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PHOTOMETRIC OBSERVATIONS OF MAIN-BELT ASTEROIDS 1990 PILCHER AND 8443 SVECICA

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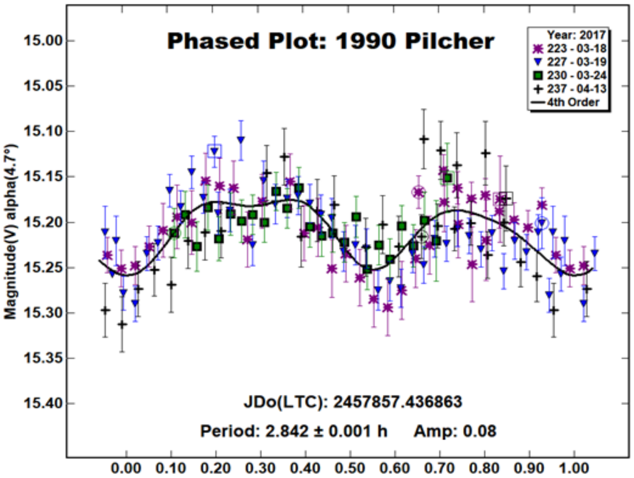
We report on photometric observations of two main-belt asteroids, 1990 Pilcher and 8443 Svecica, that were acquired from 2017 March to May. We found the synodic rotation period of 1990 Pilcher as 2.842 ± 0.001 h and amplitude of 0.08 ± 0.03 mag and of 8443 Svecica as 20.998 ± 0.001 h and amplitude of 0.62 ± 0.03 mag

During 2017, photometric observations of two main-belt asteroids were carried out from two observatories located in Malta (Europe). The two asteroids for this research were selected through the CALL website (Warner, 2016).

Observations of 1990 Pilcher were obtained from Flarestar Observatory - MPC Code: 171 (14° 28m 12.4s E, 35° 54' 37.2" N) through a 0.25-m *f*/6.3 Schmidt-Cassegrain (SCT) equipped with a Moravian G2-1600 CCD camera. Observations of 8443 Svecica were obtained through observations conducted from Antares Observatory (14° 30m 46.7s E, 35° 52' 13.0" N) that used a 0.28-m SCT coupled to a SBIG ST-11000 CCD Camera. All images were taken through a clear filter and auto-guided for the duration of the exposure. Flarestar Observatory used the camera in 1x1 binning mode with a resultant pixel scale of 0.99 arcsec per pixel while Antares Observatory used its camera in 2x2 binning mode with a resultant pixel scale of 1.32 arcsec per pixel. Both cameras were operated at sensor temperature of –15°C and images were calibrated with dark and flat-field frames.

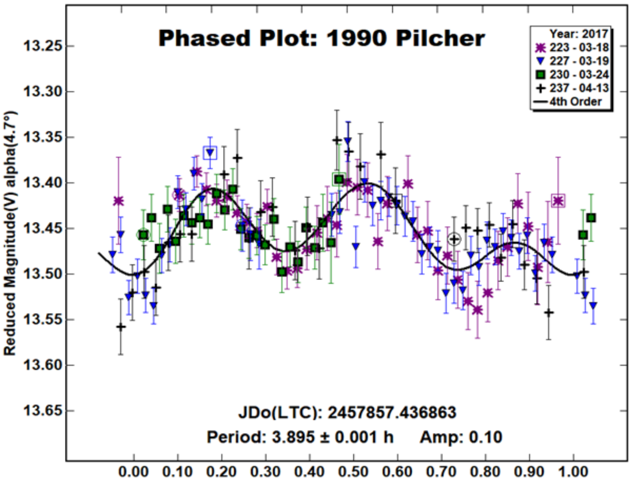
Both telescopes and cameras were controlled remotely from a nearby location via *Sequence Generator Pro* (Binary Star Software). Photometric reduction, lightcurve construction, and period analyses were done using *MPO Canopus* software (Warner, 2017). Differential aperture photometry was used and photometric measurements were based on the use of comparison stars of near-solar colour that were selected by the Comparison Star Selector (CSS) utility available through *MPO Canopus*. Asteroid magnitudes were based on MPOSC3 catalog supplied with *MPO Canopus*.

<u>1990 Pilcher</u> is an inner main-belt asteroid that was discovered on 1956 March 9 by K. Reinmuth at Heidelberg. Also known as 1956 EE, this asteroid was named in honor of Frederick Pilcher, associate professor of physics at Illinois College, Jacksonville (Illinois), who has promoted extensively, the interest in minor planets among amateur astronomers (Schmadel & Schmadel, 1992). The JPL (2017) Small-Bodies Database Browser lists the diameter as 6.754 km ± 0.167 km based on *H* = 13.14.



Number	Name	yyyy /mm/ dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1990	Pilcher	2017 03/18-04/13	134	4.7,2.5,10.6	185	-0.5	2.842	0.001	0.10	0.03	MB-I
8443	Svecica	2017 03/19-05/03	382	3.4,9.1,19.3	185	3.1	20.998	0.001	0.62	0.03	MB-M

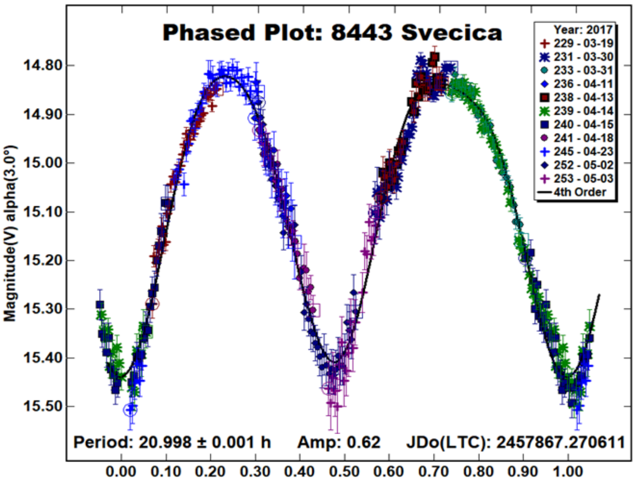
Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).



Observations conducted from Flarestar Observatory were carried out on four nights from 2017 March 18 to April 13. They indicated a synodic period of 2.842 ± 0.001 h and amplitude of 0.08 ± 0.03 mag as the most likely solution based on a bimodal lightcurve. However, if presuming that the asteroid has a non-bimodal lightcurve, the best solution would be 3.895 ± 0.001 h with amplitude of 0.10 ± 0.03.

As discussed in Harris *et al*. (2014), the presumption of a bimodal lightcurve does not always provide the correct solution since lightcurves with amplitudes of only 0.10 mag or so cannot be assumed to be bimodal, even at low phase angles. Therefore, the 3.895 hour period cannot be overlooked and this leads us to conclude that the results obtained for 1990 Pilcher are uncertain. There were no previous entries in the asteroid lightcurve database (LCDB, Warner et al., 2009) for this asteroid.

8443 Svecica is a main-belt asteroid that was discovered by on 1977 October 16 by C.J. van Houten and *I.* van Houten-Groeneveld on Palomar Schmidt plates taken by T. Gehrel. This asteroid was named for the small passerine bird - *Luscinia svecica,* also known as the Bluethroat. The JPL Small-Bodies Database Browser (JPL, 2017) lists the diameter of as 12.049 km ± 2.190 km when using $H = 12.7$.



We observed 8443 Svecica on 11 nights between 2017 March 19 and May 3. The data obtained for this asteroid were acquired on five nights at Antares Observatory and six nights at Flarestar Observatory. Our analysis yielded a synodic period of 20.998 ± 0.001h and amplitude of 0.62 ± 0.03 mag. The LCDB did not contain any references of the synodic period of this asteroid.

Acknowledgements

We would like to thank Brian Warner his work in the development of *MPO Canopus* and for his efforts in maintaining the CALL website. This research has made use of the JPL's Small-Body Database.

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THE ROTATION PERIOD OF 10041 PARKINSON

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A rotation period of 5.69 h ± 0.03 h and an amplitude of 0.03 mag has been derived from one night of observations of main-belt asteroid 10041 Parkinson.

During the night of 2017 April 24 UT the author obtained 69 data points while observing main-belt asteroid 10041 Parkinson. Observations were made with a fork-mounted 0.30-m Schmidt-Cassegrain. The imaging train consisted of a SBIG AO-8T adaptive optics unit, a FW8G-STT filter wheel, and an SBIG STT-1603ME camera working at 2x2 binning, the resulting resolution being 2.2 arc sec/pix. All observations were 300s. Camera sensor temperature was –40°C. Due to the faintness of the target, no filters were used. All images were reduced with dark and flat frames. MPO *Canopus* v10.7.7.0 was used for differential photometry and period analysis (see Ruthroff 2010, for technique details).

Data reduction reveals a probable rotation period of 5.69 h ± 0.03 h. A search of the Asteroid Lightcurve Database (LCDB; Warner et al., 2009) and the Astrophysics Data System did not find any previously reported results concerning the rotation period of 10041 Parkinson.

Acknowledgments

This paper makes use of data products from the Third U.S. Naval Observatory CCD Astrograph Catalog (UCAC3).

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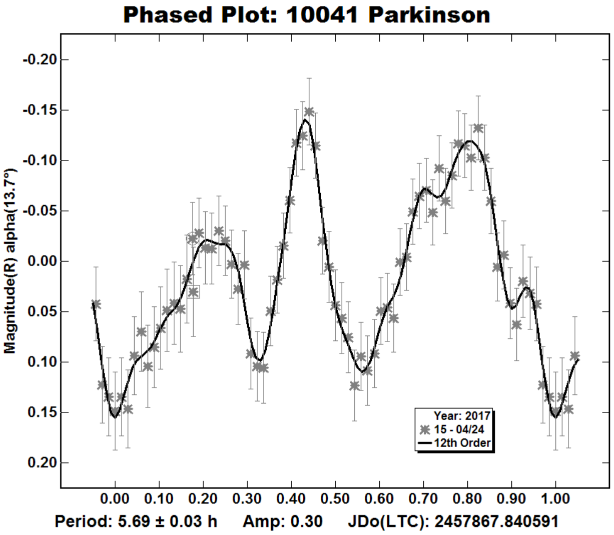

Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
10041	Parkinson	04/24	69	13.7	206	18	5.69	0.03	0.30	0.02	MBA

Table I. Observing circumstances and results. Pts is the number of data points used in the analysis. The phase angle values are for the first and last date, unless a minimum (second value) was reached. LPAB and BPAB are the average phase angle bisector longitude and latitude. Period is in hours. Amp is peak-to-peak amplitude. LPAB and BPAB are the average phase angle bisector longitude and latitude (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

ASTEROID LIGHTCURVE ANALYSIS AT CS3-PALMER DIVIDE STATION: 2017 APRIL THRU JUNE

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Lightcurves for 16 main-belt asteroids were obtained at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2017 April thru June. Many of the asteroids were “strays” in the field of planned targets, demonstrating a good reason for data mining images. Analysis shows that the Hungaria asteroid (45878) 2000 WX29 may be binary.

CCD photometric observations of 16 main-belt asteroids were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2017 April thru June. 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.

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 made using *MPO Canopus*. 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 CMC-15 (*http://svo2.cab.inta-csic.es/vocats/cmc15/)* or APASS (Henden et al., 2009) catalogs. The MPOSC3 catalog was used as a last resort. This catalog is based on the 2MASS catalog (*http://www.ipac.caltech.edu/2mass*) with magnitudes converted from J-K to BVRI (Warner, 2007). The nightly zero points for the catalogs are generally consistent to about ± 0.05 mag or better, but on occasion reach 0.1 mag and more. There is a systematic offset among the catalogs so, whenever possible, the same catalog is used throughout the observations for a given asteroid. Period analysis is also done with *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.

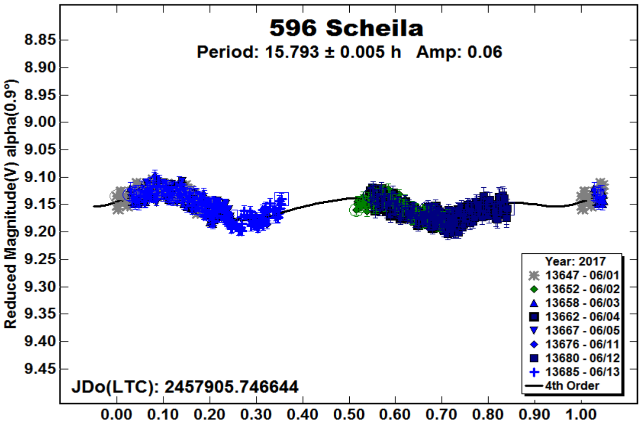
Desig	Telescope	Camera
Squirt	0.30-m f/6.3 Schmidt-Cass	ML-1001E
Borealis	0.35-m f/9.1 Schmidt-Cass	FLI-1001E
Eclipticalis	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Australius	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Zephyr	0.50-m f/8.1 R-C	FLI-1001E

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

If the plot includes an amplitude, *e.g.*, "Amp: 0.65", this is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*.

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.

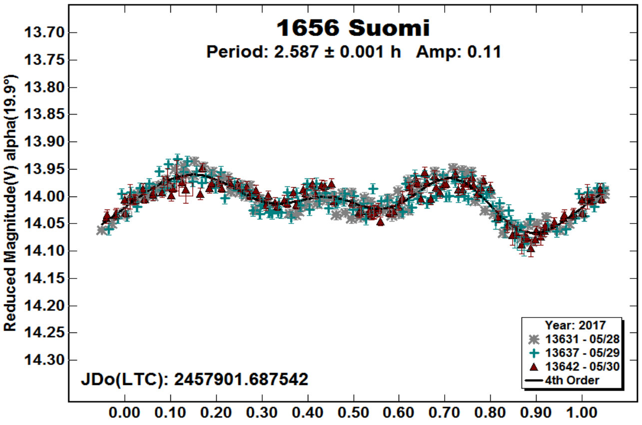
596 Scheila. When observed in 2006 (Warner, 2006), this main-belt object was found to have a period of 15.848 h. There were no signs of unusual activity. On 2010 Dec 11, Steve Larson at the Catalina Sky Survey detected a "coma" around the asteroid, suggesting that it might be a cometary outburst. Follow-up observations eventually determined that the asteroid had been hit by a smaller object of about 35-m size (Jewitt et. al, 2011; Bodewits et al., 2011). When observed in 2011 (Warner, 2011a) and again in 2017, there were no signs of cometary activity. The 2017 observations led to a period of 15.793 h, but only by assuming previous results were correct.

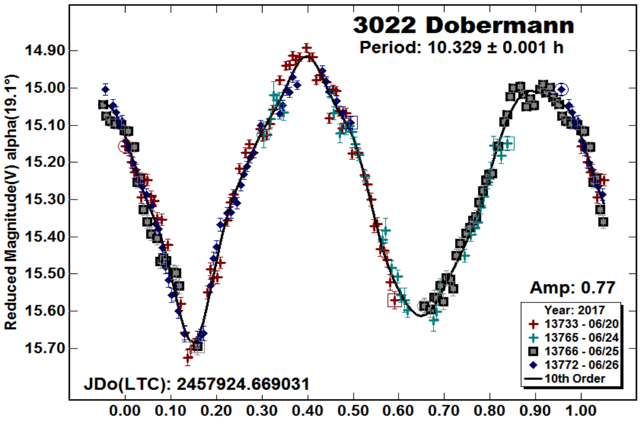


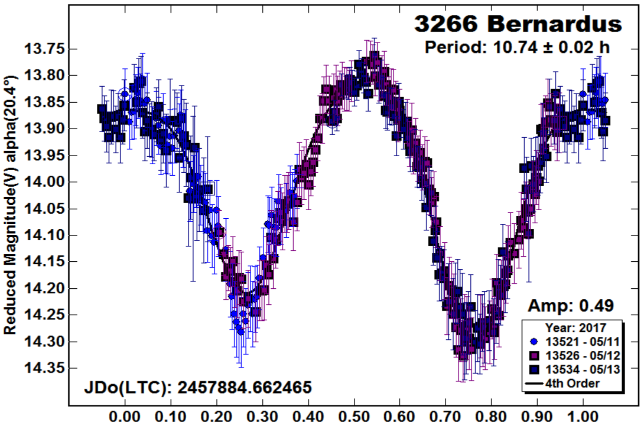
1656 Suomi, 3022 Dobermann, 3266 Bernardus, 4490 Bambery, and 6493 Cathybennett. All of these Hungarias are "repeats" that were observed to provide additional data for spin axis modeling. The periods reported from the analysis of the most recent data are all in good agreement with previous results obtained by the author.

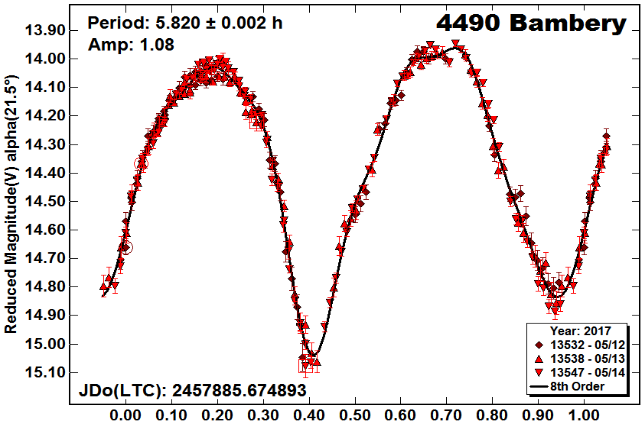
Observations in 2015 (Warner, 2016) suggested that 1656 Suomi might be binary, a secondary period of 12.6 hours with an amplitude of 0.11 mag being found. However, this was based on data from a single night that appeared to show an attenuation due to a satellite occultation/eclipse. Observations at previous apparitions as well as in 2017 found no similar "events."

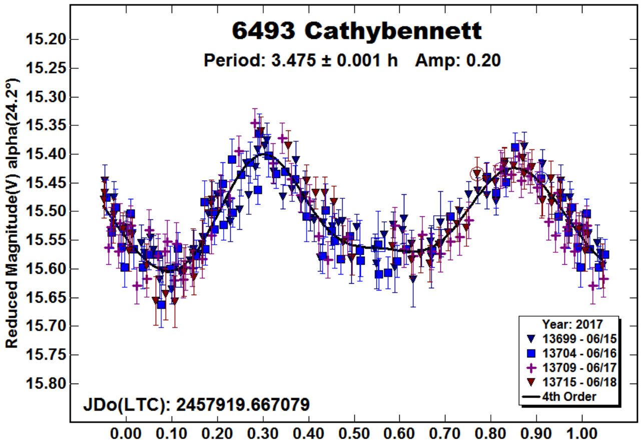
3022 Doberman and 4490 Bambery have always shown large amplitude lightcurves. The 0.49 mag amplitude for 3266 Bernardus in 2017 is a mid-range value between the reported extremes of 0.27-1.14 mag. The 0.20 mag amplitude for 6493 Cathybennett in 2017 fits within the reported range 0.19-0.23 mag.



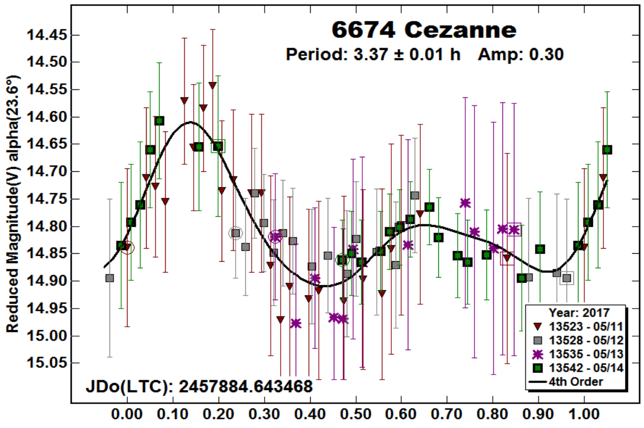






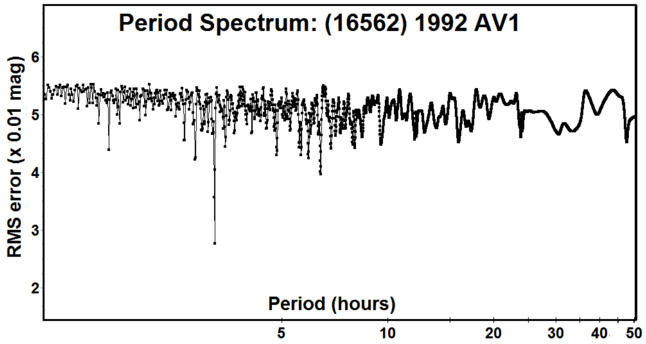


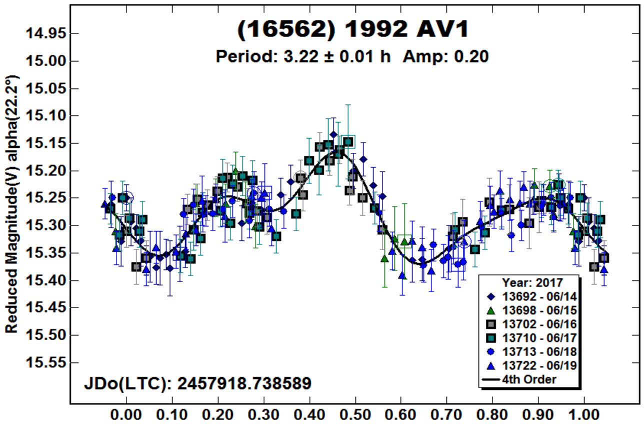
6674 Cezanne. There were no previously reported periods in the LCDB for this Nysa group member. The period of 3.37 h is reasonably secure, but additional observations are needed to confirm this result.

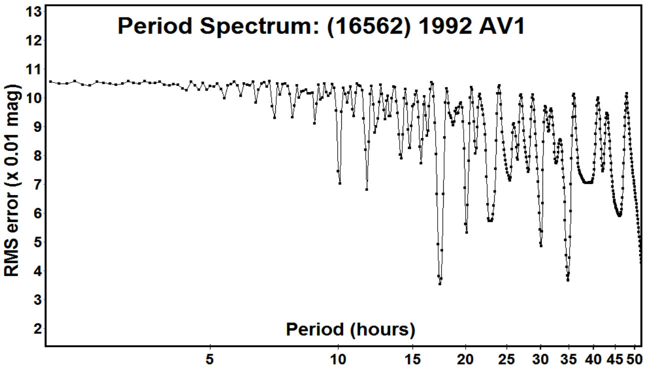


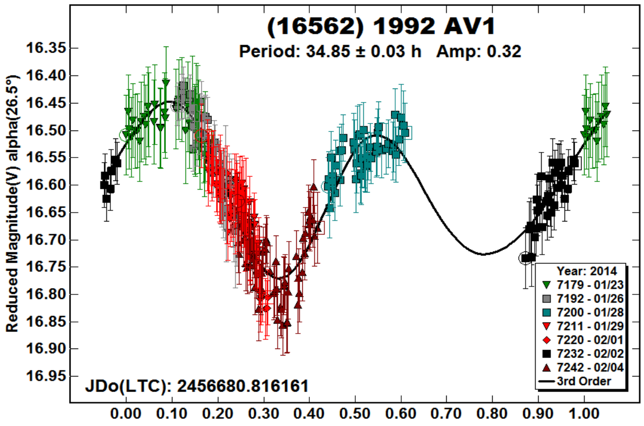
(16562) 1992 AV1. Finding a period for this Hungaria has been difficult. Previous results include Warner (2011b, 12.251 h or 6.51 h; 2014, 20.18 h). The data from 2017 led to entirely different result: 3.22 ± 0.01 h, which is close to the half-period of the alternate solution from 2011, when the amplitude was only 0.04 mag

Such divergent results prompted reviewing images from the previous apparitions to be sure that the same asteroid had been worked each time. After confirming that this was the case, the images from 2014 were measured anew. The revised data set led to a period of 34.85 h with a weak solution near the original period of 20.18 h. There seems to be no reconciliation among the various results. A final solution awaits more data from future apparitions.

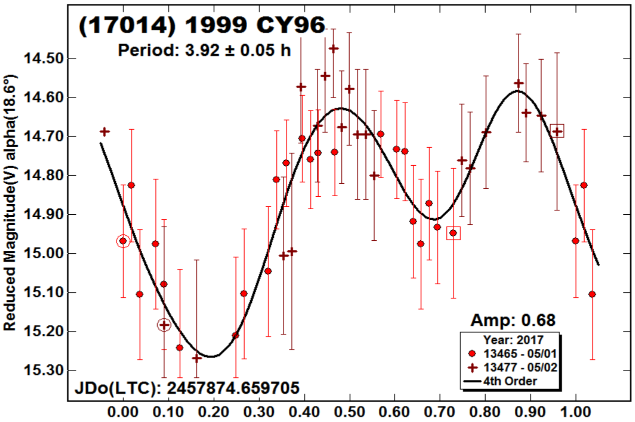




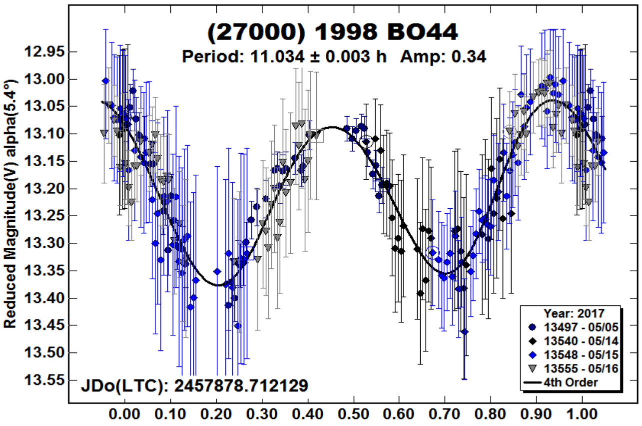




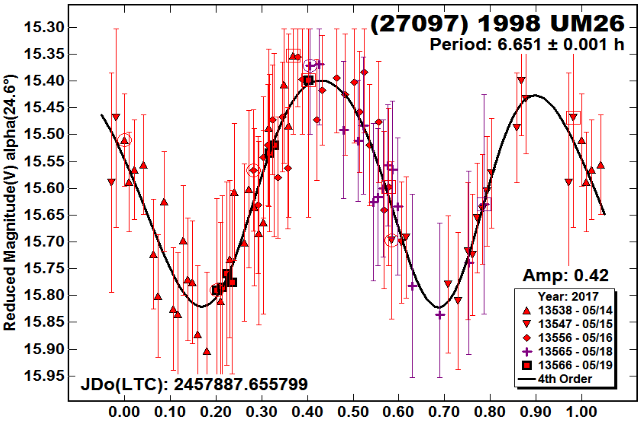
(17014) 1999 CY96. This outer main-belt asteroid was a target of opportunity in the field of a planned target. There were no reported periods in the LCDB.



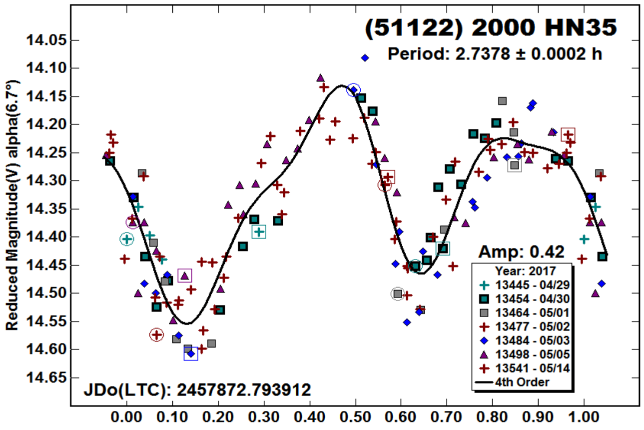
(27000) 1998 BO44. This appears to be the first reported period for this outer main-belt asteroid. The first night's observations were the result of the asteroid being in the same field as a planned target. The subsequent nights were follow-up after work on the planned target was finished.



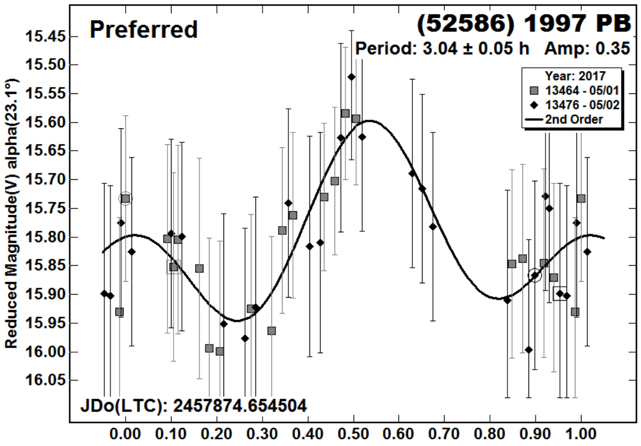
(27097) 1998 UM26. Polishook et al. (2012) using data from four nights obtained by the Palomar Transient Factory reported a period of $P > 8.7$ h and amplitude of $A > 0.07$ mag. The CS3-PDS data from 2017 led to $P = 6.651$ h and $A = 0.42$ mag. This result is considered sufficiently secure to supplant the earlier result.

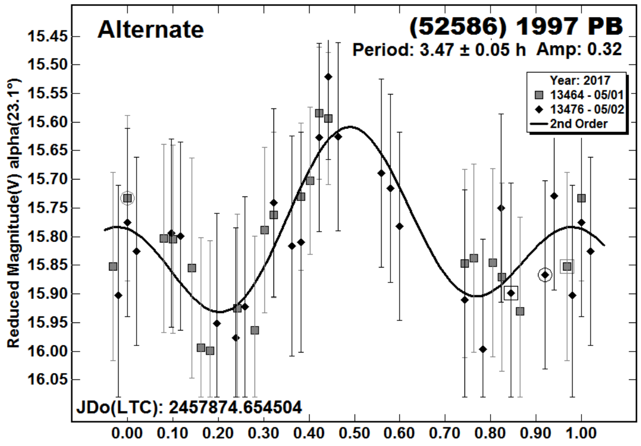


(51122) 2000 HN35. The error bars were very large for these observations (low SNR) and so are not shown in the lightcurve. Despite the larger errors, the result is considered reasonably secure because of the amplitude.



(52586) 1997 PB. This Flora group member was a target of opportunity on two nights. The data set was sparse and noisy, leading to several possible solutions, two of which are shown below. The two periods differ by one rotation over a 24-hour period. There were no other periods given in the LCDB.

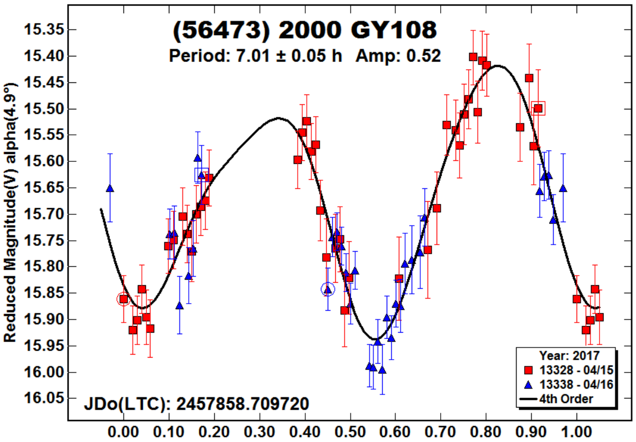




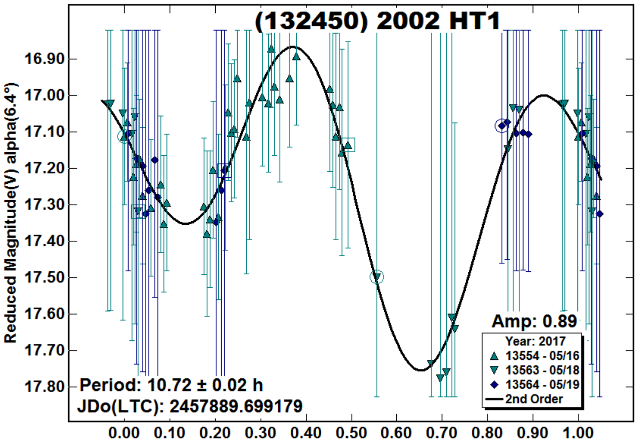
(56473) 2000 GY108. This is also a Flora group member that was a target of opportunity on two nights and had no previously-reported periods in the LCDB. Since each night covered most of the assumed lightcurve, and given the amplitude, the result is considered secure but not definitive.

Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Group
596	Scheila	06/01-06/13	922	0.9,6.6	249	0	15.793	0.005	0.06	0.01	MB-O
1656	Suomi	05/28-05/30	317	19.9,20.0	247	34	2.587	0.001	0.11	0.01	H
3022	Dobermann	06/20-06/26	211	19.1,19.8	261	33	10.329	0.001	0.77	0.02	H
3266	Bernardus	05/11-05/13	317	20.4,20.6	221	34	10.74	0.02	0.5	0.03	H
4490	Bambery	05/12-05/14	246	21.5,21.8	214	36	5.82	0.002	1.08	0.02	H
6493	Cathybennett	06/15-06/18	218	24.2,24.7	232	32	3.475	0.001	0.2	0.02	H
6674	Cezanne	05/11-05/14	75	23.6,23.8	160	4	3.37	0.01	0.3	0.03	NYSA
16562	1992 AV1	06/14-06/19	161	22.2,23.2	233	26	3.219	0.001	0.2	0.02	H
17014	1999 CY96	05/01-05/02	43	18.6,18.7	157	4	3.92	0.05	0.66	0.05	MB-O
27000	1998 BO44	05/05-05/16	217	5.4,4.7,4.8	232	13	11.034	0.003	0.34	0.03	MB-O
27097	1998 UM26	05/14-05/19	85	24.6,24.9	161	4	6.651	0.004	0.42	0.03	BAP
51122	2000 HN35	04/29-05/14	140	6.7,4.9	232	13	2.7378	0.0002	0.42	0.04	MB-O
52586	1997 PB	05/01-05/02	43	23.1,23.3	159	4	3.04	0.05	0.38	0.03	FLOR
56473	2000 GY108	04/16-04/16	73	4.6,4.6	210	6	7.01	0.05	0.52	0.03	FLOR
132450	2002 HT1	05/16-05/19	65	6.4,6.6	236	11	10.7	0.1	0.89	0.05	MB-I
247259	2001 RT98	05/03-05/05	68	11.2,10.8	241	20	6.69	0.01	0.75	0.05	MB-O

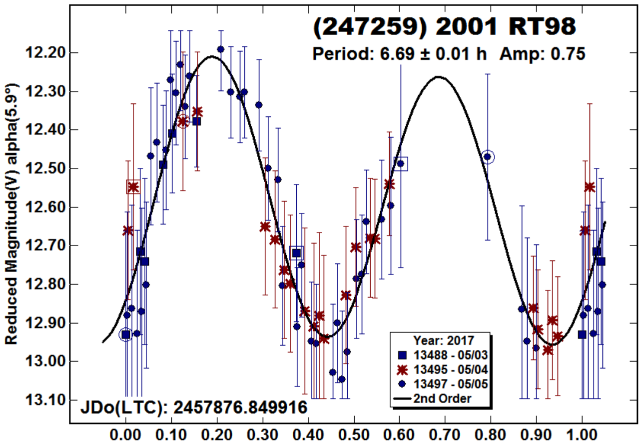
Table II. Observing circumstances and results. The phase angle (α) is given at the start and end of each date range. If three values are given, the middle one is the minimum phase angle during the range of observations. L_{PAB} and B_{PAB} are, respectively, the average phase angle bisector longitude and latitude (see Harris *et al*., 1984). 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*., 2009a). BAP = Baptistina; FLOR = Flora; H = Hungaria; MB-I/O = main-belt inner/outer.



(132450) 2002 HT1. The period spectrum for this 1.4 km inner main-belt asteroid shows several secondary solutions and one primary. However, this is likely a "fit by exclusion," which is where the Fourier analysis finds a minimum RMS by minimizing the number of overlapping data points.



(247259) 2001 RT98. The estimated size of this outer main-belt asteroid is 5.6 km. The period spectrum favored two solutions, a monomodal and bimodal lightcurve. The latter, with a period of 6.69 h, is adopted here. Given the amplitude and low phase angle, this seems a reasonable assumption (Harris et al., 2014).



Acknowledgements

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ROTATION PERIOD DETERMINATIONS FOR 46 HESTIA, 118 PEITHO, 333 BADENIA, 356 LIGURIA, AND 431 NEPHELE

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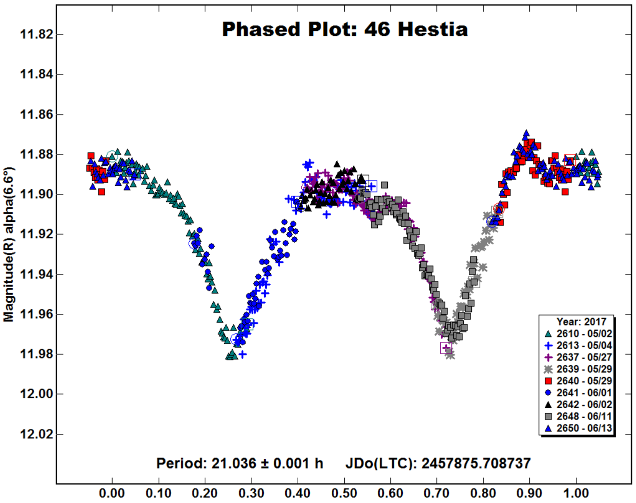
Synodic rotation periods and amplitudes are found for 46 Hestia: 21.036 ± 0.001 h, 0.09 ± 0.01 mag; 118 Peitho: 7.805 ± 0.001 h, 0.14 ± 0.01 mag; 333 Badenia: 9.862 ± 0.001 h, 0.24 ± 0.01 mag; 356 Liguria: 31.701 ± 0.001 h or 63.395 ± 0.002 h, 0.14 ± 0.01 mag; 431 Nephele: 13.530 ± 0.001 h, 0.13 ± 0.01 mag.

Observations to obtain the data used in this paper were made at the Organ Mesa Observatory with a 0.35-meter Meade LX200 GPS Schmidt-Cassegrain (SCT) and SBIG STL-1001E CCD. Exposures were 60 seconds, unguided, with a clear filter. Photometric measurement and lightcurve construction is with *MPO Canopus* software. To reduce the number of points on the lightcurves and make them easier to read, data points have been binned in sets of 3 with a maximum time difference of 5 minutes.

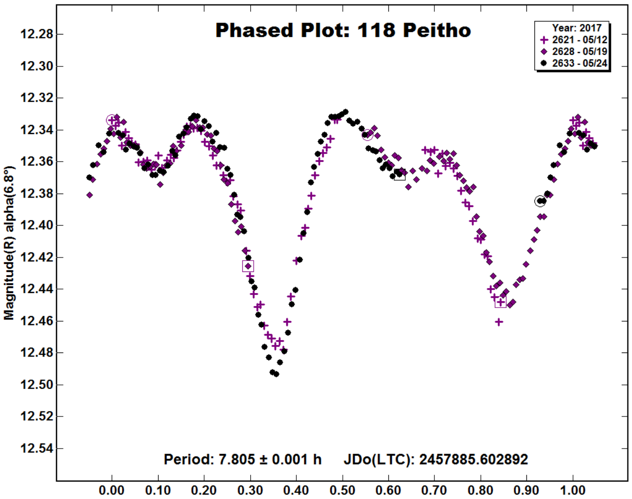
46 Hestia. Previously published rotation periods are by Scaltriti et al. (1981), 21.04 hours at celestial longitude 57 degrees; and by Pilcher (2012), 21.040 hours at celestial longitude 160 degrees. The lightcurves look almost identical with one deep minimum and one shallow minimum and amplitude 0.13 magnitudes.



New observations were obtained on eight nights from 2017 May 2 to June 13 near celestial longitude 235 degrees. They provide a good fit to a lightcurve with an almost identical period 21.036 ± 0.001 h, but with smaller amplitude 0.09 ± 0.01 mag and two minima of nearly the same depth.

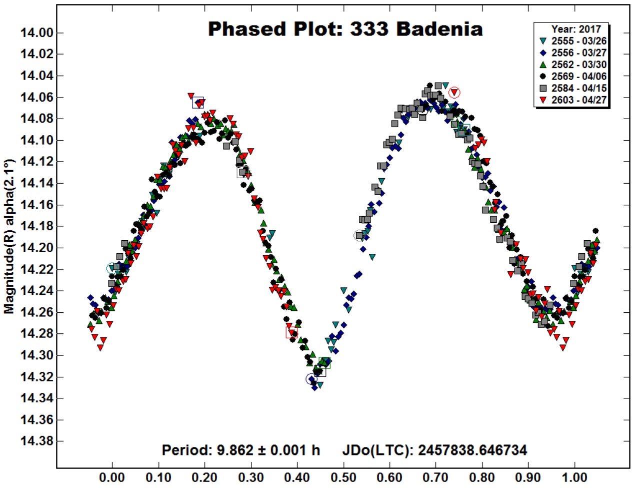
118 Peitho. The Asteroid Lightcurve Data Base (Warner et al., 2009) lists five independent published periods all between 7.78 hours and 7.823 hours, with the best value considered as 7.8055 hours.

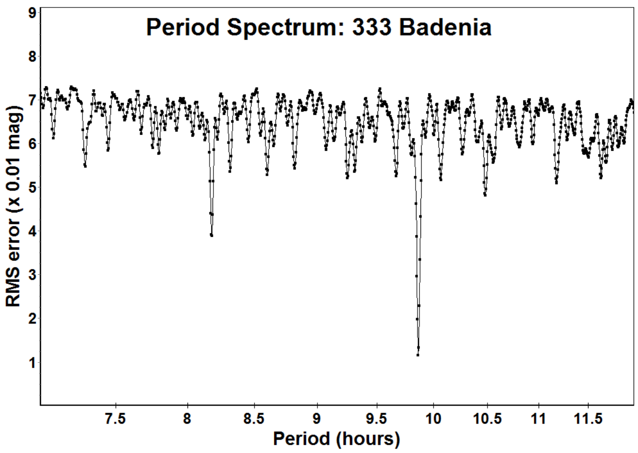
New observations on three nights from 2017 May 12-24 provide a good fit to a lightcurve with period 7.805 ± 0.001 h, amplitude 0.14 ± 0.01 mag. This is in excellent agreement with earlier results.



