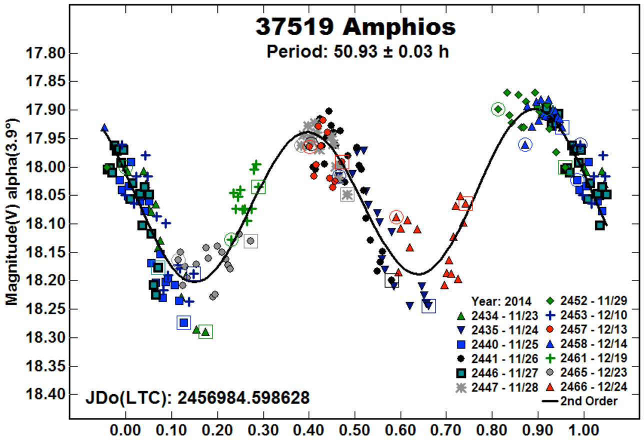

Raw Plot: (24454) 2000 QF198
Reduced Magnitude(V) alpha(2.9°)
JDo(LTC): 2456984.0
Year: 2014
29 - 11/23
30 - 11/24
31 - 11/25
32 - 11/26
33 - 11/27
34 - 11/28
35 - 11/29
11.55
11.60
11.65
11.70
11.75
11.80
11.85
11.90
11.95
12.00
12.05
12.10
12.15
12.20
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00

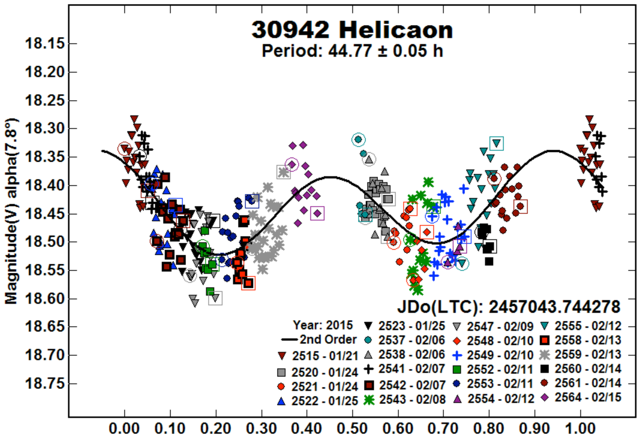

(32482) 2000 ST354
Period: 5.67 ± 0.02 h
Magnitude(V) alpha(1.2°)
JDo(LTC): 2456984.606778
Year: 2014
2432 - 11/23
2433 - 11/23
2436 - 11/24
2437 - 11/24
2438 - 11/25
2439 - 11/25
6th Order
17.60
17.65
17.70
17.75
17.80
17.85
17.90
17.95
18.00
18.05
18.10
18.15
18.20
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

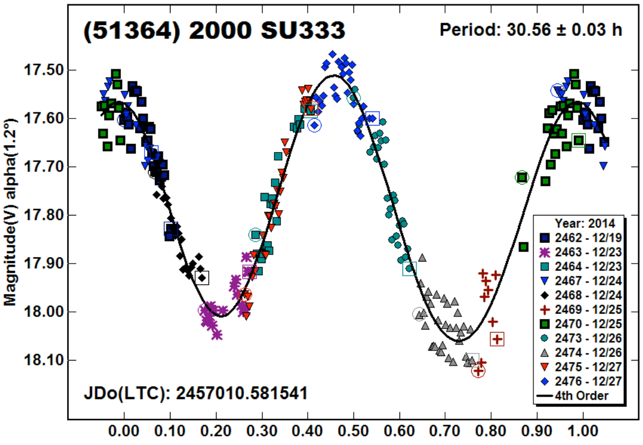

(24446) 2000 PR25
Period: 10.74 ± 0.01 h
Magnitude(V) alpha(7.6°)
JDo(LTC): 2456953.871416
Year: 2014
30 - 10/23
31 - 10/24
32 - 10/25
33 - 10/26
34 - 10/27
35 - 10/28
4th Order
17.85
17.90
17.95
18.00
18.05
18.10
18.15
18.20
18.25
18.30
18.35
18.40
18.45
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

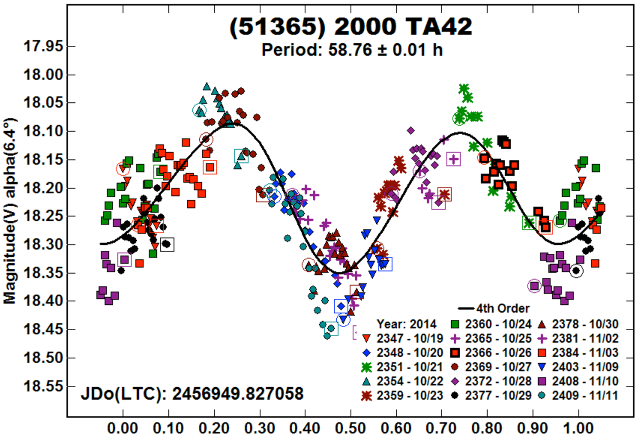

(34642) 2000 WN2
Period: 7.374 ± 0.005 h
Magnitude(V) alpha(4.2°)
JDo(LTC): 2456973.647671
Year: 2014
2413 - 11/12
2416 - 11/13
2417 - 11/13
2419 - 11/15
2420 - 11/15
2421 - 11/16
2422 - 11/16
2425 - 11/17
2426 - 11/17
2427 - 11/20
2430 - 11/22
2431 - 11/22
4th Order
17.75
17.80
17.85
17.90
17.95
18.00
18.05
18.10
18.15
18.20
18.25
18.30
18.35
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

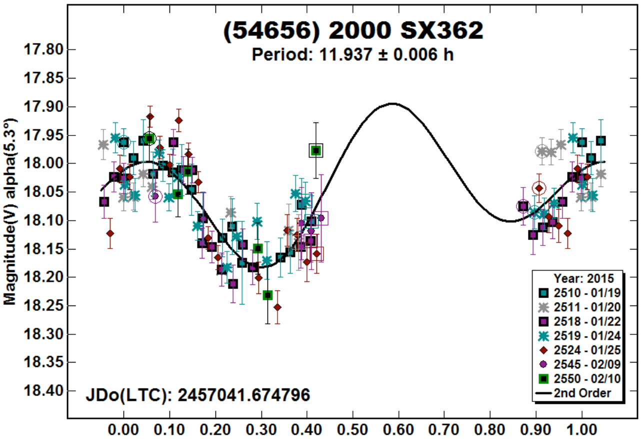

30705 Idaios
Period: 15.69 ± 0.02 h
Magnitude(V) alpha(6.9°)
JDo(LTC): 2456943.685871
Year: 2014
2335 - 10/13
2336 - 10/13
2338 - 10/14
2339 - 10/14
2340 - 10/16
2341 - 10/16
2344 - 10/17
4th Order
17.00
17.05
17.10
17.15
17.20
17.25
17.30
17.35
17.40
17.45
17.50
17.55
17.60
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

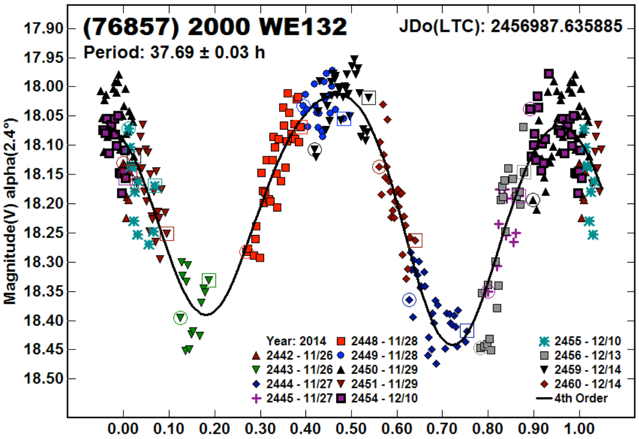

37519 Amphios
Period: 50.93 ± 0.03 h
Magnitude(V) alpha(3.9°)
JDo(LTC): 2456984.598628
Year: 2014
2434 - 11/23
2435 - 11/24
2440 - 11/25
2441 - 11/26
2446 - 11/27
2447 - 11/28
2452 - 11/29
2453 - 12/10
2457 - 12/13
2458 - 12/14
2461 - 12/19
2465 - 12/23
2466 - 12/24
2nd Order
17.80
17.85
17.90
17.95
18.00
18.05
18.10
18.15
18.20
18.25
18.30
18.35
18.40
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