333 Badenia. Previously published periods cluster around two different values. Those near 8.19 h are Blanco et al. (2000), 8.160 h; Behrend (2005), 8.192 h; Behrend (2006), 8.19 h; and Behrend (2014), 8.2 h. Near to 9.86 hours are Denchev et al. (1999, republished 2000), 9.96 h; and Aznar et al. (2016), 9.860 h. It should be noted that six cycles of 8.2 hours each is 49.2 hours while five cycles of 9.86 hours each is a nearly identical 49.3 hours. Both are slightly more than two days. For a short interval of observation, an equally good fit can be made to both periods. This explains the ambiguity in the earlier observations.

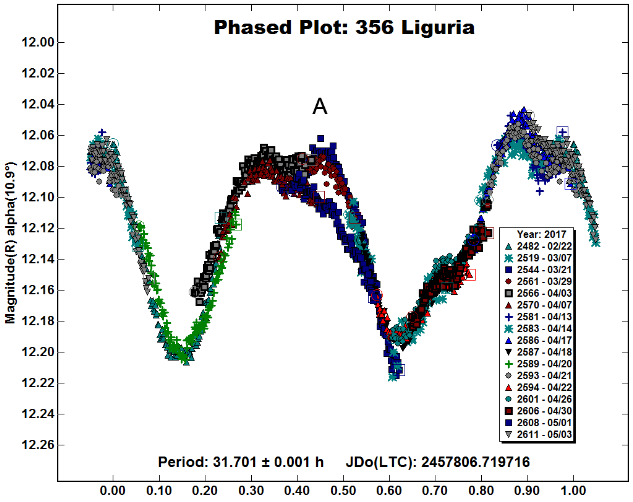
New observations on six nights over the much longer interval of one month, 2017 Mar. 26 – Apr. 27, resolve the ambiguity. They provide an excellent fit to a lightcurve with a period of 9.862 ± 0.001 h, amplitude 0.24 ± 0.02 mag. The period spectrum is also provided, which shows that a period near 8.2 hours can be rejected.



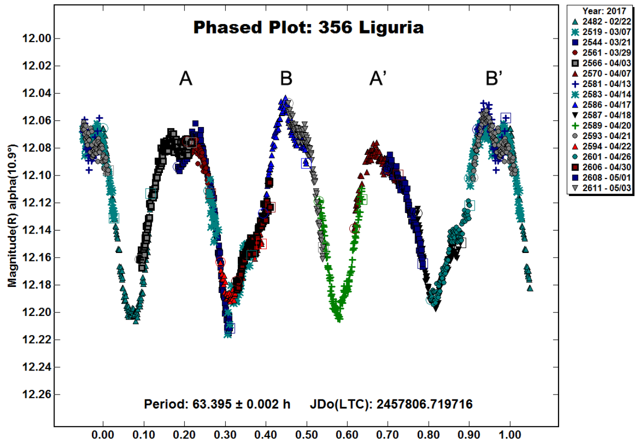


356 Liguria. The only previously published period is by Harris and Young (1980), 31.82 h with amplitude 0.22 mag. This is very close to 4/3 of the Earth's rotation period. With this commensurability, observations should begin several weeks before opposition (2017 Mar. 20) and continue until several weeks afterward. The first new session was obtained on 2017 Feb 22. Due to the need to observe other targets and bad weather, only five sessions were obtained through April 3, and frequent observation did not begin until April 13.

To cover the entire lightcurve, individual sessions of at least eight hours in duration are needed. This is possible near opposition at the declination of the target but not post opposition, i.e., April 13 – May 2. The total of 17 sessions 2017 Feb. 22 – May 3 are therefore poorly spaced in time.



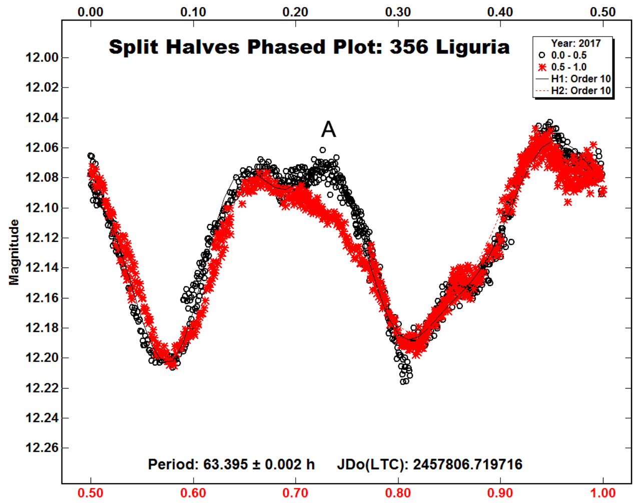
Lightcurve of 356 Liguria phased to 31.701 hours and based on all sessions 2017 Feb. 22 - May 3.



Lightcurve of 356 Liguria phased to 63.395 hours and based on all sessions 2017 Feb. 22 - May 3.

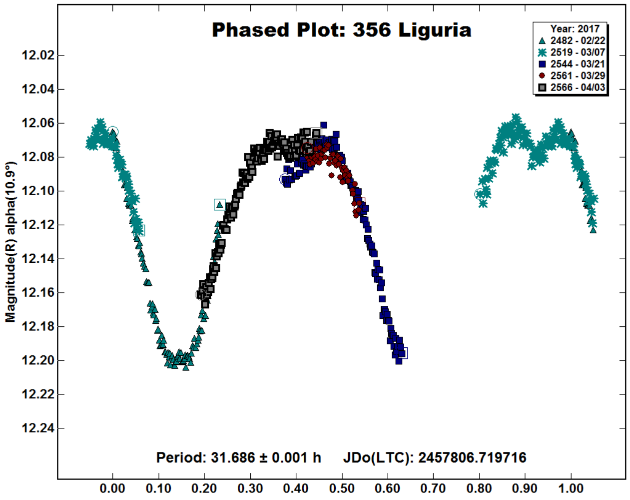
The complete data set including all 17 sessions may be interpreted either in terms of a 31.701 hour period or a 63.395 hour period; results for each period are shown in accompanying figures.

When plotted to the longer period, the lightcurve has four maxima and minima. Alternate maxima denoted A, A' have different appearances; alternate maxima denoted B, B' are slightly different; all minima look the same within reasonable photometric error. A plot to 31.701 hours produces the usual bimodal lightcurve in which the two maxima A, A' in the double period appear as a single maximum A and show significant discordance. All other corresponding segments of the double period lightcurve superpose well.

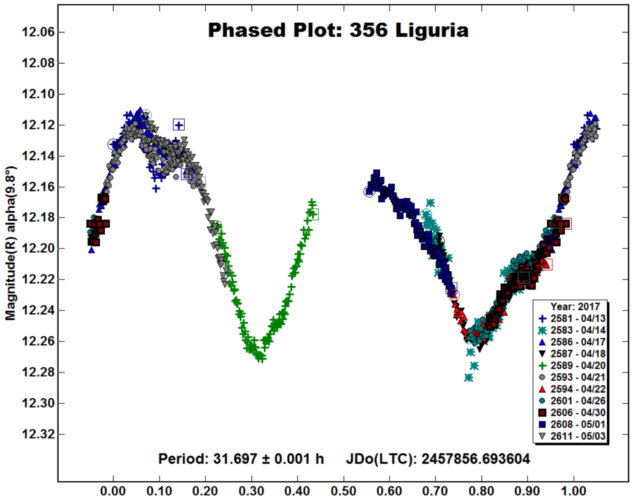


Split halves plot for 356 Liguria phased to 63.395 hours and based on all sessions 2017 Feb. 22 - May 3.

A split halves plot (above) of the double period shows appreciable distinction between the two halves only in the maximum A. The discordance at A might favor an interpretation for the double period 63.395 hours, but the similarity of other parts of the lightcurve makes this interpretation less likely. The change in the maximum at A may be related to changes in phase angle.



Lightcurve of 356 Liguria phased to 31.686 hours and based on five sessions 2017 Feb. 22 - Apr. 3.



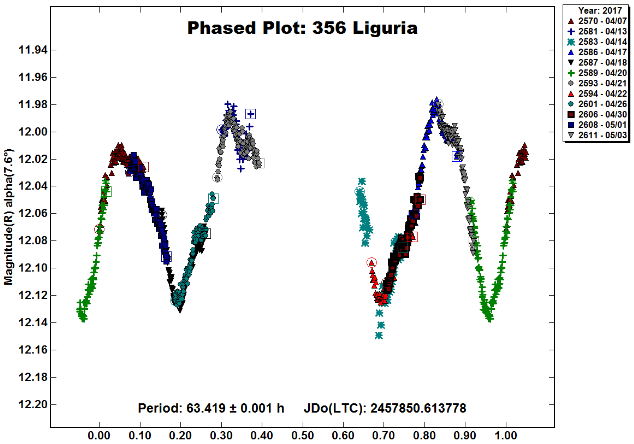
Lightcurve of 356 Liguria phased to 31.697 hours and based on eleven sessions 2017 Apr. 13 - May 3.

As shown in the accompanying figures, lightcurves plotted to near 31.7 hours separately for the five sessions 2017 Feb. 22 – Apr. 3 and for 11 sessions 2017 Apr. 13 – May 3 both lack full phase coverage but have no significant misfits. The lightcurve as shown plotted to near 63.4 hours for 12 sessions 2017 Apr. 7 – May 3 has a large data gap, but available segments separated by one half

Number	Name	2017/mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp.	A.E.
46	Hestia	05/02-06/13	1894	6.6,4.7,7.3	236	2	21.036	0.001	0.09	0.01
118	Peitho	05/12-05/24	800	6.8,11.5	216	1	7.805	0.001	0.14	0.01
333	Badenia	03/26-04/27	1713	2.1,0.9,7.9	192	-1	9.862	0.001	0.24	0.02
356	Liguria	02/22-05/03	5060	10.9,0.7,15.1	179	-1	31.701	0.001	0.14	0.01
431	Nephele	04/09-05/21	3854	12.1,0.8,1.9	236	2	13.530	0.001	0.13	0.01

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date, unless a minimum (second value) was reached. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).

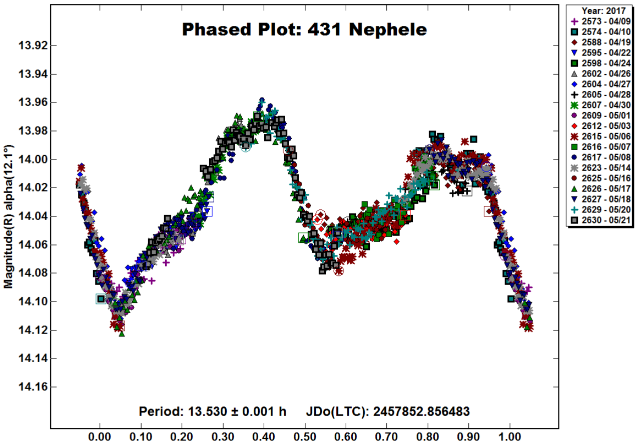
cycle have no significant differences. A lightcurve plotted to near 63.4 hours for five sessions 2017 Feb. 22 – Apr. 3 is too fragmentary to provide information useful for resolving the period ambiguity. The maximum A in the 63.395 hour plot is defined by session 2544, March 21, 0.7 degrees phase angle; and session 2561, March 29, 4.0 degrees phase angle. The maximum A' in the 63.395 hour plot is defined by sessions at larger phase angle: session 2570, April 7, 7.6 degree phase angle; and session 2608, May 1, 15.1 degrees phase angle. These data support a 31.70 hour period with the commonly encountered change of lightcurve shape with changing phase angle.



Lightcurve of 356 Liguria phased to 63.419 hours and based on twelve sessions 2017 Apr. 7 - May 3.

Summary and future work. I consider a period of 31.701 hours with the usual bimodal lightcurve whose shape changes with changing phase angle to be more likely, but cannot rule out the 63.395 hour period with four maxima and minima per cycle. Since the interval of observation is much longer than that published by Harris and Young (1980), the 31.701 hour period improves upon the 31.82 hours in this source. With a period nearly 4/3 or 8/3 of Earth period, single sessions of at least 8 hours are an absolute minimum for full phase coverage. As data near the start or end of a session commonly have reduced photometric accuracy, single sessions of 10 hours or longer are desired for good overlap. An opportunity for such observations is presented near the 2021 Jan. 1 opposition near declination +37 degrees. Complete phase coverage of the double period near 63.4 hours should be achieved in a short time interval in which there is very small change in the phase angle. Observations at widely separated longitude, that is a global collaboration, are strongly encouraged.

431 Nephele. Previously published periods are by Behrend (2002), 21.43 h; and Wang et al. (2010), 18.821 h. New observations on 20 nights from 2017 Apr. 9 – May 21 provide a good fit to a lightcurve with period 13.530 ± 0.001 h, amplitude 0.13 ± 0.01 mag, and rule out both previously published periods.



Acknowledgment

The author thanks Alan W. Harris for assistance in analyzing the data for 356 Liguria.

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ROTATION PERIOD FOR (332660) 2008 WL7

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The asteroid (332660) 2008 WL7 was observed on 2017 March 8. The synodic period was found to be 2.54 ± 0.15 h.

The outer main-belt asteroid (332660) 2008 WL7 was observed on 2017 March 8 for about 2.5 hours with the 2.12-m *f*/7.5 Ritchey-Chretien telescope of the National Astronomical Observatory in San Pedro Mártir-Mexico (OAN-SPM). The CCD camera was a Spectral with 2048x2048x13.5 micron pixels that was binned 2x2. This configuration gave a field-of-view of approximately 6x6 arcmin and an image scale of 0.176 arcsec/pix. An R filter was used; the exposure time was 90 s.

The calibration images were reduced using *IRAF* (Image Reduction and Analysis Facility). For photometry we used *MaxIm DL* (Diffraction Limited). The raw plot of the data shows the magnitude versus light-time corrected UT. The relative magnitude was obtained by subtracting the instrumental magnitude of the asteroid from that of a comparison star in the same field that was about the same brightness as the asteroid.

The phased lightcurve shows that full coverage was obtained on the single night. The peak-to-peak amplitude is about 0.10 mag. The period was found fitting a Fourier series to the data following the methodology of Harris et al. (1989). The best solution was obtained with fourth-order fit with a period of 2.54 ± 0.15 h. A search of the asteroid lightcurve database (Warner et al., 2009) did not find a previously reported result. The observational circumstances and results are summarized in Table I.

Acknowledgements

This work was possible thanks to CONIDA, the Institute of Astronomy of the UNAM, and Universidad Autónoma de Nuevo León (UANL). This work was based upon observations carried out at the Observatorio Astronómico Nacional on the Sierra San Pedro Mártir (OAN-SPM), Baja California, México.

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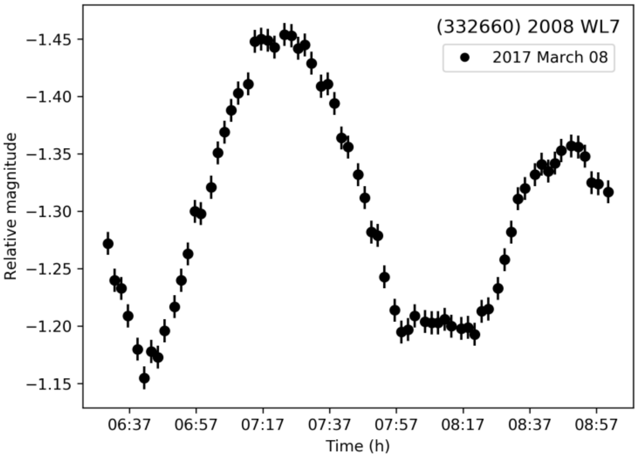

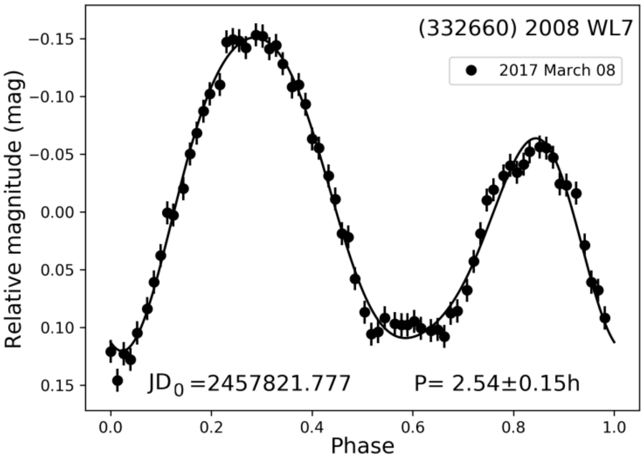

Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
332660	2008 WL7	08/03	69	8.75,8.67	195	4	2.54	0.15	0.10	0.01	MB

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

LIGHTCURVE ANALYSIS FOR 341 CALIFORNIA, 594 MIREILLE, 1115 SABAUDA, 1504 LAPPEENRANTA, AND 1926 DEMIDDELAER

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(Received: 2017 May 11)

Synodic rotation periods were determined for five main-belt asteroids: 341 California, 317 h with suspected tumbling; 594 Mireille, 4.9671 ± 0.0004 h; 1115 Sabauda, 6.7165 ± 0.0007 h; 1504 Lappeenranta, 15.16 ± 0.01 h; and 1926 Demiddelaer, 32.095 ± 0.027 h. All the data have submitted to the ALCDEF database.

CCD photometric observations of five main-belt asteroids were performed at Command Module Observatory (MPC V02) in Tempe and the Lowell Observatory Anderson Mesa Station (MPC 688) outside Flagstaff. Images at V02 were taken using a 0.32-m *f*/6.7 Modified Dall-Kirkham telescope, SBIG STXL-6303 CCD camera, and either a Cousins R or 'clear' glass filters. Exposure times for all the images were 3 minutes. The image scale after 2x2 binning was 1.76 arcsec/pixel. Images taken at 688 employed the 0.7-m *f*/8 telescope, which has a CCD camera system designed and built in the Lowell instrument shop (Buie, 2010). The image scale was 0.91 arcsec/pixel with 2x2 binning. Either Johnson V or Cousins R filters were used for the asteroid observations. Table I shows the observing circumstances and results.

The V02 images were calibrated using a dozen bias, dark, and flat frames. Flat-field images were made using an electroluminescent panel. The 688 data made use of 20 full-frame biases and 15 or more twilight flats taken each night under an automated exposure routine with the telescope aimed at the 'Chromey spot' (Chromey et al., 1996), tracked at the sidereal rate but dithered 30" between frames. The thinned, back-illuminated e2v CCD was kept at roughly –110° C using a Cryotiger chiller and so had negligible dark current.

The data reduction and period analysis were done using *MPO Canopus* (Warner, 2017). The asteroid and three to five comparison stars were measured, preserving comp stars among adjacent nights if possible (more readily done with the 45'x30' field of the V02 CCD). We attempted to keep the comparison star colors within the range roughly 0.5 < B-V < 0.95, or equivalent "asteroidal" color-ranges in other photometric systems, though this was not always possible. In order to reduce the internal scatter in the data, we typically chose the brightest stars of appropriate color that had peak ADU counts below the range where chip response becomes nonlinear in both cameras.

Although the *MPO Canopus* internal star catalogue helped in selecting comp stars, we adopted magnitudes from a combination of CMC15 (Muiñoz et al. 2014), APASS DR9 (Munari et al. 2015), GAIA1 G magnitudes (Sloan r´ = G + 0.066 for stars of asteroidal color), as well as the original SDSS DR7 (Abazajian et al., 2009) and Pan-STARRS (Magnier et al., 2016) catalogues (for faint stars only) to set the zero-points each night. This process took into consideration the number of nights of measurement and the internal scatter reported in the catalogues. We also checked for obvious variables in the TASS MkIV survey (Droege et. al., 2006) and in VSX (Watson et al., 2006). For V-band photometry the ASAS-3 (Pojmanski 2002) catalogue was also queried. These data were found using the CDS VizieR catalogue-query service (VizieR, 2017), the ASAS-3 query page, and the Pan-STARRS search page at the Space Telescope MAST archive. In most regions the Sloan r´ data sources for brighter stars yielded very similar magnitudes (within about 0.05 mag total range), so we took mean values rounded to 0.01 mag precision. We usually adopted only the higher-accuracy Pan-STARRS or SDSS DR7 data for stars fainter than about r´ = 13.5 and 15.0, respectively.

This careful adjustment of the comp star magnitudes and color-indices allowed the separate nightly runs to be linked often with no zero-point offset required, or shifts of only a few hundredths of a magnitude in a series.

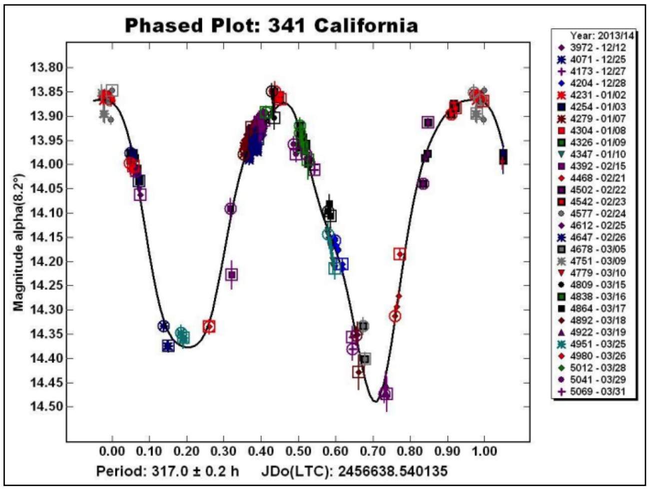
Nearly always we used 9-pixel (16 arcsec) diameter measuring apertures for the V02 data. The apertures used on the 0.7-m data varied depending on seeing, but were typically 13 or 15 pixels (12 or 14 arcsec) diameter. When necessary we made use of the *MPO Canopus* 'Star-B-Gone' feature to subtract the effects of contaminating field stars, usually successfully. For most of the asteroids described here, we note the RMS scatter on the phased lightcurves, which gives an indication of the overall data quality including errors from the calibration of the frames, measurement of the comp stars, the asteroid itself, and the actual period-fit.

The uncertainties on the period-determination are from the *MPO Canopus* Fourier-type FALC fitting method (cf. Harris et al., 1989). It is worth noting that recently Dykhius et al. (2016, their Appendix B) have checked the reliability of the error estimates resulting from the FALC method, and find from Monte Carlo tests that they are realistic one-sigma errors.

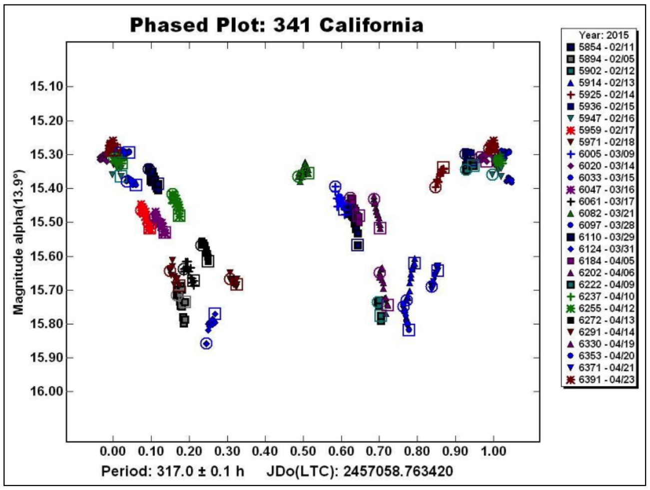
The Asteroid Lightcurve Database (LCDB; Warner et al., 2009) was consulted to locate previously published results. Finally, we note that all our new data are deposited in the ALCDEF database.

341 California. This Flora-family asteroid was discovered in 1892 by Max Wolf at Heidelberg. Due to its slow rotation, the correct period was poorly determined until recently. Behrend (2005) first reported a period of 8.74 ± 0.05 h. This, however, was based on only two isolated nights in 2005; a single follow-up night in 2008 January yielded the same erroneous period (Behrend, 2008). Skiff (2014) reported a preliminary result, to be described below, showing the period to be nearly two weeks long. More recently Pilcher et al. (2017) acquired an excellent, uniform six-month series in the second half of 2016. This allowed them to confirm that the principal rotation period near 317 h reported by Skiff was correct, and to identify a secondary "tumbling" period of some 250 h.

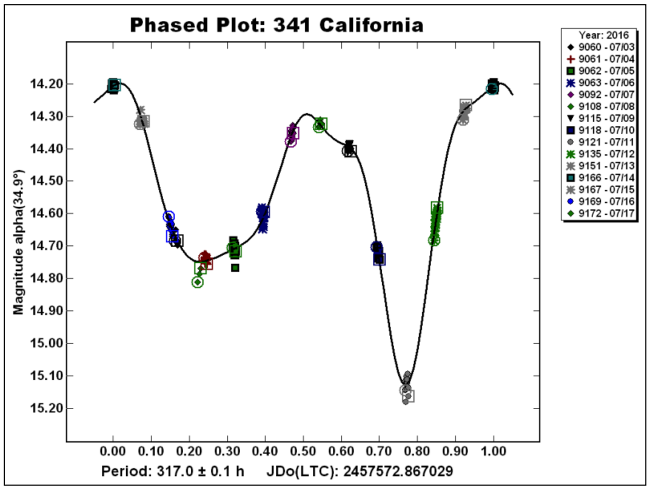
The asteroid was followed from 2013 December through 2014 March at Lowell using the LONEOS 0.55-m *f*/1.9 Schmidt camera (MPC 699) for the first two nights only (unfiltered), and then the 0.7-m telescope (Rc filter) in robotic mode for the remaining 28 nights. Since the period was clearly going to be long, data were obtained on several discrete visits each night rather than making continuous runs, similar to what Pilcher et al. have done. The resulting lightcurve showing a period of 317 hours was posted to the CALL site (Skiff 2014). At the time the data were reduced approximately to the Sloan r´ system, which has now been revised for both telescopes using more recent photometric catalogues. The first phased plot shows the data from the 2014 apparition with an order-6 fit. The correction to the magnitudes of the comp stars reduces the observed brightness range to 0.58 mag. (originally 0.75 mag.).



Another series using the 0.7-m telescope and V filter was obtained the following year, 2015 Feb-Apr. The data were adjusted as closely as possible to standard Johnson V magnitudes. The lightcurve for this apparition shows much stronger effects from tumbling. The second phased plot is a force-fit to the 317-hour period, where the tumbling effects are obvious. The brightness range is about 0.54 mag.



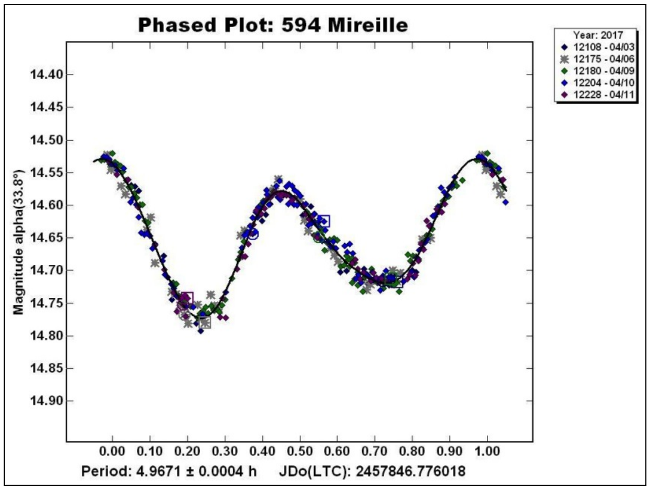
Taking advantage of anomalously clear summer weather in the Southwest US, a third run of 656 data points was acquired at V02 on fourteen consecutive nights beginning on 2016 July 3. The data thus cover just one cycle. Again we show a force-fit to the 317 h period. The data, taken mainly in groups of three 3-minute exposures, are binned here into 10-minute means. The magnitude scale is Sloan r´ and the full amplitude is 0.92 mag. at this higher phase angle.



Three additional isolated nights in 2016 were obtained at V02 and at 688 to seek short-period variations (*cf.* Warner, 2016). Like Pilcher *et al*., we found none. These are included in the ALCDEF files.

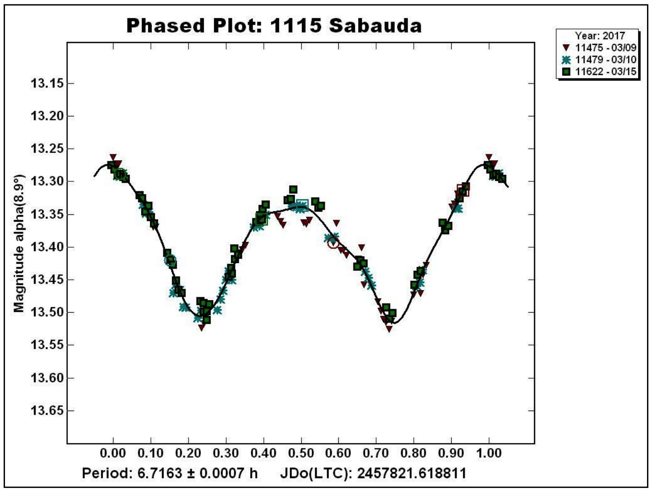
594 Mireille. This asteroid was discovered in 1906, also by Max Wolf at Heidelberg. The orbit has moderately high inclination and eccentricity. The only previous period determination was by Wisniewski (1991), who found a period of 4.966 h and an amplitude of 0.18 mag from observations in early 1988.

We obtained 352 data points from both V02 and 688 on five nights in 2017 April with the asteroid at +50° ecliptic latitude, well north in the morning sky. All data were reduced to Sloan r´. These yielded a rotation period of 4.9671 ± 0.0004 h, in excellent agreement with Wisniewski's period. The lightcurve morphology is similar to that of Wisniewski. The full amplitude is 0.25 ± 0.01 mag; the RMS scatter on the order-4 fit shown in the phased plot is 0.012 mag.



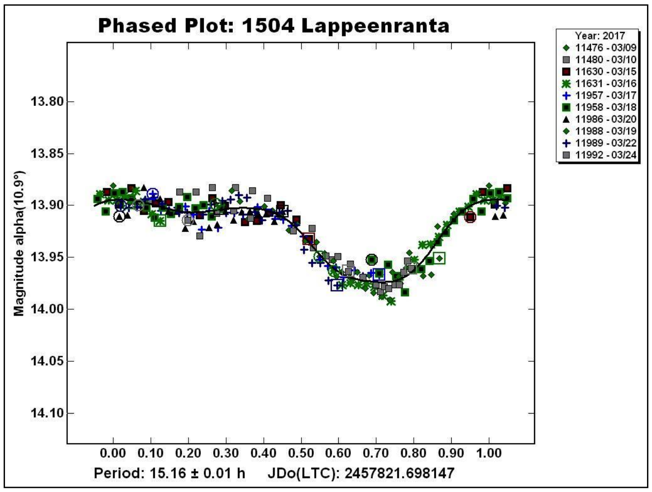
1115 Sabauda. This outer main-belt asteroid was discovered in 1928 by Luigi Volta at Pino Torinese. Four similar rotational periods have been published. Warner (2006) obtained a period of 6.72 ± 0.01 h. Behrend (2005) and Behrend (2015) show results of 6.75 ± 0.01 h and 6.66 ± 0.02 h, respectively. Finally, Ruthroff (2013) shows a period of 6.72 ± 0.01 h.

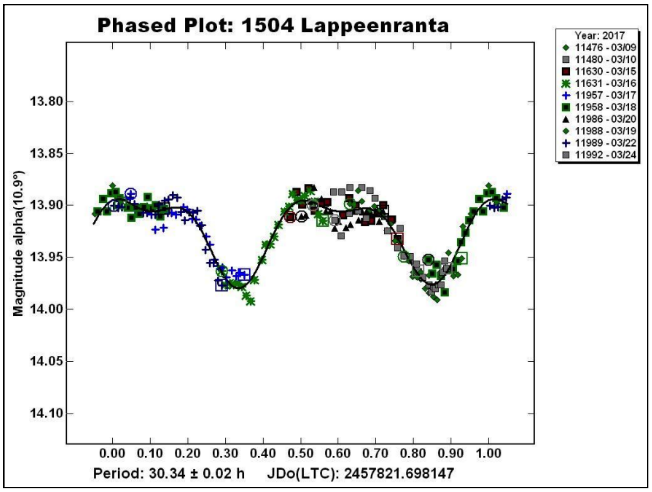
Sufficient data to produce a lightcurve for 1115 Sabauda was secured on three nights at V02 in 2017 March. From 146 data-points we find a period of 6.7165 ± 0.0007 h, in close agreement with the previous results. The phased plot shows an order-6 fit, which has a full amplitude of 0.22 ± 0.01 mag, and RMS scatter of 0.011 mag.



1504 Lappeenranta. This is an inner main-belt asteroid, discovered by Liisi Oterma at Turku in 1939. The LCDB shows four disparate rotational periods with the highest 'U' value only 2+. Binzel (1987) published a period of 10.44 ± 0.10 h and amplitude 0.29 mag from just sixteen measurements on three consecutive nights at McDonald Observatory. Results from Behrend (2002, 2006) are given approximately as 8 h. Most recently Garlitz (2013) derived a period of 15.190 ± 0.009 h and amplitude 0.22 mag.

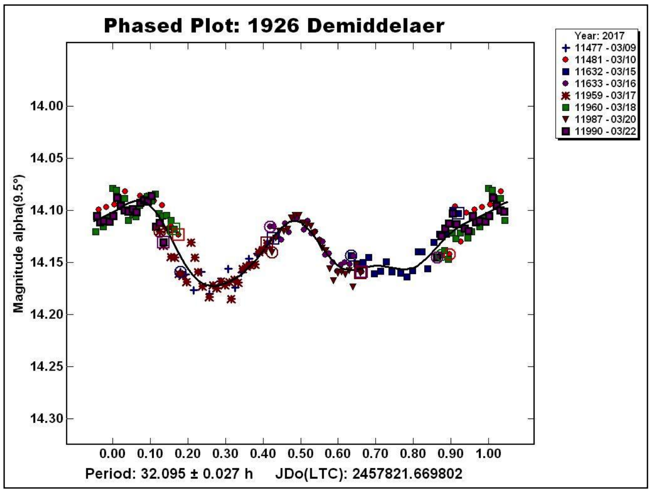
A total of 637 images from ten nights at V02 in 2017 March were used to determine the period of rotation of 1504 Lappeenranta. Both single and double-mode fits produced acceptable solutions. We therefore show two phased lightcurves, one for 15.16 ± 0.01 h and 30.34 ± 0.02 h. Both plots have the groups of 3 x 3-minute exposures averaged into 10-minute bins. While the single-mode period agrees with Garlitz, the lightcurve morphology differs significantly. The amplitude during 2017 March was only 0.09 ± 0.01 mag, and the RMS scatter on both fits is 0.009 mag.





1926 Demiddelaer. This Eunomia-family asteroid was discovered by Eugène Delporte at Uccle in 1935. Only one period determination has been published, that of Behrend (2008), who computed 18.5 ± 0.3 h.

During eight nights in 2017 March, 525 images of 1926 Demiddelaer were acquired at V02. An unambiguous period of 32.095 ± 0.027 h was computed from these, which differs substantially from the previously published one. The phased plot shows an order-5 fit to the data binned into 10-minute averages. The amplitude is again small, only 0.08 ± 0.01 mag, and the RMS scatter on the fit is 0.010 mag.



Acknowledgments

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Number	Name	20yy/mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.	Obs
341	California	13/12/12-14/03/31	1284	8.3,24.4,22.0	77	5	317.0	0.2	0.58	0.03	BS
341	California	15/02/11-15/04/23	375	21.8,2.1,17.4	173	4	317.0	0.1	0.54	0.03	BS
341	California	16/07/03-16/07/17	656	34.9,34.1	355	-5	317.0	0.1	0.92	0.03	TP
594	Mirelle	17/04/03-17/04/11	352	33.8,33.7	165	20	4.9671	0.0004	0.25	0.01	TP,BS
1115	Sabauda	17/03/09-17/03/15	146	8.9,9.5	235	42	6.7163	0.0007	0.22	0.01	TP
1504	Lappeenranta	17/03/09-17/03/24	637	10.9,9.9,10.5	177	16	15.16	0.01	0.09	0.01	TP
1504	Lappeenranta	17/03/09-17/03/24	637	10.9,9.9,10.5	177	16	30.34	0.02	0.09	0.01	TP
1926	Demiddelaer	17/03/09-17/03/22	525	9.5,9.4,10.4	172	18	32.095	0.027	0.08	0.01	TP

Table I. Observing circumstances and results. The phase angle (α) is given at the start and end of each date range, unless it reached a minimum or maximum, which is then the second of three values. LPAB and BPAB are each the average phase angle bisector longitude and latitude (see Harris et al., 1984). The Obs. column gives the observer.

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ROTATION PERIOD DETERMINATION FOR 213 LILAEA

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CCD photometry of 213 Lilaea in April-May 2017 yields a synodic rotation period 12.042 ± 0.001 hours and a lightcurve amplitude of 0.20 ± 0.02 magnitudes.

Two previously published rotation periods of 213 Lilaea are both based on sparse lightcurves covering only a short time interval. These periods are by Zeigler (1987), 7.85 hours; and by Di Martino et al. (1995), 8.045 hours. A. W. Harris and B. D. Warner examined the lightcurve by Di Martino et al. (1995), considered their 8.045 hour period to be unreliable, and recommended a more comprehensive study. Observations from a wide range of geographical longitudes (Franco in Europe, Phillips Academy Observatory in eastern North America, and Pilcher in western North America) were necessary to achieve full phase coverage for a period very nearly Earth commensurate.

Pilcher at Organ Mesa Observatory used a 35 cm Meade LX200 GPS, SBIG STL-1001E CCD, clear filter. Franco at Balzaretto Observatory used a 20 cm Meade LX200 SCT, SBIG ST7XME CCD. The Phillips Academy Observatory used a 40 cm DFM Engineering f/8 R-C, Andor Tech iKon DW 436C CCD, clear filter.

Observations on eleven nights 2017 Apr. 5 – May 11 provide a good fit to an irregular lightcurve with period 12.042 ± 0.001 hours, amplitude 0.20 ± 0.02 magnitudes. A period spectrum is also provided, and a period near 8.045 hours is definitively ruled out.

Acknowledgments

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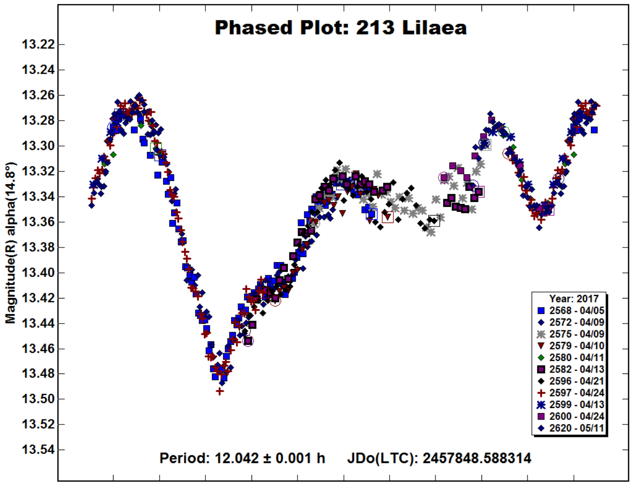

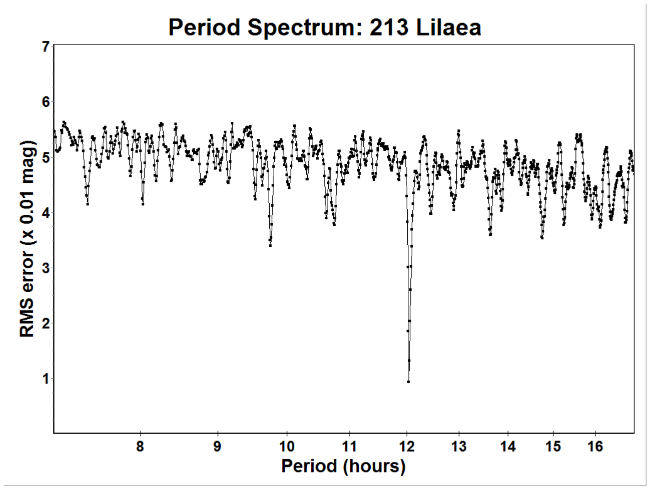

Number	Name	2017/mm/dd	Pts	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.
213	Lilaea	04/05-05/11	1342	14.8, 20.4	156	+5	12.042	0.001	0.20	0.02

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first date and last date. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).

LIGHTCURVE OBSERVATIONS OF NINE MAIN-BELT ASTEROIDS

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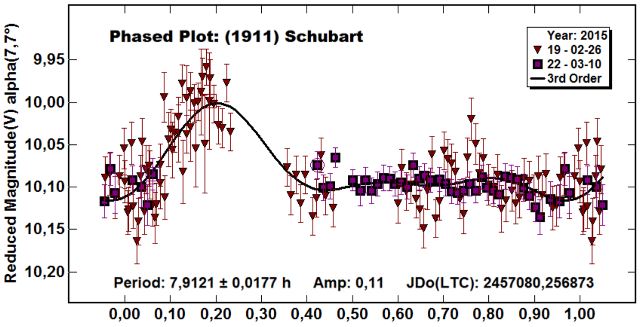
Photometric observations of nine main-belt asteroids were obtained in 2014-2016. The selected objects all had unusually favourable apparitions. Lightcurves and rotation periods are presented for 1911 Schubart, 2042 Sitarski, 2383 Bradley, 3000 Leonardo, 4974 Elford, 5471 Tunguska, 8679 Tingstäde, (16206) 2000 CL39 and (24691) 1990 RH3.