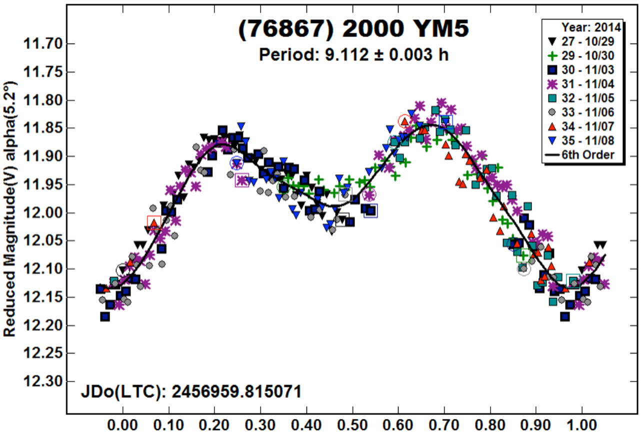

30942 Helicaon
Period: 44.77 ± 0.05 h
Magnitude(V) alpha(7.8°)
JDo(LTC): 2457043.744278
Year: 2015
2nd Order
2515 - 01/21
2520 - 01/24
2521 - 01/24
2522 - 01/25
2523 - 01/25
2537 - 02/06
2538 - 02/06
2541 - 02/07
2542 - 02/07
2543 - 02/08
2547 - 02/09
2548 - 02/10
2549 - 02/10
2552 - 02/11
2553 - 02/11
2554 - 02/12
2555 - 02/12
2558 - 02/13
2559 - 02/13
2560 - 02/14
2561 - 02/14
2564 - 02/15
18.15
18.20
18.25
18.30
18.35
18.40
18.45
18.50
18.55
18.60
18.65
18.70
18.75
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


(51364) 2000 SU333
Period: 30.56 ± 0.03 h
Magnitude(V) alpha(1.2°)
JDo(LTC): 2457010.581541
Year: 2014
2462 - 12/19
2463 - 12/23
2464 - 12/23
2467 - 12/24
2468 - 12/24
2469 - 12/25
2470 - 12/25
2473 - 12/26
2474 - 12/26
2475 - 12/27
2476 - 12/27
4th Order
17.50
17.60
17.70
17.80
17.90
18.00
18.10
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00









ROTATION PERIOD DETERMINATION FOR 3395 JITKA

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Analysis of photometric observations of the main-belt asteroid 3395 Jitka performed by the authors in February 2015 revealed a bimodal lightcurve with a synodic rotation period of 18.293 ± 0.006 hours as the most likely solution.

3395 Jitka (1985 UN) is a main-belt asteroid discovered on 1985 October 20 by Antonín Mrkos at Klet Observatory. It is named in honor of Jitka Beneš in recognition of her assistance at Klet during the International Halley Watch. It orbits with a semi-major axis of about 2.79 AU, eccentricity 0.06, and a period of 4.67 years. 3395 Jitka is a member of the Agnia family of asteroids, named after the asteroid 847 Agnia. This group most likely formed from the breakup of a basaltic object, which in turn was spawned from a larger parent body that underwent igneous differentiation (Milani *et al.*, 2014; Sunshine *et al.*, 2004). According to the WISE satellite infrared radiometry, the diameter is 10.909 ± 0.155 km based on an absolute magnitude *H* = 11.7 (Masiero *et al.*, 2011). Bus and Binzel (2002) observed 3395 Jitka during Phase II of the Small Main Belt Asteroid Spectrographic Survey (SMASS II) and assigned a spectral classification of Sr.

A search of the asteroid lightcurve database (LCDB; Warner *et al.*, 2009) indicates that our results constitute the first reported lightcurve observations and results for this object. The asteroid was reported as a lightcurve photometry opportunity in the *Minor Planet Bulletin* (Warner *et al.*, 2015).

Observations at the Astronomical Observatory of the University of Siena were carried out on five nights from 2015 February 10-18. We used a 0.30-m *f*/5.6 Maksutov-Cassegrain telescope, SBIG STL-6303E NABG CCD camera, and clear filter. The pixel scale was 2.20 arcsec when binning 2x2. Exposure times were either 300 or 420 seconds.

A total of 433 data points were collected. Over the interval of about 9 days, the phase angle ranged from 2.2 degrees to 5.3 degrees after the opposition.

Images were calibrated with bias, flat, and dark frames. Data processing, including reduction to R band, and period analysis was performed using *MPO Canopus* (BDW Publishing, 2012). Differential photometry measurements were performed using the Comp Star Selector (CSS) procedure in *MPO Canopus* that allows selecting of up to five comparison stars of near solar color. Subsequently, additional adjustments of the magnitude zero-points for the particular data sets were carried out in order to achieve the best alignment among them by finding the minimum RMS value from the Fourier analysis.

The period analysis yielded several possible solutions that clearly stand out in the period spectrum (RMS vs. period; Fig. 1) with nearly comparable RMS errors. Despite the period spectrum showing possible solutions at 9.15 h (monomodal lightcurve), 18.29 h (bimodal), 27.44 h (trimodal), we concluded that the most likely value of the synodic period for 3395 Jitka is associated with the bimodal lightcurve phased to 18.293 ± 0.006 hours with an amplitude of 0.40 ± 0.03 mag (Fig. 2) because large amplitudes would be improbable for monomodal or trimodal lightcurves at lower phase angles, as explained in the *MPO Users Guide* (Warner, 2012).

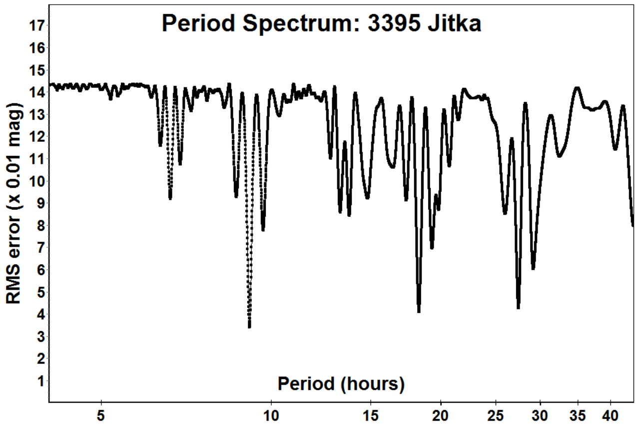

Figure 1. The period spectrum for 3395 Jitka shows several possible solutions.

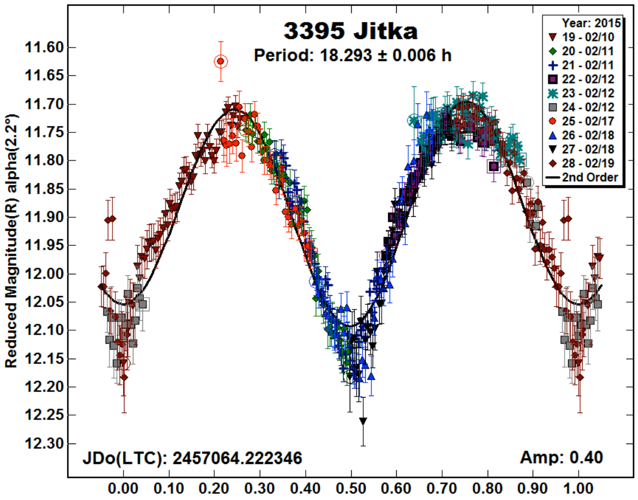

Figure 2. The lightcurve for 3395 Jitka phased to the adopted period of 18.293 h.

Acknowledgments

Some observing sessions of 3395 Jitka at the Astronomical Observatory of the University of Siena were attended by four high school students from Liceo "Galileo Galilei" (Siena): Linda Capannoli, Amal Gasmi, Leonella Filippa Saya, and Shinju Torsellini, who are involved in an interesting vocational guidance project about astronomy. The authors would like to thank Lorenzo Franco and Riccardo Papini for their support during the observations and data analysis.

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ROTATION PERIOD DETERMINATION FOR 1511 DALERA AND 2271 KISO

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Photometric observations of the main-belt asteroids 1511 Dalera and 2271 Kiso were performed by the authors from Italy in 2015 February and March. Analysis of the data revealed a bimodal lightcurve for 1511 Dalera with a synodic period 3.880 ± 0.001 hours. A period of 17.14 ± 0.01 h, also with a bimodal lightcurve, was found for 2271 Kiso.

Asteroids 1511 Dalera and 2271 Kiso were observed by a group of amateur astronomers at the Astronomical Observatory of the University of Siena and at the Balzaretto Observatory, both located in Italy. This paper presents the results of these campaigns.

At the Astronomical Observatory of the University of Siena, data were obtained with a 0.30-m *f*/5.6 Maksutov-Cassegrain telescope, SBIG STL-6303E NABG CCD camera, and clear filter. The pixel scale was 2.20 arcsec when binning 2x2 and the exposure times were 300 or 420 seconds. At the Balzaretto Observatory, data were obtained with a 0.20-m Schmidt-Cassegrain (SCT), reduced to *f*/5.5, equipped with an SBIG ST7-XME CCD camera. The pixel scale was 1.65 arcsec and the exposure times were 420 sec.

For both asteroids, images were calibrated with bias, flats, and darks. Data processing, including reduction to R band, and period analysis were performed using *MPO Canopus* (BDW Publishing, 2012). Differential photometry measurements were performed using the Comp Star Selector (CSS) procedure in *MPO Canopus* that allows selecting of up to five comparison stars of near solar color. Subsequently, additional adjustments of the magnitude zero-points for the particular data sets were carried out in order to achieve the best alignment among them, i.e., to reach the minimum RMS value from the Fourier analysis.

<u>1511 Dalera (1939 FB).</u> This main-belt asteroid was discovered on 1939 March 22 by Louis Boyer. It orbits with a semi-major axis of about 2.36 AU, eccentricity 0.10, and a period of 3.62 years. Observations were made on four nights from 2015 February 27 to March 09 with a total of 252 data points collected. During the interval of ten days, the phase angle ranged from 4.1° to 4.9° after opposition.

The period analysis yielded a few possible solutions that clearly stand out in the period spectrum (Fig. 1) with nearly comparable RMS errors. We concluded that the most likely value of the synodic period for 1511 Dalera is associated with a bimodal lightcurve phased to 3.880 ± 0.0001 hours with an amplitude of 0.18 ± 0.03 mag (Fig. 2).

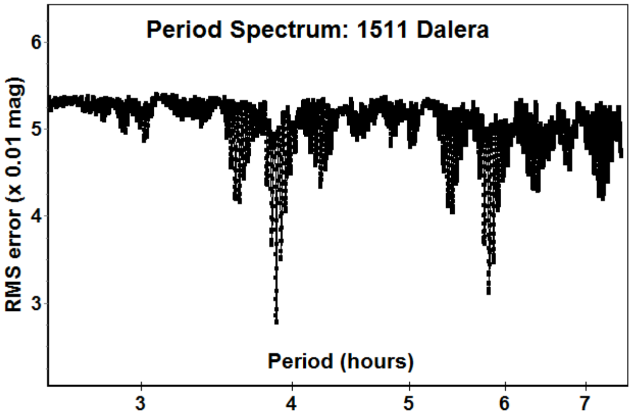

Figure 1. The period spectrum for 1511 Dalera.

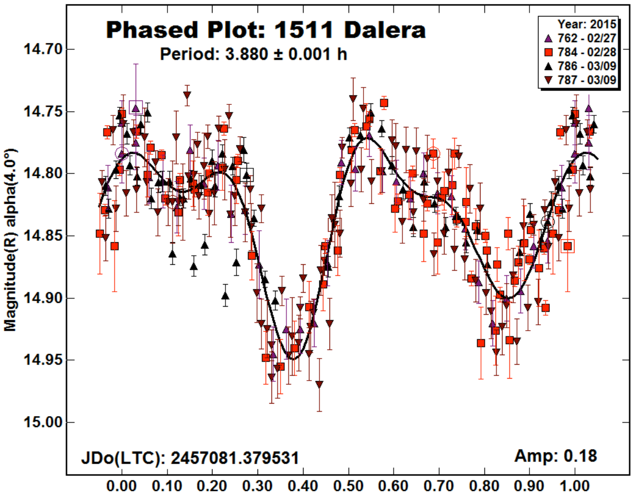

Figure 2. The lightcurve for 1511 Dalera phased to the adopted period of 3.880 h.

<u>2271 Kiso (1976 UV5)</u> is a main-belt asteroid discovered on 1976 October 22 by Hiroki Kosai and Kiichiro Furukawa at the Tokyo Observatory's Kiso Station and is named after the observatory. It orbits with a semi-major axis of about 2.79 AU, eccentricity 0.06, and a period of 4.6 years. According to the WISE satellite infrared radiometry, the diameter is 34.42 ± 0.43 km based on an absolute magnitude $H = 10.9$ (Masiero *et al*., 2012).

Observations were made on eight nights from 2015 February 19 to March 20 with a total of 408 data points collected. During an interval of about one month, the phase angle ranged from 0.4° to 11.3° after opposition.

The period analysis yielded several possible solutions that clearly stand out in the period spectrum (Fig. 3) with nearly comparable RMS errors: 8.67 h (monomodal), 17.14 h (bimodal), and 26.01 h (trimodal). We concluded that the most likely value of the synodic period for 2271 Kiso is associated with the bimodal lightcurve phased to 17.14 ± 0.01 hours with an amplitude of 0.14 ± 0.03 mag (Fig. 4). This is based on the presumption that large amplitudes would be improbable for monomodal or trimodal lightcurves at lower phase angles, as explained in the *MPO Users Guide* (Warner, 2012).

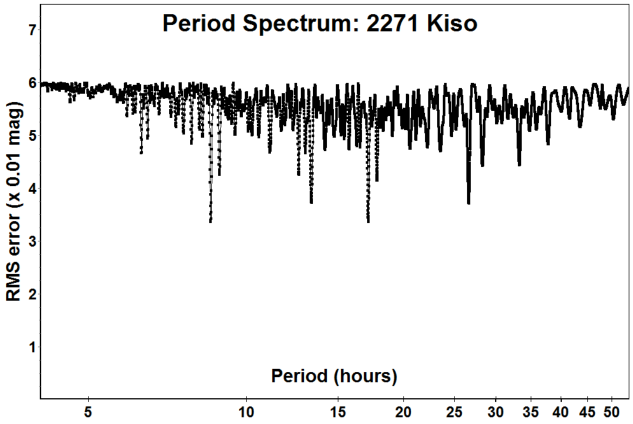

Figure 3. The period spectrum for 2271 Kiso.

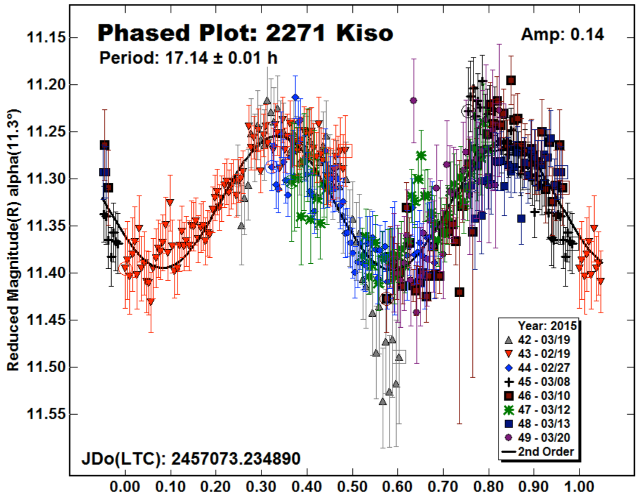

Figure 4. The lightcurve for 2271 phased to the adopted period of 17.14 h.

A search of the asteroid lightcurve database (LCDB; Warner *et al.*, 2009) indicates that these are the first observations and results for these objects. Both asteroids were reported as a lightcurve photometry opportunity in the *Minor Planet Bulletin* (Warner *et al.*, 2015).

Acknowledgments

The authors would like to thank Riccardo Papini for his support during the observations and data analysis.

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LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2015 JULY-SEPTEMBER

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

We present several lists of asteroids that are prime targets for photometry during the period 2015 July-September.

In the first three sets of tables, "Dec" is the declination and "U" is the quality code of the lightcurve. See the asteroid lightcurve data base (LCDB; Warner *et al.*, 2009) documentation for an explanation of the U code:

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

The ephemeris generator on the CALL web site allows you to create custom lists for objects reaching V ≤ 18.5 during any month in the current year, e.g., limiting the results by magnitude and declination.

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

We refer you to past articles, e.g., *Minor Planet Bulletin* **36**, 188, for more detailed discussions about the individual lists and points of advice regarding observations for objects in each list.

Once you've obtained and 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. We urge you to consider submitting your raw data to the ALCDEF page on the Minor Planet Center web site:

http://www.minorplanetcenter.net/light_curve

We believe this to be the largest publicly available database of raw lightcurve data that contains 1.8 million observations for more than 2700 objects.

Now that many backyard astronomers and small colleges have access to larger telescopes, we have expanded the photometry opportunities and spin axis lists to include asteroids reaching V = 15.5.

In both of those lists, a line in *italics text* indicates a near-Earth asteroid (NEA). In the spin axis list, a line in **bold text** indicates a particularly favorable apparition. To keep the number of objects manageable, the opportunities list includes only those objects reaching a particularly favorable apparition, meaning they could all be presented in bold text.

Lightcurve/Photometry Opportunities

Objects with U = 3– or 3 are excluded from this list since they will likely appear in the list below for shape and spin axis modeling. Those asteroid rated U = 1 should be given higher priority over those rated U = 2 or 2+ but not necessarily over those with no period. On the other hand, d*o not overlook asteroids with* U = 2/2+ *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.