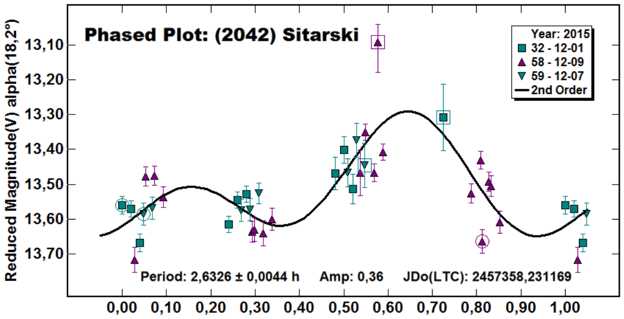
The observations of nine main-belt asteroids were carried out at Lindby Observatory (MPC code K60) in southernmost Sweden. Images were obtained with a 0.25-m *f*/10 Schmidt-Cassegrain (SCT) operating at *f*/4.6, a Starlight Xpress SXV-H9 CCD camera, and a clear imaging filter. The pixel scale was 2.3 arc seconds and image exposure times were 45, 120 or 180 seconds. All images were calibrated with bias, flats and darks. Lightcurve analysis and photometric reduction to the V filter band were made with *MPO Canopus* software using the MPOSC3 star catalog and the Photometry Magnitude Method (Warner 2014). With the *Canopus* Comparison Star Selector, up to five comparison stars with near-solar colors were used to derive differential magnitudes for each image. Within *Canopus*, the FALC routine (Harris *et. al.*, 1989) was used to fit multi-night observations and compute synodic rotation periods for the targets.

The observations and targets are summarized in Table I. Using the CALL web site, targets were selected primarily near favourable oppositions and had neither notified nor submitted previous observations. Unless otherwise noted, a search of the asteroid lightcurve database (LCDB; Warner et al. 2009) and the web identified no previously reported lightcurves of these objects.

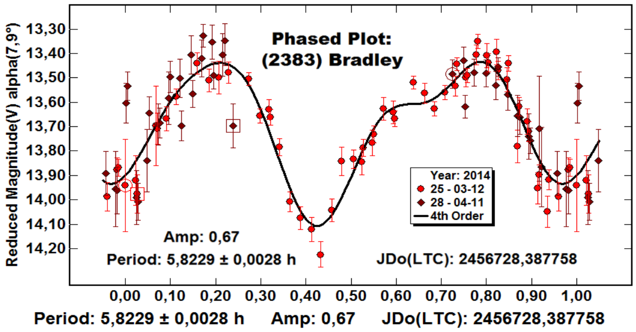
1911 Schubart. This is a well-observed target with a single-peak light curve of small amplitude, 0.11 mag. The reported period of 7.91 h is covered fully in one of the observing sessions and has a pronounced RMS minimum. Black et al. (2016) and Hess et al. (2016) observed this target but did not report a period. Stephens (2016) reported a period of 11.915 h based on a longer time series; this period cannot be verified with the present data.



2042 Sitarski. A period of 2.63 h and an amplitude of 0.36 mag were found for this object from three nights of observations. One session covers the full period and indicates a bimodal and highly asymmetric light curve. A competing period of 2.78 h was found with nearly as low RMS. More observations are needed.



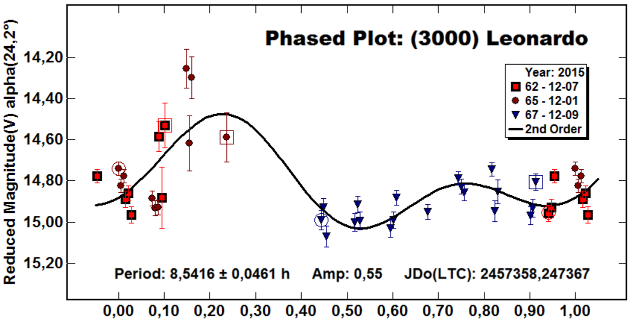
2383 Bradley. This object clearly has an asymmetric bimodal lightcurve that is well-determined with good overlap between the two sessions. The period is 5.83 h with 0.67 mag. amplitude.



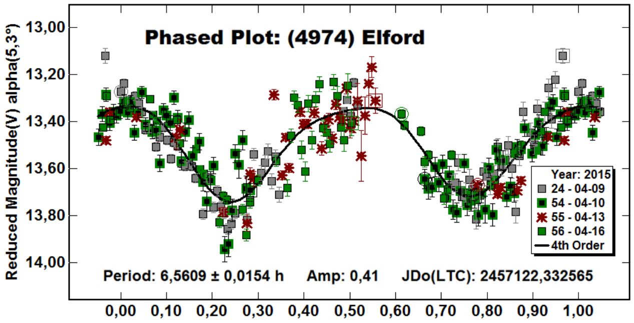
3000 Leonardo. The period determination is uncertain since full phase coverage is lacking and the number of data points is small. The most likely period is 8.54 h with an amplitude of 0.55 mag. Periods of 7.21 h and 10.40 h are other possibilities. Hayes-Gehrke et al. (2016) reported a period of 7.52 h and amplitude of 0.28 mag with a data set with better phase coverage and less noise.

Number	Name	yyyy mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
1911	Schubart	2015 02/26-03/10	143	7.4, 11.0	134,5	-1,1	7.91	0.02	0.11	0.03
2042	Sitarski	2015 12/01-12/09	37	18.0, 21.3	29,3	+2,4	2.63	0.01	0.36	0.05
2383	Bradley	2014 03/12-04/11	95	7.8, 10.5	184,0	+0,9	5.823	0.003	0.67	0.05
3000	Leonardo	2015 12/01-12/09	38	22.1, 24.7	31,9	-1,4	8.54	0.05	0.55	0.05
4974	Elford	2015 04/09-04/16	248	5.5, 5.2	204,1	+8,8	6.56	0.02	0.41	0.05
5471	Tunguska	2015 08/24-09/02	154	18.9, 18.8	56,3	+3,9	5.17	0.01	0.25	0.05
8679	Tingstäde	2016 09/07-09/12	143	9.8, 7.3	5,4	+0,0	6.65	0.03	0.63	0.07
16206	2000 CL39	2016 09/07-09/12	148	9.5, 7.5	6,1	-1,2	7.21	0.04	0.28	0.10
24691	1990 RH3	2016 09/07-09/12	130	10.0, 7.5	5,8	-1,7	6.76	0.05	0.30	0.10

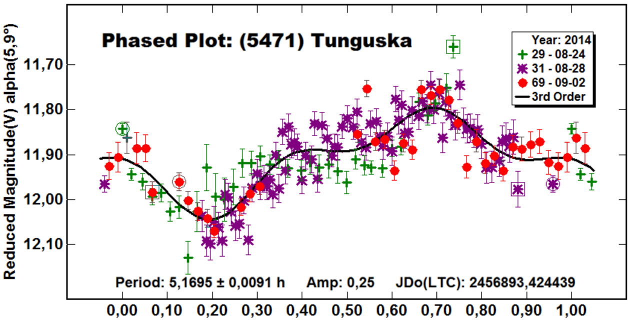
Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).



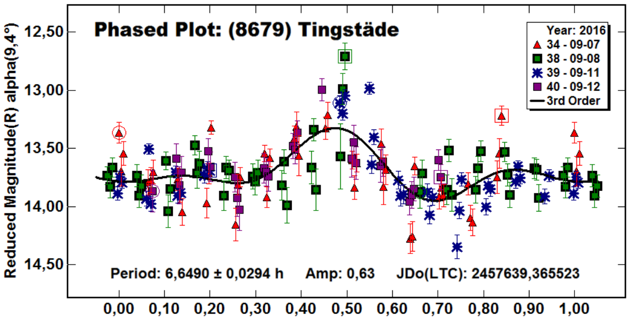
4974 Elford. The period with the marginally lowest RMS for this object, 3.28 h, is considered unlikely since it represents a unimodal light curve. The most likely period of 6.56 h produces a nice bimodal, slightly asymmetric, lightcurve that has an RMS only 1 % larger. The amplitude is 0.41 mag.



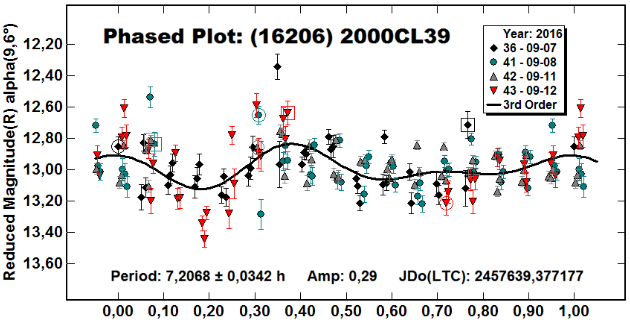
5471 Tunguska. A well-fit period of 5.17 h gives an undulating lightcurve with one minimum and one maximum. The amplitude is 0.25 mag. Two sessions marginally covered the full period.



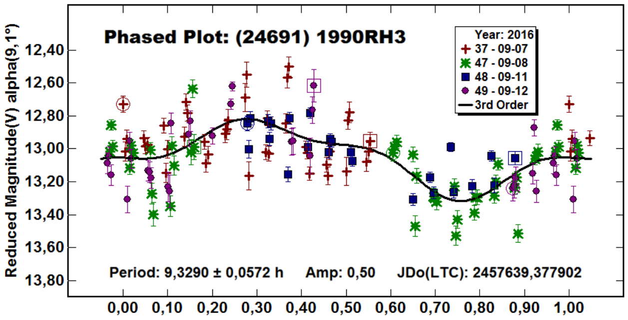
8679 Tingstäde. The scatter is significant in the photometry and the period spectrum shows a single pronounced RMS minimum. The lightcurve, P = 6.65 h, has single maximum with a large amplitude of 0.63 mag.



(16206) 2000 CL39). A period of 7.21 h with a shallow minimum and maximum in an otherwise flat lightcurve (amplitude 0.29 mag) was found at a clear RMS minimum in the period search. Four sessions covered the full period with ample overlap.



(24691) 1990 RH3. A period of 9.33 h and amplitude of 0.50 mag were found for this object. The scatter is significant but the RMS minimum is quite pronounced, with session overlap across almost the full period. Half-period and double-period solutions in the period spectrum have significantly larger RMS values.



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LIGHTCURVE ANALYSIS FOR 2142 LANDAU

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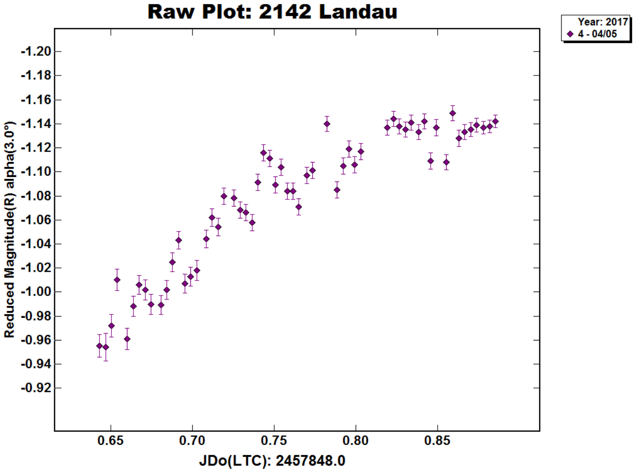
Lightcurve analysis using *MPO Canopus* of three nights of observations of 2142 Landau produced a tentative rotation period of 19.2 ± 0.2 h, supporting a previous determination of 19.4 h.

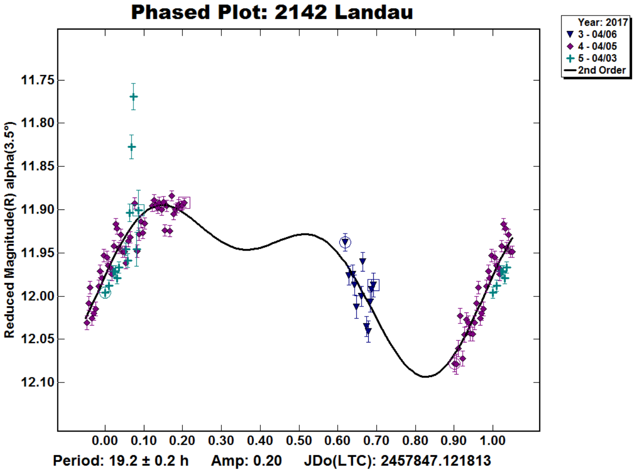
Asteroid 2142 Landau was discovered on 1972 April 3 by L. I. Chernykh at the Crimean Astrophysical Observatory and named in memory of Lev Davydovich Landau. It is a main-belt asteroid with an orbital period of 5.64 years, absolute magnitude of 12.0, geometric albedo of 0.05, and a diameter of 20.1 km (MPC 5284).

Observations were conducted remotely from telescopes operated by iTelescope.net. The telescope used on 2017 April 3 and 6 was T17 (MPC Q62), located at the Siding Spring Observatory. The coordinates of T17 are 31° 16’ 24” S and 149° 03’ 52” E. T17 has an array of 1024 pixels by 1024 pixels, a primary diameter of 0.43 m, a focal length of 2917 mm, pixel size of 13 microns by 13 microns, and a full well of 100,000 e-. There were 13 usable images from 2017 April 3 and 12 usable images from 2017 April 6. The telescope used on 2017 April 5 was T11 (MPC H06), located at the New Mexico Skies Observatory. The coordinates of T11 are 32° 54’ 13” N and 105° 31’ 42” W. T11 has an array of 4008 pixels by 2672 pixels, a primary diameter of 0.5 m, a focal length of 2280 mm, pixel size of 9 microns by 9 microns, and a full well of 60,000 e-. There were 58 usable images from 2017 April 5. Images taken had an exposure of 300 seconds each, using a clear/luminance filter with binning set to 1. We used periodic recentering to keep our telescope pointed at 2142 Landau. The data were analyzed through *MPO Canopus* using the lightcurve wizard to perform aperture and differential photometry.

Previously published work by *Chang et al* (2016) found a possible rotation period of 9.7 ± 0.2 h. The Lightcurve Database (LCDB) also lists a second possible period of 19.4 h. Neither reference provided lightcurves, due to being part of a mass analysis of many asteroids from a survey program.

The largest amount of data we obtained was on 2017 April 5 over a period of 4 hours. These data show a steady upward trend for the entire observing period, with possible peaking near the end, so we believe that the second period determined by *Chang et al* (2016) of 19.4 h is more likely. The fitted curves in MPO Canopus support this, as we found a fit for 19.2 ± 0.2 h. However, due to limited observing time, phasing to such a long period leaves large gaps in the plot, so our fit is not definitive. However, our data do provide a first look at parts of this asteroid’s lightcurve.





Acknowledgements

Telescope time and research was funded by the Department of Astronomy, University of Maryland, College Park. Observations were conducted by the ASTR315 class of Spring 2017, taught by Dr. Melissa Hayes-Gehrke at the University of Maryland, College Park. The two facilities used were operated remotely through the iTelescope service.

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Number	**Name**	**2017 mm/dd**	**Pts**	**Phase**	**Period(h)**	**P.E.**	**Amp**
2142	Landau	04/03-04/06	83	3.5	19.2	0.2	0.2

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for range between first and last date.

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THE ROTATION PERIOD OF 1117 REGINITA

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The lightcurve of main-belt asteroid 1117 Reginita was determined using images taken at Xingming Observatory (C42) on four nights in 2017 Jan. Analysis of the observations shows a bimodal solution with a synodic rotation period of 2.946 ± 0.001 h and an amplitude of 0.15 mag.

The main-belt asteroid 1117 Reginita was discovered by Josep Comas Solá on 1927 May 29 at Barcelona, Spain. It was named in honor of the niece of its observer. The most recent work by Waszczak et al. (2015) found a rotation period P = 2.9275 ± 0.0134 h with and amplitude of 0.10 mag in R band

The four nights of observations we report were all made at Xingming Observation (C42) using 0.5-m *f*/4 reflector telescope with an unfiltered QHY11 CCD at 2x2 binning. Exposures were 90 sec. The image scale of was 1.8 arcsec/pixel. All images were calibrated with flat, dark, and bias frames using *Maxim DL*.

MPO Canopus was used to analyze the data. Based on a data set of 477 data points, we found a period of 2.946 ± 0.001 h with an amplitude of 0.15 mag. This agrees with the period found by Waszczak et al. (2015).

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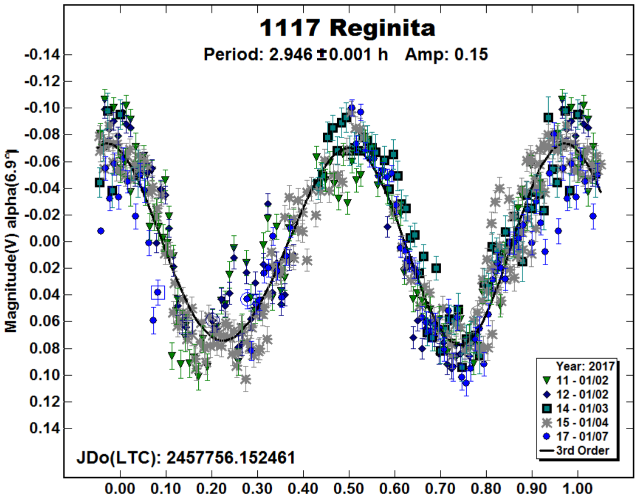

Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	D
1117	Reginita	01/02-01/07	477	6.9,4.7	117	-3	2.946	0.001	0.15	0.02	5.1

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984). D is the estimated diameter (km).

LIGHTCURVE AND ROTATION PERIOD FOR MINOR PLANET 2504 GAVIOLA

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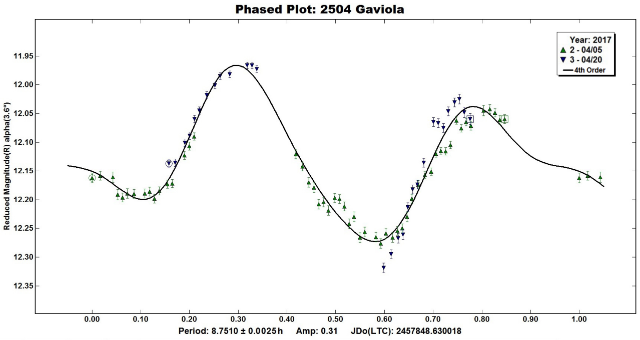
CCD photometric observations using iTelescope T21 of asteroid 2504 Gaviola were made in April 2017. A rotation period of 8.751 ± 0.003 h and lightcurve amplitude of 0.31 mag was determined from two nights of observations.

The main-belt asteroid 2504 Gaviola was discovered in 1967 by Carlos Ulrrico Cesco and Arnold R. Klemola at Astronomical facility Leoncito in Argentina and named in honor of astrophysicist Ramón Enrique Gaviola. Its orbital period is 4.59 years. The absolute magnitude *H* = 12.0 and assumed albedo of 0.301 give a diameter of 10.579 km (JPL, 2017). 2504 Gaviola has been assigned a taxonomic classification of Sq-type by Bus and Binzel (2002) during Phase II of the small main-belt asteroid spectroscopic survey of 2002.

The observations were made using iTelescope T21 located in Mayhill, New Mexico (MPC code H06) on 04/04 and 04/19. Observations were made with a Planewave 0.43-m Corrected Dall Kirkham (CDK) telescope operating at *f*/4.5 using a FLI-PL6303E CCD camera with a 3072 x 2048 array of 9-micron pixels. The resulting images were 0.96 arcsec per pixel. All images were mid-exposure times light-time corrected using *MPO Canopus* 10.7.7.0. A total of 85 data points were used in the calculation. Table I includes observing conditions and the determined results. Data analysis was conducted in *MPO Canopus* using differential photometry. Accurate results were achieved by selecting five comparison stars using the "comp star selector" feature of the lightcurve wizard. The period analysis was completed using *MPO Canopus's* lightcurve analysis that incorporates the Fourier analysis algorithm developed by Harris (Harris *et al.* 1989).

The phased lightcurve demonstrates a classical tri-axial shape by the asteroid. The period determination of 8.751 ± 0.003 h is in close agreement with the value present in the Small Body Database. The rotation period for this asteroid was initially determined by Waszczak *et al.* (2015) as a part of a survey for large number of asteroids. The period of 8.751 h determined here is not uniquely distinct, because there were many different alternatives due to aliases between our ~8-h observing window and the asteroid's ~8-h rotation period. This period however, complies with the earlier observations and provides a first look at this asteroid's lightcurve.



Acknowledgements

Funding for observations were provided by the Astronomy Department at the University of Maryland. We would also like to thank iTelescope for their facilities to study the asteroid.

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Number	Name	2017 mm/dd	Pts	Phase	Period(h)	P.E.	Amp	Grp
2504	Gaviola	04/04-04/19	085	3.6	8.751	0.003	0.31	MB-O

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the mid date. Grp is the asteroid family/group (Warner *et al.*, 2009).

LIGHTCURVE FOR ASTEROID 4404 ENIRAC

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CCD observations made of the asteroid 4404 Enirac during 2017 April led to a lightcurve with a rotation period of 2.9979 ± 0.0003 h and an amplitude of 0.27 mag.

Asteroid 4404 Enirac is a main-belt object that was discovered by A. Maury at Palomar on 1987 April 2 (JPL, 2013). The T21 telescope at the Mayhill, New Mexico observatory (MPC H06) was used for the asteroid lightcurve research we report for this asteroid. The telescope is located at 32° 54’ N and 105° 31’ W and is at an elevation of 2,225 meters above sea level. The telescope is a Planewave CDK that has a diameter 0.43 meters. The CCD is a FLI-PL6303E and the CCD are 3072 by 2048 pixels, which are 9μm square in size. iTelescope software was used to control the telescope on observing nights. Each image was taken with 300-s exposure through a luminance filter. A total of 105 usable images were taken on the nights of 2017 March 30, April 2, 5 and 17. MPO Canopus version 10.7.7.0 was used to analyze our data.

The fitted lightcurve of 4404 Enirac yields a rotation period of 2.9979 ±0.0003 h, which refines a previous determination by Klinglesmith III, Jesse Hanowell, Janek Turk, Angelica Vargas and Curtis Alan Warren, who found a rotation period of 2.998 ±0.002 h. The scattered points from 2017 April 5 were likely caused by the bright sky due to a waning gibbous moon.

Acknowledgements

This research was made possible by data collected using the iTelescope network and funding by the University of Maryland, College Park.

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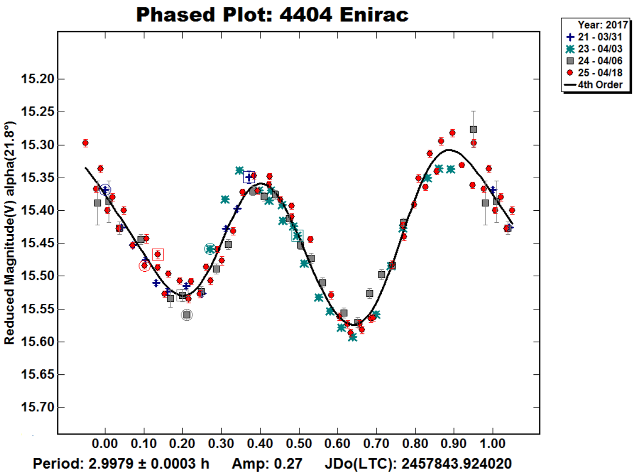

Number	Name	2017 mm/dd	Pts	Phase	Period(h)	P.E.	Amp
4404	Enirac	03/30-04/17	105	21.8	2.9979	0.0003	0.27

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the mid-date. Period is the rotation period in hours. P.E. is the period error and Amp is amplitude.

LIGHTCURVE ANALYSIS FOR NEAR-EARTH ASTEROID (138404) 2000 HA24

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Lightcurve analysis of asteroid (138404) 2000 HA24 from a single night of observation, 2017 April 17, yielded an estimated rotation period of 3.8 ± 0.2 h, with an amplitude of 0.3 mag.

Asteroid (138404) 2000 HA24 was originally discovered on 2000 April 28 at LINEAR- Lincoln Laboratory ETS in New Mexico. It has an eccentricity of 0.319 and a semi-major axis of 1.140 AU (JPL, 2016). No previous rotation period was found in the Lightcurve Database (Warner, B.D. 2015).

The T17 telescope (MPC Q62) located in Siding Spring, Australia (iTelescope, 2017) was used for the observations on 2017 April 17. It is a 0.43-m f/6.8 reflector + CCD. It is equipped with a FLI ProLine E2V CCD47-10-1-109 CCD, which has a pixel array of 1024×1024 pixels of size 13×13 microns. The telescope was accessed through itelescope.net, and exposures of 300s were taken through the luminance filter.

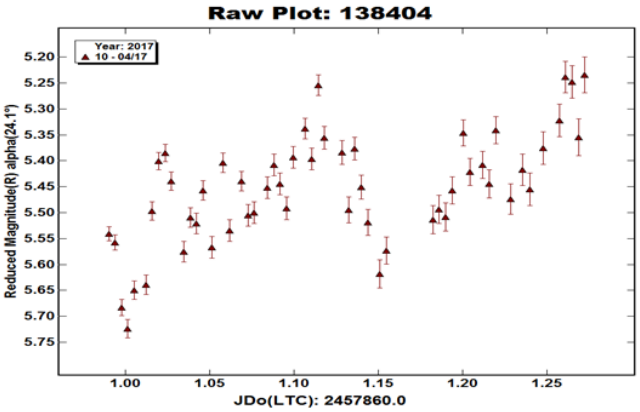

Figure 1. Raw data from 2017 March 17

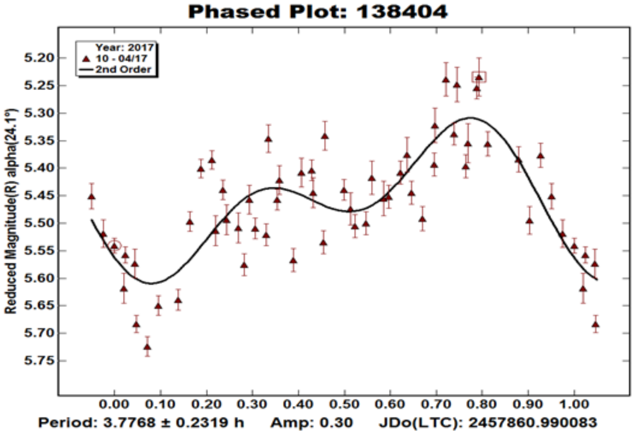

Figure 2. Observations of (138404) 2000 HA24 phased to a period of 3.7768 h

One point of data from an image taken at 17:56 UTC on April 17 was excluded due to its unusually high brightness, attributed to a hot pixel. As can be seen from the raw plot (Fig. 1), the data exhibit significant scatter, created by the faintness of the asteroid and consequent low-signal-to noise ratio for the measurements. Some of the early images in the session were not centered and the asteroid moved through the field of view quickly. This limited the number of comparison stars available, creating some uncertainty in the aperture photometry results. The results presented in Figure 2 used four comparison stars and an order of 2 in the Fourier model used to fit a sinusoidal curve to the points by MPO Canopus (Warner, 2013); the fitted period is 3.8 ± 0.2 h.

Acknowledgements

This research was funded by the Astronomy department at the University of Maryland, College Park. The observations were conducted using internet telescopes provided by iTelescope at the Siding Spring Observatory in New South Wales, Australia. We would like to thank Dr. Tony Farnham of the University of Maryland for his help in determining asteroid 138404 2000 HA24's rotation period.

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Number	Name	2017 mm/dd	Pts	Phase	Period(h)	P.E.	Amp.
(138404)	2000HA24	04/27	54	24.1	3.7768	0.2319	0.30

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the date.

ROTATION PERIODS FOR THREE MAIN BELT ASTEROIDS

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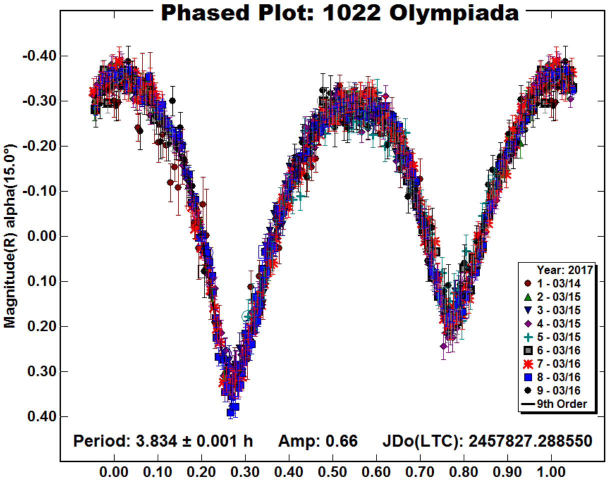
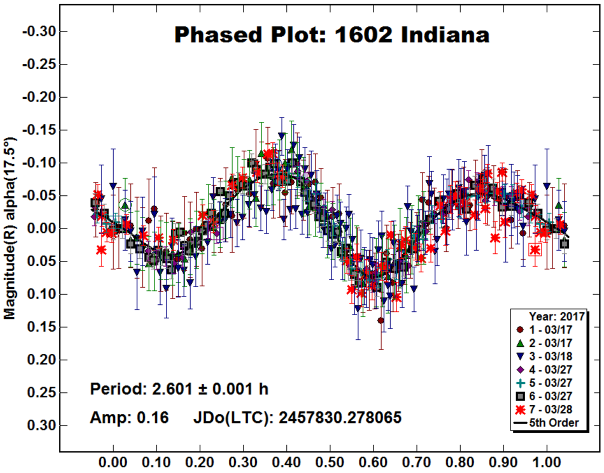
Photometric observations of three main-belt asteroids were made from Italy in order to determine their synodic rotation periods. For 1022 Olympiada the period is 3.834 ± 0.001 hr, amplitude 0.66 mag. For 1602 Indiana the results are 2.601 ± 0.001 hr and 0.16 mag. and for 2501 Lohja we report 3.809 ± 0.001 hr and 0.44 mag.

A collaborative observing campaign was organized by the asteroids section of the UAI (Italian Amateur Astronomers Union) in order to involve its members into asteroid photometry projects. For this purpose we selected some asteroids with known and fast rotation periods. The CCD observations for three main-belt asteroids were made in March-April 2017 using the instrumentation described in Table I. Lightcurve analysis were made at the Balzaretto Observatory with *MPO Canopus* (BDW Publishing, 2016). All the images were calibrated with dark and flat frames and converted to R magnitudes using solar colored field stars from CMC15 catalogue, distributed with *MPO Canopus*. Table II shows the observing circumstances and results.

<u>1022 Olympiada</u> is a X-type middle main-belt asteroid discovered on 1924 June 23 by Albitzkij, V. at Simeiz Observatory. Collaborative observations of this asteroid were made over three nights. There are six previously published rotation periods determinations, ranging from 3.822 to 3.835 h with amplitudes ranging from 0.27 to 0.46 mag. More details are reported into lightcurve database (LCDB; Warner et al., 2009). We derive a synodic period of P = 3.834 ± 0.001 h with an amplitude A = 0.66 ± 0.05 mag. This period is consistent with the previous ones and the high amplitude is explained by the observed equatorial aspect, evaluated as an angle of 96°, using the spin axis solution by Hanus et al. (2011; Lambda = 46°, Beta = 10°).



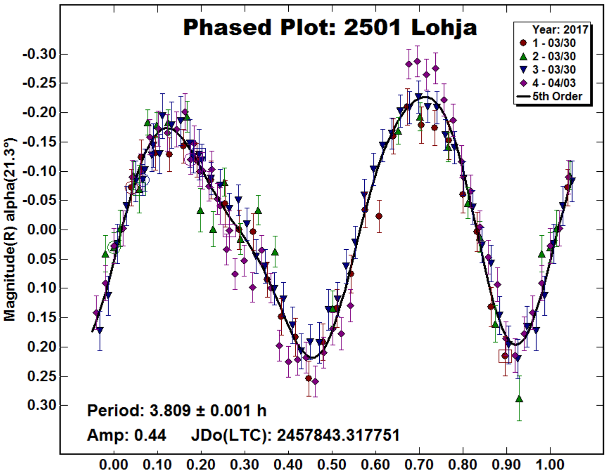
<u>1602 Indiana</u> is a S-type inner main-belt asteroid, discovered on 1950 March 14 at the Goethe Link Observatory at Brooklyn, IN. Collaborative observations of this asteroid were made over four nights. There are three previously published rotation periods determinations, ranging from 2.570 to 2.610 h with amplitudes ranging from 0.12 to 0.19 mag. More details are reported into lightcurve database (LCDB; Warner et al., 2009). We derive a synodic period of P = 2.601 ± 0.001 h with an amplitude A = 0.16 ± 0.05 mag, consistent with the previously published results.



<u>2501 Lohja</u> is an A-type inner main-belt asteroid discovered on 1942 April 14 by Oterma, L. at Turku. Collaborative observations of this asteroid were made over two nights. There are twelve previously published rotation periods determinations, ranging from 3.804 to 3.810 h with amplitudes ranging from 0.26 to 0.45 mag. More details are reported into lightcurve database (LCDB; Warner et al., 2009). We derive a synodic period of P = 3.809 ± 0.001 h with an amplitude A = 0.44 ± 0.05 mag, consistent with the previously published results.

Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E	Amp	A.E.
1022	Olympiada	03/14-03/16	942	14.7,15.3	140	15	3.834	0.001	0.66	0.05
1602	Indiana	03/17-03/28	402	17.0,21.4	150	6	2.601	0.001	0.16	0.05
2501	Lohja	03/30-04/03	153	21.0,22.1	145	2	3.809	0.001	0.44	0.05

Table II. Observing circumstances and results. Pts is the number of data points. The phase angle values are for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).



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Warner, B.D., Harris, A.W., Pravec, P. (2009). "The asteroid lightcurve database." *Icarus* **202**, 134-146. Updated 2017 April. *http://www.minorplanet.info/lightcurvedatabase.html*

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Observatory (MPC code)	Telescope, CCD	Observed Asteroids
K38	0.30-m RCT f/5.8, SBIG ST10ME	1022, 1602, 2501
K65	0.40-m SCT f/5.6, SBIG ST9XE	1022, 1602, 2501
A29	0.40-m NRT f/5, DTA EL-260E	1022, 2501
C62	0.30-m f/4 NRT, QHY9	1022, 1602
104	0.60-m f/4 NRT, Apogee Alta	1022

Table I. Observing Instrumentations. SCT: Schmidt-Cassegrain. RCT: Ritchey-Chretien, NRT: Newtonian Reflector.

LIGHTCURVE ANALYSIS OF L4 TROJAN ASTERIODS AT THE CENTER FOR SOLAR SYSTEM STUDIES 2017 APRIL - JUNE

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(Received: 2017 July 7)

Lightcurves for eight Jovian Trojan asteroids were obtained at the Center for Solar System Studies (CS3) from 2017 April to June.

CCD Photometric observations of eight Trojan asteroids from the L_4 (Trojan) Lagrange point were obtained at the Center for Solar System Studies (CS3, MPC U81). For several years, CS3 has been conducting a study of Jovian Trojan asteroids. This is another in a series of papers reporting data being accumulated for family pole and shape model studies. It is anticipated that for most Jovian Trojans, two to five dense lightcurves per target at oppositions well distributed in ecliptic longitudes will be needed and can be supplemented with reliable sparse data for the brighter Trojan asteroids. For most of these targets, we were able to get preliminary pole positions and create shape models from sparse data and the dense lightcurves obtained to date. These preliminary models will be improved as more data are acquired at future oppositions and will be published at a later date.

Table 1 lists the telescopes and CCD cameras that were used to make the observations. Images were unbinned with no filter and had master flats and darks applied. The exposures depended upon various factors including magnitude of the target, sky motion, and Moon illumination.

Telescope	Camera
0.40-m F/10 Schmidt-Cass	FLI Proline 1001E
0.35-m F/11 Schmidt-Cass	Fli Microline 1001E
0.35-m F/10 Schmidt-Cass	SBIG STL-1001E

Table 1. List of telescopes and CCD cameras used at CS3.

Image processing, measurement, and period analysis were done using *MPO Canopus* (Bdw Publishing), which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al*., 1989). Night-to-night calibration (generally < ±0.05 mag) was done using field stars from the CMC-15 catalog or APASS (Henden *et al*., 2009) The Comp Star Selector feature in *MPO Canopus* was used to limit the comparison stars to near solar color.

In the lightcurve plots, the "Reduced Magnitude" is Johnson V corrected to a unity distance by applying -5*log (rΔ) to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and the Earth-asteroid distances in AU. The magnitudes were normalized to the phase angle given in parentheses using G = 0.15. The X-axis rotational phase ranges from -0.05 to 1.05.

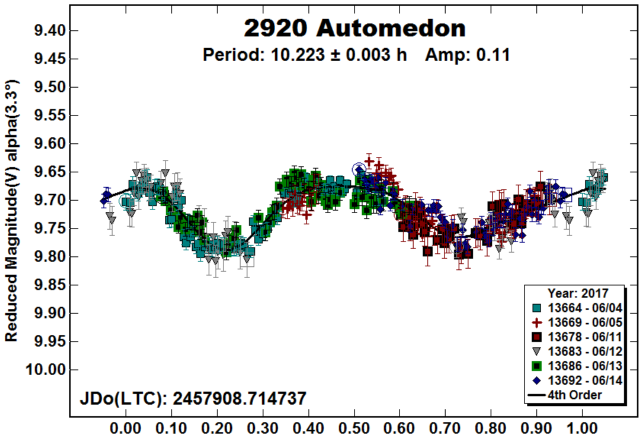
The amplitude indicated in the plots (e.g. Amp. 0.23) is the amplitude of the Fourier model curve and not necessarily the adopted amplitude of the lightcurve.

Targets were selected for this L_4 observing campaign based upon the availability of dense lightcurves acquired in previous years. We obtained 2 to 4 lightcurves for most of these Trojans at previous oppositions, and some data were found from the Palomar Transient Factory, Waszczak *et al.,* (2015).

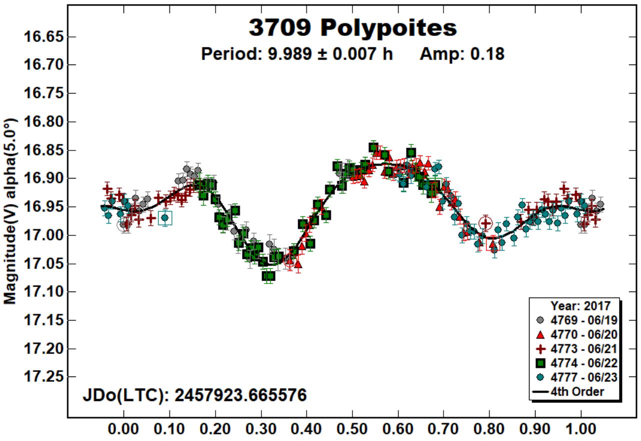
For brevity, only some of the previously reported rotational periods may be referenced. A complete list is available at the lightcurve database (LCDB; Warner *et al*., 2009).

To evaluate the quality of the data obtained to determine how much more data might be needed, preliminary pole and shape models were created for all of these targets which will be published at a later date. Sparse data observations were obtained from the Catalina Sky Survey and USNO-Flagstaff survey using the AstDyS-3 site (*http://hamilton.dm.unipi.it/asdys2/*). This sparse data was combined with our dense data as well as any other dense data found in the Asteroid Lightcurve Database (*http://www.alcdef.org/*) using *MPO LCInvert*, (Bdw Publishing) a Windows-based program that incorporates the algorithms developed by Kassalainen *et al* (2001a, 2001b) and converted by Josef Durech from the original FORTRAN to C. A period search was made over a sufficiently wide range to assure finding a global minimum in χ^2 values.

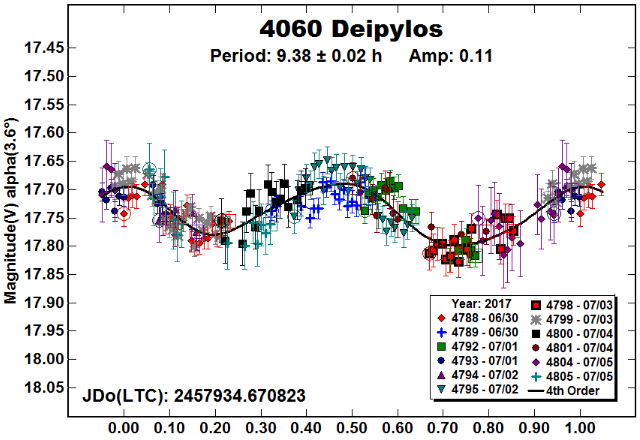
2920 Automedon. This large Trojan has been studied in the past. Molnar *et al.* (2008) and Mottola *et al.,* (2011) each found synodic rotational periods near 10.2 h. The result found this year is in good agreement.



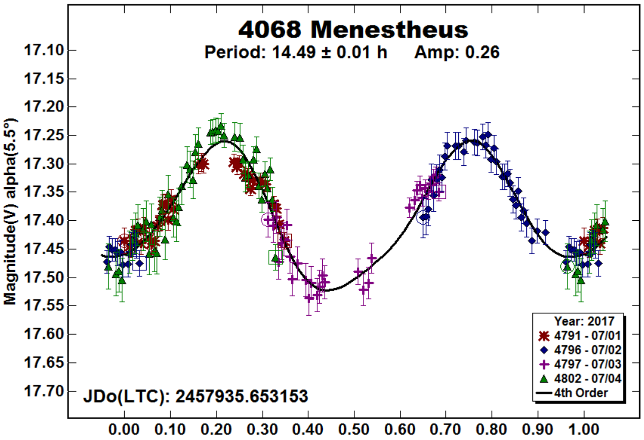
3709 Polypoites. We observed this Trojan three times in the past (French *et al.* 2011, Stephens *et al.* 2016a, Stephens *et al.* 2016b). The 2016 observations enabled us to resolve aliases and determine the period over all three oppositions to be about 10.04 h. The period found this year of 9.989 h supports that conclusion.



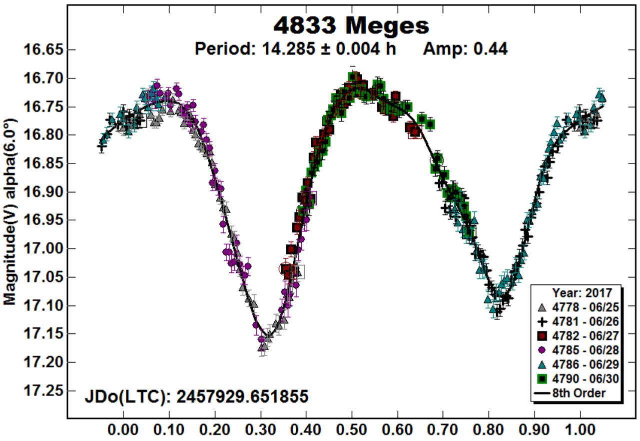
4060 Deipylos. Using sparse photometry from the Palomar Transient Factory, Waszczak et al. (2015) reported a period of 11.4905 h for Deipylos. That period appears to be a 5:4 alias of the period of rotation period of 9.3 h periods we found in 2015 and 2016 (Stephens *et al*., 2015 and 2016b). This year's finding of 9.38 h is in good agreement.



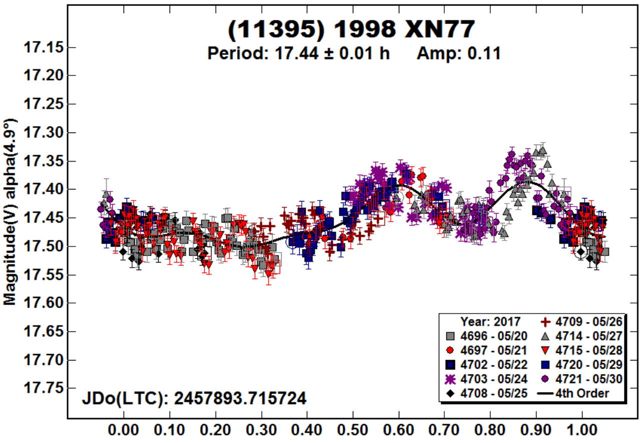
4068 Menestheus. We studied this asteroid on three previous occasions: French *et al.* (2013) and Stephens *et al.* (2016a and 2016b), each time finding a period near 14.4 h. The result this year of 14.40 h is in good agreement with those findings.



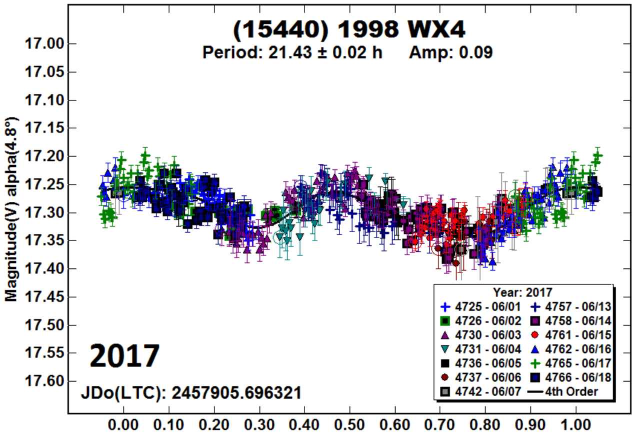
4833 Meges. The synodic period we found this year agrees with previous synodic results (Mottola *et al.,* 2011, Stephens *et al.,* 2016b).

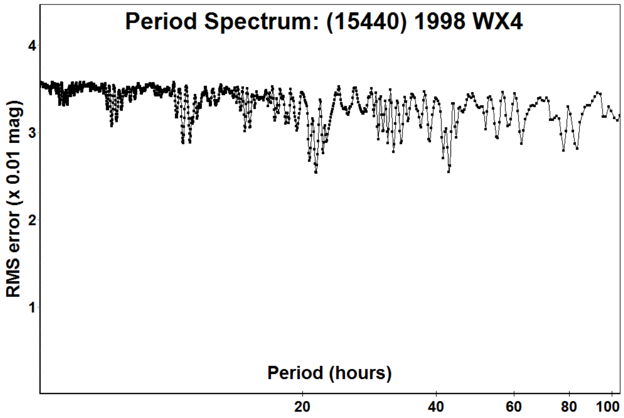


(11395) 1998 XN77. Mottola *et al*. (2011) observed this Trojan in 2009 and 2010, finding periods of 13.70 h and 13.696 h, respectively. We first observed the asteroid in 2015 using the 0.9-m SMARTS telescope at CTIO and then in a follow-up session using the 0.35-m telescope at CS3 (Stephens *et al*., 2016b), finding a period of 17.89 h. We observed it again in 2016 from CS3, obtaining a much denser data set, and found a period of 17.383 h with a classic bimodal shaper to the lightcurve. Determining a rotation period with the 2015 data proved difficult because of the low amplitude and strong aliases. We were able to rephase the 2015 data to this period, but because of the low amplitude, many rotation periods were possible. The rotational period found this year was 17.44 h period, consistent with the shorter period found in 2016.



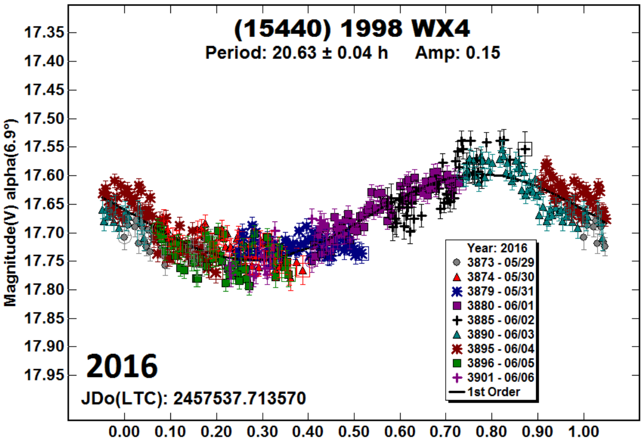
(15440) 1998 WX4. We observed this Trojan in 2013 (French *et al*., 2013) and 2014 (Stephens *et al*., 2014). In both cases, the raw lightcurves spanning multiple nights were featureless. We observed it again in 2015 and 2016 (Stephens *et al*., 2016a and 2016b) finding rotation periods near 41 h with a bimodal shape to the lightcurves. However, with amplitudes of only 0.10 and 0.16 mag. respectively, it is possible that the lightcurve could have only a single extrema, or three or more extrema (Harris *et al* 2014). During a preliminary shape model attempt using the 2015 and 2016 data, we identified an alias in the period of about 21 h. The data obtained this year again found aliases at 21 h and 41 h with the 21 h period having a slightly stronger solution in the Period Spectrum. The 2017 21 h solution also produced the classic bimodal shape while phasing it to 41 h resulted in four extrema. Rephasing the 2015 and 2016 data to 21 h results in monomodal lightcurves. For these reasons, we now adopt the 21.43 h solution as more likely. However, additional observations in the future are needed to help resolve the ambiguities.

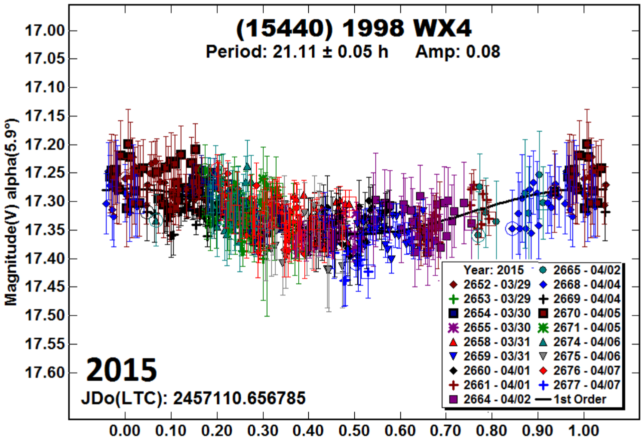




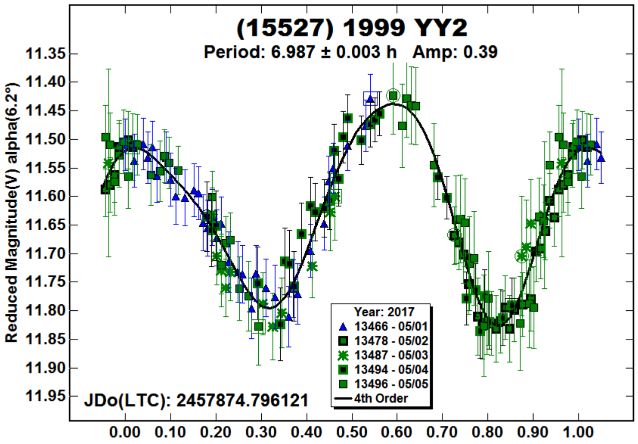
Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
2920	Automedon	06/04-06/14	364	3.3,2.8	263	13	10.223	0.003	0.11	0.02
3709	Polypoites	06/20-06/23	191	5.1,5.5	251	20	9.989	0.007	0.18	0.02
4060	Deipylos	06/30-07/05	204	3.6,4.1	269	17	9.38	0.02	0.11	0.02
4068	Menestheus	07/02-07/04	159	5.7,5.9	259	19	14.49	0.01	0.26	0.02
4833	Meges	06/25-06/30	286	6.0,6.6	249	21	12.285	0.004	0.44	0.02
11395	1998 XN77	05/20-05/30	384	4.9,4.0	254	18	17.44	0.01	0.11	0.02
15440	1998 WX4	06/01-06/18	482	4.8,4.4,4.5	260	22	21.43	0.02	0.09	0.02
15527	1999 YY2	05/01-05/05	144	6.2,5.7	243	22	6.987	0.003	0.39	0.02

Table II. Observing circumstances and results. Pts is the number of data points. Phase is the solar phase angle for the first and last date. If there are three values, the middle value is the minimum phase angle. L_{PAB} and B_{PAB} are, respectively, the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984).





(15527) 1999 YY2. Galad *et al.* (2010) previously observed this Trojan finding a rotational period of 6.9903 h. Our finding agrees with that result.



Acknowledgements

Work on the asteroid lightcurve database (LCDB) was also funded in part by National Science Foundation grants AST-1210099 and AST-1507535. This research was made possible in part based on data from CMC15 Data Access Service at CAB (INTA-CSIC) (*http://svo2.cab.inta-csic.es/vocats/cmc15/)* and through the use of the AAVSO Photometric All-Sky Survey (APASS), funded by the Robert Martin Ayers Sciences Fund. The purchase of a FLI-1001E CCD cameras was made possible by a 2013 Gene Shoemaker NEO Grants from the Planetary Society.

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ROTATION PERIOD DETERMINATION FOR 397 VIENNA

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CCD photometry of minor planet 397 Vienna shows that it has a synodic rotation period of 15.461 ± 0.001 hours, amplitude 0.16 ± 0.02 magnitudes.

Previously published periods for 397 Vienna were reported by Harris and Young (1983), 15.48 hours; Behrend (2009), >8 hours; and Ruthroff (2010), 15.45 hours. The authors of this study agreed to collaborate to obtain a dense observation set and complete phase coverage.

Observer Pilcher at the Organ Mesa Observatory used a 0.35-meter Meade LX200 GPS Schmidt-Cassegrain (SCT), SBIG STL-1001E CCD, clear filter (sessions 2619, 2632, 2636, 2643, 2653, 2655). Oey at Blue Mountain Observatory used a 35 cm SCT operating at f/5.9, SBIG ST-8XME CCD, clear filter (sessions 2657, 2658). The staff of A. Mickiewicz University obtained data at Borowiec station with 0.4 meter Newtonian telescope, SBIG ST7 CCD, clear filter (sessions 2644, 2645), and at Winer Observatory near Sonoita, Arizona, USA with a 0.7 meter corrected Dall-Kirkham telescope, Andor iXon CCD, R filter (session 2646). Ogloza at Mt. Suhora Observatory used a 0.6 meter Cassegrain, Apogee Alta U47 CCD, R filter (session 2661). Photometric measurement and lightcurve construction are with *MPO Canopus* software. To reduce the number of points on the lightcurves and make them easier to read, data points have been binned in sets of 3 with a maximum time difference of 5 minutes. Observations on 12 nights 2017 May 10 – June 18 provide a good fit to an irregular lightcurve with period 15.461 ± 0.001 hours, amplitude 0.16 ± 0.02 magnitudes. This is consistent with previous measurements.

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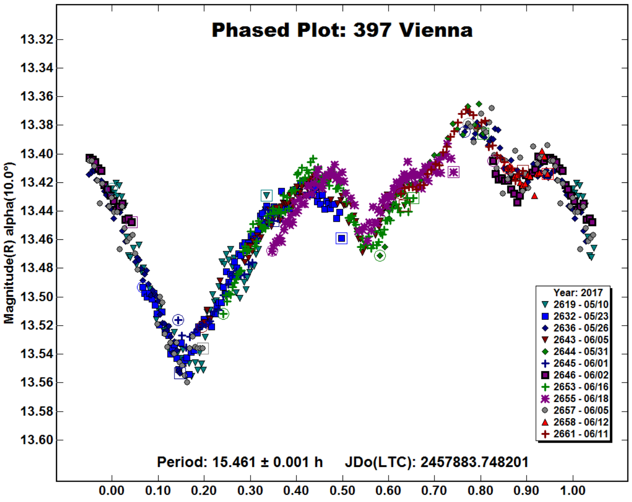

Number	Name	2017/mm/dd	Pts	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.
397	Vienna	05/10-06/18	1786	10.3, 5.2, 7.3	253	6	15.461	0.001	0.16	0.02

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first date, minimum (second) value reached, and last date. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).

LIGHTCURVES OF 131 VALA AND 612 VERONIKA DURING THEIR 2017 APPARITIONS

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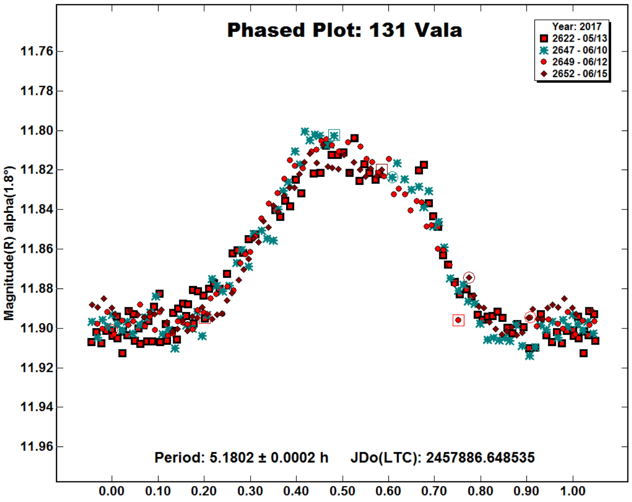
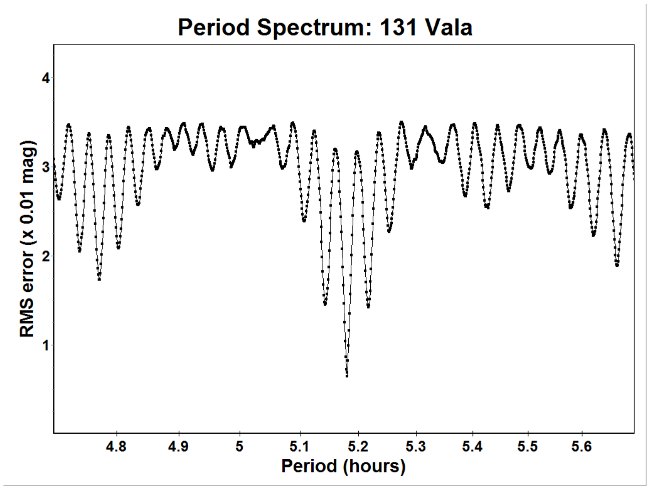
(Received: 2017 July 2)

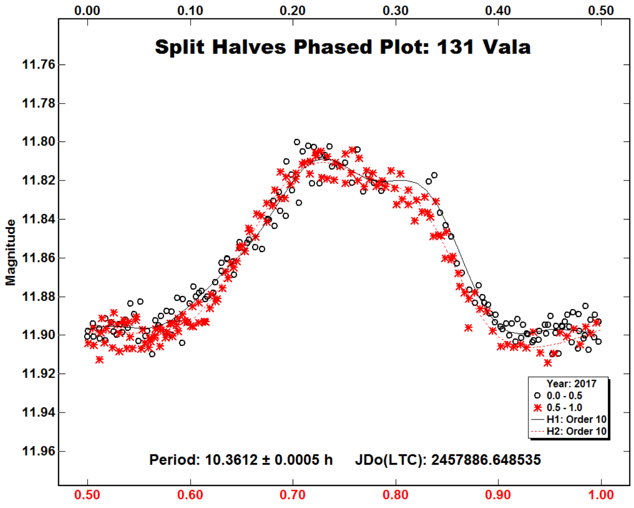
Synodic rotation periods and amplitudes are found for 131 Vala 5.1802 ± 0.0002 hours, 0.08 ± 0.01 magnitudes; and for 612 Veronika 8.243 ± 0.001 hours, 0.09 ± 0.01 magnitudes.

Observations to obtain the data used in this paper were made at the Organ Mesa Observatory with a 0.35-meter Meade LX200 GPS Schmidt-Cassegrain (SCT) and SBIG STL-1001E CCD. Exposures were 60 seconds, unguided, with a clear filter. Photometric measurement and lightcurve construction is with *MPO Canopus* software. To reduce the number of points on the lightcurves and make them easier to read, data points have been binned in sets of 3 with a maximum time difference of 5 minutes.

131 Vala. Pilcher (2008) published a highly symmetrical bimodal lightcurve of 131 Vala with period 10.359 hours, amplitude 0.09 magnitudes based on observations in 2007 October-November near celestial longitude 45 degrees. Parallel studies near the next opposition 2009 February-April near celestial longitude 200 degrees by Behrend (2009), Galad (2010), and Pilcher (2009) all produced bimodal lightcurves with a good fit to periods near 5.181 hours and amplitudes near 0.25 magnitudes. Pilcher (2009) replotted his year 2007 observations to a monomodal lightcurve with period 5.179 hours. New observations on 4 nights 2017 May 13 – June 15 near celestial longitude 230 degrees, almost directly opposite in the sky to the 2007 observations, provide a good fit to a monomodal lightcurve with period 5.1802 ± 0.0002 hours, amplitude 0.08 ± 0.01 magnitudes. This is in excellent agreement with earlier studies. A split halves plot of the double period shows that the two halves are identical within reasonable photometric error, and a period spectrum is also presented.



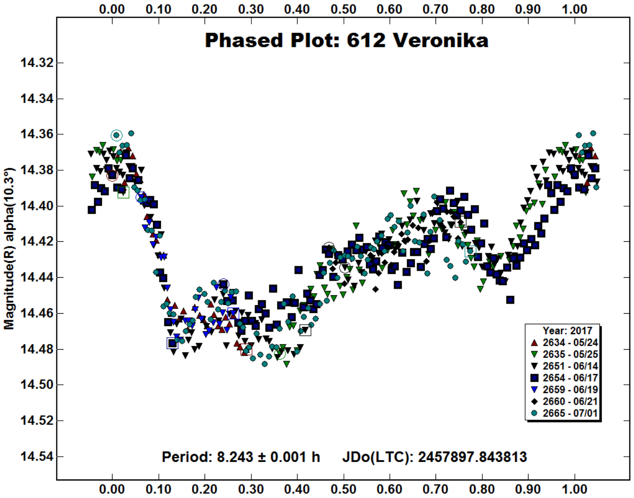


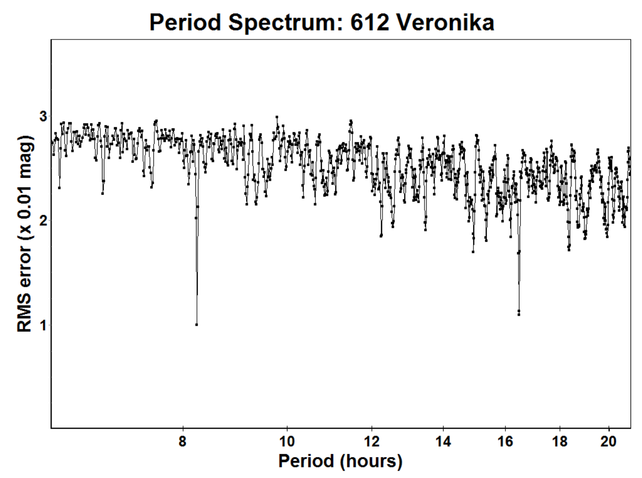


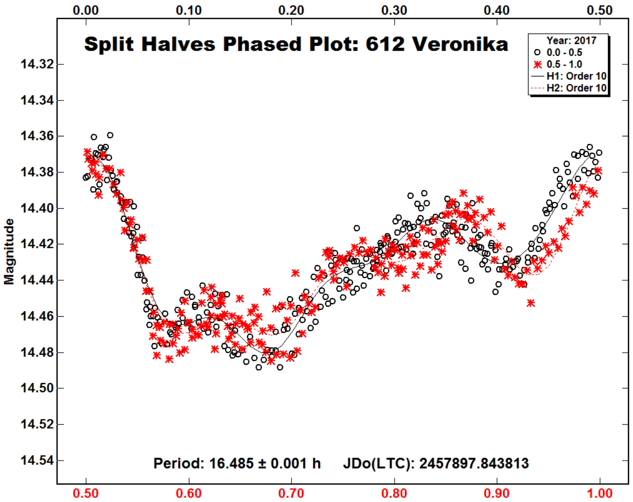
612 Veronika. Parallel studies by Pilcher (2013), and by Strabla et al. (2013) obtained periods of 8.243 hours and 8.244 hours respectively, and almost identical lightcurves, based on observations 2012 August – October. New observations on 7 nights 2017 May 24 – July 1 are in complete agreement, providing a good fit to an irregular lightcurve with period 8.243 ± 0.001 hours, amplitude 0.09 ± 0.01 magnitudes. A period spectrum rules out all other periods except for the double period, and a split halves plot shows that the two halves of the double period are identical within reasonable photometric error.

Number	Name	2017/mm/dd	Pts	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.
131	Vala	05/13-06/15	882	1.8, 16.9	230	1	5.1802	0.0002	0.08	0.01
612	Veronika	05/24-07/01	1521	10.4, 10.2, 14.3	255	22	8.243	0.001	0.09	0.01

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date, unless a minimum (second value) was reached. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).







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Harris, A.W., Young, J.W., Scaltriti, F., Zappala, V. (1984). "Lightcurves and phase relations of the asteroids 82 Alkmene and 444 Gyptis." *Icarus* **57**, 251-258.

Pilcher, F. (2008). "Period determinations for 84 Klio, 98 Ianthe, 102 Miriam, 112 Iphigenia, 131 Vala, and 650 Amalasuntha." *Minor Planet Bull.* **35**, 71-72.

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(24495) 2001 AV1 – A SUSPECTED VERY WIDE BINARY

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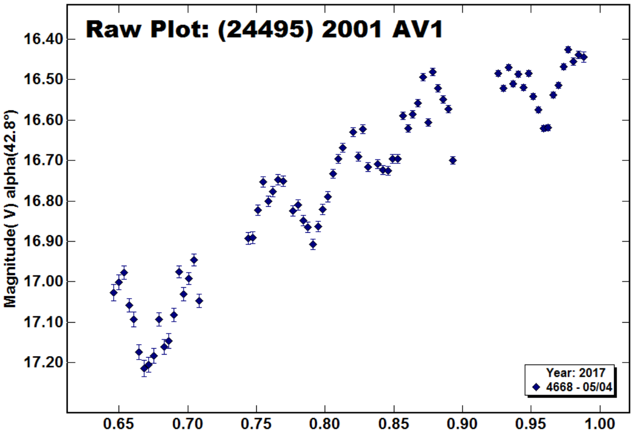
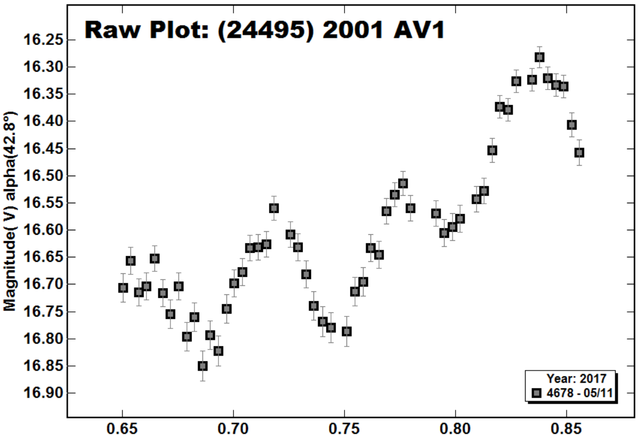
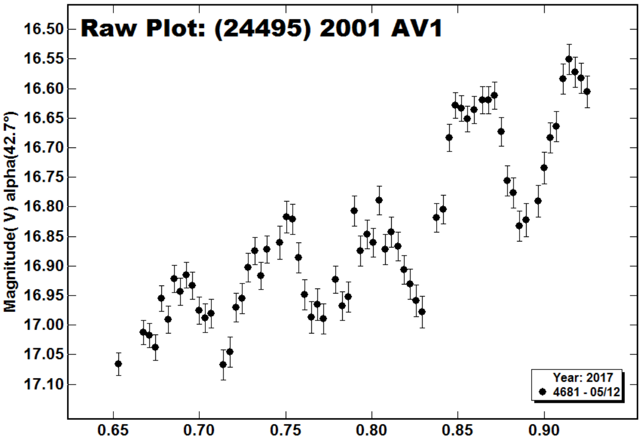
We report that asteroid (24495) 2001 AV1 is a binary asteroid. It is another candidate for the special case of very wide binaries. The primary lightcurve has a period of 24.083 ± 0.005 h and an amplitude 0.58 ± 0.05 mag. and the secondary lightcurve has a period of 2.7375 ± 0.0001 h.

The Mars crosser (24495) 2001 AV1 was initially observed by Stephens using a 0.40-m Schmidt-Cassegrain telescope with Finger Lakes ProLine ML-1001E CCD camera from the Center for Solar System Studies (U82) located in Landers California.

The analysis of the first few sessions showed the signature of another possible candidate for a special case of very wide binaries (see Jacobson *et al*., 2014, Warner 2016). This is where the primary period belonging to the main body is long with a large amplitude and the secondary period is short with a low amplitude. For wide binaries, the chance of observing a *mutual event* (eclipse or occultation) would be very rare because of the long primary period. In the case of (24495) 2001 AV1, each of the first sessions showed a trend of brightening over the course of the night with a secondary frequency less than three hours superimposed on the upward trend.







From the angle of the slope of the ascension and the lack of a clear extrema in any session, it appeared the main dominant, primary period was close to a multiple of the Earth's rotation with the most likely period being near 48 h.

A call for observations were made to several observers located in Europe, about 110°-150° in longitude from the CS3 observatories in California. Aznar from his observatory in Valencia, Spain was able to observe the asteroid on several nights. Benishek observed the asteroid two nights overlapping Aznar's data. Table 1 gives the telescopes and CCD cameras used for observations. Exposures were unfiltered and ranged from 240 to 300 seconds. Table II gives the dates and session numbers in the lightcurves for each observer.

The raw images were flat-field and dark subtracted before being measured in *MPO Canopus*. Night-to-night linkage was aided by the Comp Star Selector utility which helps find near-solar color comparison stars, thus reducing color difference issues. Stars were chosen from the CMC-15 catalog (*http://svo2.cab.inta-csic.es/vocats/cmc15/*). Generally, needed zero points adjustments are within ±0.05 of one another, but larger adjustments can be required to minimize the RMS value from the Fourier analysis.

Observer	Telescope	Camera
Stephens	0.40m SCT	FLI Proline 1001E
Aznar	0.35m SCT	SBIG STL-1001E
Benishek	0.35m SCT	SBIG ST-8X ME

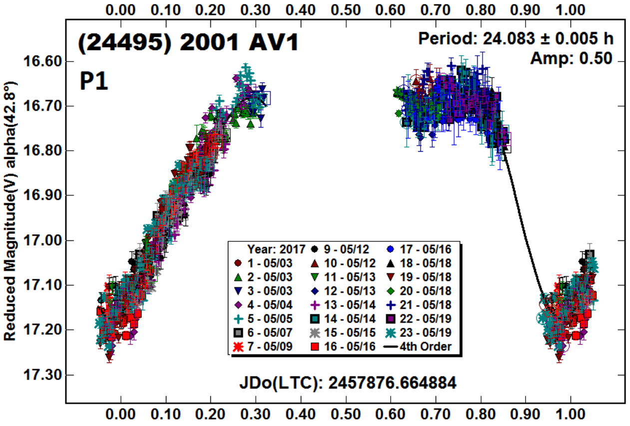
Table I. List of observers and equipment. SCT: Schmidt-Cassegrain.

Observer	Telescope	Sess
Stephens	0.40m SCT	1,2,3,4,5,6,7,8,9, 11,13,15,16,19,23
Aznar	0.35m SCT	10,12,14,17,18,21
Benishek	0.35m SCT	20,22

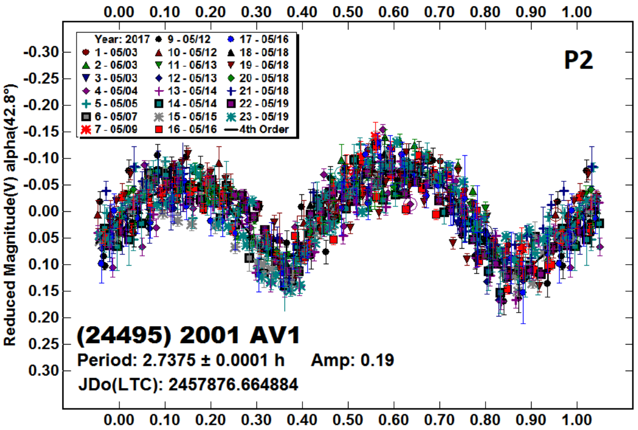
Table II. List of observation and session numbers in the lightcurves for each observer.

Period Analysis

Period analysis was done using *MPO Canopus*, which employs the FALC Fourier analysis algorithm developed by Harris (Harris *et al.*, 1989). *MPO Canopus* can do a dual-period search process. The program first finds an initial value for the dominant (usually shorter) period. The Fourier model lightcurve is subtracted from the data set in the succeeding search for a second period. The Fourier curve for that second period is then subtracted from the data set in a new search for the dominant period. The iterative process continues until both periods stabilize and it produces reasonable lightcurves.



The dual period analysis found a primary lightcurve belonging to the main body of P_1 = 24.083 ± 0.005 h, A_1 = 0.50 ± 0.02 mag (“P1” plot). Assuming an equatorial view of the asteroid, this leads to an a/b ratio of the asteroid’s silhouette of 1.6:1. As expected, subtracting this lightcurve from the data set and doing a period search found a solution that showed no *mutual events* (occultations and/or eclipses) due to a satellite (“P2” plot). The lightcurve has a period of P_2 = 2.7375 ± 0.0001 h, A_2 = 0.19 mag. In the case of a Very Wide Binary, the larger amplitude is assumed to be for the main body. “The amplitude of the longer period if it were due to the secondary with about a magnitude of "dilution" from the primary, it would have to have an unphysically great elongation plus being viewed almost exactly equatorially in order to produce the "diluted" amplitude that large. The inferred size ratio comes from the secondary having extracted almost all of the angular momentum of the primary spin but not quite escaping.” (Harris *private communication*).



Conclusion

Because the primary period is so close to an Earth day, it was not possible to get a complete lightcurve for P1. This asteroid should be a prime target for follow up at its next opposition in January 2020 when the northern hemisphere nights will be much longer.

Acknowledgements

Work on the asteroid lightcurve database (LCDB) was also funded in part by National Science Foundation grant AST-1507535. The purchase of the FLI-1001E CCD camera was made possible by a 2013 Gene Shoemaker NEO Grant from the Planetary Society.

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Number	Name	mm\dd	Pts	Phase	L_{PAB} B_{PAB}	Period	P.E.	Amp	A.E.
24495	2001 AV1	05/03-05/19	82043	198	3624.0830.0050.50		0.02		
						2.73750.00010.19	0.02		

Table III. Observing circumstances and results. Pts is the number of data points. Grp is the asteroid family/group (Warner et al., 2009). The first line is the primary (P1) period and the second line is the secondary (P2) period.

ASTEROIDS OBSERVED FROM CS3: 2017 APRIL - JUNE

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(Received: 2017 July 7)

CCD photometric observations of 11 main-belt asteroids were obtained from the Center for Solar System Studies from 2017 April to June.

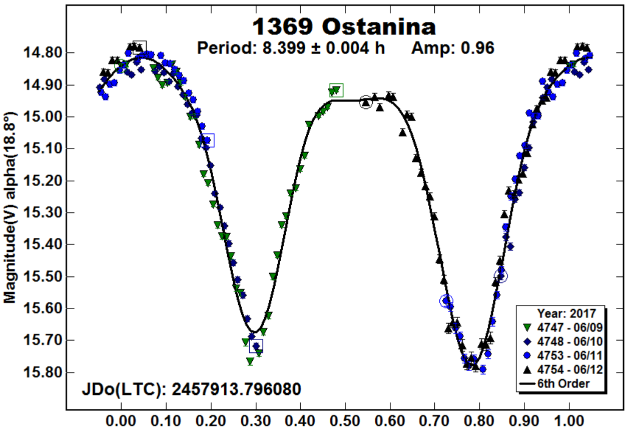
The Center for Solar System Studies "Trojan Station" (CS3, MPC U81) has two telescopes which are normally used in program asteroid family studies. During the 2nd quarter of 2017 the Jovian Trojans which are normally studied were out of season, so targets of opportunity amongst the Main Belt families were selected.

All images were made with a 0.4-m or a 0.35-m SCT using an FLI ML-Proline 1001E or FLI ML-Microline 1001E CCD camera. Images were unbinned with no filter and had master flats and darks applied. Image processing, measurement, and period analysis were done using MPO Canopus (Bdw Publishing), which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris et al., 1989). Night-to-night calibration (generally < ±0.05 mag) was done using field stars from the CMC-15 catalog or APASS (Henden *et al*., 2009) The Comp Star Selector feature in *MPO Canopus* was used to limit the comparison stars to near solar color.

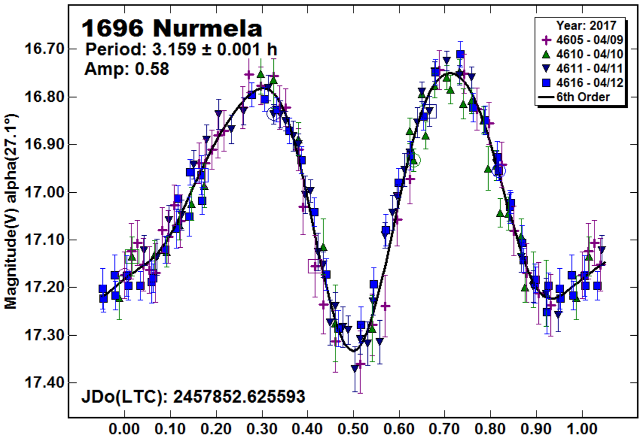
In the lightcurve plots, the "Reduced Magnitude" is Johnson V corrected to a unity distance by applying -5*log (rΔ) to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and the Earth-asteroid distances in AU. The magnitudes were normalized to the phase angle given in parentheses using G = 0.15. The X-axis rotational phase ranges from -0.05 to 1.05.

The amplitude indicated in the plots is the amplitude of the Fourier model curve and not necessarily the adopted amplitude of the lightcurve.

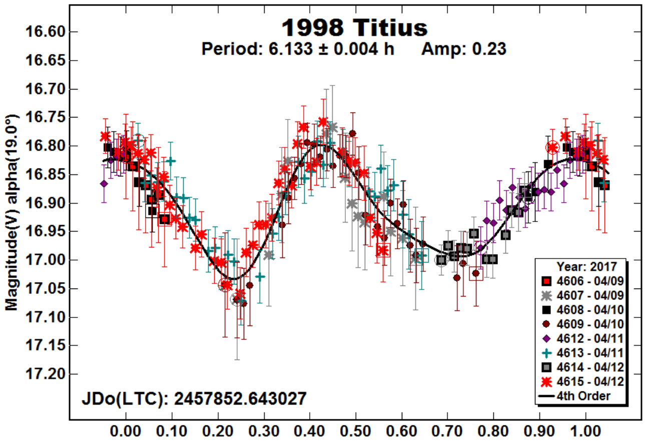
1369 Ostanina. The rotational period for this Outer Main Belt asteroid has been determined several times in the past. Chiorny (2007), Behrend (2006, 2011, 2012, and 2016) each reported a rotational period near 8.4 h. The result from this opposition is in good agreement with those results.



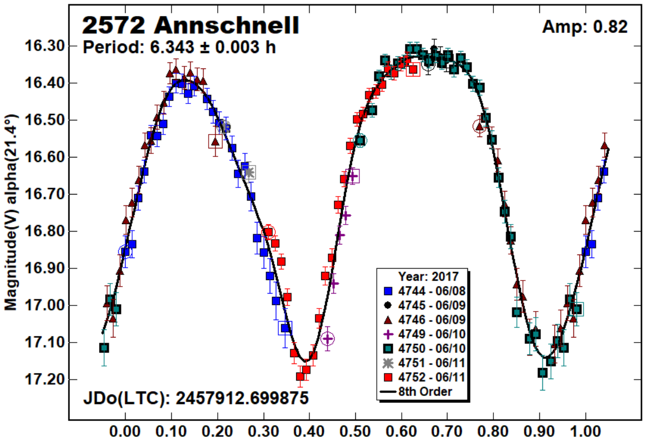
1696 Nurmela. The rotational period for this Vestoid has been found twice in the past (Stephens *et al.* 2007 and Galad *et al.* 2008). Both sets of prior observations were obtained within a few weeks of each other. The result found this year is in good agreement with those findings.



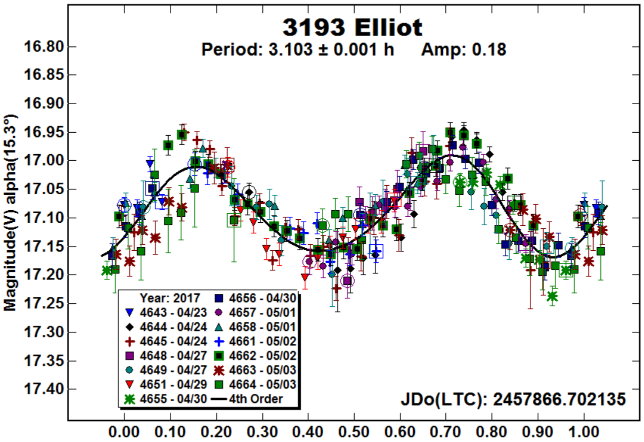
1998 Titius. The period found this year agrees with our previous finding of 6.13 h (Stephens 2002).



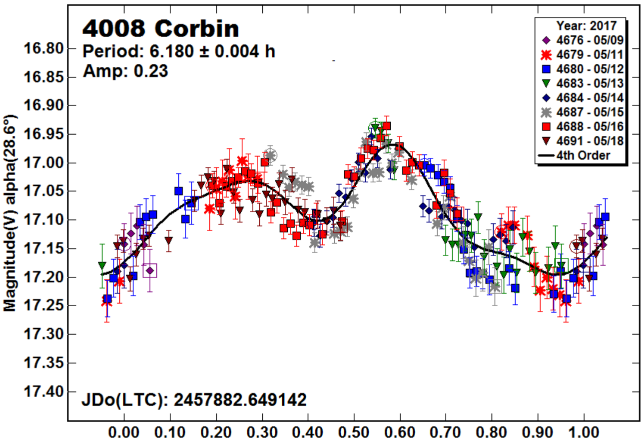
2572 Annschnell. This Vestoid had its rotational period determined once before (Behrend 2006). The result found this year is in good agreement with that result.



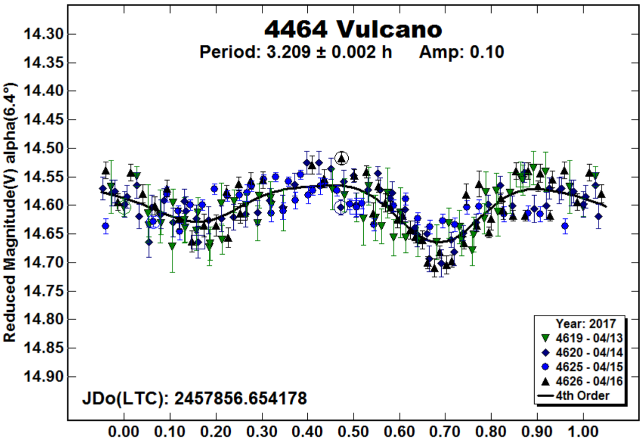
3193 Elliot. No entry for this Vestoid could be found in the Lightcurve Database (Warner *et al.* 2009).



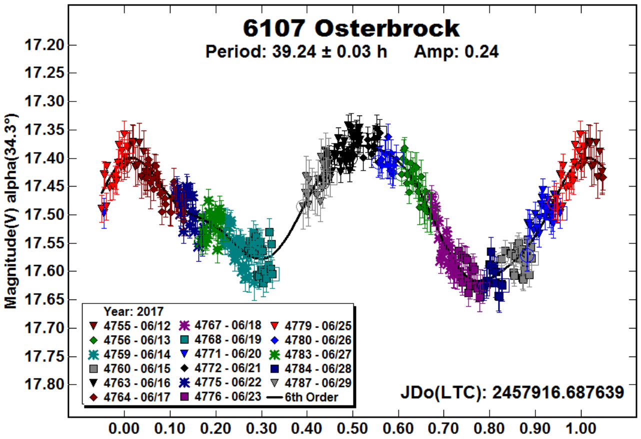
4008 Corbin. Parvec (2017) reported a rotational period of 6.203 h from the Photometric Survey for Asynchronous Binary Asteroids. This result agrees with that determination.