		Brightest			LCDB Data		
Number	Name	Date	Mag	Dec	Period	Amp	U
12214	Miroshnikov	07 02.8	15.4	-13			
14687	1999 YR13	07 04.0	15.0	-23			
5445	Williwaw	07 04.3	14.4	-18			
8895	Nha	07 04.3	15.1	-16		0.1	
3466	Ritina	07 04.9	15.0	-23			
19576	1999 LP22	07 05.0	15.3	-22			
5631	Sekihokutouge	07 05.3	15.5	-25			
11438	Zeldovich	07 05.4	14.7	-16	5.2	0.12	2-
1476	Cox	07 05.8	14.6	-33			
16147	Jeanli	07 06.7	15.2	-32			
21188	1994 GN	07 06.8	15.4	-29			
21967	1999 WS9	07 07.5	15.3	-30			
31367	1998 WB9	07 07.7	15.1	-43			
9648	Gotouhideo	07 08.4	15.5	-30			
3298	Massandra	07 08.9	15.2	-22			
4802	Khatchaturian	07 08.9	15.4	-23			
684	Hildburg	07 09.2	13.6	-30	15.89	0.22-0.23	2
10682	1980 KK	07 10.0	15.0	-21			
3477	Kazbegi	07 10.4	15.0	-10	12.65	0.25	2
1247	Memoria	07 10.5	13.7	-20			
14229	1999 XV94	07 10.5	15.5	-31			
8289	An-Eefje	07 12.2	15.4	-20			
5861	Glynjones	07 12.4	15.1	-25			
5930	Zhiganov	07 12.4	15.5	-17			
9561	van Eyck	07 13.5	15.1	-30			
5512	1988 VD7	07 13.9	14.8	-30			
11865	1989 SC	07 14.5	15.3	-37			
40429	1999 RL27	07 15.1	15.2	-46	>24.	0.1	1
2407	Haug	07 15.5	13.8	-25			
19281	1996 AP3	07 16.0	15.1	-17			
4864	1988 RA5	07 17.5	15.3	-24			
1353	Maartje	07 17.7	13.6	-7	22.98	0.40	2
1569	Evita	07 18.7	15.1	-26			
9773	1993 MG1	07 19.3	14.3	-7			
4901	1988 VJ	07 20.0	15.0	-12			
2389	Dibaj	07 20.7	14.3	-31			
3050	Carrera	07 20.7	15.1	-18			
32143	2000 LA27	07 20.9	15.2	-12			
12229	Paulsson	07 21.4	15.2	-30			
6701	Warhol	07 21.9	15.1	-26			
14083	1997 GH22	07 22.7	15.4	-40			
13844	1999 XW34	07 22.9	15.5	-22			
5051	Ralph	07 23.9	15.1	-14			
3302	Schliemann	07 26.9	15.0	-16			
27995	1997 WL2	07 28.0	14.9	-27			
3858	Dorchester	07 28.4	14.4	-33			
12746	Yumeginga	07 29.1	15.1	-13			
11861	1988 VY2	07 29.3	15.3	-35			
6469	Armstrong	07 30.8	15.3	-14			

		Brightest			LCDB Data		
Number	Name	Date	Mag	Dec	Period	Amp	U
6649	Yokotatakao	07 31.0	14.4	-23			
11864	1989 NH1	07 31.0	14.6	-20			
11927	Mount Kent	07 31.1	15.4	-24			
2160	Spitzer	07 31.9	15.3	-18	5.9		2-
3303	Merta	08 01.1	15.5	-22			
7899	Joya	08 01.1	15.4	-27			
10005	Chernega	08 01.2	15.5	-25			
5518	Mariobotta	08 01.5	14.2	-19			
2166	Handahl	08 01.6	14.1	-12			
12234	Shkuratov	08 01.6	15.4	-12			
6609	1992 BN	08 03.1	15.5	-20			
5480	1989 YK8	08 03.8	14.9	-19			
22409	1995 SU3	08 04.1	14.6	-22			
5463	Danwelcher	08 04.3	15.0	-24			
6140	Kubokawa	08 04.4	15.3	-20			
2684	Douglas	08 04.5	15.5	-13			
39551	1992 EW5	08 05.8	15.5	-21			
9801	1997 FX3	08 07.1	14.7	-12			
18487	1996 AU3	08 07.6	14.8	-17	6.512	0.72	2
2997	Cabrera	08 08.0	14.8	-25			
18229	3222 T-1	08 08.4	15.5	-12			
5717	Damir	08 08.6	15.4	-19			
12207	1981 EU28	08 08.8	15.1	-13			
61123	2000 MN1	08 09.1	15.3	-29			
49953	1999 XL215	08 09.5	15.5	-8			
1260	Walhalla	08 10.0	15.5	-13		0.16	
26818	1987 QM	08 10.3	15.1	-27			
16157	Toastmasters	08 11.7	15.4	-15			
47410	1999 XE135	08 12.1	15.4	-15			
53168	1999 CV10	08 12.2	15.1	-14			
56696	2000 LQ26	08 12.2	15.5	-13			
3945	Gerasimenko	08 13.1	15.0	-17			
10672	Kostyukova	08 14.0	15.4	+0			
6630	Skepticus	08 14.1	14.7	-28			
8930	Kubota	08 14.2	15.2	-9			
348400	***2005 JF21***	***08 14.3***	***12.5***	***-49***			
1331	Solvejg	08 14.9	13.2	-16	>10.	0.3	1
783	Nora	08 15.4	12.0	-14	34.4	0.08-0.2	2-
1056	Azalea	08 15.4	12.9	-21	11.893	0.07-0.79	2+
7702	1991 PO13	08 15.8	15.5	-19			
206378	***2003 RB***	***08 16.0***	***13.8***	***+5***	***>16.***	***0.2***	***2***
2243	Lonnrot	08 16.2	13.8	-27			
5330	Senrikyu	08 16.8	15.3	+8	14.44	0.08	2
13999	1993 FH43	08 16.9	15.5	-15			
3093	Bergholz	08 17.0	14.0	+3			
6184	Nordlund	08 17.4	15.3	-24			
14198	1998 XZ73	08 18.1	15.4	-19			
3326	Agafonikov	08 18.4	14.9	-17			
7776	Takeishi	08 19.9	14.4	-7	8.9	0.05	1
9038	Helensteel	08 20.4	15.5	-16			
3040	Kozai	08 20.5	15.1	-21			
18389	1992 JU2	08 20.6	15.5	-2			
4556	Gumilyov	08 22.1	15.2	-17			
2676	Aarhus	08 22.2	14.8	-7			
5657	Groombridge	08 22.2	15.4	-4			
4615	Zinner	08 22.6	14.7	-27			
1357	Khama	08 22.8	15.0	-31			
7254	Kuratani	08 23.6	15.4	-15			
14938	1995 DN	08 24.3	15.5	-7			
20963	Pisarenko	08 25.2	15.2	-16			
31044	1996 NY	08 25.4	15.2	-34			
3964	Danilevskij	08 26.3	15.3	-11			
1383	Limburgia	08 27.2	15.0	-10	> 5.	0.07	
16579	1992 GO	08 27.6	15.5	-11			
44506	1998 XS39	08 27.8	15.5	+2			
4145	Maximova	08 28.5	14.6	-3			
23120	Paulallen	08 29.5	14.4	+6			
981	Martina	08 30.2	13.5	-12	11.267	0.20	2
3434	Hurless	08 31.0	15.0	-15			
11786	Bakhchivandji	08 31.0	15.5	-10			
53090	1998 YS7	08 31.6	15.4	-2			
7748	1987 TA	09 01.0	14.5	-9			
4327	Ries	09 01.2	14.6	-36			
11282	Hanakusa	09 01.2	15.4	-16			
8563	1995 US	09 01.5	15.0	-1			
2740	Tsoj	09 01.9	15.3	+0			
1988	Delores	09 02.3	15.1	-15			
11624	1996 UF	09 03.0	15.5	-8			
23941	1998 UW1	09 03.6	15.5	-28			
7107	Peiser	09 04.6	15.5	-5			
2379	Heiskanen	09 05.4	13.3	-7			
18070	2000 AC205	09 06.5	15.1	-52			
4919	Vishnevskaya	09 06.6	14.4	-8			
24642	1984 SA	09 06.9	15.4	+6			
18085	2000 JZ14	09 07.0	15.4	-19			
14457	1993 FR23	09 07.1	15.4	-10			
31450	1999 CU9	09 07.4	14.1	+3			
9947	Takaishuji	09 07.8	15.5	+5			
9955	1991 PU11	09 08.0	15.1	-6			
10360	1993 VN	09 08.0	15.2	-5			
3084	Kondratyuk	09 09.0	14.8	-3			
26573	2000 EG87	09 09.0	15.4	-4			
1024	Hale	09 09.2	13.8	-32	16.	0.10	1+
1611	Beyer	09 09.8	15.3	+1	13.29	0.35	2+
3054	Strugatskia	09 10.0	14.4	-6			
3875	Staehle	09 10.0	14.5	-12			
18096	2000 LM16	09 10.2	15.1	-7	86.	0.18	2-
8860	Rohloff	09 11.1	15.5	-15			
22303	1990 QE4	09 11.1	15.4	-10			
5981	Kresilas	09 12.0	14.8	-6			
2311	El Leoncito	09 14.6	15.3	-6			
2748	Patrick Gene	09 14.8	15.1	-3			
6295	Schmoll	09 15.1	15.3	-1			
5505	Rundetaarn	09 15.3	15.2	+7			
2362	Mark Twain	09 15.5	14.2	-6			
8145	Valujki	09 15.6	15.1	+12			
5873	Archilochos	09 15.7	15.2	-9			
26097	1988 VJ1	09 15.9	15.1	+7			
4962	Vecherka	09 16.7	15.0	+11			
13852	Ford	09 17.8	15.3	+0			
4714	Toyohiro	09 17.9	14.8	+2			
2057	Rosemary	09 20.9	15.2	-2			
7195	Danboice	09 21.0	15.1	-14	8.67	0.16	1+
7345	Happer	09 21.1	15.3	-9			
8079	Bernardlovell	09 21.9	15.3	+4			
9442	1997 GQ27	09 21.9	15.3	-23			
3111	Misuzu	09 22.4	15.0	-4	>40.	0.25	2-
14276	2000 CF2	09 22.5	14.7	-8		0.12	
2219	Mannucci	09 22.8	14.9	-11		0.3	
3045	Alois	09 23.3	15.1	-3		0.52	
5792	Unstrut	09 23.7	15.1	-12			
3958	Komendantov	09 24.1	14.0	-2			
1136	Mercedes	09 24.3	12.7	+9	24.64	0.10-0.15	2
10318	Sumaura	09 24.4	15.0	-9			
6440	Ransome	09 24.8	15.5	+0			
30522	2001 MQ15	09 24.9	15.2	-15			
4800	Veveri	09 26.7	15.2	+0			
2671	Abkhazia	09 27.2	15.4	+3			
26843	1991 UK1	09 27.3	15.5	+7			
91252	1999 CS49	09 27.4	15.5	+19			
8556	Jana	09 27.9	14.6	-9			
14893	1992 DN6	09 27.9	14.9	-3			
6934	1994 YN2	09 28.2	15.4	-12			
15012	1998 QS92	09 28.6	15.1	-11			
14480	1994 PU1	09 28.7	15.3	-4			
6277	1949 QC1	09 28.8	15.2	+10			
27351	2000 DO73	09 29.2	14.8	+3			
6174	Polybius	09 29.3	15.0	-4			
3537	Jurgen	09 29.7	15.3	-13	>14.	0.3	1
2188	Orlenok	09 29.8	15.0	+0			
85950	1999 FQ7	09 29.8	15.3	+3			
16556	1991 VQ1	09 30.0	14.9	-11		0.17	
3781	Dufek	09 30.2	15.5	+3			
9400	***1994 TW1***	***09 30.2***	***14.7***	***+52***			
1570	Brunonia	09 30.4	15.3	+3			
5455	Surkov	09 30.9	15.0	+3			