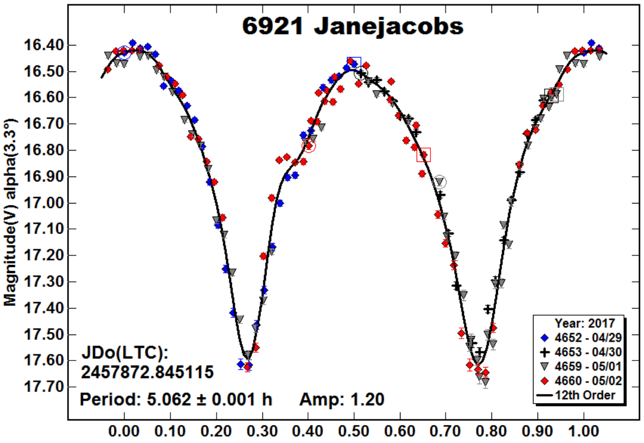
4464 Vulcano. Warner (2011, 2014a, 2016) observed this Hungaria several times in the past finding rotational periods near 3.2 h.



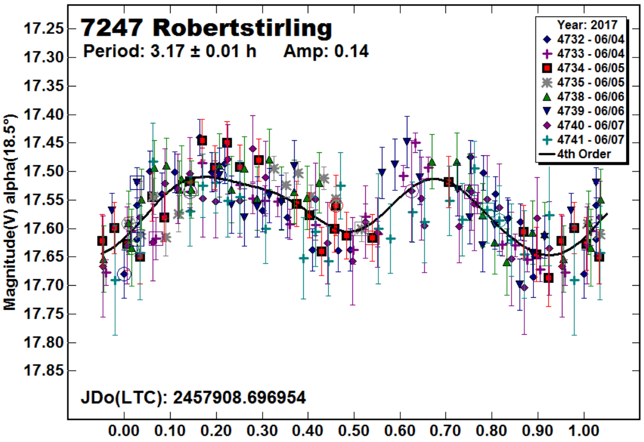
6107 Osterbrock. Warner (2012, 2014a) previously reported periods of 2.372 h and 2.215 h, each with an amplitude under 0.1 mag. and multiple extrema using observations spanning 3 or 4 nights. No signature for these shorter periods could be found in this dataset and the rotational period of 39.24 h could not be reconciled to the previous results.



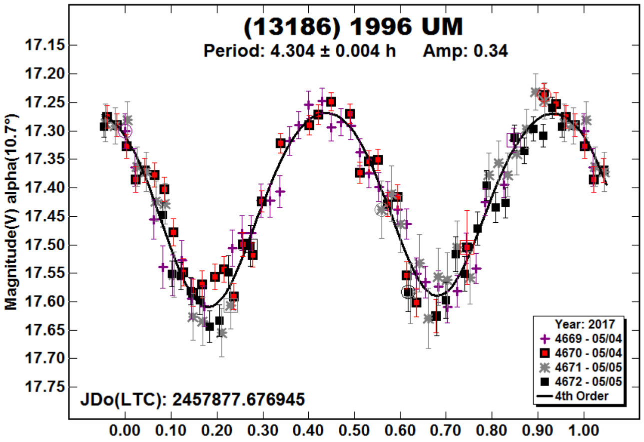
6921 Janejacobs. No entry for this Vestoid could be found in the Lightcurve Database (Warner *et al.* 2009).



7247 Robertstirling. Warner (2013a, 2014b) determined a rotational period for this Hungaria twice in the past both times with a rotational period near 3.18 h. This year's result agrees with those past findings.



(13186) 1996 UM. Warner observed this Hungaria three times in the past (Warner 2013b, 2014b and 2016) each time finding a period near 4.3 h. This year's results agree with those findings.



Acknowledgements

This research was made possible in part based on data from CMC15 Data Access Service at CAB (INTA-CSIC) (*http://svo2.cab.inta-csic.es/vocats/cmc15/)*. The purchase of a FLI-1001E CCD cameras was made possible by a 2013 Gene Shoemaker NEO Grants from the Planetary Society.

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Number	Name	mm\dd	Pts	Phase	LPAB	BPAB	Period	P.E.	Amp	A.E.	Grp
1369	Ostanina	06/09-06/12	167	18.8,18.1	298	17	8.399	0.004	0.96	0.02	MB-O
1696	Nurmela	04/09-04/12	163	27.1,27.6	144	5	3.159	0.001	0.58	0.02	V
1998	Titius	04/09-04/12	163	19.1,20.0	159	1	6.133	0.004	0.24	0.02	V
2572	Annschnell	06/08-06/11	122	21.5,22.5	221	4	6.343	0.003	0.82	0.02	V
3193	Elliot	04/23-05/03	213	15.3,18.7	184	0	3.103	0.001	0.18	0.03	V
4008	Corbin	05/09-05/18	185	28.6,29.4	173	11	6.180	0.004	0.23	0.02	PHO
4464	Vulcano	04/13-04/16	196	6.4,8.3	194	-3	3.209	0.002	0.10	0.02	H
6107	Osterbrock	06/12-06/29	380	34.3,35.2	215	30	39.24	0.03	0.24	0.03	H
6921	Janejacobs	04/29-05/02	161	3.3,4.0	217	6	5.062	0.001	1.20	0.02	V
7247	Robertstirling	06/04-06/07	180	18.5,18.6	257	30	3.17	0.01	0.14	0.02	H
13186	1996 UM	05/04-05/05	123	10.7,10.9	222	17	4.304	0.004	0.34	0.02	H

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle values are for the first and last date. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

LIGHTCURVE ANALYSIS OF NEA (190166) 2005 UP156: A NEW FULLY-SYNCHRONOUS BINARY

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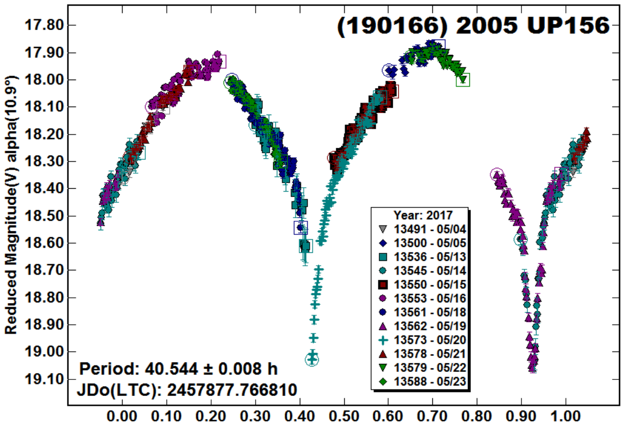
(Received: 2017 July 7)

CCD photometric observations of the near-Earth asteroid (190166) 2005 UP156 in 2017 May show it to be a fully-synchronous binary with rotation and orbital period P = 40.542 ± 0.008 h. The estimated effective diameter ratio of the two bodies is 0.8 ± 0.1. However, the 0.5 mag out-of-eclipse lightcurve indicates quite elongated shapes and so the size ratio should be viewed with caution.

The near-Earth asteroid (190166) 2005 UP156 was observed by Warner in 2014 (Warner, 2015) who found a period of 40.5 h and amplitude of 0.79 mag. Based on a relatively sparse data set, there were no indications of the asteroid being other than a single, highly-elongated body. Those observations were made at about 43° solar phase angle and phase angle bisector longitude of 5° (see Harris et al., 1984).

Warner began observing the asteroid during the 2017 apparition on May 4. By May 19, there was clear evidence that the asteroid was a fully-synchronous binary, i.e., two bodies in close proximity with the rotation period of each body the same as the orbital period. After the observations on May 23, the lightcurve was sufficiently covered to determine the period and approximate size ratio of the bodies. At that time Warner and Harris (2017) submitted a CBET that was published shortly afterwards.

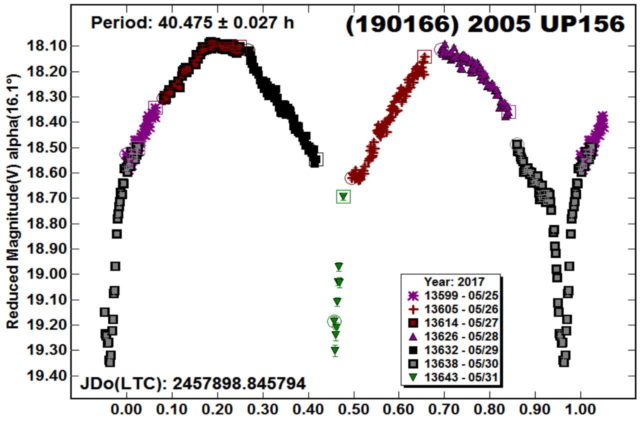
They reported an orbital/rotation period of 40.542 ± 0.008 h and total lightcurve amplitude of 1.1 mag. the out-of-eclipse lightcurve showed an amplitude of 0.5 mag with the eclipse events being about 0.6 mag. Using the latter value gives an effective diameter ratio of the two bodies of 0.8 ± 0.1. This should be considered only a first approximation since the large amplitude of the out-of-eclipse lightcurve indicates that the individual bodies are quite elongated.

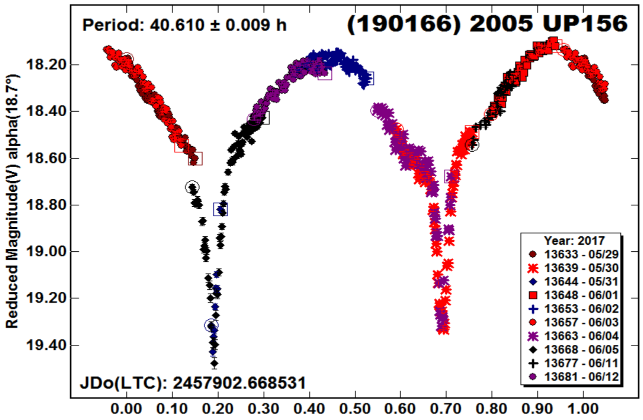


Soon after the discovery announcement, Aznar and Oey provided data to Warner to try to improve lightcurve and event coverage as well as the orbital/rotational period. Table II shows the instrumentation used during the campaign.

OBS	Telescope	Camera
Warner	0.30-m *f*/9.6 SCT	FLI ML-1001E
Aznar	0.35-m f/10 SCT	SBIG STL-1001E
Oey	0.35-m f/11 SCT	Apogee U6M

Table II. List of observers and equipment.



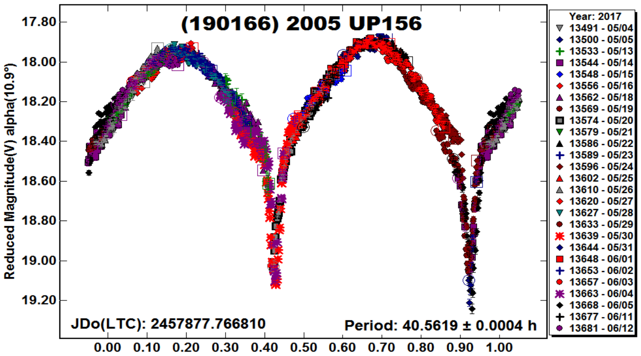


Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
190166	2005 UP156	05/04-06/12	1585	10.8,28.2	230-252	6-16	48.6	0.1	0.12	0.01

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude over the range of dates (see Harris *et al.*, 1984).

Additional observations by all observers provided the opportunity to follow changes in the lightcurve. For example, in the few days after the initial lightcurve, the "shoulders," sharp changes in the lightcurve slope, became more apparent. These gave further evidence of the binary nature of the asteroid. Note that the depths of the two events were almost identical.

A third lightcurve, including data from May 29 to June 12 also shows shoulders, more so at the second event around 0.7 rotation phase. More so, the depth of the two events was no longer symmetrical. The full effect of the lightcurve changes is seen when trying to find a single period using the entire data set.



Going Deeper into the Analysis

The 40.6 hour orbit period implies that the two components, if equal spheres of density ~2.5 gm/cm^3, would have an orbit radius about 9 times the radius of the two bodies. Since the non-eclipse amplitude of the lightcurve implies nearly 2:1 elongation of the bodies, the separation may be more like 6 times the long semi-axis, but the short semi-axis profiles would be closer to 1/12 of the separation (or full-width ratio about 1/6). This geometrical proportion is approximately confirmed by the width of the eclipse events, which are only about 0.05 rotation phase wide. A consequence of the narrowness of the events is that events will only be seen within about ten degrees of equatorial aspect, thus not seeing eclipse events at other apparitions is not surprising.

Acknowledgements

Work on the asteroid lightcurve database (LCDB) is funded by National Science Foundation grant AST-1507535.

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LIGHTCURVE ANALYSIS OF THE NEAR-EARTH ASTEROID 6063 JASON

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(Received: 2017 July 7)

CCD photometric observations of the near-Earth asteroid 6063 Jason were made in 2017 June. A collaboration of five observers at widely-separated longitudes proved critical in finding a synodic period of 48.6 h, nearly commensurate with an Earth day, and confirming that the asteroid is most likely tumbling.

Previous data for near-Earth asteroid 6063 Jason indicated it may be a low amplitude non-principal axis rotation ("tumbler"; Petr Pravec, private communications, 2013). Using data from Warner (2014), Pravec found a strong signal for a period at about 51.3 h. He also found a secondary period of 238 h, but it was not possible to find a definitive answer.

Renewed CCD photometric observations of the asteroid were made by the authors in 2017 June. Table I gives the equipment used. The hope was to confirm and improve the earlier results.

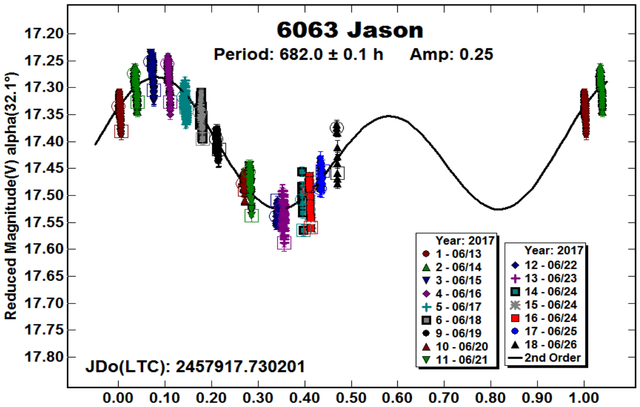
OBS	**Telescope**	**Camera**
Warner	0.30-m *f*/9.6 SCT	FLI ML-1001E
Aznar	0.35-m f/10 SCT	SBIG STL-1001E
Benishek	0.35-m f/10 SCT	SBIG ST-8XME
Oey	0.35-m f/11 SCT	Apogee U6M
Groom	0.30-m f/7.2 SCT	SBIG ST-8XME

Table I. List of observers and equipment.

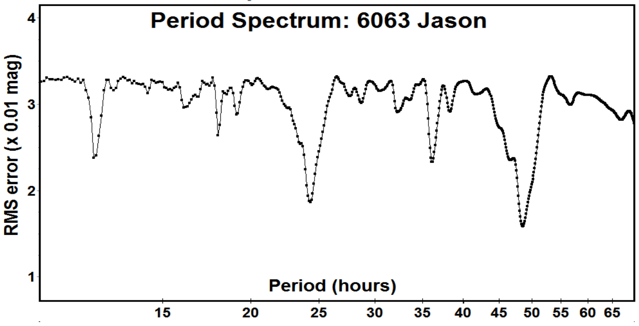
All observers used *MPO Canopus* to measure images, taking advantage of the Comp Star Selector utility to find near solar-color stars for ensemble differential photometry. The V magnitudes of stars from the APASS catalog (Henden *et al.*, 2009) were used for the reductions.

The initial observations by Warner (Jun 13-18) indicated the possibility of a longer period, just as was seen in the 2013 apparition. In that earlier work, it was obvious that data from a single station alone could not find an answer and so the collaboration of the five authors was formed.

Based on the data set that spanned more than two weeks and leaving the nightly zero points almost untouched (adjustments <0.05 mag), even the raw plot, i.e., magnitude vs. JD without fitting to a period, showed a sinusoidal curve that apparently confirmed a long period component. Assuming a bimodal shape, analysis of the data set showed a period of about 680 h, which was much longer than the previously reported long period. However, that previous result was just one many possible solutions based on data from one location.

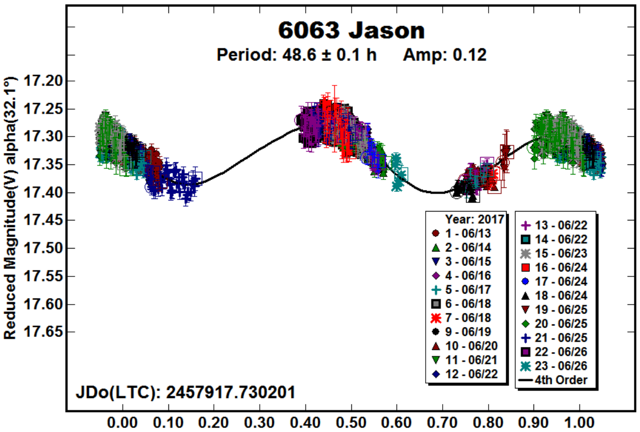


An email query to radar observers got a response from Ellen Howell (private communications) who had also worked the asteroid in 2013 as well as the 2017 apparition. She said there were no obvious indications of the long period, originally suspected by Warner to be one component of a very wide binary asteroid. She did, however, confirm a dominant period of about 48 hours based on radar images and other data.



MPO Canopus is not capable of analyzing tumbling asteroids; it can do dual-period searches only when the two periods are additive, such as happens with a binary asteroid. However, because the tumbling is thought to be low-level with very long periods, we attempted to find a dominant period by using a search to a range of 10-70 hours and then forcing the nightly zero points to get a best Fourier fit, favoring one near 50 hours in case of any ambiguities.

The period spectrum shows several noticeable minimum points, all nearly commensurate with an Earth day. This alone made it imperative to have data from widely-separated longitudes. The final result was a period of 48.6 ± 0.1 h with an amplitude of 0.12 mag. Given the uncertainties in the results from 2013 and 2017, this period is in reasonable agreement with the one from 2013.



As it turns out, because of the low-level tumbling action, the dual-period search in *MPO Canopus* found nearly identical results for the "short" period. This is rarely the case, and never when the periods are very short and/or the tumbling is in a very excited state. However, this does point to the need for caution in interpreting the analysis. As mentioned previously, the analysis also led to the false conclusion that they system was a special type of binary.

Unfortunately, because of the long periods, even with a good network of observers, it may never be possible to find the true parameters of the system, unless the combination of radar and optical data might do so. Often the best possible result in cases such as this is to be able to use only descriptive terms: "With reasonable certainty, the asteroid is a tumbler with long periods."

Acknowledgements

Work on the asteroid lightcurve database (LCDB) is funded by National Science Foundation grant AST-1507535. This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation. (*http://www.ipac.caltech.edu/2mass/*)

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Warner, B.D. (2014). "Near-Earth Asteroid Lightcurve Analysis a CS3-Palmer Divide Station: 2013 September-December." *Minor Planet Bull.* **41**, 113-124.

Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
6063	Jason	06/13-06/26	1208	32.3,28.6	247	13	48.6	0.1	0.12	0.01

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).

LIGHTCURVE ANALYSIS OF TWO NEAR-EARTH ASTEROIDS: 2010 VB1 AND 2014 JO25

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(Received: 2017 July 7)

CCD photometric observations were made of the near-Earth asteroids (NEAs) 2010 VB1 in 2017 June and 2014 JO25 in 2017 April. The lightcurves for both asteroids showed significant day-to-day evolution due to changing viewing aspects. For 2010 VB1, the average synodic period was 0.18919 ± 0.0002 h while the amplitude decreased in near step with the phase angle, going from 0.99 mag at 54° to 0.61 mag at 27°. For 2014 JO25, the average synodic period was 4.60 ± 0.04 h. Its amplitude ranged from 0.39 to 0.14 mag.

The somewhat close flybys of the near-Earth asteroids 2010 VB1 and 2014 JO25 in 2017 provided a good opportunity to study their lightcurve evolution as the viewing aspects (phase angle and phase angle bisector) changed by significant amounts.

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

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

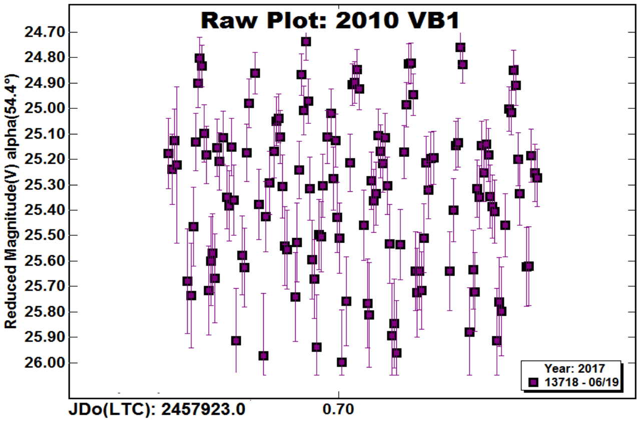
Table I gives the telescope-camera combinations used for the two campaigns conducted at CS3-PDS. All observations were unfiltered since a clear filter can result in a 0.1-0.3 magnitude loss. The exposure duration varied depending on the asteroid's brightness and sky motion. If necessary, an elliptical aperture with the long axis parallel to the asteroid's path was used.

Measurements were made using *MPO Canopus*. 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 CMC-15 (*http://svo2.cab.inta-csic.es/vocats/cmc15/)* or APASS (Henden *et al.*, 2009) catalogs. Period analysis is also done with *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.

If the plot includes an amplitude, *e.g.*, "Amp: 0.65", this is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*. The value is provided as a matter of convenience.

2010 VB1. This NEA made its closest approach in 2017 June. The exposures on June 19 and 20 were only 20 seconds. This was because 1) of the asteroid's rapid sky motion and 2) given its estimated size of only 70 meters, the possibility that its rotation period could be on the order of only a few minutes. Pravec et al. (2000) showed that exposures can be no longer than about 0.187x the period. Otherwise, "rotational smearing" occurs, meaning that details of the lightcurve are lost since the single observation covers too much of a rotation. Because of the rapid sky motion, up to five "sessions" were required, i.e., five different sets of comparison stars were used.



The plot above shows the raw data from just one session on June 19. At first glance, it appears to be useless data because of large scatter. However, because of the possible super-fast rotation, a period search was run from 0.001 to 1.500 h in steps of 0.001 h using all the data from that night. The result was a dense, well-defined bimodal lightcurve with a period of 0.18908 ± 0.00004 h and amplitude of about 0.98 mag.

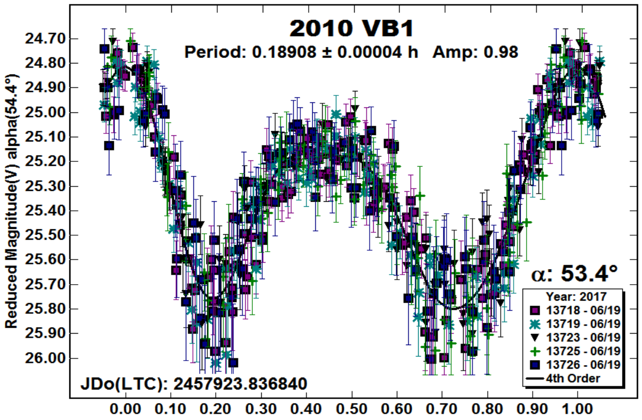
Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.
	2010 VB1	06/19	481	53.4	245	17	0.18908	0.00004	0.98	0.05
		06/20	250	46.9	249	15	0.18912	0.00005	0.81	0.03
		06/21	357	41.5	251	13	0.18920	0.00005	0.83	0.03
		06/22	136	37.2	254	11	0.1891	0.0001	0.67	0.03
		06/23	217	33.8	256	9	0.18895	0.00005	0.63	0.03
		06/24	47	31.1	257	8	0.1895	0.0004	0.70	0.05
		06/25	148	29.0	259	7	0.18915	0.00008	0.62	0.03
		06/26	51	27.3	261	6	0.1894	0.0002	0.61	0.03
	2014 JO25	04/20	328	38.3,30.6	197	12	4.64	0.01	0.21	0.01
		04/21	265	24.7,24.2	198	3	4.53	0.02	0.39	0.03
		04/22-04/24	473	23.9,25.1	201	-6	4.561	0.007	0.14	0.01

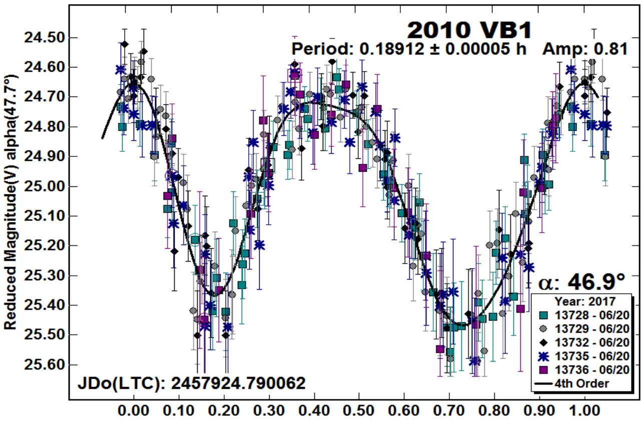
Table II. Observing circumstances. Pts is the number of data points used in the analysis. The phase angle (α) and phase angle bisector longitude (L) and latitude (B) are the average values for the given date or date range.

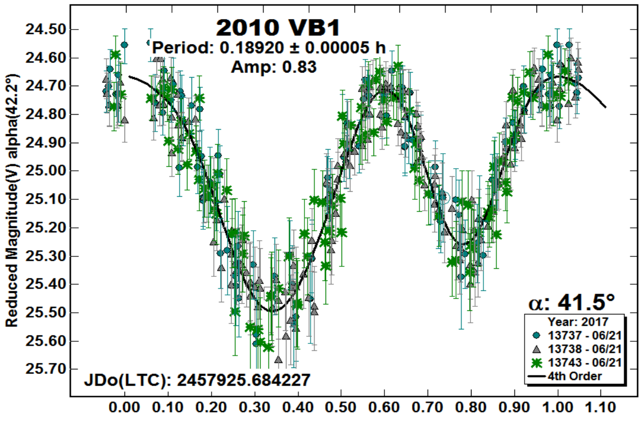
As the asteroid retreated from the Earth's neighborhood and the sky motion decreased, exposures were gradually lengthened to keep the signal-to-noise as high as possible. From June 22-25, 40 second exposures were used while for June 26 exposures were extended to 120 seconds. In all 1687 data points were acquired over the eight consecutive nights of observations.

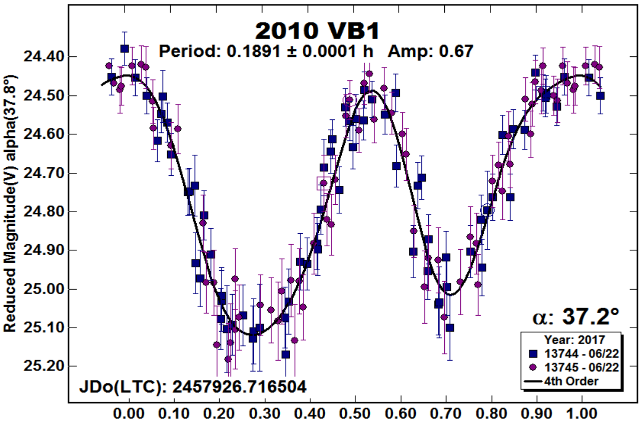
The lightcurves below go from June 19-26 and show how the shape and amplitude evolved as the phase angle decreased from about 54° to 28°. The biggest change is the decreasing depth of the second minimum at about 0.75 rotation phase.

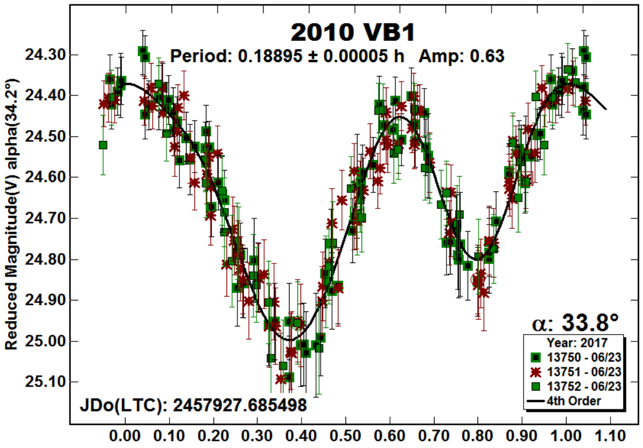
The final plot in the set shows the amplitude versus phase angle. As expected, the amplitude decreased along with the phase angle (Zappala et al., 1990). From the trend line alone, the amplitude would be about 0.28 mag at 0° phase angle. That should be taken with a healthy dose of skepticism since the shadowing effects (or lack of them) at near 0° phase angle could easily change things.

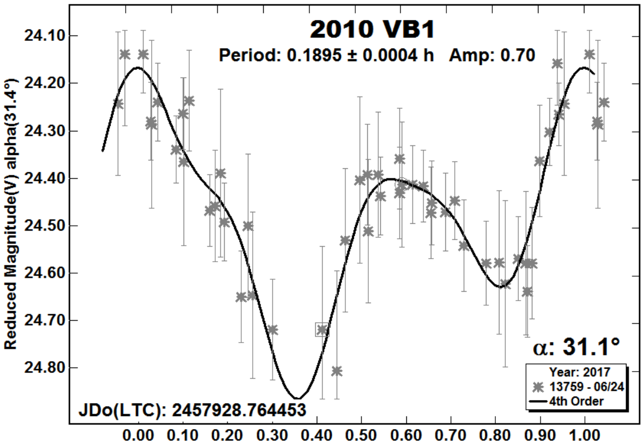


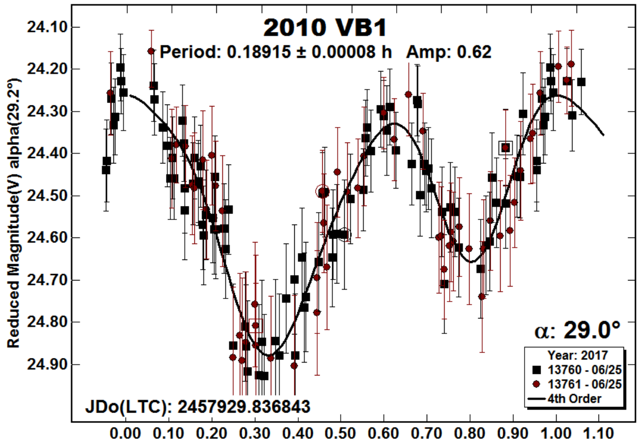


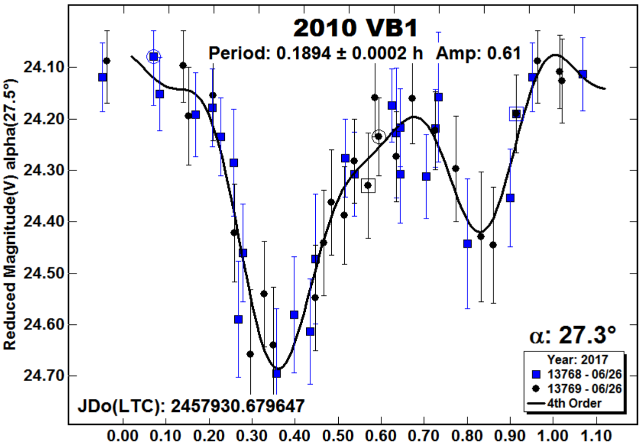


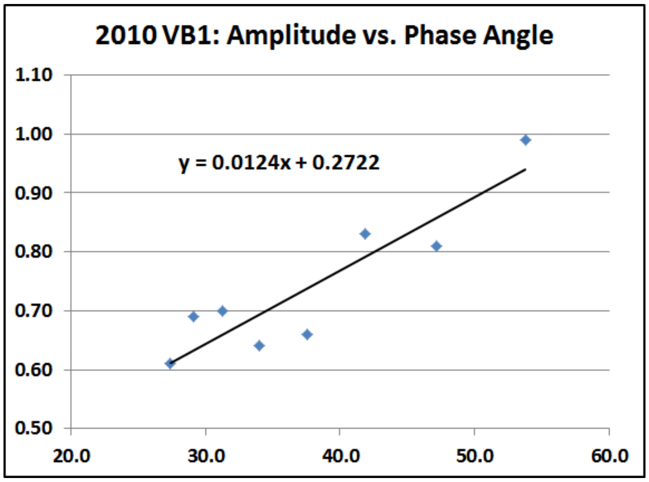




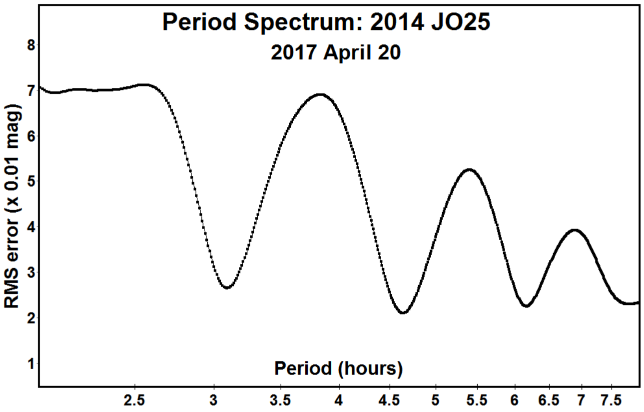




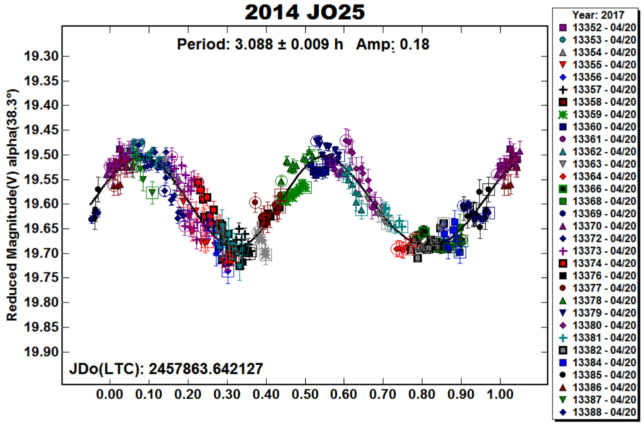


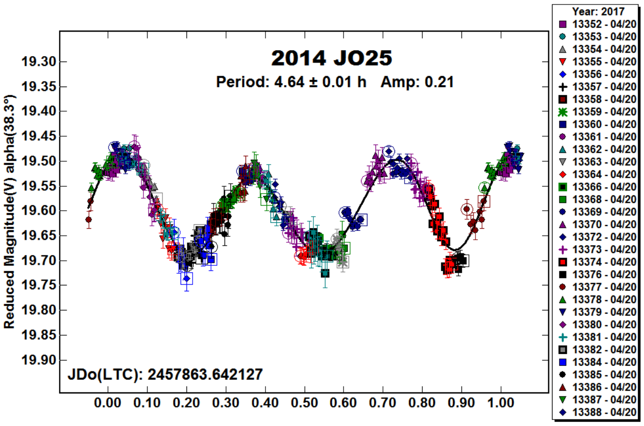


2014 JO25. This NEA made its closest approach in mid-April 2017 when it was the target of radar and optical observations. The first observations at PDS were made on April 20. Here again, due to rapid sky motion, exposures were very short, only 5 seconds. Fortunately, the asteroid was V ~ 10.5 and so a reasonable SNR was obtained. Exposures on April 21 were 10 seconds and increased to 30 seconds for April 22-24. Unlike for 2010 VB1, the estimated size of 2014 JO25 (*D* ~ 860 m) was well above the limit where a superfast rotator might be expected.



The initial analysis of the April 20 data showed three likely periods: about 3, 4.5, and 6 hours, the second and third periods being 1.5x and 2x the shortest period. A bimodal lightcurve is typically the correct solution when the amplitude is about 0.2 mag and greater, but – in truth – Harris et al. (2014) allow for a non-bimodal solution up to an amplitude of about 0.37 mag. Since this was a known to be a target for the radar team, an email was sent to them to see if their observations supported the shortest period. They did not (Patrick Taylor, private communications), but instead favored a period of about 4.5 hours.



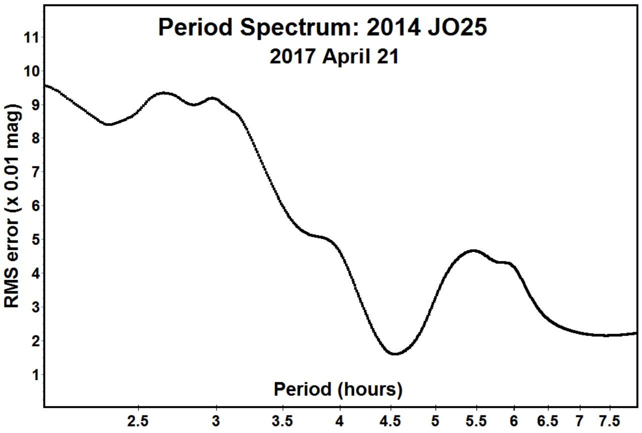


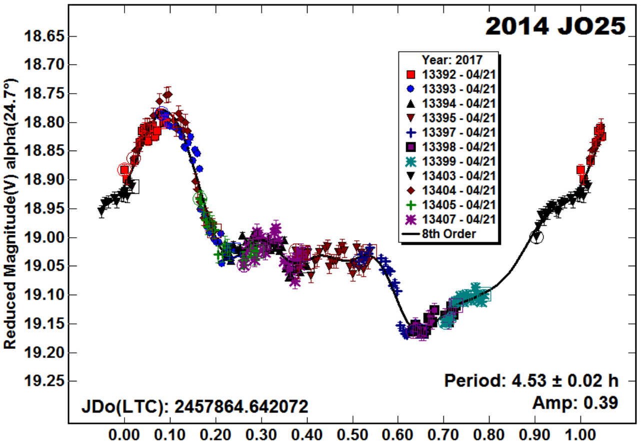
The longer period was adopted, resulting the in second lightcurve for April 20, and for period searches on subsequent days.

The lightcurve for April 21 remains a mystery. Measuring the images required using several sets of comp stars. To help assure good session-to-session zero point alignment, the last 5-10 images of a given session were remeasured for the following session. This should have led to 5-10 data overlapping data points in the raw plot. Slight adjustments (usually <0.05 mag) were required to get the best overlapping fit between the two sessions. This process was repeated for each subsequent session. Despite this, the lightcurve was dramatically different in shape and amplitude from the night before. The same algorithm to correct for changing phase angle and viewing aspect was used throughout, so it would be strange that this lightcurve would be so different. The possible, maybe even probable, cause is the shape of the asteroid, which was found by radar to be a double-lobed (highly bifurcated) body, along with a different viewing aspect.

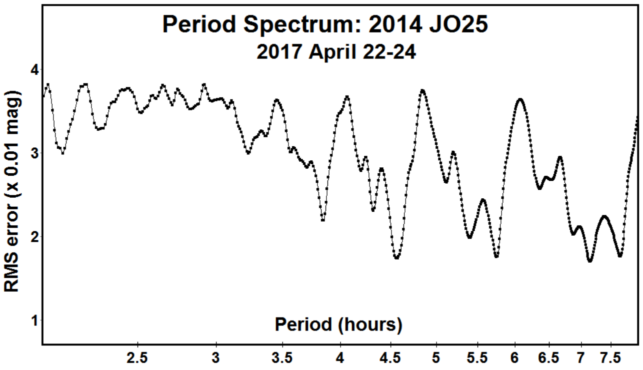
There are some excellent radar image animations available of this asteroid, for example,

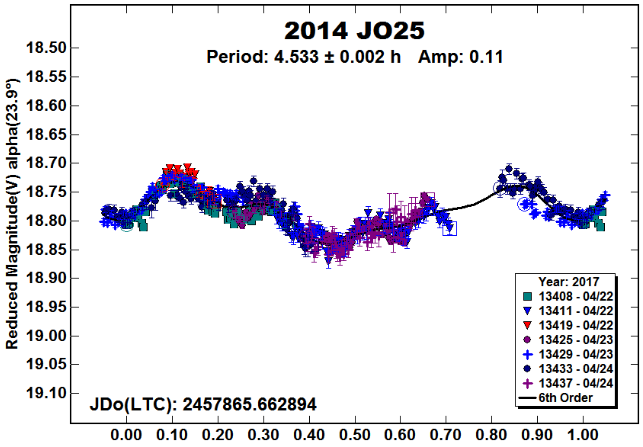
https://www.youtube.com/watch?v=usPrwjyggEM





As the asteroid receded on April 22-24, the phase angle and viewing aspects did not change by large amounts. Given this and an assumed spin axis alignment that meant a similar silhouette was seen each night, the lightcurve returned to a low amplitude shape that was then bimodal when keeping the period near 4.5 h. Despite only small changes in viewing aspect and phase angles, there are still signs of slight changes in the lightcurve.





Acknowledgements

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LIGHTCURVE ANALYSIS OF HILDA ASTEROIDS AT THE CENTER FOR SOLAR SYSTEM STUDIES: 2017 APRIL THRU JULY

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(Received: 2017 July 10)

Lightcurves for ten Hilda asteroids were obtained at the Center for Solar System Studies (CS3) from 2017 April thru July.

CCD photometric observations of ten Hilda asteroids were made at the Center for Solar System Studies (CS3) from 2017 April thru July. This is another in a planned series of papers on this group of asteroids, which is located between the outer main-belt and Jupiter Trojans in a 3:2 orbital resonance with Jupiter. The goal is to determine the spin rate statistics of the group and find pole and shape models when possible. We also we look to examine the degree of influence that the YORP effect (Rubincam, 2000) has on distant objects and to compare the spin rate distribution against the Jupiter Trojans, which can provide evidence that the Hildas are more "comet-like" than main-belt asteroids.

Table I lists the telescopes and CCD cameras that are combined to make observations. Up to nine telescopes can be used for the campaign, although seven is more common. All the cameras use CCD chips from the KAF blue-enhanced family and so have essentially the same response. The pixel scales ranged from 1.24-1.60 arcsec/pixel. All lightcurve observations were unfiltered since a clear filter can result in a 0.1-0.3 magnitude loss. The exposures varied depending on the asteroid's brightness and sky motion.

Telescopes	Cameras
0.30-m *f*/6.3 Schmidt-Cass	FLI Microline 1001E
0.35-m *f*/9.1 Schmidt-Cass	FLI Proline 1001E
0.35-m *f*/11 Schmidt-Cass	SBIG STL-1001E
0.40-m f/10 Schmidt-Cass	
0.50-m *f*/8.1 Ritchey-Chrétien	

Table I. List of available telescopes and CCD cameras at CS3. The exact combination for each telescope/camera pair can vary due to maintenance or specific needs.

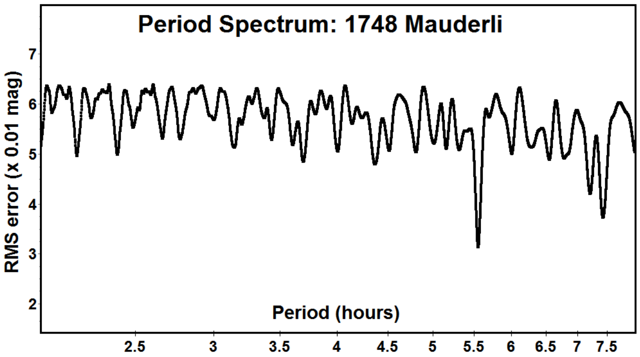
Measurements were made using *MPO Canopus*. The Comp Star Selector utility in *MPO Canopus* found up to five comparison stars of near solar-color for differential photometry. Catalog magnitudes were usually taken from the CMC-15 (*http://svo2.cab.inta-csic.es/vocats/cmc15/)* or APASS (Henden *et al.*, 2009) catalogs. The MPOSC3 catalog was used as a last resort. The last catalog is based on the 2MASS catalog (*http://www.ipac.caltech.edu/2mass*) with magnitudes converted from J-K to BVRI (Warner, 2007). The nightly zero points for the catalogs are generally consistent to about ±0.05 mag or better, but on occasion reach 0.1 mag and more. There is a systematic offset among the catalogs so, whenever possible, the same catalog is used throughout the observations for a given asteroid. Period analysis is also done with *MPO Canopus*, which implements the FALC algorithm developed by Harris (Harris *et al.,* 1989).

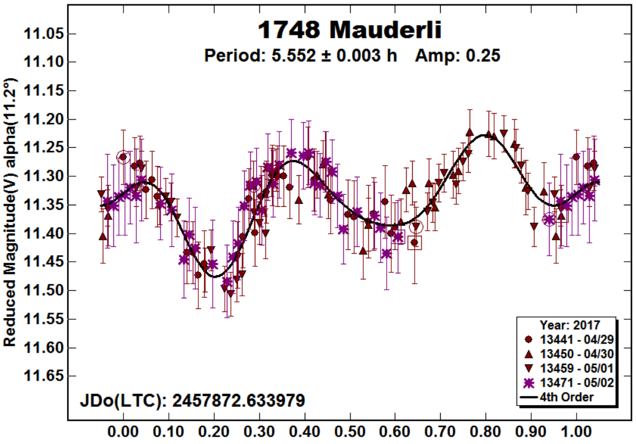
In the plots below, the "Reduced Magnitude" is Johnson V as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distance by applying –5*log (rΔ) to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances 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.

If the plot includes an amplitude, *e.g.*, "Amp: 0.65", this is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*.

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.

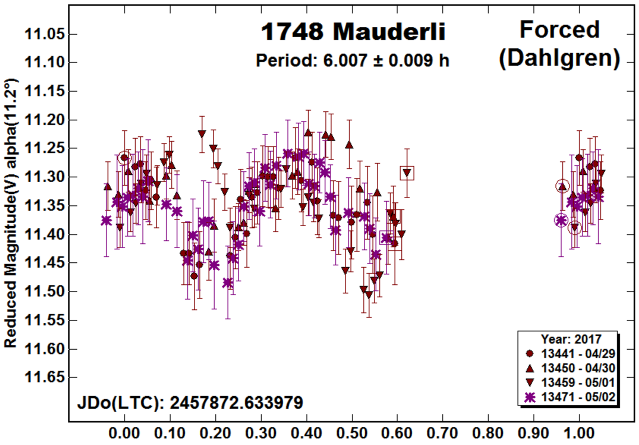
1748 Mauderli. Dahlgren et al. (1998) and Slyusarev et al. (2012) both reported a period of 6.0 hours and amplitudes of 0.12 and 0.1 mag, respectively. Analysis of the CS3 data does not seem to support that result. The period spectrum shows a clear minimum at about 5.55 h, with only a very slight local minimum at 6 h. The CS3 lightcurve has an amplitude of 0.25 mag, which gives us confidence in the shorter period, as does forcing the CS3 data to a period near 6 h. Even at 0.25 mag, a bimodal lightcurve is not certain (Harris et al., 2014); therefore, we are not overly concerned about the trimodal solution, especially given its asymmetry.



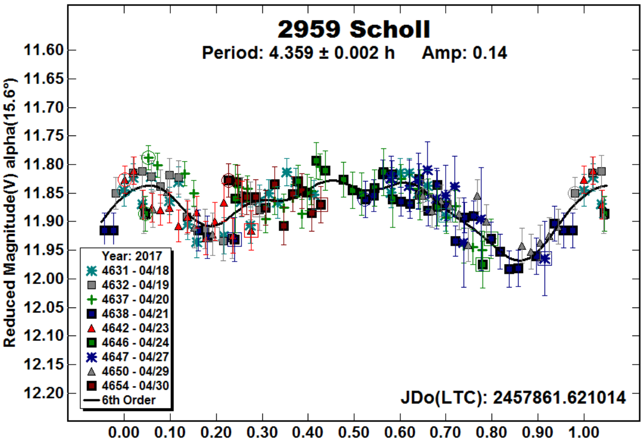


Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
1748	Mauderli	04/29-05/02	125	11.2,11.4	159	2	5.552	0.003	0.25	0.02
2959	Scholl	04/18-04/30	154	15.6	133	2	4.359	0.002	0.14	0.02
3254	Bus	05/01-05/12	112	12.1,12.6	154	4	8.99	0.01	0.46	0.03
3290	Azabu	04/16-04/18	190	7.0,7.6	185	3	7.670	0.005	0.23	0.02
7174	Semois	04/29-05/03	74	12.5,12.9	159	2	7.456	0.006	0.38	0.03
8130	Seeberg	04/04-04/20	329	5.8,2.4	211	7	35.1	0.2	0.42	0.03
8130	Seeberg	05/19-06/03	397	9.1,12.5	211	7	38.10	0.03	0.23	0.03
9829	Murillo	04/06-04/22	473	1.8,6.8	191	1	21.754	0.006	0.81	0.02
13504	1988 RV12	04/29-05/20	522	5.4,4.0,4.5	232	14	26.562	0.005	0.50	0.05
15540	2000 CF18	04/13-04/24	600	5.7,7.5	197	17	28.41	0.02	0.51	0.03
22058	2000 AA64	04/22-04/30	207	6.8,8.7	191	9	17.04	0.05	0.23	0.03

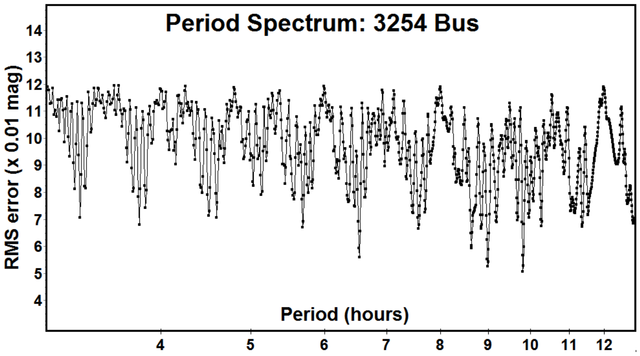
Table II. Observing circumstances. The phase angle (α) is given at the start and end of each date range, unless it reached a minimum, which is then the second of three values. L_{PAB} and B_{PAB} are each the average phase angle bisector longitude and latitude (see Harris *et al*., 1984).

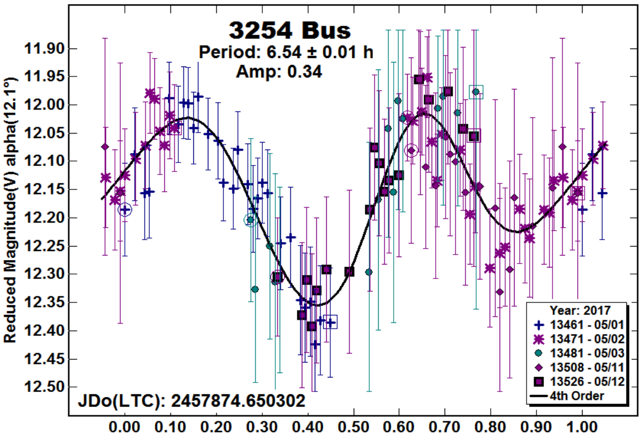


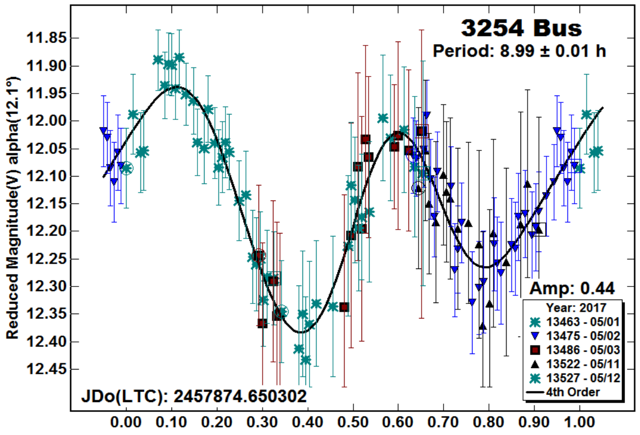
2959 Scholl. Dahlgren et al. (1998) found a period $P > 16$ h and amplitude $A > 0.1$ mag, but that result is rated U = 1 (likely wrong) in the asteroid lightcurve database (LCDB; Warner et al., 2009). Our data led to a period of 4.359 ± 0.002 h and amplitude of 0.14 mag. The low amplitude and unequal spacing of maximums vs. minimums casts a small shadow of doubt on the solution, but our data could not be fit to a longer period.



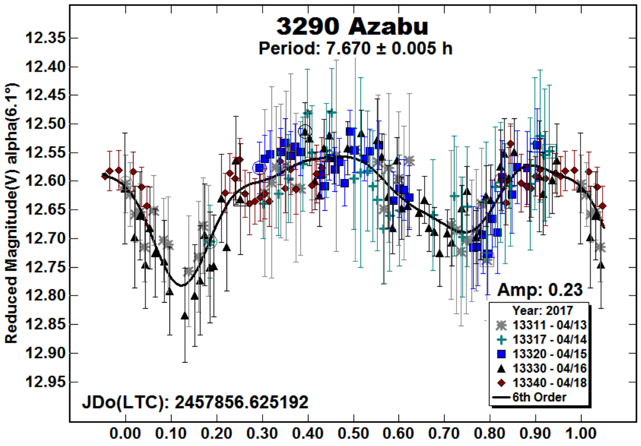
3254 Bus. Binzel and Sauter (1992) first reported a period 6.62 h with amplitude of 0.31 mag. The original analysis made only slight adjustments of nightly zero points and found a period of 8.99 h. By taking more than usual liberties with zero point adjustments, especially the one on May 1, it was possible to get a good fit to a solution near the one from Bus and Sauter (1992). We have adopted the shorter period of 6.54 h for this paper. Both lightcurves are shown for comparison.



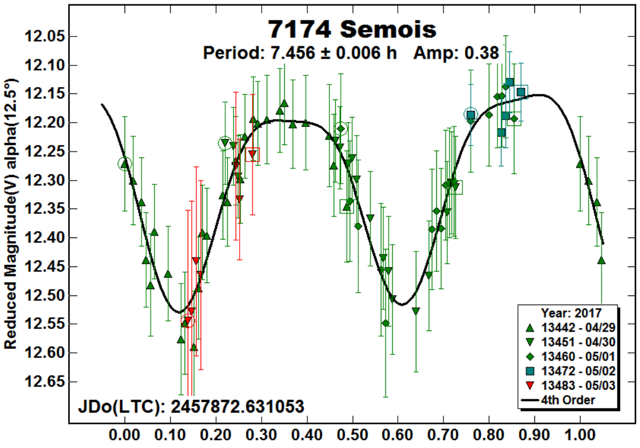




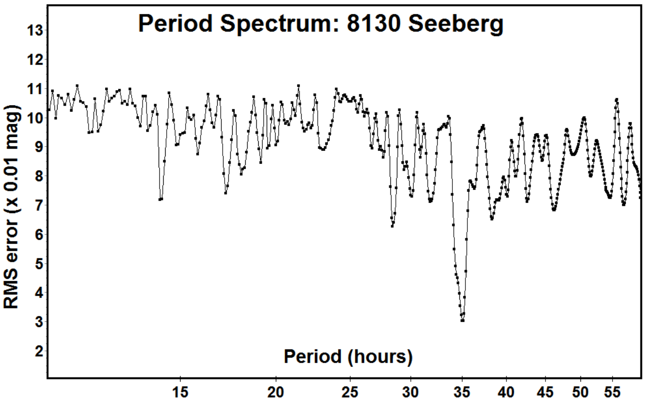
3290 Azabu. Dahlgren et al. (1998) found $P > 12$ h and $A > 0.08$ mag for this 20 km Hilda, which is rated U = 1 in the LCDB. Our analysis led what we consider a secure period of 7.670 ± 0.005 h,

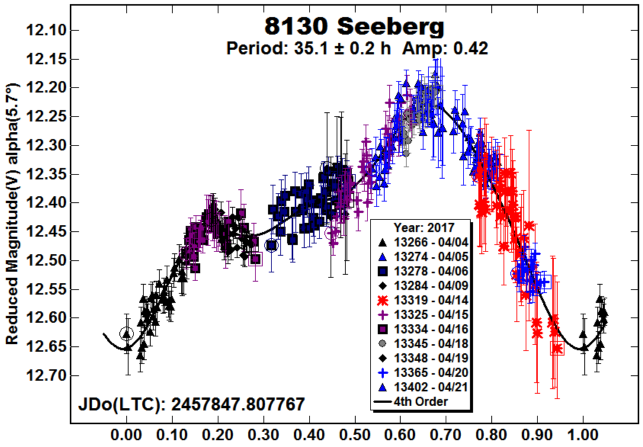


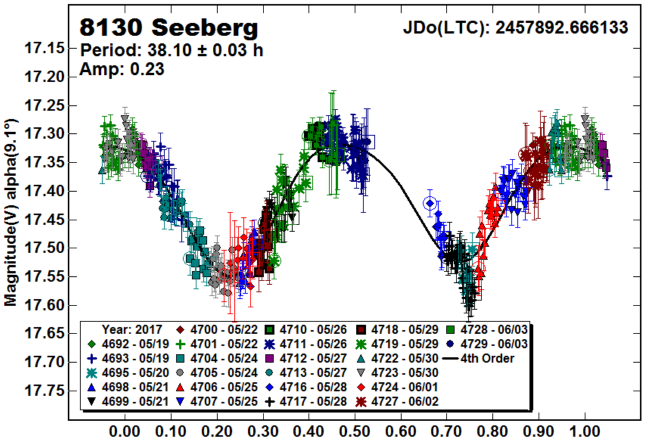
<u>7174 Semois</u>. The estimated diameter of this Hilda is 27 km. This appears to be the first reported result. Despite the sparse data set, the amplitude and a very good fit to a half-period of 3.73 h makes the solution reasonably secure.



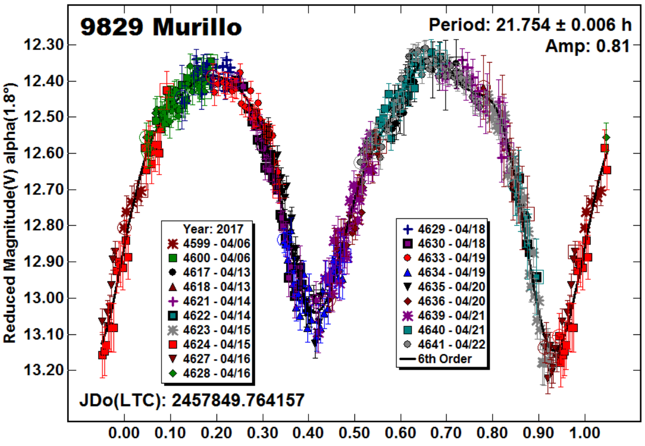
<u>8130 Seeberg</u>. Warner worked Seeberg in 2017 April and found a period of about 85 h with the possibility of tumbling. When Stephens observed it a month later, there were no obvious signs of tumbling and he found a good bimodal fit to a period of 38.1 h. In light of this, the April data were revisited to see if the data would fit a period near 38 h. The period spectrum shows a sharp minimum at 35 hours, which is close but still significantly off the longer period. Maybe more data at a future apparition will lead to a stronger solution.



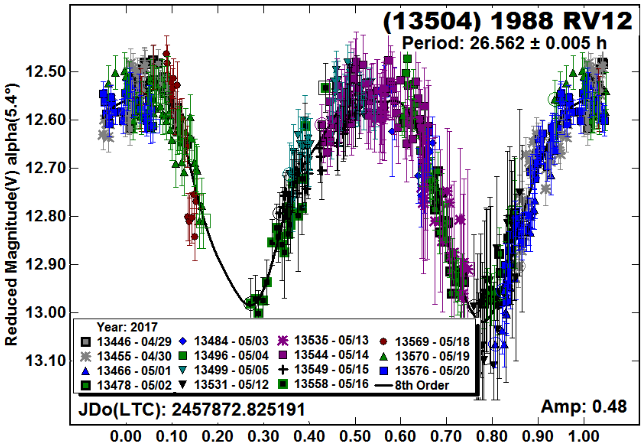




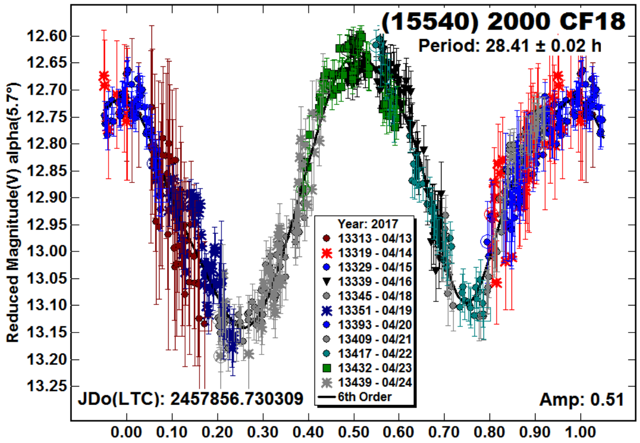
<u>9829 Murillo</u>. Slyusarev et al. (2012) reported a period of *P* > 4 h. No lightcurve was published, making direct comparison of results impossible. Our result of 21.754 ± 0.006 h does tally with theirs in that the period is longer than 4 hours. Given the more than double coverage of the lightcurve and amplitude, we consider this solution to be secure.



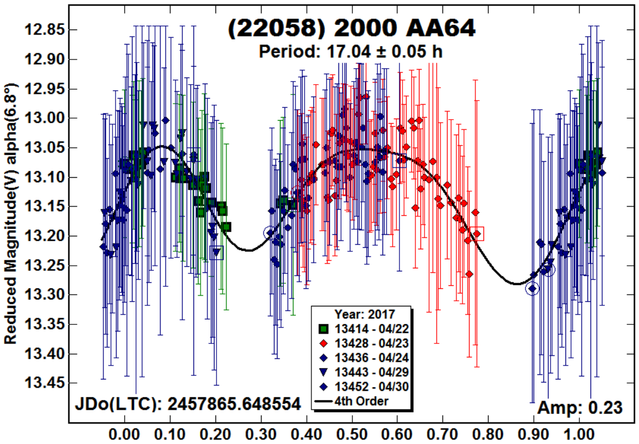
<u>(13504) 1988 RV12</u>. Stephens (2016) observed 1988 RV12 in 2016 March and reported a period of 26.543 h with an amplitude of 0.61 mag. Analysis of the data obtained by Warner in 2017 led to a similar result of 26.562 ± 0.006 h but a smaller amplitude of 0.48 mag. The 2017 observations were at a phase angle bisector longitude 60° greater than in 2016 (172° vs. 232°). It would be a reasonable guess to say that the spin axis pole longitude is near 260° (or 80°) and the latitude |β| > 45°.



(15540) 2000 CF18. This appears to be the first reported period for the 20-km Hilda. We consider the period secure.



(22058) 2000 AA64. This also appears to be the first reported period for 2000 AA64. The large error bars compared to the amplitude of the lightcurve make the solution probable but not certain.



Acknowledgements

Funding for observations, analysis, and publication for Warner and Stephens was provided by NASA grant NNX13AP56G. Work on the asteroid lightcurve database (LCDB) by Warner was also funded in part by National Science Foundation grant AST-1507535. The authors gratefully acknowledge Shoemaker NEO Grants from the Planetary Society (2007, 2013, 2015). These were used to purchase some of the telescopes and CCD cameras used in this research. This research was made possible through the use of the AAVSO Photometric All-Sky Survey (APASS), funded by the Robert Martin Ayers Sciences Fund and in was based in on data from CMC15 Data Access Service at CAB (INTA-CSIC) (*http://svo2.cab.inta-csic.es/vocats/cmc15/)*. This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation. (*http://www.ipac.caltech.edu/2mass/*)

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NEAR-EARTH ASTEROID LIGHTCURVE ANALYSIS AT CS3-PALMER DIVIDE STATION: 2017 APRIL THRU JUNE

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Lightcurves for 31 near-Earth asteroids (NEAs) obtained at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2017 April thru June were analyzed for rotation period and signs of satellites or tumbling.

CCD photometric observations of 31 near-Earth asteroids (NEAs) were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2017 April thru June. 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. If necessary, an elliptical aperture with the long axis parallel to the asteroid's path was used.

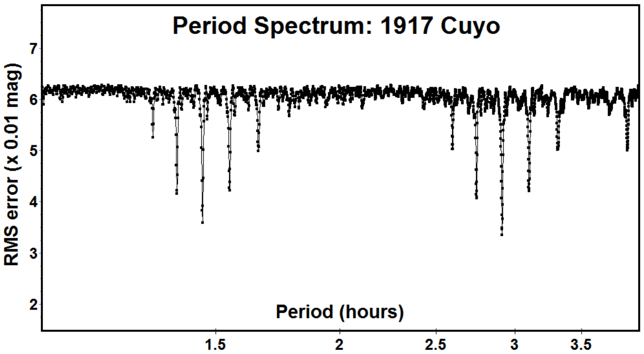
Measurements were made using *MPO Canopus*. The Comp Star Selector utility in *MPO Canopus* found up to five comparison stars of near solar-color for differential photometry. Catalog magnitudes were usually taken from the CMC-15 (*http://svo2.cab.inta-csic.es/vocats/cmc15/)* or APASS (Henden *et al.*, 2009) catalogs. The MPOSC3 catalog was used as a last resort. This catalog is based on the 2MASS catalog (*http://www.ipac.caltech.edu/2mass*) with magnitudes converted from J-K to BVRI (Warner, 2007). The nightly zero points for the catalogs are generally consistent to about ± 0.05 mag or better, but on occasion reach 0.1 mag and more. There is a systematic offset among the catalogs so, whenever possible, the same catalog is used throughout the observations for a given asteroid. Period analysis is also done with *MPO Canopus*, which implements the FALC algorithm developed by Harris (Harris *et al.,* 1989).

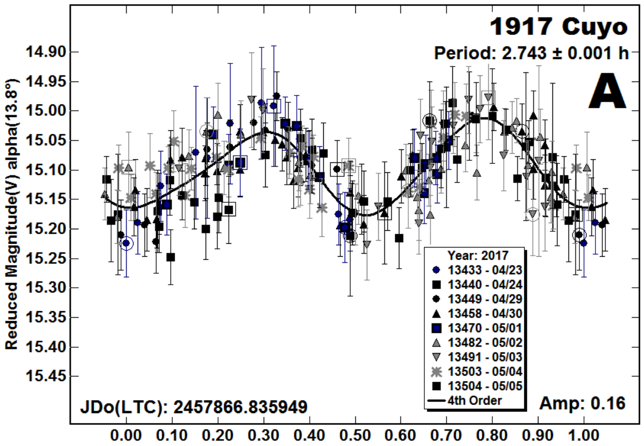
In the plots below, the "Reduced Magnitude" is Johnson V as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distances by applying $-5*\log(r\Delta)$ to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid 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.

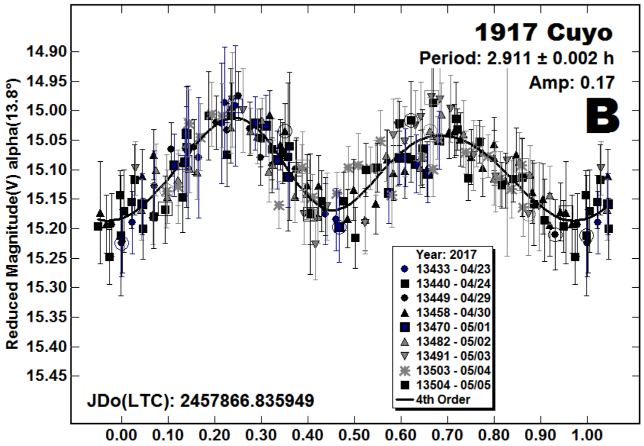
For the sake of brevity, only some of the previously reported results may be referenced in the discussions on a specific asteroid. For a more complete listing, the reader is directed to the asteroid lightcurve database (LCDB; Warner *et al.,* 2009). The on-line version at *http://www.minorplanet.info/lightcurvedatabase.html* 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. When possible, readers are strongly encouraged to check against the original references listed in the LCDB.

If the plot includes an amplitude, *e.g.*, "Amp: 0.65", this is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*. The value is provided as a matter of convenience.

1917 Cuyo. There are many previous results in the LCDB, all near 2.7 h. The 2017 data did not lead to a unique result.



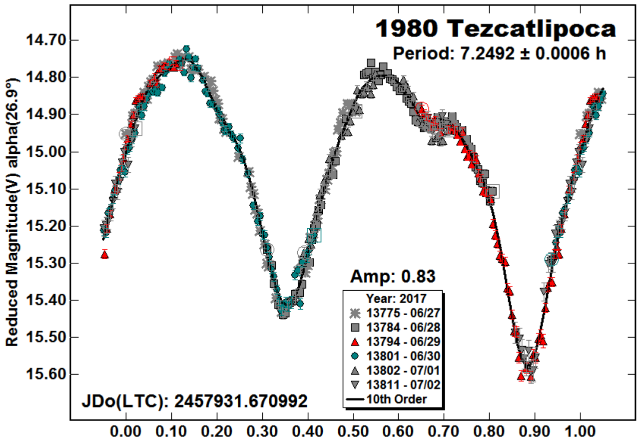




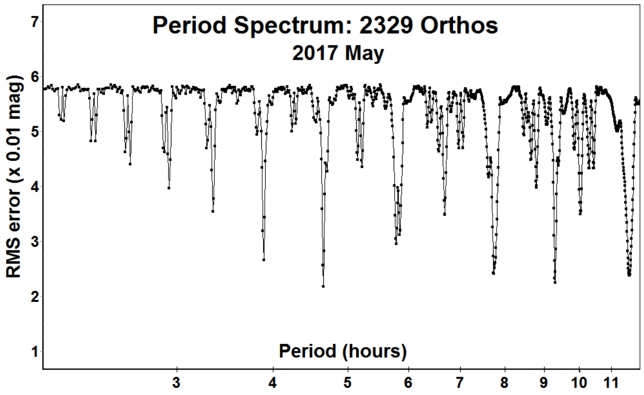
The period spectrum and half-period search both strongly favor a period of 2.911 h over one of 2.743 h. As shown in the two lightcurves, either period apparently gives the same quality fit. It's worth noting that the two differ by exactly one-half rotation over 24 hours. Finding such aliased periods such as these can often be attributed to mismatching to which half of a symmetrical lightcurve a given data set applies. However, both of these are sufficiently asymmetrical to almost rule out that possibility.

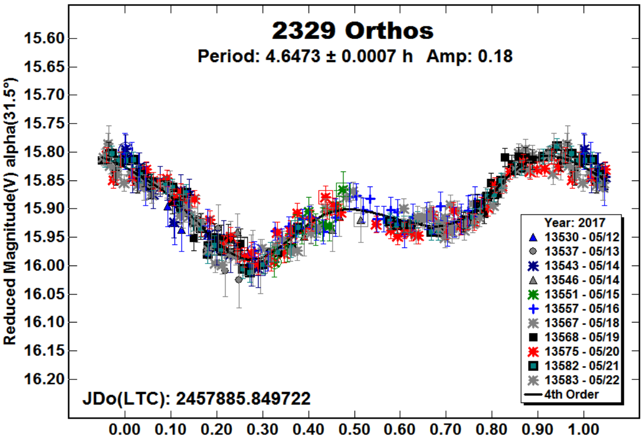
The data from 2014 (Warner, 2014b; 2015a) were re-examined to see if they might help resolve the ambiguity. The data from May could also be equally fit to two periods of about 2.7 and 2.9 hours. However, the April data showed a decided preference for 2.7 h and an almost certain exclusion of 2.9 h. For this reason, the period of 2.743 h found from the 2017 data is the one adopted for this paper.

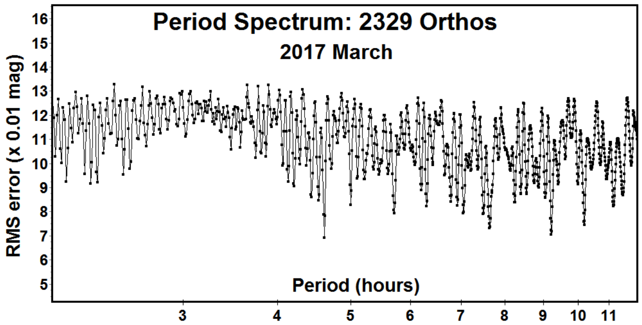
1980 Tezcatlipoca. This NEA always has a fairly large amplitude (0.55-1.01 mag; LCDB). The period found from the 2017 data is in excellent agreement with past results.

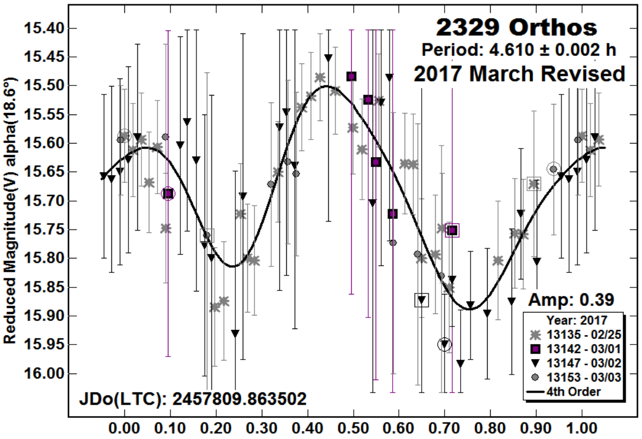


2329 Orthos. Warner (2017b) reported a period of 6.178 h based on data obtained in 2017 February-March. That solution appears to be wrong. Based on the period spectrum and a search of half-periods using the May data, a period of 4.6473 h was found and is adopted as the correct result. The earlier data were re-analyzed, usually by slight modifications to nightly zero points, to see if they would fit the shorter period. As the revised period spectrum shows, a period of 4.610 h is favored. However, the measurement error bars are significant in relation to the amplitude, which makes the revised solution suspect, even if it is in near agreement with one based on the high-quality data set from May.

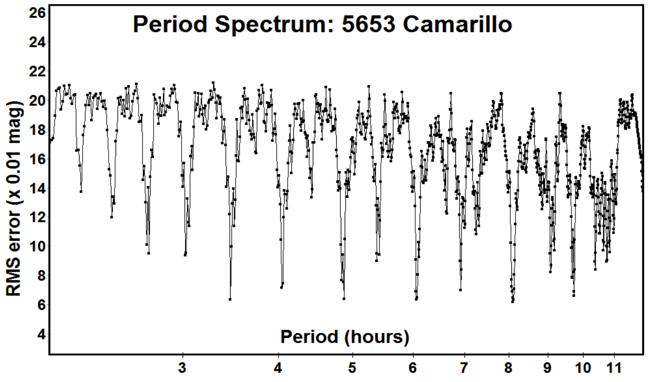


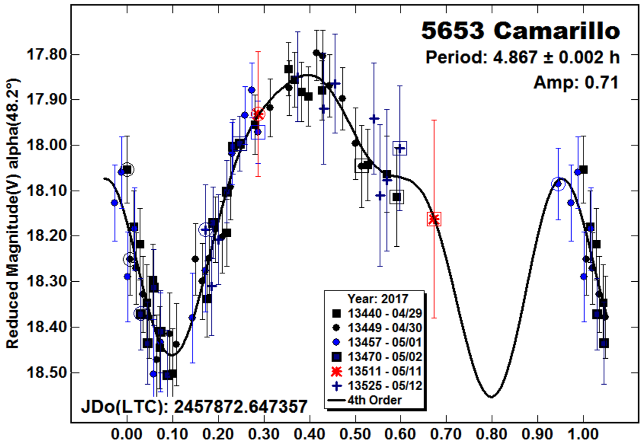




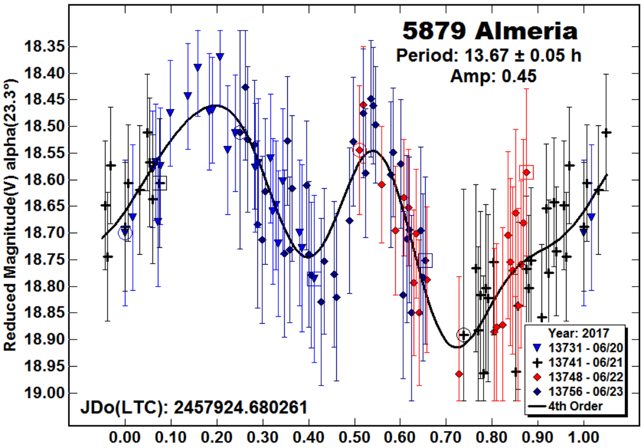


5653 Camarillo. The incomplete coverage of the lightcurve from the data set obtained in 2017 April-May leads to a period spectrum with many nearly-equal solutions. The period of 4.867 h was adopted because it produced somewhat symmetric bimodal fit and it agreed with numerous results in the LCDB.

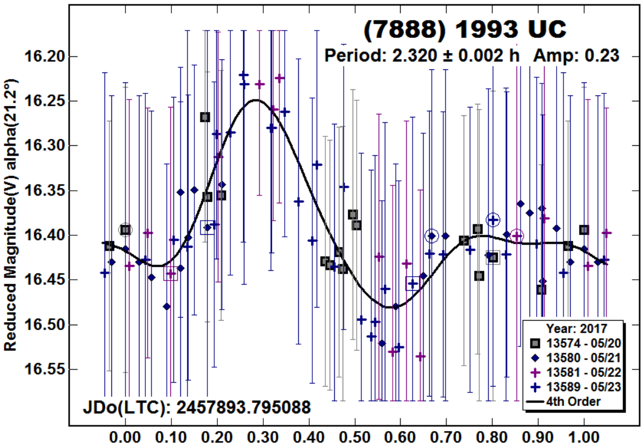




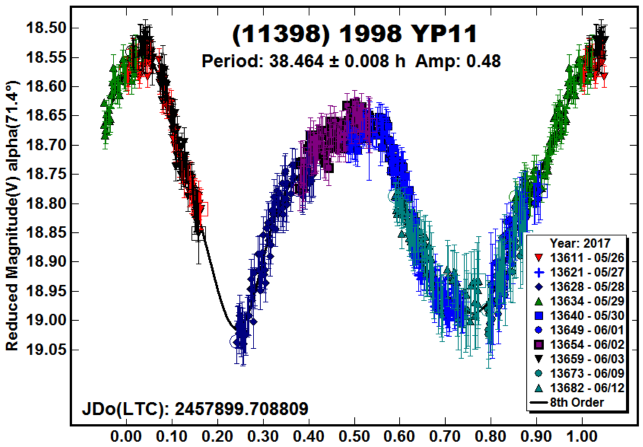
5879 Almeria. No previous results were found in the LCDB for this 1-km NEA.



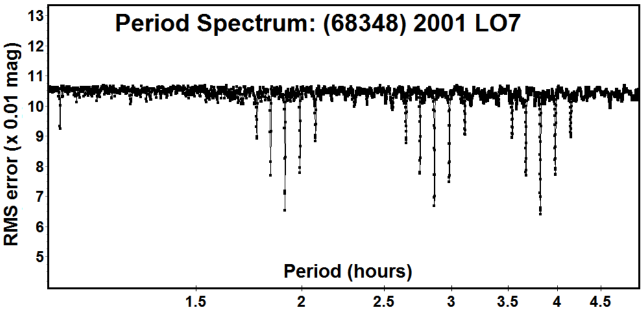
(7888) 1993 UC. The solution was forced to match one found earlier (Warner, 2017a). As a stand-alone result, it is unreliable.

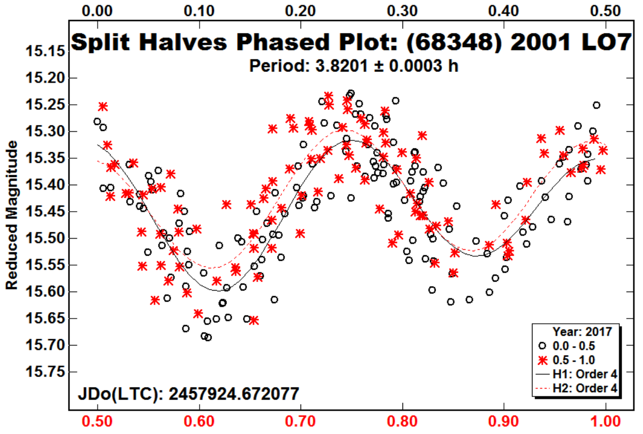


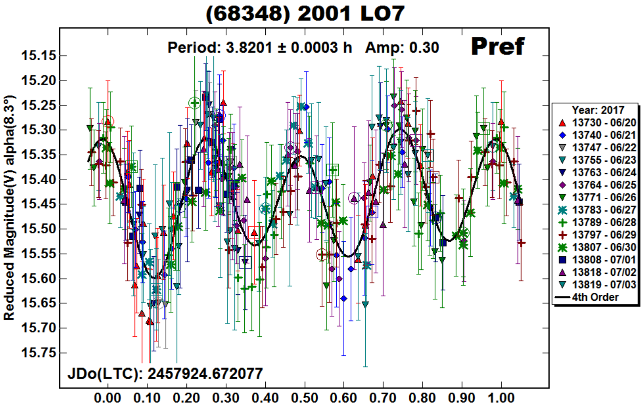
(11398) 1998 YP11. Pravec et al. (2005) found a period of 38.6 h. Given the period and estimated size, this asteroid is a very good candidate for non-principal axis rotation ("tumbling"). However, neither Pravec et al. or Warner (2008) found obvious signs of tumbling. This was true again based on two data sets in 2017, one in February (Warner, 2017b) and the one reported here that led to a period of 38.464 h, in good agreement with all previous results.

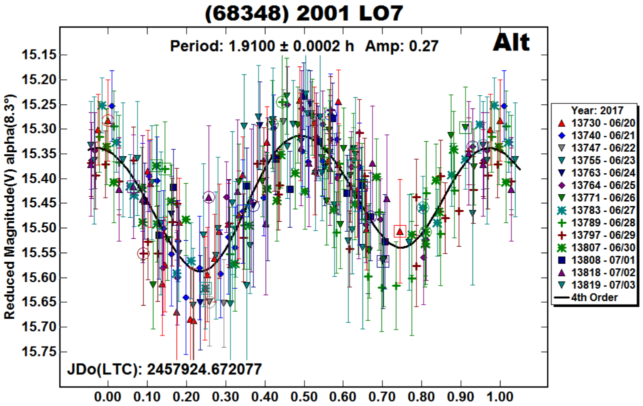


(68348) 2001 LO7. This asteroid proved to be an exception to the rule that having an amplitude of about 0.3 mag or greater strongly favors a bimodal solution. The better (but not definitive) cutoff is about 0.38 mag (Harris et al., 2014).







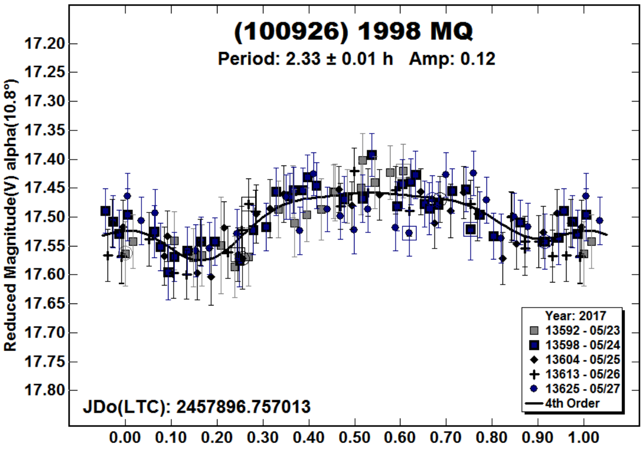


Earlier results from Skiff (2011; 3.324 h) and Warner (2015b; 3.8759 h) both showed a bimodal lightcurve. Because of the larger amplitude in 2017, it was thought that a bimodal solution was most likely, which led to a solution of 1.9100 h. This places the asteroid just above the so-called "spin barrier," which separates rubble pile asteroids (gravitationally-bound) from those that are strength-bound. However, that barrier is not hard-fast and so there was room for this asteroid to be an exception.