Low Phase Angle Opportunities

The Low Phase Angle list includes asteroids that reach very low phase angles. The "α" column is the minimum solar phase angle for the asteroid. 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." To allow asteroids with longer names in the list, only the maximum amplitude in the LCDB is given. Uses the on-line query form for the LCDB

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

to get more details about a select asteroid.

You will have the best chance of success working objects with low amplitude and periods that allow covering at least half a cycle every night. Objects with large amplitudes and/or long periods are much more difficult for phase angle studies since, for proper analysis, the data have to be reduced to the average magnitude of the asteroid for each night. This reduction requires that you determine the period and the amplitude of the lightcurve; for long period objects that can be tricky. Refer to Harris, *et al.* ("Phase Relations of High Albedo Asteroids." *Icarus* **81**, p365 ff) for the details of the analysis procedure.

As an aside, some use the maximum light to find the phase slope parameter (*G*). However, this can produce a significantly different value for both *H* and *G* versus when using average light, which is the method used for values listed by the Minor Planet Center.

Num	Name	Date	α	V	Dec	Period	Amp	U
1247	Memoria	07 10.5	0.93	13.7	-20			
1210	Morosovia	07 16.3	0.74	13.6	-23	15.2616	0.56	3
551	Ortrud	07 21.0	0.17	13.9	-21	13.05	0.18	2
468	Lina	07 23.0	0.26	13.2	-21	16.33	0.18	3
415	Palatia	07 31.7	0.15	13.0	-19	20.73	0.33	3
301	Bavaria	08 01.8	0.74	13.4	-16	12.253	0.28	3
100	Hekate	08 03.0	0.22	10.7	-18	27.066	0.23	3
442	Eichsfeldia	08 09.2	0.15	12.6	-16	11.871	0.38	3
65	Cybele	08 13.4	0.44	11.0	-13	6.0814	0.12	3
1331	Solvejg	08 15.0	0.72	13.2	-16	> 10.	0.3	1
783	Nora	08 15.5	0.25	12.0	-14	34.4	0.2	2
893	Leopoldina	08 18.9	0.10	12.8	-13	14.115	0.35	3
182	Elsa	08 19.1	0.95	11.7	-15	80.088	0.72	3
1430	Somalia	08 19.5	0.23	13.8	-13	6.913	0.45	3
200	Dynamene	08 25.0	0.51	11.5	-10	37.394	0.10	3
1082	Pirola	08 27.0	0.11	13.4	-11	15.8525	0.60	3
3628	Boznemcova	08 28.1	0.40	13.5	-09	3.33541	0.09	3
177	Irma	09 02.0	0.17	11.8	-09	13.856	0.37	3
303	Josephina	09 02.4	0.29	12.8	-09	12.497	0.15	3
2379	Heiskanen	09 05.4	0.19	13.3	-07			
661	Cloelia	09 06.2	0.57	13.8	-05	5.536	0.26	3
1636	Porter	09 07.2	0.34	14.0	-06	2.9653	0.22	3-
201	Penelope	09 10.1	0.85	10.6	-07	3.7474	0.73	3
846	Lipperta	09 10.8	0.19	13.5	-05	1641.	0.30	2
325	Heidelberga	09 13.4	0.42	12.5	-03	6.737	0.20	3
328	Gudrun	09 15.5	0.14	13.0	-03	10.992	0.32	3
788	Hohensteina	09 18.5	0.32	13.2	-01	37.176	0.18	3
3958	Komendantov	09 24.0	0.93	14.0	-02			
3447	Burckhalter	09 24.5	0.25	13.8	+00	59.8	0.39	3
1160	Illyria	09 27.1	0.09	13.8	+01	4.1025	0.91	3
1275	Cimbria	09 28.4	0.72	13.1	+03	5.65	0.57	3

Shape/Spin Modeling Opportunities

Those doing work for modeling should contact Josef Ďurech at the email address above. If looking to add lightcurves for objects with existing models, visit the Database of Asteroid Models from Inversion Techniques (DAMIT) web site

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

Included are objects that:

1. Are rated U = 3– or 3 in the LCDB
2. Do not have reported pole in the LCDB Summary table
3. Have at least two entries in the Details table of the LCDB where the lightcurve is rated U ≥ 2.

The caveat for condition #3 is that no check was made to see if the lightcurves are from the same apparition or if the phase angle bisector longitude at either of the two apparitions differs significantly from the upcoming apparition. The last check is often not possible because the LCDB does not list the approximate date of observations for all details records. Including that information is a long, on-going project.

An additional dense lightcurve, along with sparse data, could lead to the asteroid being added to or improving one in DAMIT, thus increasing the total number of asteroids with spin axis and shape models.