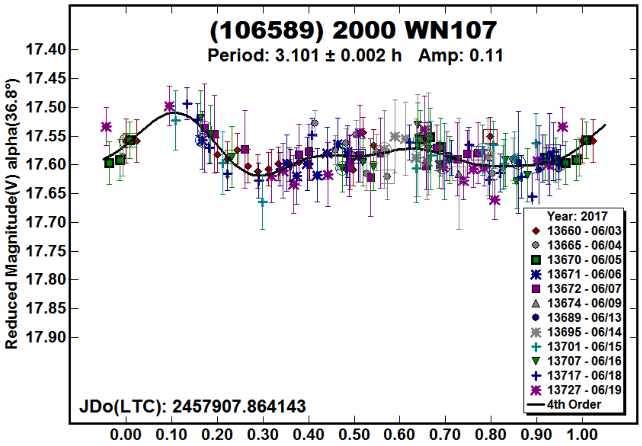
It took about two weeks to obtain sufficient data to break the period ambiguity by examining the "split-halves" plot. This is where the data are phased to a given period but the second half of the lightcurve is superimposed on top of the first half. If the two halves show sufficient disagreement (a subjective analysis), the period is more likely correct than the potential half-period. This plot and analysis were used to solve a similar case: 5404 Uemura (Harris et al., 2104).

Given the earlier results and the split-halves analysis, the conclusion is that the period of 3.8201 h found from the 2017 data is most likely correct.

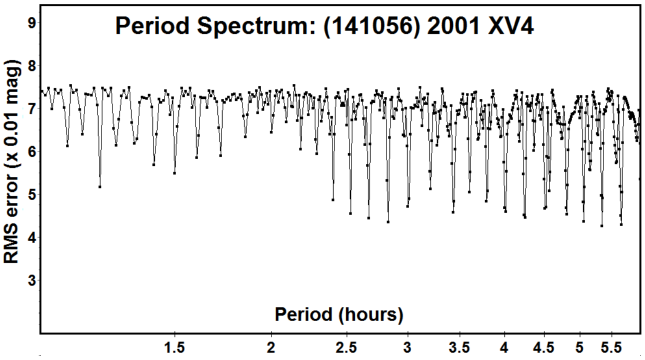
(100926) 1998 MQ. Warner (2011) found a period of 2.328 h based on data obtained in 2010 October. The 2017 data led to the same result, although it does produce an asymmetrical lightcurve. The period spectrum showed weaker "side-lobes" (periods that differ by one-half cycle over 24 hours). Forcing the data to those produced unsatisfactory results.

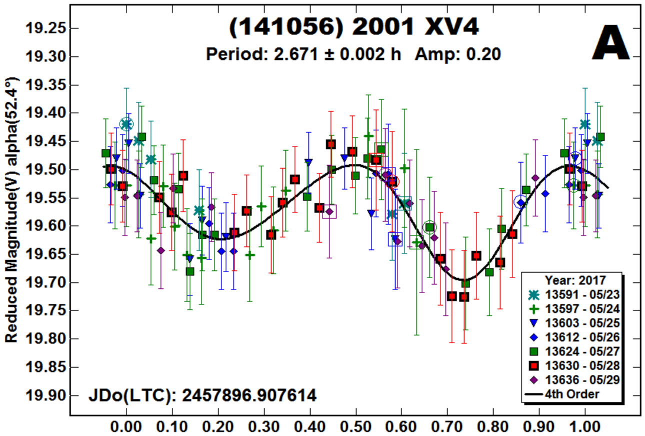


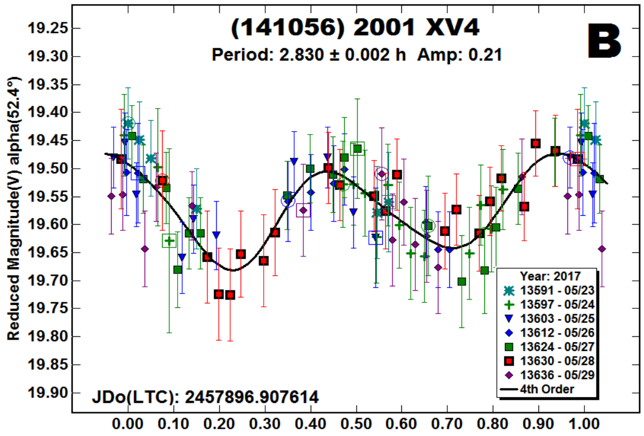
(106589) 2000 WN107. This appears to be the first reported period for 2000 WN107, which has an estimated diameter of 1.9 km. The low amplitude and somewhat noisy data make the solution probable but far from certain.



(141056) 2001 XV4. The period spectrum for the 1.1 km asteroid shows numerous possibilities.

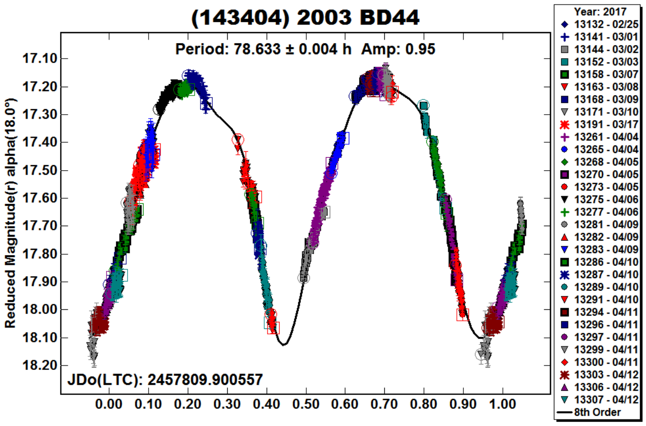




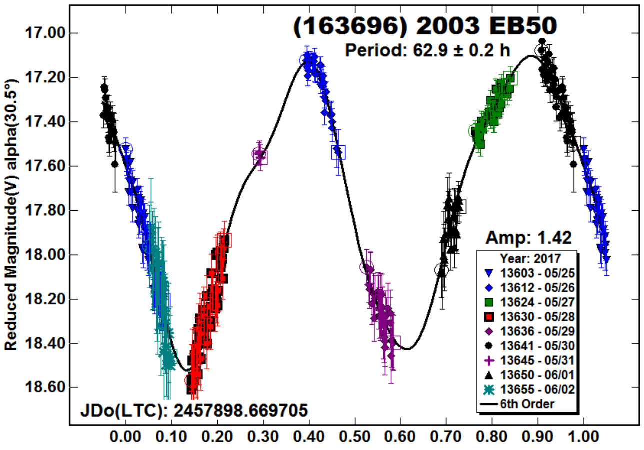


It favored a period of 2.83 hours. However, when doing a half-period search, one that doubles to about 2.67 h is favored. This is another case where the two periods differ by one-half a rotation over 24 hours. The solution of 2.671 h is adopted for this paper, based primarily on its Fourier curve having a better fit to the data.

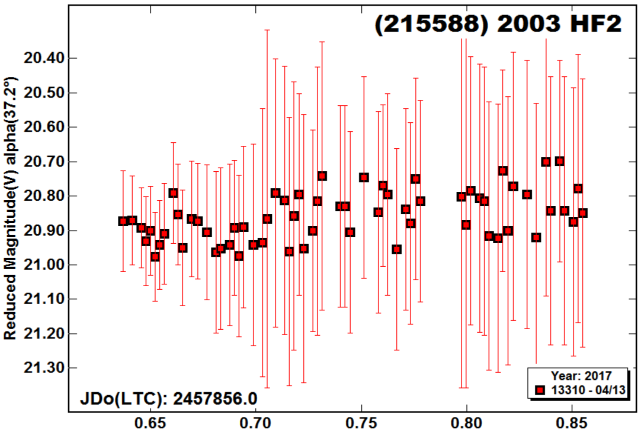
(143404) 2003 BD44. By rights, 2003 BD44 should be in a tumbling state (Pravec et al., 2014; 2005). There are small signs of this, i.e., the data from the second and following cycles did not quite overlap those from the first cycle. However, this could also be due to changes in the lightcurve over the range of observations. If tumbling, it is at a low-level and would be nearly impossible to characterize accurately.

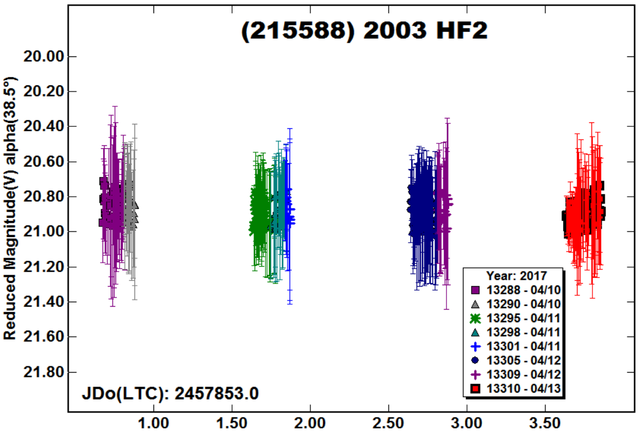


(163696) 2003 EB50. Using data from 2013 (Warner, 2014a), a period of 27.2 h was found, with the possibility of tumbling. Observations in 2015 (Warner, 2016a), found a period of 62.4 h with no obvious signs of tumbling. The data obtained in 2017 led to a period of 62.9 h. Here again, if tumbling is present, it's at a very low level and likely not to be fully characterized.

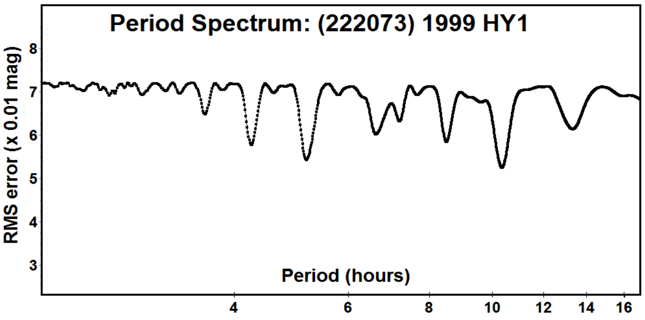


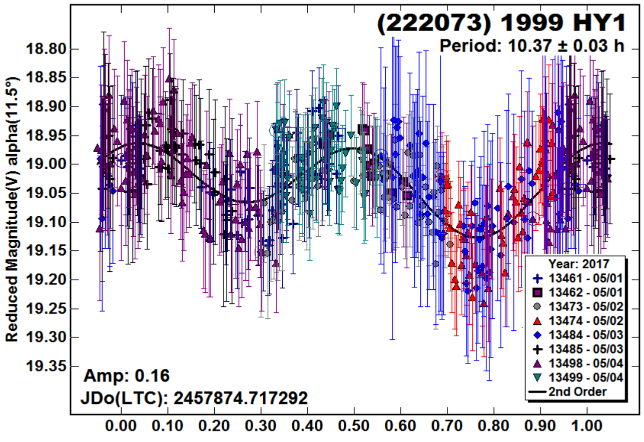
(215588) 2003 HF2. The data from the initial run for this 400-meter asteroid resembled what is often seen for superfast rotation, i.e., $P < 1$ h, with *maybe* a slight upward trend. A search from 0.001-1.500 h using 0.001 h steps found no hints of a very short period. This was not a surprise: the size of the asteroid made it highly unlikely for a period much less than about 2 hours. After four nights of observations and almost no adjustments to nightly zero points, it appeared that there was no long term trend and the asteroid was just too near the observing limits at the time to get a sufficient signal-to-noise ratio.



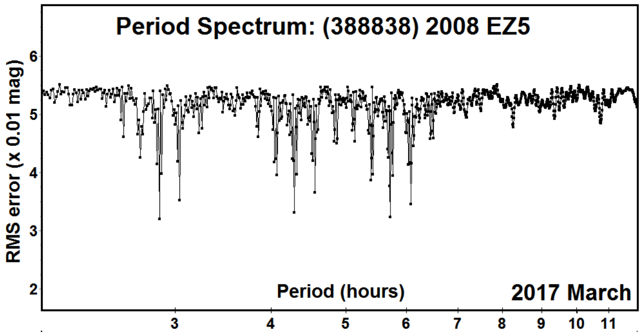


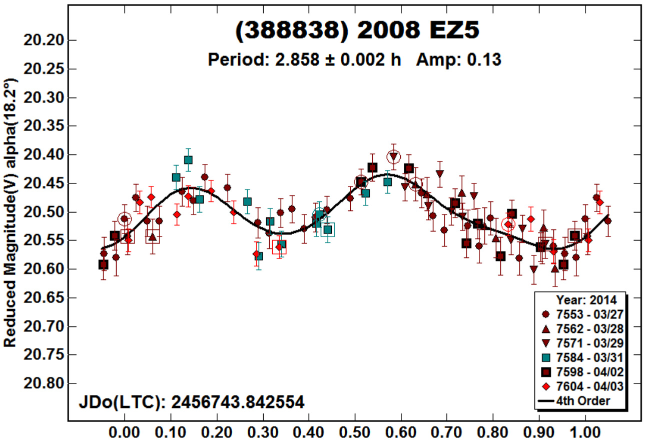
(222073) 1999 HY1. Despite the noisy data, a reasonably secure solution was found. Given the amplitude, a bimodal lightcurve would not be a certainty, but the asymmetry of the lightcurve moved the solution to the fore.

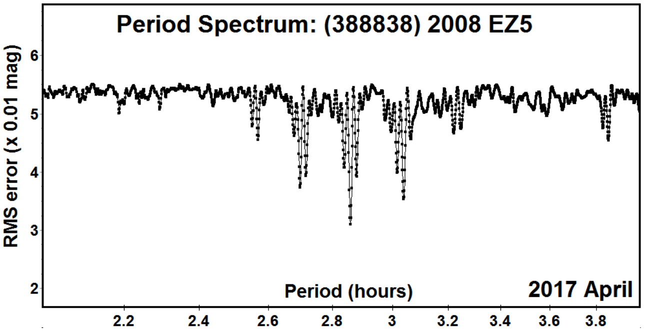


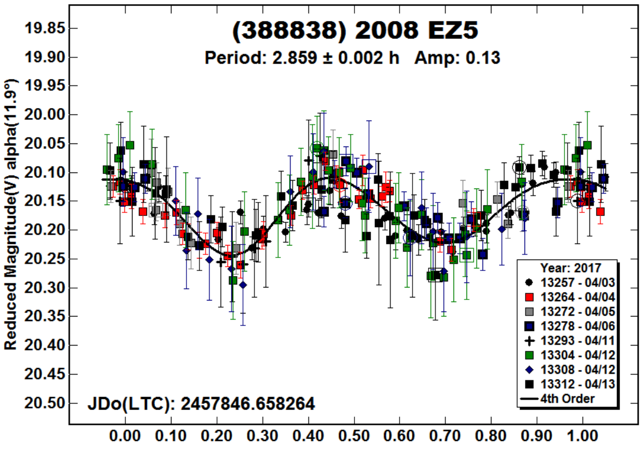


(388838) 2008 EZ5. This NEA was first observed in 2017 March-April. Assuming a bimodal lightcurve, a period of 2.858 h was found. This was confirmed by a denser data set obtained a month later, which produced a period spectrum with fewer and more certain potential solutions.

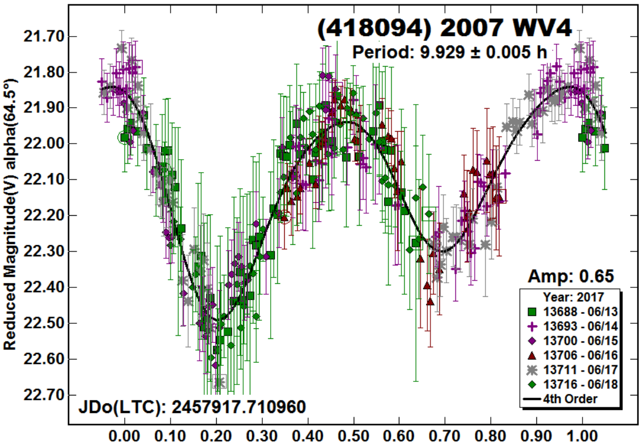




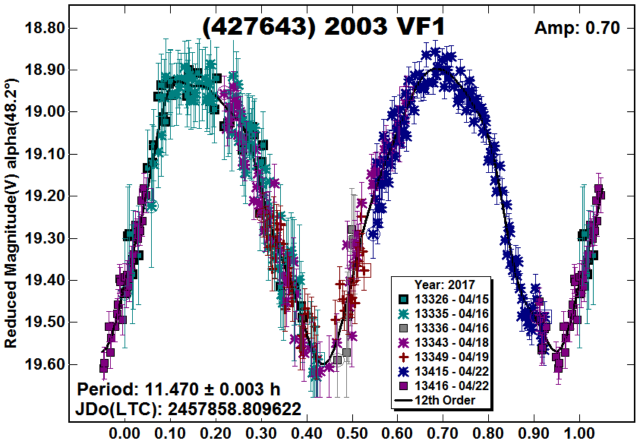




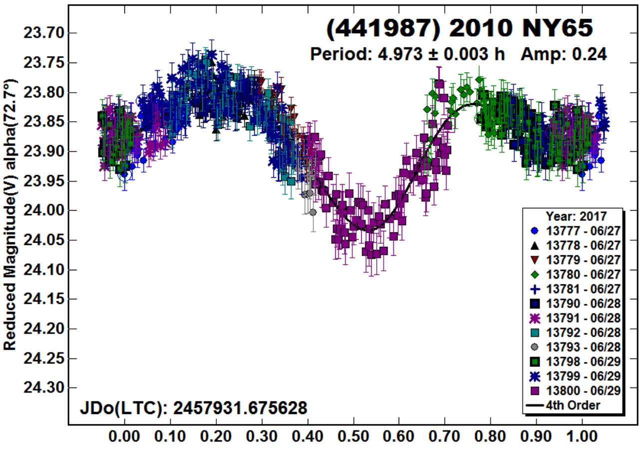
(418094) 2007 WV4. There were no previous entries in the LCDB for this 400-meter NEA. Fortunately, the amplitude was large, which helped overcome the noisy data and virtually assured a bimodal lightcurve.



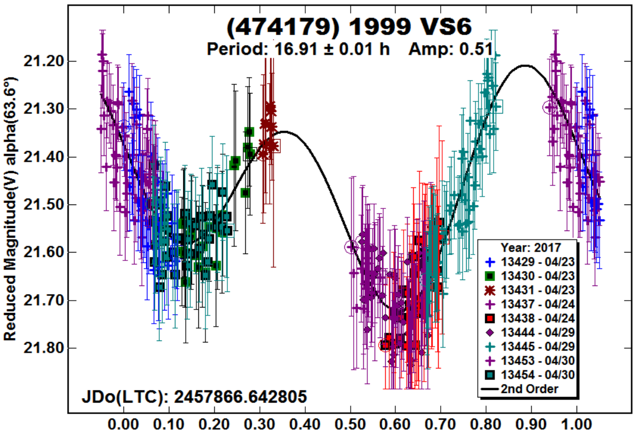
(427643) 2003 VF1. This also appears to be the first reported lightcurve for this 1-km asteroid. The period is too short for the given size to expect tumbling, nor was there any evidence of such.



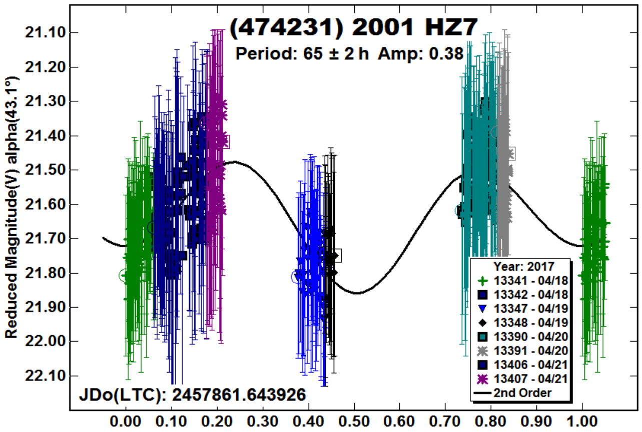
(441987) 2010 NY65. The unusual shape of the lightcurve was a concern, but the period of 4.973 h is in close agreement with earlier results (Warner, 2016b).



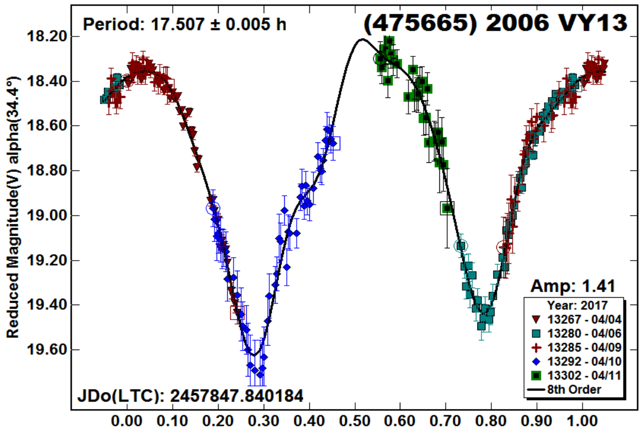
(474179) 1999 VS6. The period and size (*D* ~ 490 m) make this a very good candidate for tumbling (Pravec et al., 2014; 2005). With the incomplete lightcurve and the noisy data, it would nearly impossible to detect tumbling, unless it were very pronounced.

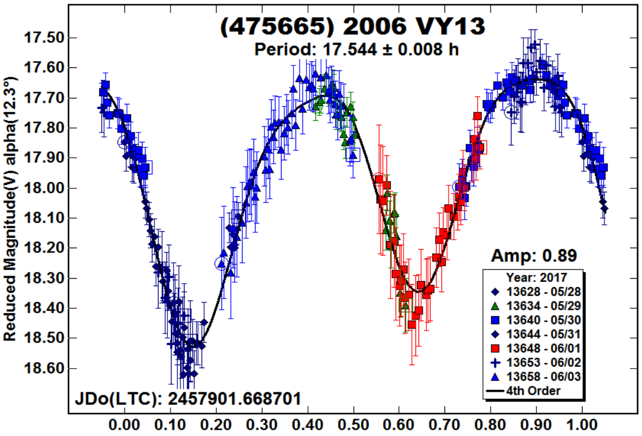


(474231) 2001 HZ7. The adopted period is a best guess. The data are very noisy. However, there seems to be a sufficient trend in the data near 0.10 rotation phase to overcome that and so try to fit the data to a low order Fourier solution.



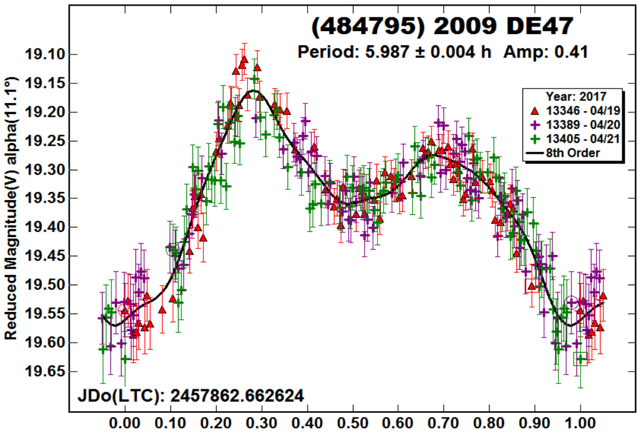
(475665) 2006 VY13. This 1.1-km NEA was first observed in 2017 April. Despite incomplete coverage of the lightcurve, the period of 17.507 h seemed reasonably secure. This was confirmed about a month later with a denser data set and period of 17.544 h. Note how the amplitude of the lightcurve decreased from April to June, as expected with a decreasing solar phase angle (Zappala et al., 1990).

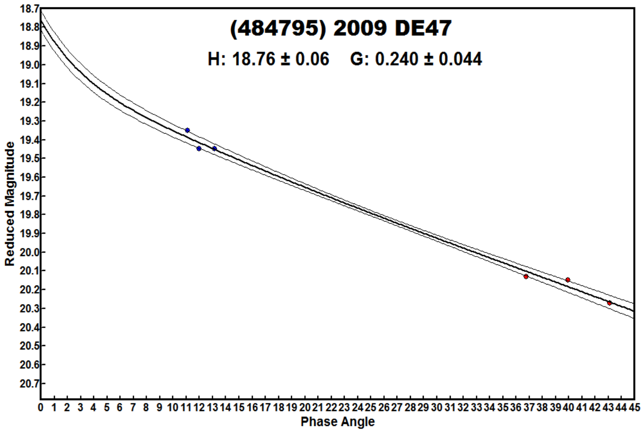




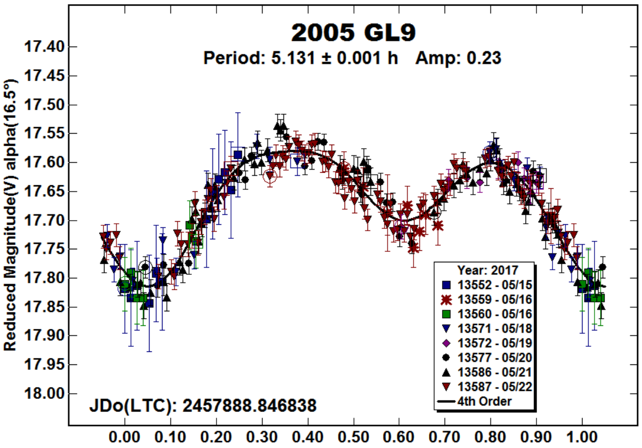
(484795) 2009 DE47 was observed by the author in 2017 March (Warner, 2017b) at a phase angle of about 41°. It was observed again a month later, at phase angle 12°. Oddly, the amplitude was smaller at the larger phase angle. The anomaly may be due to the orientation of the spin axis and the line-of-sight to the asteroid each time.

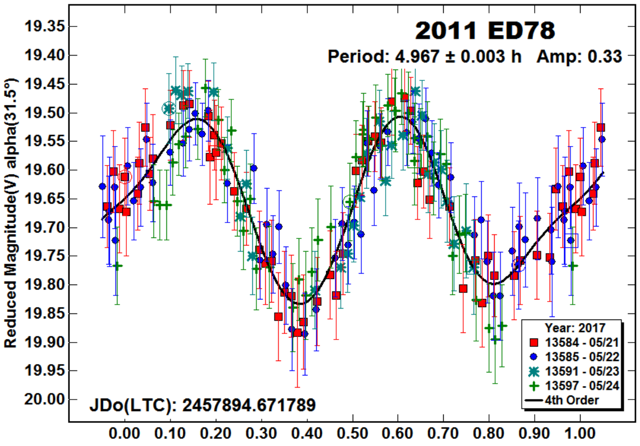
The H-G calculator in *MPO Canopus* was used to find the absolute magnitude (*H*) and phase slope parameter (*G*). Ideally, data below 7° phase angle would have been obtained in order to fully characterize the result for *G*. However, the minimum phase angle during the apparition was about 9°. The result of $H = 18.76 \pm 0.06$ closely resembles the value in the MPCORB file (18.6). The value for *G* is *consistent with but not confirmation of* a medium albedo, e.g., $p_V \sim 0.2$ for S-type asteroids, the type assumed for 2009 DE47.

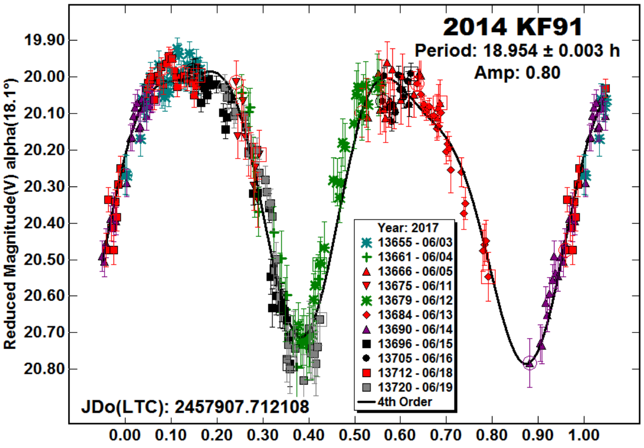




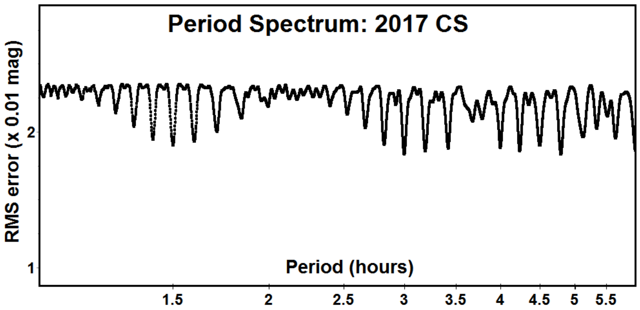
2005 GL9, 2011 ED78, 2014 KF91. There were no previous entries in the LCDB for these three NEAs. The estimated diameters are, respectively, 1.4 km, 0.65 km, and 0.45 km.

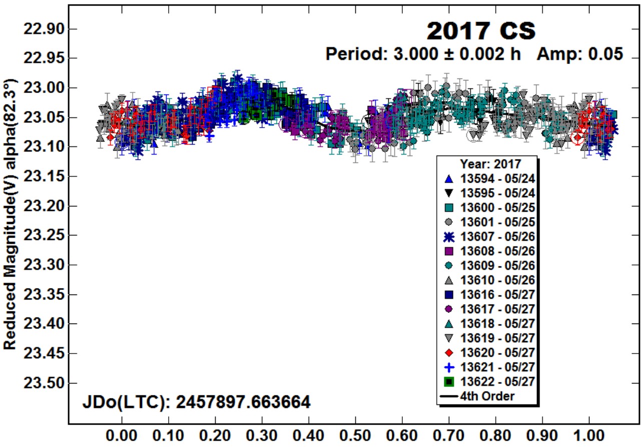




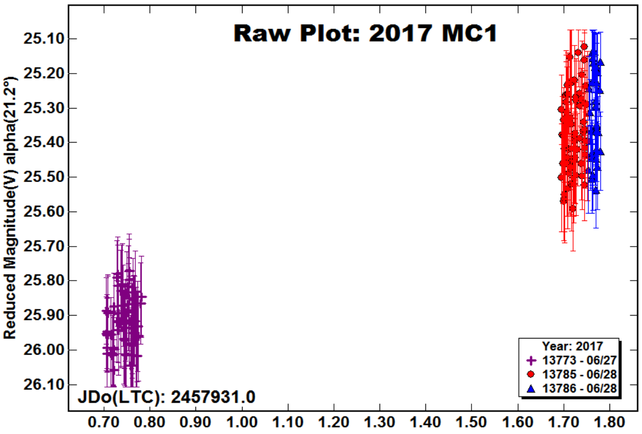


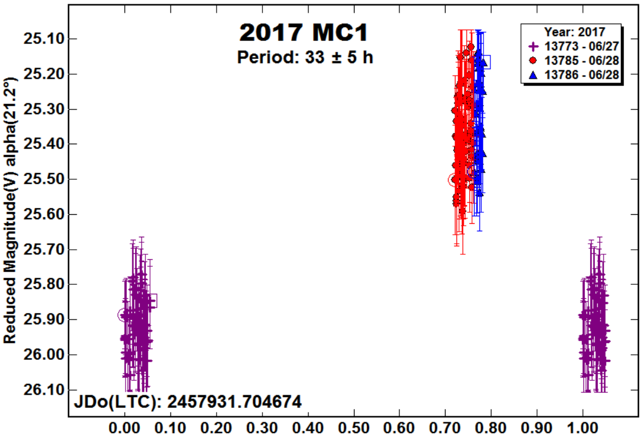
2017 CS. The period spectrum shows numerous solutions, including those near a monomodal, bimodal, and trimodal lightcurve. None of these can be formally excluded given the amplitude of 0.05 mag. Since there was no compelling evidence to support otherwise, a bimodal lightcurve was assumed, leading to a period of 3.000 h.





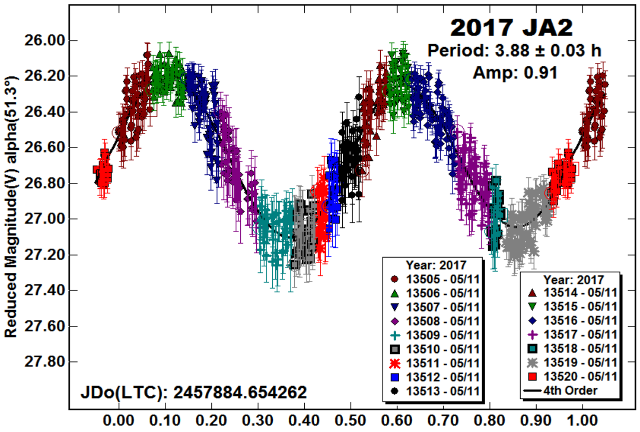
2017 MC1. The observations for the 40-meter asteroid were made in support of radar observations using a speckle technique (Michael Busch, private communications). His main concern was that the asteroid was not spinning extremely fast.

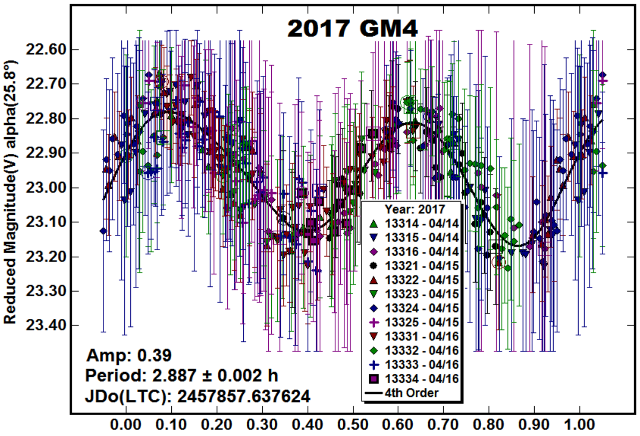


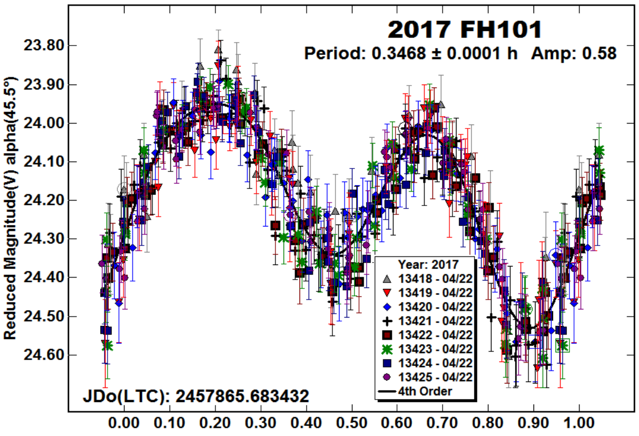


A fit to a very short period (0.001-1.500 h) was tried after the first night, but there was no good solution. The second night showed similar data but were nearly 0.7 mag brighter after correcting for changing viewing aspect. On the assumption that the two nights represented a minimum and immediately following maximum, several half-period and full-period solutions were tried with a 2nd order Fourier fit. The aim was to find a model curve that had reasonable slopes and the two extremes separated by 0.25 rotation phase. The end result was a solution of 33 ± 5 h for a bimodal curve. This must be considered as only as a guess.

2017 JA2, 2017 GM4, 2017 FH101. There were no previous entries in the LCDB for these NEAs. The estimated diameters are, respectively, 33 m, 120 m, and 95 m. The solutions for 2017 JA2 and 2017 FH101 are considered secure. The one for 2017 GM4 is less so, but still very likely correct.







Acknowledgements

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Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
1917	Cuyo	04/23-05/05	187	13.8,11.7	240	23	^{A}2.743	0.001	0.16	0.02
1980	Tezcatlipoca	06/27-07/02	382	27.0,30.4	244	9	7.2492	0.0006	0.81	0.02
2329	Orthos	02/25-03/03	73	18.6,17.1	195	10	4.610	0.002	0.39	0.04
2329	Orthos	05/11-05/22	280	30.9,37.1	192	23	4.6473	0.0007	0.18	0.01
5653	Camarillo	04/29-05/12	73	48.2,46.5	159	1	4.867	0.002	0.6	0.03
5879	Almeria	06/20-06/23	109	23.3,23.2	261	30	13.67	0.05	0.45	0.05
7888	1993 UC	05/20-05/23	81	21.2,20.5	258	35	2.320	0.002	0.22	0.03
11398	1998 YP11	05/26-06/12	696	71.4,63.3	229	46	38.464	0.008	0.46	0.03
68348	2001 LO7	06/20-07/03	257	8.3,13.5	256	14	^{A}3.8201	0.0003	0.3	0.04
100926	1998 MQ	05/23-05/27	130	10.7,12.3	241	15	2.328	0.002	0.12	0.02
106589	2000 WN107	06/03-06/19	131	36.9,26.5	296	20	3.101	0.002	0.07	0.01
141056	2001 XV4	05/23-05/29	99	52.5,48.7	292	9	^{A}2.671	0.002	0.21	0.02
143404	2003 BD44	02/25-04/12	1818	18.1,3.3,54.4	177	1	78.863	0.003	1.05	0.05
163696	2003 EB50	05/25-06/02	295	30.5,35.1	210	18	62.9	0.2	1.42	0.05
215588	2003 HF2	04/10-04/13	281	38.5,37.2	176	1	-	-	<0.1	-
222073	1999 HY1	05/01-05/04	420	11.5,14.6	223	11	10.37	0.03	0.16	0.03
388838	2008 EZ5	03/27-04/03	82	18.2,17.8,18.2	202	1	2.858	0.002	0.13	0.02
388838	2008 EZ5	04/03-04/13	191	11.9,21.8	188	-1	2.859	0.002	0.13	0.02
418094	2007 WV4	06/13-06/18	296	64.5,60.5	250	38	9.929	0.005	0.65	0.05
427643	2003 VF1	04/16-04/22	369	47.0,37.4	233	28	11.470	0.003	0.7	0.03
441987	2010 NY65	06/27-06/29	593	71.2,58.3	257	29	4.973	0.003	0.24	0.02
474179	1999 VS6	04/23-04/30	316	63.5,58.6	178	16	16.91	0.05	0.51	0.04
474231	2001 HZ7	04/18-04/21	402	43.0,40.4	185	14	65.	2.	0.35	0.06
475665	2006 VY13	04/04-04/11	216	34.4,28.9	224	10	17.507	0.005	1.39	0.03
475665	2006 VY13	05/28-06/03	240	12.3,14.8	235	8	17.544	0.008	0.89	0.02
484795	2009 DE47	04/19-04/21	249	11.1,13.1	201	3	5.987	0.004	0.41	0.02
	2005 GL9	05/15-05/22	237	16.5,15.0	248	12	5.131	0.001	0.24	0.02
	2011 ED78	05/21-05/23	137	31.5,32.6	219	19	4.976	0.004	0.34	0.03
	2014 KF91	06/03-06/19	269	18.2,28.0	245	8	18.954	0.003	0.8	0.03
	2017 CS	05/24-05/27	665	82.0,76.4	204	8	3.000	0.002	0.05	0.01
	2017 MC1	06/27-06/28	167	20.6,17.1	267	2	33.	5.	0.7	0.1
	2017 JA2	05/11-05/11	675	54.1,54.1	205	9	3.88	0.03	0.91	0.05
	2017 GM4	04/14-04/14	265	26.5,26.5	189	-2	2.878	0.002	0.45	0.05
	2017 FH101	04/22-04/22	428	46.2,46.2	203	24	0.3468	0.0001	0.58	0.03

Table II. Observing circumstances. ^{A}Period is preferred of two or more solutions. 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. 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; *Icarus* **202**, 134-146.).

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ASTEROIDS OBSERVED FROM ESTCORN OBSERVATORY

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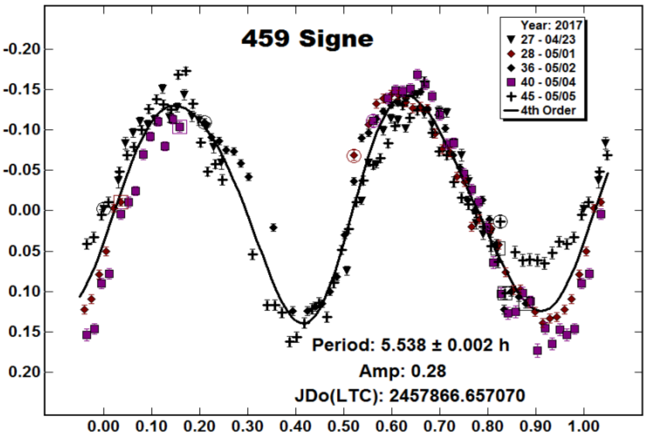
We provide lightcurves for seven asteroids from the Spin/Shape Modeling Opportunities listed by Warner et al. (2017)

The asteroids for which we report results were selected from the list of shape/spin modeling (SSMO) opportunities given by Warner et al. (2017). We selected photometry opportunities based on asteroid brightness and period. We wanted to be able to obtain a complete lightcurve in one night.

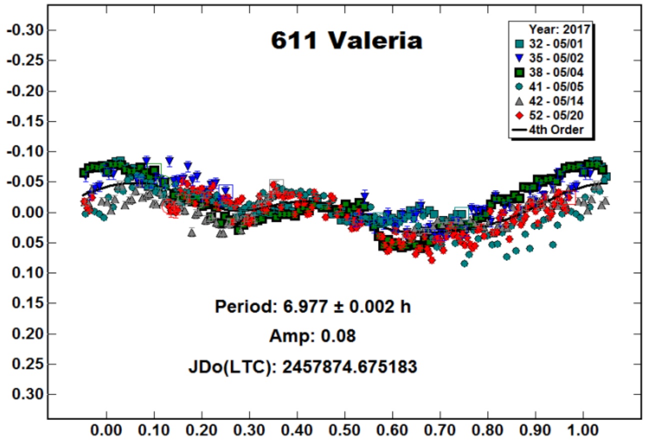
Our observations were obtained with three Celestron 0.35-m telescopes and SBIG CCD cameras at Etscorn Campus Observatory (Klinglesmith and Franco, 2016). The images were processed and calibrated using *MPO Canopus* 10.4.7.6 (Warner,2015). Depending on the brightness of the asteroids, the exposures were between 180 and 420 seconds through clear filters. The multi-night data sets for each asteroid were combined with the FALC algorithm (Harris et al., 1989) within *MPO Canopus* to provide synodic periods for each asteroid.