		Brightest			LCDB Data		
Num	Name	Date	Mag	Dec	Period	Amp	U
2511	**Patterson**	**07 01.5**	**14.5**	**-27**	**4.144**	**0.65- 0.8**	**3**
1113	Katja	07 02.0	14.4	-36	18.465	0.08-0.17	3
308	Polyxo	07 04.1	11.6	-16	12.029	0.08-0.15	3-
4440	Tchantches	07 04.9	15.2	-24	2.7883	0.21-0.34	3
117	Lomia	07 05.1	12.4	-43	9.127	0.10-0.35	3
1318	Nerina	07 05.6	15.5	-62	2.528	0.06-0.32	3
829	Academia	07 06.7	14.6	-35	7.891	0.36-0.44	3-
1563	Noel	07 09.5	15.0	-31	3.5495	0.14-0.18	3
244	Sita	07 09.7	14.0	-17	129.51	0.80-0.82	3-
469	Argentina	07 09.8	13.3	-34	17.573	0.12	3-
909	Ulla	07 10.9	14.1	-6	8.73	0.08-0.24	3
840	**Zenobia**	**07 11.1**	**13.7**	**-18**	**5.565**	**0.08-0.20**	**3**
688	Melanie	07 11.7	13.6	-6	18.87	0.07-0.14	3
9068	1993 OD	07 12.2	15.3	-34	3.4073	0.19-0.20	3
385186	1994 AW1	07 15.0	14.1	-26	2.5193	0.10-0.17	3
781	**Kartvelia**	**07 16.0**	**13.5**	**-8**	**19.04**	**0.16-0.28**	**3-**
1210	**Morosovia**	**07 16.3**	**13.6**	**-23**	**15.2616**	**0.36-0.56**	**3**
175	Andromache	07 17.7	11.6	-27	8.324	0.21-0.30	3
826	Henrika	07 19.2	14.1	-9	5.9846	0.26	3
1297	Quadea	07 20.4	14.9	-20	6.267	0.35	3
21088	***Chelyabinsk***	***07 21.3***	***14.3***	***-48***	***22.49***	***0.13***	***3***
85989	***1999 JD6***	***07 21.9***	***13.8***	***+59***	***7.6638***	***0.99- 1.2***	***3***
3121	Tamines	07 22.9	15.4	-19	4.043	0.04-0.16	3
468	Lina	07 23.1	13.2	-21	16.33	0.10-0.18	3
57	Mnemosyne	07 23.6	11.9	+1	12.463	0.12-0.14	3
1119	Euboea	07 23.7	13.9	-33	11.41	0.46-0.50	3
1406	Komppa	07 23.7	15.3	-31	3.508	0.16-0.20	3
3382	Cassidy	07 25.2	14.5	-31	4.258	0.10-0.15	3-
1377	Roberbauxa	07 26.5	15.4	-9	7.3627	0.22-0.24	3
1313	Berna	07 27.7	14.8	-17	25.46	0.20-0.28	3
907	Rhoda	07 27.8	14.7	-46	22.44	0.08-0.16	3-
604	Tekmessa	07 28.8	13.7	-25	5.5596	0.49-0.52	3
2365	Interkosmos	07 29.6	15.0	-16	6.1548	0.23-0.25	3
3409	Abramov	07 30.5	15.5	-16	7.791	0.49-0.50	3
1338	Duponta	07 30.9	15.4	-21	3.8545	0.23-0.26	3
78	Diana	07 31.4	12.3	+21	7.2991	0.02-0.30	3
853	Nansenia	07 31.5	14.2	-5	7.931	0.13-0.20	3-
251	Sophia	07 31.9	14.5	-11	20.216	0.30-0.61	3
1806	Derice	08 01.0	14.9	-14	3.224	0.07-0.19	3
301	**Bavaria**	**08 01.7**	**13.4**	**-16**	**12.253**	**0.25-0.31**	**3**
772	Tanete	08 01.9	13.2	-53	17.258	0.07-0.18	3
921	Jovita	08 01.9	13.8	+7	15.64	0.07-0.12	3-
3478	Fanale	08 02.3	14.6	-18	3.245	0.47-0.60	3
500	**Selinur**	**08 02.7**	**12.0**	**-12**	**8.0111**	**0.10-0.16**	**3**
4949	Akasofu	08 02.9	15.3	-21	2.6798	0.1-0.15	3
100	**Hekate**	**08 03.0**	**10.7**	**-18**	**27.066**	**0.11-0.23**	**3**
4223	**Shikoku**	**08 03.3**	**14.4**	**-8**	**9.137**	**0.17-0.18**	**3**
1680	Per Brahe	08 04.2	14.1	-22	3.428	0.08-0.17	3
21688	1999 RK37	08 04.8	15.3	-39	5.696	0.68-0.80	3
2453	Wabash	08 05.0	15.0	-31	6.878	0.63-0.67	3
5635	**Cole**	**08 06.1**	**15.0**	**-6**	**5.7937**	**0.30-0.33**	**3**
976	Benjamina	08 07.8	13.9	-6	9.746	0.17-0.18	3-
1189	Terentia	08 07.8	13.5	-7	19.308	0.32-0.38	3
657	Gunlod	08 08.8	14.6	-11	15.6652	0.19-0.20	3
442	Eichsfeldia	08 09.1	12.6	-16	11.871	0.24-0.38	3
956	**Elisa**	**08 11.0**	**13.5**	**-5**	**16.492**	**0.35-0.37**	**3**
316	Goberta	08 11.8	14.5	-16	8.605	0.20-0.27	3
701	Oriola	08 14.0	13.6	-5	9.09	0.20	3
1687	Glarona	08 14.3	14.4	-17	6.3	0.75	3
854	Frostia	08 15.0	14.0	-6	37.56	0.05-0.38	3
2494	Inge	08 15.0	15.0	-4	6.79	0.90-0.92	3
3982	**Kastel'**	**08 15.2**	**14.0**	**-3**	**8.488**	**0.12-0.28**	**3**
3007	Reaves	08 15.9	14.8	-29	4.1555	0.38	3
1304	Arosa	08 16.0	13.9	-35	7.7478	0.13-0.38	3
1008	La Paz	08 16.1	14.9	-25	8.998	0.14-0.19	3
1449	Virtanen	08 17.9	14.2	-20	30.495	0.08-0.69	3-
893	***Leopoldina***	***08 18.9***	***12.8***	***-13***	***14.115***	***0.18-0.35***	***3***
942	Romilda	08 19.3	15.0	-28	6.965	0.26-0.35	3
1430	**Somalia**	**08 19.5**	**13.8**	**-13**	**6.913**	**0.40-0.45**	**3**
1427	**Ruvuma**	**08 19.7**	**13.7**	**-28**	**4.797**	**0.26-0.36**	**3**
402	Chloe	08 20.1	12.8	-18	10.664	0.07-0.37	3
466	Tisiphone	08 20.9	13.8	+3	8.824	0.03-0.16	3
288	Glauke	08 21.8	13.8	-15	170.	0.36- 0.9	3
1829	Dawson	08 21.8	15.1	-6	4.254	0.05-0.28	3
1127	Mimi	08 22.1	13.7	-21	12.749	0.72-0.95	3
5240	Kwasan	08 22.4	15.5	-3	5.675	0.42-0.48	3-
1710	**Gothard**	**08 22.8**	**14.3**	**-22**	**4.939**	**0.31-0.32**	**3**
1777	Gehrels	08 23.9	14.8	-12	2.8355	0.21-0.27	3
963	Iduberga	08 24.0	15.2	-25	3.0341	0.30-0.34	3
273	**Atropos**	**08 24.7**	**12.4**	**-6**	**23.924**	**0.52-0.65**	**3**
1296	Andree	08 24.8	15.1	-5	5.1837	0.23-0.27	3
200	Dynamene	08 25.0	11.5	-10	37.394	0.10	3
1071	Brita	08 26.4	14.2	-18	5.8169	0.18-0.38	3
2951	Perepadin	08 26.6	15.2	-26	4.781	0.54-0.60	3
1082	**Pirola**	**08 27.0**	**13.4**	**-11**	**15.8525**	**0.53-0.60**	**3**
1695	**Walbeck**	**08 27.1**	**14.9**	**+15**	**5.1607**	**0.22-0.34**	**3**
790	Pretoria	08 27.8	12.6	+19	10.37	0.05-0.18	3
2341	Aoluta	08 27.9	14.9	-18	3.	0.25-0.28	3
5817	Robertfrazer	08 28.0	14.9	-16	4.051	0.22-0.33	3

		Brightest			LCDB Data		
Num	Name	Date	Mag	Dec	Period	Amp	U
1790	Volkov	08 31.4	15.4	-12	10.7419	0.09-0.14	3
10046	Creighton	09 01.3	15.5	-20	6.566	0.65-0.68	3
98	Ianthe	09 01.7	13.3	-14	16.479	0.27-0.34	3
4490	Bambery	09 01.7	14.9	-31	5.815	0.9-1.16	3
769	Tatjana	09 01.9	12.6	-17	35.08	0.30-0.33	3-
177	Irma	09 02.1	11.8	-9	13.856	0.24-0.37	3
303	**Josephina**	**09 02.4**	**12.8**	**-9**	**12.497**	**0.12-0.15**	**3**
818	Kapteynia	09 03.7	13.5	-30	16.35	0.09-0.12	3
490	**Veritas**	**09 04.1**	**12.2**	**-4**	**7.93**	**0.21-0.58**	**3**
342	Endymion	09 04.3	13.9	+3	6.319	0.15-0.23	3
564	Dudu	09 04.4	13.5	-33	8.882	0.43-0.55	3
6084	**Bascom**	**09 04.4**	**14.7**	**-18**	**2.7454**	**0.14-0.23**	**3**
2478	Tokai	09 05.9	14.7	-1	25.885	0.41-0.78	3
427	Galene	09 06.6	13.5	-1	3.705	0.55-0.68	3
1636	Porter	09 07.2	14.0	-6	2.9658	0.22-0.24	3
4055	***Magellan***	***09 07.2***	***12.2***	***-4***	***7.475***	***0.46-0.76***	***3***
970	Primula	09 07.3	14.3	-2	2.777	0.16-0.30	3
180	Garumna	09 08.9	14.3	-5	23.866	0.42- 0.6	3
472	Roma	09 09.6	12.2	-21	9.8007	0.27-0.45	3
1117	**Reginita**	**09 10.5**	**13.1**	**-8**	**2.946**	**0.13-0.33**	**3**
410	Chloris	09 11.6	11.7	-19	32.5	0.28-0.33	3
223	Rosa	09 12.3	14.1	-7	20.283	0.06-0.13	3
1656	Suomi	09 12.9	14.5	+1	2.583	0.09-0.20	3
109	Felicitas	09 13.1	11.2	-8	13.191	0.06-0.12	3
325	**Heidelberga**	**09 13.4**	**12.5**	**-3**	**6.737**	**0.11-0.20**	**3**
1375	Alfreda	09 14.4	14.5	-12	19.14	0.17	3-
232	Russia	09 15.9	14.1	-6	21.905	0.14-0.31	3
869	Mellena	09 16.0	15.0	-6	6.5155	0.20-0.27	3
361	Bononia	09 16.7	13.7	-10	13.83	0.25	3
463	**Lola**	**09 17.3**	**13.7**	**-22**	**6.206**	**0.20-0.22**	**3**
461	Saskia	09 17.9	14.8	-3	7.348	0.25-0.36	3
806	Gyldenia	09 18.5	15.1	-16	16.846	0.10-0.27	3-
286	Iclea	09 18.8	13.3	-13	15.365	0.13-0.20	3
971	Alsatia	09 18.8	13.8	-23	9.614	0.17-0.29	3
1052	Belgica	09 19.6	13.8	-10	2.7097	0.08-0.10	3
742	**Edisona**	**09 19.7**	**13.3**	**-17**	**18.52**	**0.24-0.30**	**3**
1146	Biarmia	09 20.3	13.6	+14	5.47	0.20-0.32	3
1642	Hill	09 23.2	14.6	+5	6.056	0.21-0.25	3
3724	Annenskij	09 24.2	14.6	+12	3.974	0.28-0.30	3
3447	**Burckhalter**	**09 24.5**	**13.9**	**+0**	**59.8**	**0.30-0.39**	**3**
255	Oppavia	09 25.7	14.3	-2	19.499	0.14-0.19	3
1152	Pawona	09 25.7	14.1	+5	3.4154	0.16-0.26	3
206	Hersilia	09 26.1	12.2	-2	11.128	0.08-0.20	3
1177	Gonnessia	09 26.4	14.4	+19	30.51	0.10-0.25	3-
1847	Stobbe	09 27.9	14.9	-14	5.617	0.27-0.35	3
577	Rhea	09 28.0	13.1	+6	12.249	0.21-0.31	3-
693	Zerbinetta	09 28.2	13.5	+6	11.475	0.14-0.29	3-
1275	**Cimbria**	**09 28.5**	**13.1**	**+3**	**5.65**	**0.40-0.57**	**3**
642	Clara	09 29.1	14.5	+2	8.2308	0.26-0.31	3
3332	Raksha	09 29.1	14.6	-15	4.8065	0.25-0.36	3
2215	Sichuan	09 29.2	14.2	-16	3.975	0.38-0.39	3
2015	Kachuevskaya	09 29.7	15.0	+10	42.532	0.76-1.20	3
2253	**Espinette**	**09 29.8**	**13.7**	**-2**	**7.442**	**0.18-0.48**	**3**
3266	Bernardus	09 30.1	15.0	-44	10.757	0.26-1.14	3
4464	**Vulcano**	**09 30.1**	**14.7**	**-2**	**3.2038**	**0.08-0.22**	**3**
885	**Ulrike**	**09 30.2**	**13.7**	**+0**	**4.9**	**0.55-0.72**	**3**

Radar-Optical Opportunities

There are several resources to help plan observations in support of radar.

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
http://www.naic.edu/~pradar

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

However, these are based on *known* targets at the time the list was prepared. It is very common for newly discovered objects to move up the list and become radar targets on short notice. We recommend that you keep up with the latest discoveries using the RSS feeds from the Minor Planet Center

http://www.minorplanetcenter.net/iau/rss/mpc_feeds.html

In particular, monitor the NEA feed and be flexible with your observing program. In some cases, you may have only 1-3 days when the asteroid is within reach of your equipment. Be sure to keep in touch with the radar team if you get data (through Dr. Benner's email listed above). They may not always be observing the target but, in some cases, your initial results may change their plans. In all cases, your efforts are greatly appreciated.

Use the ephemerides below as a guide to your best chances for observing, but remember that photometry may be possible before and/or after the ephemerides given below. Note that *geocentric* positions are given. Use these web sites to generate updated and *topocentric* positions:

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

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

Several of the targets listed here are carry-overs from the previous quarter's photometry opportunities article since they can be followed well into July, and beyond in some cases.

(85989) 1999 JD6 (Jul, H = 17.1, PHA)

1999 JD6 has been studied extensively and many of its physical properties are well known. It has a rotation period of 7.68 h; a lightcurve amplitude of 1.2 mag suggests a very elongated shape. Mainzer *et al.* (2011) used WISE data to estimate a diameter of 1.8 km and an optical albedo of 0.075, which indicates that this is a relatively dark object. Spectroscopic results have been ambiguous, suggesting multiple possible classifications, not all consistent with the low albedo from WISE data.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/01	21 27.0	+15 02	0.29	1.20	16.5	44.7	124	64	+0.99	-25
07/05	21 27.9	+17 22	0.24	1.17	16.1	45.3	125	28	-0.88	-24
07/09	21 28.1	+20 33	0.20	1.14	15.6	46.5	126	57	-0.47	-21
07/13	21 27.2	+25 21	0.15	1.11	15.0	49.1	125	101	-0.10	-18
07/17	21 24.1	+33 45	0.11	1.07	14.4	55.1	120	130	+0.01	-12
07/21	21 12.6	+51 57	0.07	1.04	13.8	70.6	106	118	+0.23	+2
07/25	12 20.3	+82 40	0.05	1.00	14.7	110.6	67	96	+0.59	+34
07/29	09 52.5	+39 18	0.07	0.96	19.8	151.3	27	129	+0.93	+51

1566 Icarus (Jul, H = 16.9, PHA)

Somewhat a surprise is the small number of rotation periods recorded in the LCDB for this well-known NEA. The last one has a 1995 reference! The period is about 2.3 hours. It's long past time to get an updated rotation period. The rotation period and size make Icarus a binary candidate, so high-precision observations covering a number of days, the initial group preferably being on consecutive nights, are encouraged.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/01	15 01.3	-19 31	0.26	1.20	15.9	40.7	130	37	+0.98	+34
07/03	15 05.0	-20 52	0.29	1.22	16.2	40.3	129	64	-0.99	+32
07/05	15 08.2	-21 56	0.33	1.25	16.5	40.0	128	91	-0.89	+31
07/07	15 11.1	-22 48	0.36	1.27	16.8	39.8	127	119	-0.71	+30
07/09	15 13.8	-23 31	0.40	1.29	17.0	39.7	126	146	-0.48	+29
07/11	15 16.3	-24 08	0.43	1.31	17.2	39.6	125	169	-0.27	+28
07/13	15 18.8	-24 40	0.47	1.33	17.5	39.5	123	158	-0.10	+27
07/15	15 21.1	-25 08	0.51	1.36	17.6	39.4	122	133	-0.01	+27

1685 Toro (Jul-Aug, H = 14.2)

The rotation period for this near-Earth asteroid is well established at 10.20 h. The amplitude of the lightcurve ranges from 0.47 to 1.80 mag. With the phase angle changing significantly during the apparition, it would be a good idea to get blocks of lightcurves separated by a week or so and then analyze each block independently. This can reveal not only a changing synodic period but changes in the shape and amplitude of the lightcurve from block to block. See Warner (2013; *MPB* **40**, 26-29).

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/01	15 45.2	-24 19	0.74	1.65	15.7	23.0	141	28	+0.99	+24
07/06	15 38.5	-23 08	0.75	1.63	15.9	26.6	134	99	-0.80	+26
07/11	15 33.4	-22 02	0.76	1.60	16.0	30.0	128	169	-0.26	+27
07/16	15 29.9	-21 02	0.78	1.58	16.1	33.0	122	122	+0.00	+28
07/21	15 27.9	-20 08	0.80	1.55	16.2	35.8	117	60	+0.23	+29
07/26	15 27.4	-19 22	0.82	1.52	16.2	38.2	112	5	+0.69	+30
07/31	15 28.2	-18 43	0.84	1.50	16.3	40.5	107	68	+1.00	+30
08/05	15 30.2	-18 10	0.86	1.47	16.4	42.5	103	141	-0.72	+31

(294739) 2008 CM (Jul-Aug, H = 17.3, PHA)

Warner (2014) found a rotation period of 3.054 h. The amplitude of 0.48 mag at the time suggests an elongated shape. The estimated diameter is about 1 km.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/01	20 22.9	-00 47	0.67	1.62	18.5	20.5	146	43	+0.99	-21
07/06	20 12.3	+02 56	0.63	1.59	18.3	19.5	149	36	-0.80	-16
07/11	19 59.8	+06 51	0.60	1.56	18.1	19.4	149	104	-0.26	-12
07/16	19 45.5	+10 53	0.57	1.53	18.0	20.8	148	152	+0.00	-7
07/21	19 29.7	+14 52	0.56	1.50	18.0	23.6	144	116	+0.23	-1
07/26	19 12.9	+18 39	0.55	1.47	18.1	27.2	138	64	+0.69	+4
07/31	18 55.7	+22 05	0.55	1.44	18.1	31.4	132	42	+1.00	+9
08/05	18 38.8	+25 05	0.56	1.41	18.2	35.6	126	93	-0.72	+1

(385186) 1994 AW1 (Jul-Aug, H = 17.5, PHA, Binary)

1994 AW1 is a binary system that has not yet been observed by radar. This was the first candidate binary NEA identified by possible mutual events in lightcurves (Mottola *et al*., 1995; Pravec and Hahn, 1997). The effective diameter of the system, based on the absolute magnitude, is roughly 1 km. The primary has a low lightcurve amplitude of 0.12 mag, suggesting a shape with low elongation. The secondary has an orbital period of 22.3 h. Pravec *et al*. (2006) estimate a secondary/primary diameter ratio of 0.49; if correct, then the secondary could be about 0.5 km in diameter. The lightcurve observations suggest a low elongation for the secondary as well.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/01	10 29.0	-71 36	0.12	1.05	15.5	70.9	103	78	+0.99	-12
07/06	12 08.1	-64 19	0.09	1.05	14.9	69.9	105	107	-0.80	-2
07/11	13 27.2	-47 28	0.07	1.04	14.3	68.7	107	141	-0.26	+15
07/16	14 20.9	-19 57	0.07	1.04	14.1	70.1	106	105	+0.00	+38
07/21	14 56.9	+06 50	0.08	1.03	14.6	75.0	101	50	+0.23	+54
07/26	15 22.2	+23 57	0.10	1.03	15.3	79.0	96	39	+0.69	+56
07/31	15 40.8	+33 52	0.13	1.03	15.9	81.0	92	82	+1.00	+53
08/05	15 55.1	+39 57	0.16	1.03	16.4	81.7	89	120	-0.72	+50

2011 UW158 (Jul-Sep, H = 19.4, PHA)

This asteroid will approach within 0.0164 AU on 2015 July 19 and will be one of the strongest radar targets of the year. Its estimated size is about 450 meters, assuming a typical albedo for NEAs. 2011 UW158 will be within range of Goldstone from late June into early August. The window for Arecibo is July 12-17. As far as optical photometry goes, the asteroid is available from July through September. Three ephemerides are given below, one for each month and roughly near new moon but more so when the moon and asteroid are well away from each other in the sky.

Note that the solar phase angle is very high in July and August. Deep shadowing effects could make for some very unusual lightcurve shapes requiring careful analysis. At the very least, it will probably not be practical or wise to try to combine lightcurves from each month because of the significantly different viewing aspects. Treat this asteroid as we suggested for 1685 Toro above.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/07	12 40.2	-13 05	0.05	1.02	15.8	87.3	90	155	-0.71	+50
07/08	12 41.1	-11 29	0.04	1.02	15.8	88.9	89	168	-0.60	+51
07/09	12 42.1	-09 36	0.04	1.02	15.7	90.5	87	172	-0.48	+53
07/10	12 43.2	-07 25	0.04	1.01	15.5	92.3	86	160	-0.37	+55
07/11	12 44.5	-04 50	0.03	1.01	15.4	94.1	84	146	-0.27	+58
07/12	12 46.1	-01 46	0.03	1.01	15.3	96.0	82	132	-0.18	+61
07/13	12 47.9	+01 58	0.03	1.01	15.2	98.1	80	117	-0.10	+65
07/14	12 50.2	+06 30	0.03	1.01	15.1	100.4	78	103	-0.05	+69

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
08/10	00 21.4	+44 39	0.07	1.04	16.3	69.5	107	69	-0.20	-18
08/11	00 21.7	+44 03	0.08	1.04	16.3	68.3	108	78	-0.13	-19
08/12	00 21.8	+43 29	0.08	1.04	16.4	67.0	109	88	-0.07	-19
08/13	00 21.9	+42 57	0.08	1.04	16.4	65.8	110	98	-0.03	-20
08/14	00 21.9	+42 27	0.09	1.05	16.5	64.6	111	108	+0.00	-20
08/15	00 21.8	+41 58	0.09	1.05	16.5	63.4	112	117	+0.00	-21
08/16	00 21.7	+41 30	0.09	1.05	16.6	62.1	113	126	+0.02	-21
08/17	00 21.5	+41 04	0.10	1.06	16.6	60.9	114	134	+0.05	-21
09/10	00 07.6	+31 48	0.17	1.15	17.3	33.8	141	114	-0.10	-30

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
09/11	00 06.8	+31 24	0.18	1.15	17.3	32.8	142	125	-0.05	-31
09/12	00 06.0	+31 00	0.18	1.16	17.4	31.8	143	134	-0.01	-31
09/13	00 05.3	+30 36	0.19	1.16	17.4	30.8	144	143	+0.00	-31
09/14	00 04.5	+30 12	0.19	1.17	17.4	29.8	145	149	+0.00	-32
09/15	00 03.8	+29 47	0.19	1.17	17.4	28.8	146	152	+0.03	-32
09/16	00 03.0	+29 23	0.20	1.18	17.5	27.8	147	150	+0.07	-32
09/17	00 02.3	+28 58	0.20	1.18	17.5	26.9	148	144	+0.12	-33

(206378) 2003 RB (Aug, H = 18.7, PHA)

Pravec *et al*. (2003) reported a period of $P > 16$ h and amplitude $A > 0.2$ mag. Given the short observing window for 2003 RB, it may not be possible for a single station to get enough data to find a reliable period. This will make a good target for a collaboration involving observers at well-separated longitudes.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
08/05	21 36.4	-20 22	0.10	1.12	14.6	8.7	170	55	-0.73	-45
08/07	21 43.1	-17 34	0.09	1.11	14.4	8.2	171	81	-0.51	-46
08/09	21 50.8	-14 10	0.09	1.10	14.2	8.5	171	105	-0.30	-46
08/11	21 59.7	-10 01	0.08	1.09	14.0	10.1	169	128	-0.13	-46
08/13	22 10.1	-04 57	0.07	1.08	13.9	13.3	166	149	-0.03	-46
08/15	22 22.5	+01 09	0.06	1.07	13.8	18.1	161	166	+0.00	-44
08/17	22 37.1	+08 24	0.06	1.07	13.8	24.4	154	164	+0.05	-42
08/19	22 54.7	+16 42	0.06	1.06	13.9	31.9	146	149	+0.17	-38

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

Radar observations of 2005 WK4 (Benner *et al*., 2013) indicated a period of about 2.7 h. Analysis of optical observations by Stephens (2014) found a period of 2.595 h with amplitude of 0.29 mag. The lightcurve was rated U = 2+, so additional observations could prove useful for refining the period.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
08/10	14 00.5	-01 08	0.17	0.97	19.8	98.3	72	124	-0.20	+57
08/15	14 40.2	-09 13	0.17	0.99	19.5	91.5	79	74	+0.00	+45
08/20	15 22.2	-17 11	0.17	1.01	19.2	84.3	86	26	+0.25	+33
08/25	16 05.1	-24 09	0.18	1.03	19.1	77.4	93	26	+0.73	+21
08/30	16 47.2	-29 36	0.19	1.05	19.2	71.6	98	87	-1.00	+10
09/04	17 26.9	-33 29	0.21	1.07	19.3	67.0	102	148	-0.64	+1
09/09	18 03.1	-36 00	0.24	1.09	19.4	63.4	104	146	-0.16	-7
09/14	18 35.6	-37 29	0.26	1.11	19.6	60.7	106	97	+0.01	-1

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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* * * * *

The deadline for the next issue (42-4) is July 15, 2015. The deadline for issue 43-1 is October 15, 2015.