Discovery information was obtained from the JPL small bodies node (JPL, 2017). The seven asteroids were suggested as possible targets in order to derive their spin / shape models (Warner et al. 2017). Table I contains the observation circumstances and results. Table II is a compilation of the previously obtained lightcurves with their references for all asteroids except for 1016 Anitra. The information for it is listed in Table III.

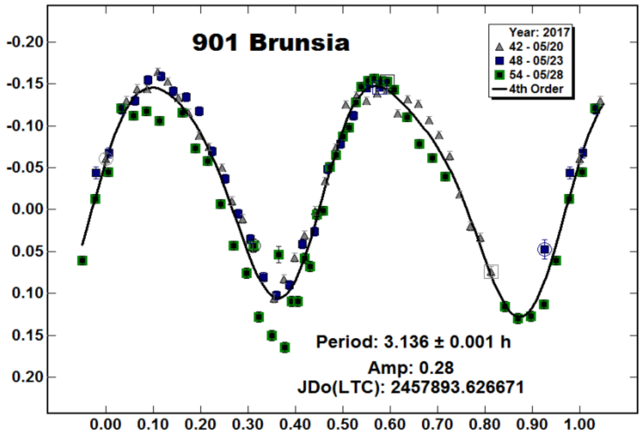
459 Signe is a main-belt asteroid discovered by M. Wolf at Heidelberg on 1900 Oct 22. It is also known as 1900 FM, 1934 VH, 1938 SE1, A917 TF, and A921 RD. We observed it on five nights between 2017 Apr 23 and May 5. We obtained a synodic period of 5.538 ± 0.002 h with an amplitude of 0.28 mag.



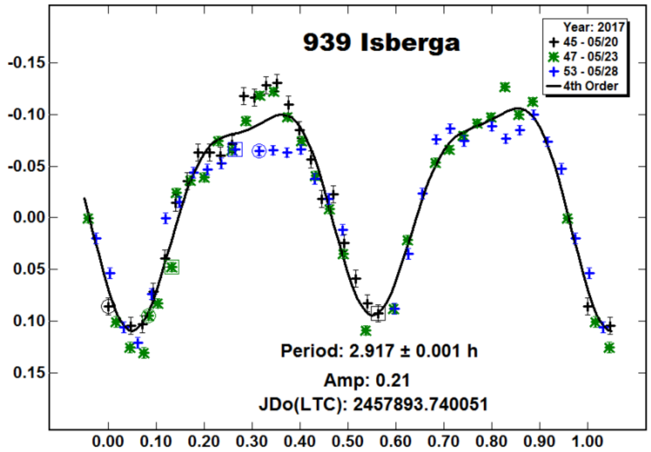
611 Valeria is a main-belt asteroid discovered by J. H. Metcalf at Taunton on 1906 Sep 24. It is also known as 1906 VL, and A901VA. We observed it on six nights between 2017 May 1-20. We obtained a synodic period of 6.977 ± 0.002 h with an amplitude of 0.08 mag.



901 Brunsia is a main-belt asteroid discovered by M. Wolf at Heidelberg on 1918 Aug 30. It is also known as 1918 EE, 1941 MH, 1948 VJ, 1970 EP1, and A905 VD. We observed in on three nights between 2017 May 20-28. We obtained a synodic period of 3.136 ± 0.001 h with an amplitude of 0.28 mag.

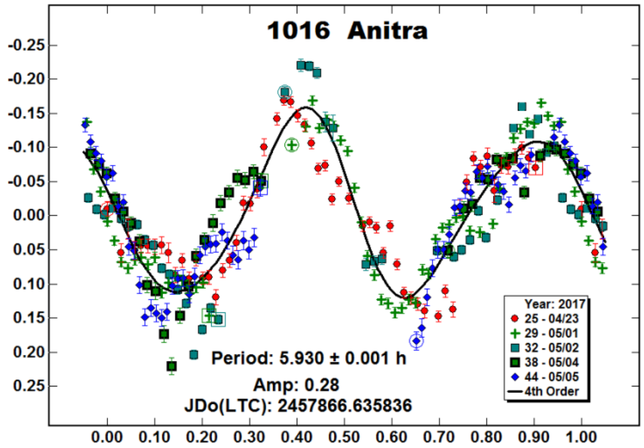


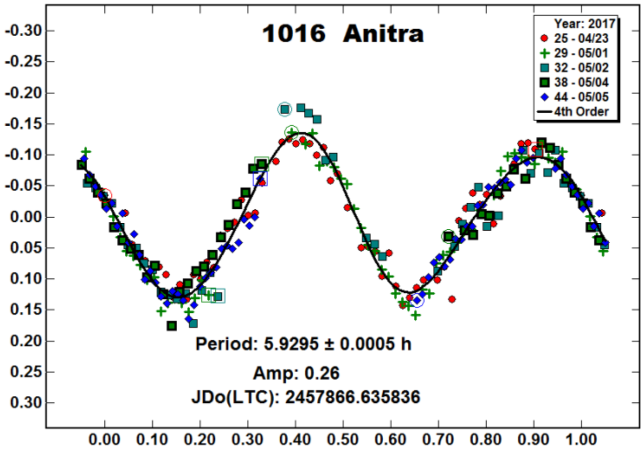
939 Isberga is a main-belt asteroid discovered by K. Reinmuth at Heidelberg on 1920 Oct 4. It is also known as 1920 HR, 1930 QP, 1957 QE, and 1957 UU. We observed it on three nights between 2017 May 20-28. We obtained a synodic period of 2.917 ± 0.001 h with an amplitude of 0.21 mag.

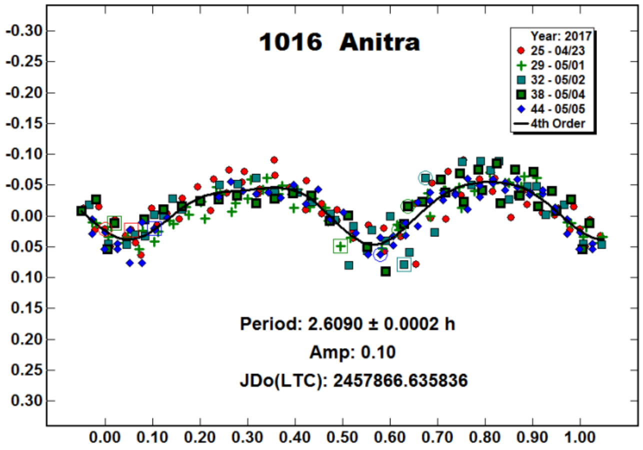


1016 Anitra is a main-belt asteroid discovered by K. Reinmuth at Heidelberg on 1924 Jan 31. It is also known as 1924 QG and 1929

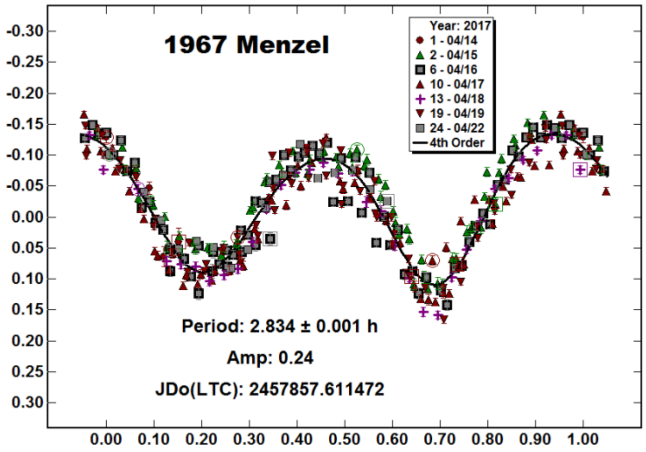
TE1. Pilcher et al. (2016) reported that 1016 Anitra is an asynchronous binary asteroid. Our observations confirm that the object does have two periods. We observed it on five nights between 2017 Apr 23 and May 5. Using the single-period mode we found a synodic period of 5.930 ± 0.001 h with an amplitude of 0.28 mag. and a fair amount of scatter. Using the dual-period search within Canopus (Warner, 2015), we confirm the two periods found by Pilcher et al. Our results were P_1= 5.9259 ± 0.0005 h with an amplitude of 0.26 mag and P_2= 2.6090 ± 0.0002 h with an amplitude of 0.10 mag. The scatter in magnitudes was much smaller using the dual-period search. The previous results for 1016 Anitra can be found in Table III.



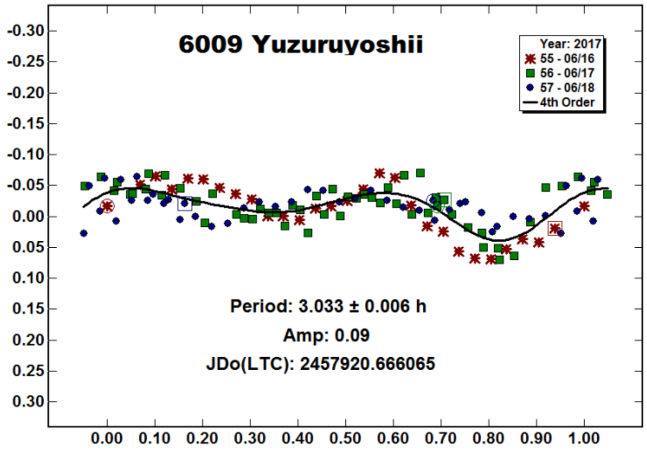




1967 Menzelis a main-belt asteroid discovered by M. Wolf at Heidelberg on 1095 Nov 1. It is also known as A905 VC, 1930 DS, 1965 SF, 1965 VH, 1970 EM, 1973 CE, 1975 UH, and 1975 VE. We observed it on seven nights between Apr 14-22. We obtained a synodic period of 2.834 ± 0.001 h with an amplitude of 0.24 mag.



6009 Yuzuruyoshii is a main-belt asteroid discovered by E.F. Helin at Palomar on 1990 Mar 24. It is also known as 1990 FQ1, 1952 HE3, and 1957 WJ1. We observed it on three nights: 2017 Jun 16-18. We obtained a synodic period of 3.003 ± 0.006 h with an amplitude of 0.09 mag.



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Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
459	Signe	04/23-05/05	207	1.4,5.9	209	0	5.538	0.002	0.28	0.03	MB-M
611	Valeria	05/01-05/20	486	3.2,7.5	220	9	6.977	0.002	0.08	0.05	MB-O
901	Brunsia	05/20-05/28	104	10.2,14.0	221	-3	3.316	0.001	0.28	0.07	MB-I
939	Isberga	05/20-05/28	85	8.8,12.7	224	-4	2.917	0.001	0.21	0.05	MB-I
1016	Anitra	04/23-05/20	244	4.1,15.6	205	-3	5.930	0.001	0.28	0.05	MB-I
1967	Menzel	04/14-04/22	318	5.7,9.3	193	3	2.834	0.001	0.24	0.03	MB-I
6007	Yuzuruyoshii	06/16-06/18	119	15.4,15.6	263	25	3.033	0.006	0.09	0.05	PHO

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984). Grp is the asteroid family/group (Warner *et al.*, 2009).

Num	Name	References	Date	L_{PAB}	B_{PAB}	Phase	Period	Amp
459	Signe	This paper	2017 Apr 29	209	0	4.1	5.538	0.28
		Lagerkvist 1978	1974 Apr 20	165	9	7.2	6.38	0.25
		Behrend 2007	2007 Feb 09	45	5	26.9	5.5362	0.43
611	Valeria	This paper	2017 May 10	220	9	4.7	6.977	0.08
		Koff 2001	2001 Mar 20	177	-4	1.7	10.8	0.09
		Behrend 2002	2002 May 31	250	14	5.0	6.9814	0.16
		Behrend 2003	2003 Jul 19	321	13	10.0	6.98	0.10
		Behrend 2005	2005 Jan 02	55	-13	18.2	6.98	0.08
		Pilcher 2012	2012 Apr 29	231	10	5.7	6.977	0.08
901	Brunsia	This paper	2017 May 24	221	-3	12.2	3.136	0.28
		Wisniewski 1997	1991 Oct 08	355	5	15.3	4.872	0.12
		Behrend 2001	2001 Oct 02	7	6	4.5	3.1357	0.11
		Vander Haagen 2009	2009 Jan 08	82	0	13.1	3.1363	0.28
		Behrend 2011	2011 Oct 20	20	5	5.5	3.1335	0.17
		Klinglesmith 2016a	2016 Feb 01	122	-3	4.3	3.136	0.09
939	Isberga	This paper	2017 May 24	223	-4	10.8	2.917	0.21
		Molnar 2008	2006 Feb 28	129	1	13.1	2.9173	0.25
		Behrend 2011	2011 Nov 23	30	3	18.3	2.917067	0.22
		Carry 2015	2011 Oct 26	27	3	4.8	2.91695	0.20
1967	Menzel	This paper	2017 Apr 18	193	3	7.5	2.834	0.24
		Pray 2006	2005 Sep 24	19	-4	12.6	2.8350	0.28
		LeCrone 2006	2005 Nov 02	23	-3	11.6	2.834	0.38
		Pravec 2007	2007 Apr 10	195	4	3.1	2.8344	0.24
		Higgins 2008	2007 Apr 10	195	4	3.1	2.8346	0.25
		Behrend 2005	2005 Oct 27	22	-3	8.2	2.83481	0.27
		Pravec 2010	2010 Jan 14	151	5	18.8	2.8343	0.25
		Clark 2015	2015 Jun 15	230	0	15.2	2.8364	0.39
		Liu 2016	2015 Oct 11	18	-4	2.7	2.84	0.28
		Klinglesmith 2016b	2015 Nov 06	20	-3	15.0	2.835	0.29
		Behrend 2016	2015 Nov 05	20	-3	14.5	2.83497	0.27
6009	Yuzuruyoshii	This paper	2017 Jun 17	147	26	15.5	3.033	0.09
		Pravec 2006	2006 Aug 10	349	25	21.1	3.0302	0.15
		Behrend 2006	2006 Sep 16	351	22	12.4	3.0304	0.14
		Pravec 2010	2010 Sep 21	19	11	12.4	3.030	0.10

Table II: Summation of solar bisector angles, phase angles, periods and amplitudes for the asteroids discussed in this paper.

Num	Name	References	Date	L_{PAB}	B_{PAB}	Phase	Period	Amp
1016	Anitra	This paper	2017 Apr 30	205	-3	7.5	5.930	0.28
		Pray 2006	2005 Oct 10	10	1	4.6	5.928	0.30
		Kyrszczynska 2012	2005 Sep 29	9	0	2.2	5.9288	0.28
		Alkema 2013	2012 Dec 07	94	9	13.4	5.929	0.42
		Schmidt 2016	2015 Oct 30	27	3	6.6	5.9301	0.27
		Pilcher 2016	2015 Nov 08	27	4	11.8	5.92951	0.30
		Pilcher 2016	2015 Oct 05	25	2	9.2	5.92943	0.30
		Pilcher 2016	2015 Oct 15	26	2	3.5	5.9294	0.28
		Pilcher 2016	2015 Nov 06	27	4	10.7	5.9295	0.28
		Pilcher 2016	2015 Nov 18	29	4	17.0	5.92960	0.33
		Pilcher 2016	2015 Dec 18	35	5	27.2	5.9300	0.41

Table III: Summation of solar bisector angles, phase angles, periods and amplitudes for 1016 Anitra.

ROTATION PERIOD DETERMINATION FOR 3892 DEZSO AND 14339 KNORRE

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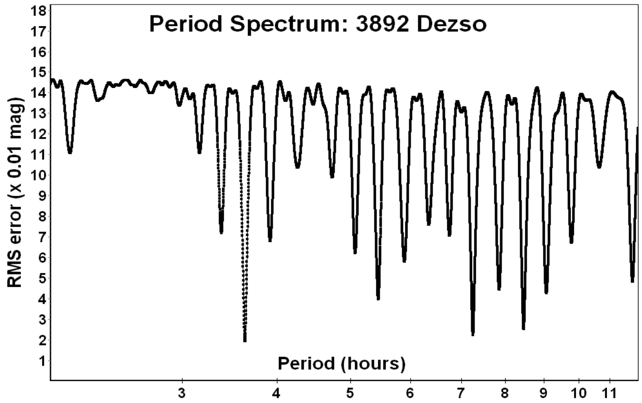
Photometric observations of two main-belt asteroids were made from the Astronomical Observatory of the University of Siena (Italy) in order to determine their synodic rotation periods. For 3892 Dezso, we found a period of 3.629 h with an amplitude of 0.47 mag. For 14339 Knorre, the period was 3.795 h with an amplitude of 0.21 mag.

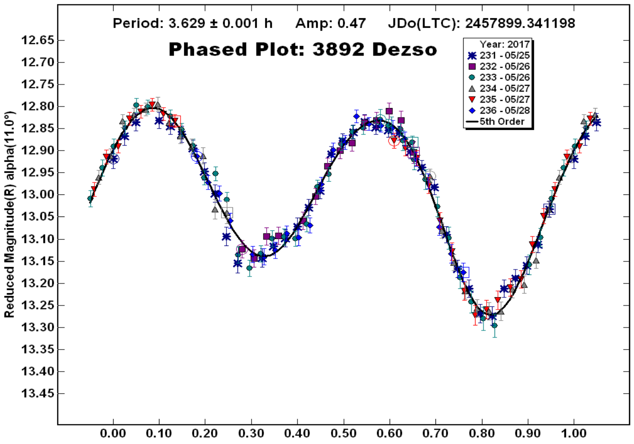
CCD photometric observations of two main-belt asteroids were carried out in 2017 May at the Astronomical Observatory of the University of Siena (K54), a facility of the Department of Physical Sciences, Earth and Environment (DSFTA, 2017). We used a 0.30-m *f*/5.6 Maksutov-Cassegrain telescope, SBIG STL-6303E CCD camera, and clear filter. The pixel scale was 2.30 arcsec with binning of 2x2 pixels. All exposures were 300 sec. Data processing and analysis were done with *MPO Canopus* (BDW Publishing, 2017). All the images were calibrated with dark and flat-field frames and converted to R magnitudes using solar-colored field stars from a version of the CMC-15 catalogue distributed with *MPO Canopus*. Table I shows the observing circumstances and results.

A search of the asteroid lightcurve database (LCDB; Warner et al., 2009) indicates that our results may be the first reported lightcurve observations and results for these objects.

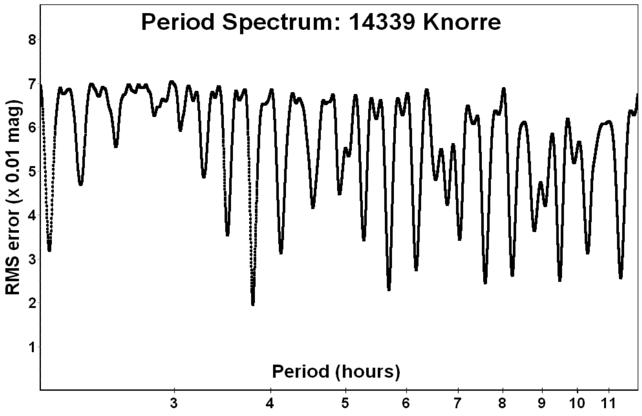
<u>3892 Dezso</u> (1941 HD) was discovered on 1941 April 19 by L. Oterma at Turku and is named in honor of the Hungarian astronomer Dezso Lorant, founder of the Observatory for Solar Physics in Debrecen and its director for many years. The asteroid orbits with a semi-major axis of about 2.605 AU, eccentricity 0.141, inclination 13.76°; the orbital period is 4.20 years. According to MPC (2017), JPL (2017), and WISE (Masiero et al., 2012), the absolute magnitude is $H = 12.5$ and $D = 7.836 \pm 0.907$ km. This leads to an optical albedo of $p_V = 0.315 \pm 0.063$.

A total of 159 data points were obtained over four nights. The period analysis shows a clear bimodal solution at $P = 3.629 \pm 0.001$ h with an amplitude $A = 0.47 \pm 0.02$ mag.



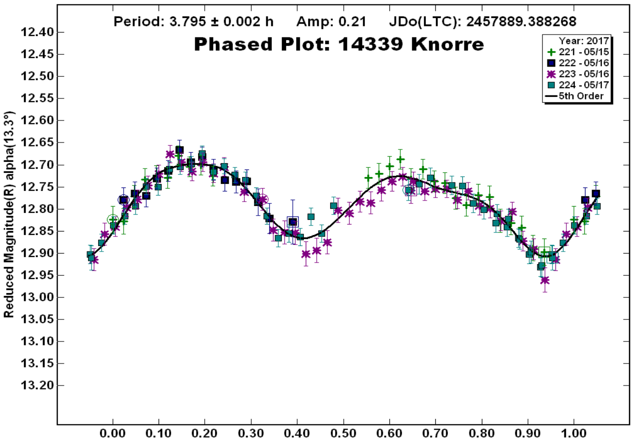


<u>14339 Knorre</u> (1983 GU) was discovered on1983 April 10 by L. I. Chernykh at the Crimean Astrophysical Observatory and is named in honor of Ernest Khristov Knorre (1759-1810) who was the first astronomer at Tartu University. The asteroid orbits with a semi-major axis of about 2.601 AU, eccentricity 0.174, inclination 14.40°; the orbital period is 4.19 years. Its absolute magnitude is $H = 12.4$ (JPL, 2017; MPC, 2017).



Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E	Amp	A.E.	Grp
3892	Dezso	05/24-28	159	11.3,10.9	249.3	19.1	3.629	0.001	0.47	0.02	EUN
14339	Knorre	05/15-18	125	13.6,12.6	254.5	14.5	3.795	0.002	0.21	0.03	EUN

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given at the start and end of each date range, unless it reached a minimum, which is the second of three values. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984). Grp is the asteroid family/group (Warner et al., 2009; Zappalà et al., 1997).



Observations of this asteroid were conducted on three nights, collecting a total of 125 data points. The period analysis shows a bimodal solution with P = 3.795 ± 0.002 h with an amplitude A = 0.21 ± 0.03 mag.

Acknowledgements

The authors want to thank Piero Giannini, a high school student from Istituto “Tito Sarrocchi” (Siena) involved in an interesting vocational guidance project about astronomy, for his help during the data reduction of some observing sessions.

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STULL OBSERVATORY LIGHTCURVE OBSERVATIONS: 1998-2002

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Using the Stull Observatory 0.82m telescope, from July 1998 to August 2002 we observed several asteroids to measure their rotation periods. We present lightcurves periods for 314 Rosalia, 1084 Tamarwina, 1758 Naantali, 1845 Helewalda, 2544 Gubarev, 3028 Zhangguoxi, 5215 Tsurui, (20713) 1999 XA32, and (234871) 1991 GT4.

Between 1998 July and 2002 August, we used the Stull Observatory 0.82-m *f*/4 Newtonian telescope to observe asteroid lightcurves. Our first observations used an SBIG-ST6 CCD camera with a Bessel R filter. After 1999 May we were able to hit much fainter targets with a Finger Lakes Instruments camera with a rear-illuminated TK 1024 chip. We took biases and dark current frames every night, and twilight flats fields when possible. The flats had very little variation in them from one night to the next, so missing a few nights of flats was not a problem.

We chose our targets among the asteroids near opposition in the 14 to 16 magnitude range: the faintest we can get good signal-to-noise ratios with 90 to 120-second integrations. When there was a choice of targets, we chose members of dynamical families.

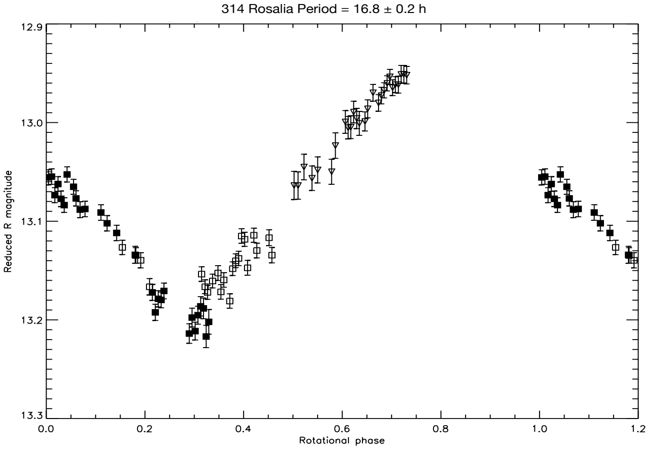
We observed each asteroid in the R filter until it got close to the meridian, then we would observe in V and R and take exposures in V and R of nearby secondary standard stars from the LONEOS catalog (Skiff). Unfortunately, the skies downwind from the Great Lakes are not very stable, so the values given for the individual asteroids are only accurate to about 0.1 magnitudes. This is not very reliable, so all magnitudes reported should be taken as instrumental values instead of being on any standard scale.

We analyzed our images using the CCDPHOT aperture photometry package in IDL (Buie, 2000) choosing the aperture with the highest S/N. We then used Dahlgren’s technique (Dahlgren et al., 1991) to perform the ensemble photometry with five to twelve reference stars. We corrected the times for light delay and adjusted the magnitudes for earth and sun distances of 1.0 AU.

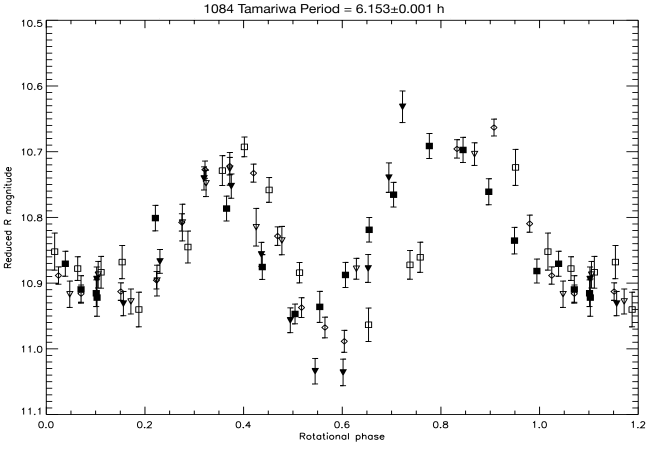
We then used an IDL program using Harris’s Fourier fitting technique (Harris et al., 1989) to find the period. This method takes a range of periods, calculates the phase, does a four-component Fourier fit, and then plots the values of χ^2 as a function of period. The various minimum values in the χ^2 plot can be explored to look for physically reasonable fits. Once a period has been determined, we can find the night-to-night offset (produced by changing distance from the Earth and Sun as well as viewing geometry and inaccuracies in the ability to place our observations on the standard magnitude scale) then find the optimum number of terms used in the Fourier fit, and re-calculate the best period from the Fourier scan. We iterated through this process until it converged on a solution.

We tested the reliability of our period-determining code by measuring previously known rotation periods, using results obtained in *MPO Canopus* v10.4.7.6 in observations from 2007 (Stoelting) and finding rotation periods published after we made our observations. This last test is a symptom of severe procrastination and is not recommended.

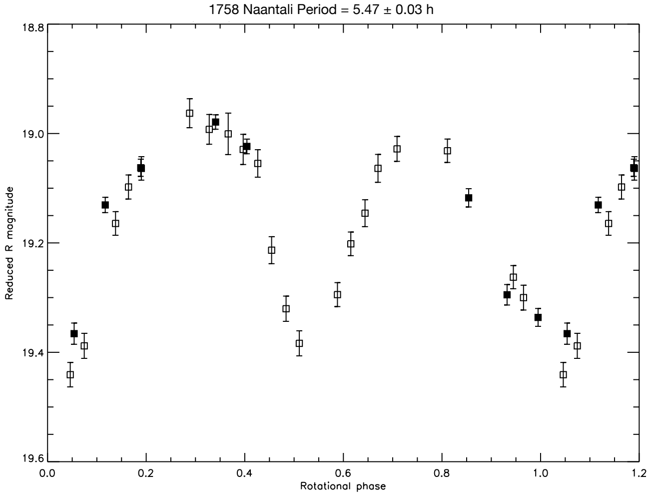
314 Rosalia is an SMASS class C asteroid with an absolute magnitude H = 9.5 ± 0.15, a diameter of 59.7 ± 2.2 km, and an albedo of 0.0787 ± 0.006 (SBN, 2017). We measured its period to be 16.8 ± 0.2 hours. Our results are almost consistent with Behrend's (2004) period of 15.84 ± 0.05 h but not with the 20.4 h period obtained by Hawkins (2008) and Warner (2006). The closest χ^2 minimum to that period was 19.8 h, but there are gaps in the curve which have unrealistic amplitudes in the fit. Open squares are 2002 Jun 18, solid squares are 2002 Jun 20 and open triangles are 2002 Jun 21. The zero-point for the phase is JD 2452443.5 (LTC).



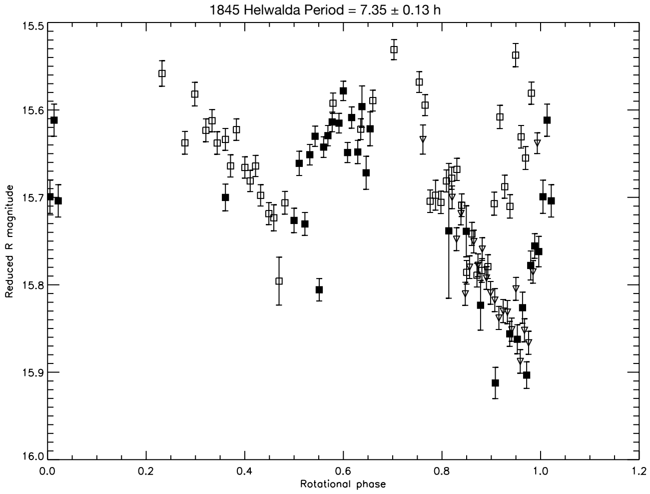
1084 Tamarwina is a C class asteroid with an absolute magnitude H = 10.78, an albedo of 0.1165 ± 0.018 and a diameter of 27.2 ± 1.9 km (SBN, 2017). The lightcurve for this asteroid shows a period of 6.153 ± 0.001 h. The previously published 7.08 hour period (Binzel 1987), which had less than full phase coverage, is within 15% of our full phase coverage period. The asteroid has also been measured by Ivarson (2004), Behrend (2007), Sada (2008), and Stecher (2008), all of whom found periods around 6.2 hours (LCDB; Warner *et al.*, 2009). Open squares are for 1998 Jul 16, solid squares are for 1998 Jul 19, open triangles are for 1998 Jul 21, solid triangles are for 1998 Jul 27, and open diamonds are for 1998 Jul 28. The phase zero-point is JD 2451010.5 (LTC).



1758 Naantali is a member of the Eos family with H = 10.9 (SBN, 2017). We found a highly symmetric double-peaked lightcurve with a period of 5.47 ± 0.03 h. This is consistent with other results from Behrend (2010), Waszczak (2016), and Durech (2016). Hollow squares are 2000 May 3 and solid squares are 2000 May 4. The phase zero-point is JD 2451182.5 (LTC)



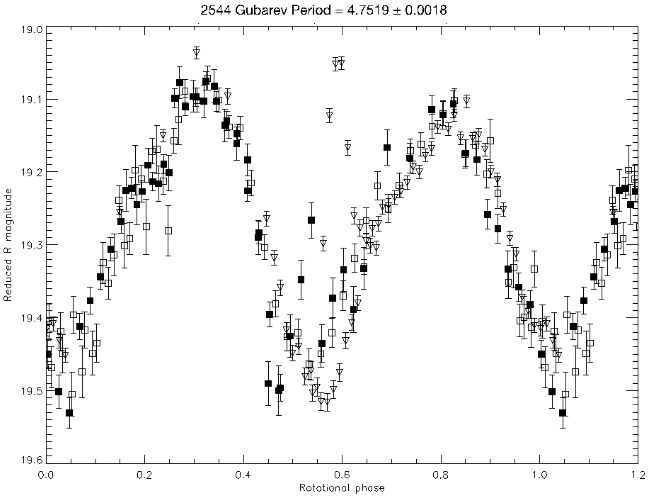
1845 Helewalda is an Eros family member with H = 11.3 (SBN, 2017). We found the lightcurve best represented by a 7.35 ± 0.13 h, which is consistent with results from Carbo (2009), Brinsfield (2010), Behrend (2010), and Waszczak (2016) who all got periods around 7.4 hours. Open squares from 2001 Jun 18, filled squares from the 2001 Jun 19, and open triangles from 2001 Jun 20. The zero-point for the phase is JD 2450778.5 (LTC).



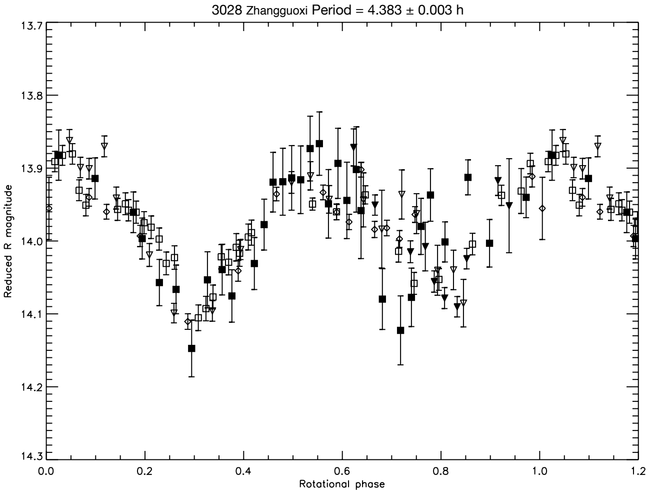
2544 Gubarev a member of the Phocaea family, has an absolute magnitude H = 12.3, diameter of 9.4 ± 0.4 km, and albedo of 0.243 ± 0.025 (SBN, 2017). The rotation period of 4.8 hours is very close to one-fifth of a day, so the three nights together didn't pin the period down any better than we got in a single night. Each of the individual nights gave us a period of 4.8 ± 0.2 hours. Nominally, the best period for the combined data, using a four-component Fourier fit is 4.7519 ± 0.0018 hours, but 4.66 h and 4.84 h were almost as good a fit because of the ambiguity of the number of rotations from one day to the next. Bolt (2007), Pravec (2012), and Behrend (2012) also obtained periods of 4.75 hours. Open squares are from 2002 Aug 4, filled squares are from 2002 Aug 14, and triangles are from 2002 Aug 19. The zero-point for the phase is JD 2452500.5 (LTC).

Number	Name	yyyy/ mm/dd-mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
314	Rosalia	2002/06/18-06/21	94	6.1,6.0	268	15	16.9	0.2	0.26	0.05
1084	Tamariwa	1998/07/16-07/28	68	4.0,2.8,4.2	299	5	6.153	0.001	0.27	0.05
1758	Naantali	2000/05/03-05/04	28	5.4	223	13	5.47	0.03	0.46	0.05
1845	Helewalda	2001/06/18-06/20	105	5.3,5.7	217	6	7.35	0.13	0.34	0.05
2544	Gubarev	2002/08/04-08/19	181	6.5,4.35,5.1	322	8	4.7519	0.0018	0.45	0.05
3028	Zhangguoxi	2002/05/16-06/03	111	7,13	217	6	4.383	0.003	0.24	0.05
5215	Tsurui	2001/06/01-06/19	129	9.7,7.7,8.2	261	14	2.08	0.01	0.18	0.05
20713	1999 XA32	2002/08/01	41	5.6	321	7	3.5	0.2	0.23	0.05
23481	1991 GT4	2002/08/03-08/19	116	8.6,4.6,5.4	321	6	5.958	0.007	0.65	0.05

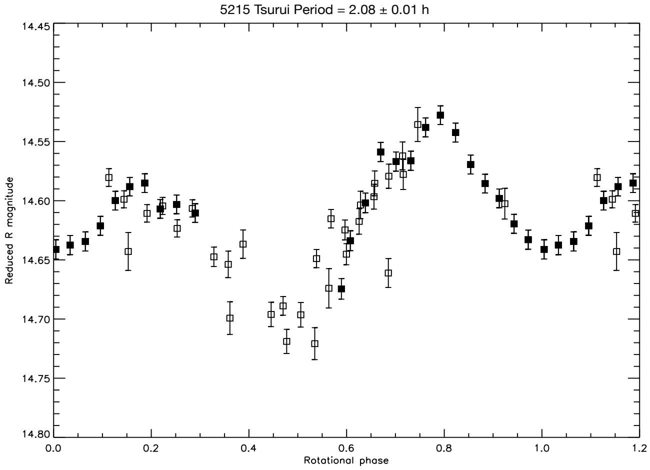
Table I. Observing circumstances and results. Pts is the number of data points. The phase angle values are for the first and last date, unless a minimum (second value) was reached. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).



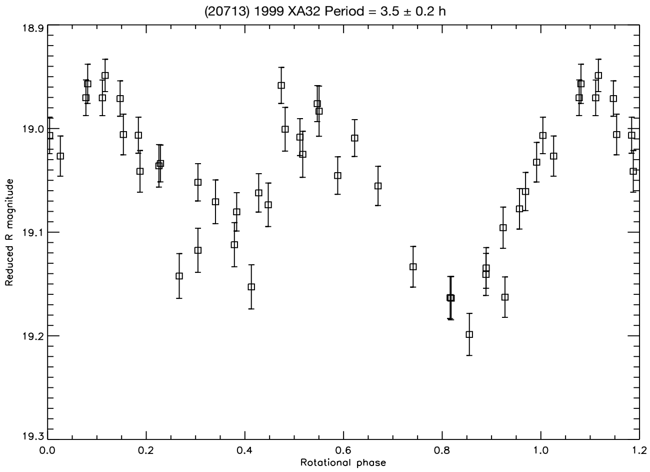
3028 Zhangguoxi is a member of the Eos family with a Bus class of K; it has an absolute magnitude *H* = 10.7, diameter of 25.6 ± 1.4 km, and albedo 0.142 ± 0.017 (SBN, 2017). Using a 3-component Fourier fit, we found a period of 4.383 ± 0.003 hours, consistent with the 4.4 h period of Gross (2011), but slightly off from the 4.8 h periods found by Behrend (2007), Brinsfield (2007), and Stephens (2007). Filled squares are from 2002 May16, open squares are from 2002 May 23, open triangles are from 2002 June 1, filled triangles are from 2002 Jun 2, and open diamonds are from 2002 Jun 3. The phase zero-point is JD 2452410.5 (LTC).



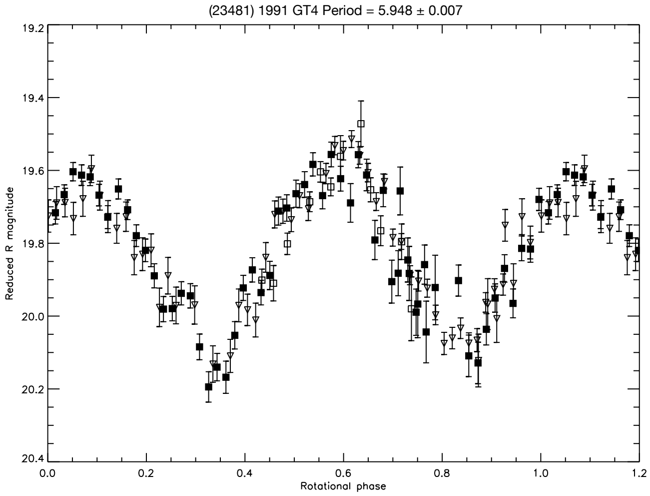
5215 Tsurui. The absolute magnitude of Tsurui, a member of the Eunomia family, is *H* = 11.2 (SBN, 2017). We found a period with a well-defined dip in the χ^2 function at 2.08 ± 0.01 hours. Other results include Behrend (2009; 3.76 h), Hamanowa (2011; 3.836 ± 0.002 h, and Stephens (2005; 3.81 h). Our observations show a peak in the χ^2 plot at 3.7 hours instead of a minimum, so those results are not consistent with ours. Filled squares are from 2000 Jun 1 and the open squares are from 2000 Jun19. The zero-point for the phase is JD 2450779.5 (LTC).



(20713) 1999 XA32 serendipitously drifted through the field while we were observing 23481 on 2002 Aug 1. This asteroid has an absolute magnitude of 11.7. We were able to find a two-component Fourier fit that has a rotational period of 3.5 ± 0.2 h. Waszczak (2016) found a period of 3.548 ± 0.005 h. The zero-point for the phase is JD 2452487.5 (LTC).



(234871) 1991 GT4, a possible member of the Baptistina or Flora families, has an absolute magnitude of *H* = 14.3, and an SDSS taxonomy class of S (SBN, 2017). We found a period of 5.958 ± 0.007 h, although a slightly less better period of 5.81 hours is also possible. The open squares are from 2002 Aug 3, the filled squares 2002 Aug 14, and the open triangles 2002 Aug 19. There did not seem to be any other published periods for this asteroid when we checked the Small Body Node on 2017 Jun 19 or on the LCDB (Warner 2009). The phase zero-point is JD = 2452489.5 (LTC).



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I wish to acknowledge the contributions of the various summer research students over the years who were instrumental in helping obtain and analyze the data: Adrienne Robbins, Ryan Boas, Rob Gutermuth, Jessie Crast, Joy Lambert, Jamie Kern, and Carolyn Windus. We would also like to thank Marc Buie of SWRI Observatory for making his IDL routines available, and Brian Skiff, also of Lowell, for his list of secondary standard stars. This research has also made use of the Small Bodies Data Ferret (*http://sbn.psi.edu/ferret/*), supported by the NASA Planetary System.

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ROTATION PERIOD DETERMINATION FOR 3760 POUTANEN AND 14309 DEFOY

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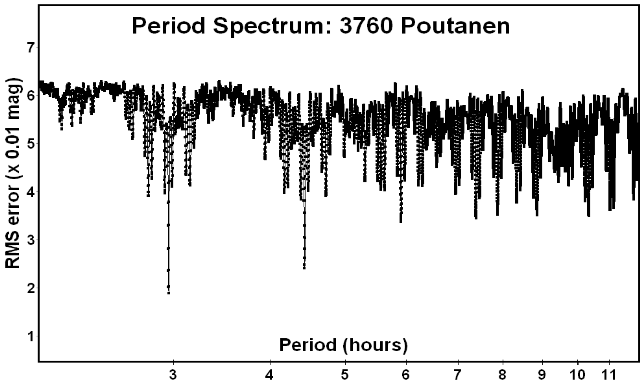
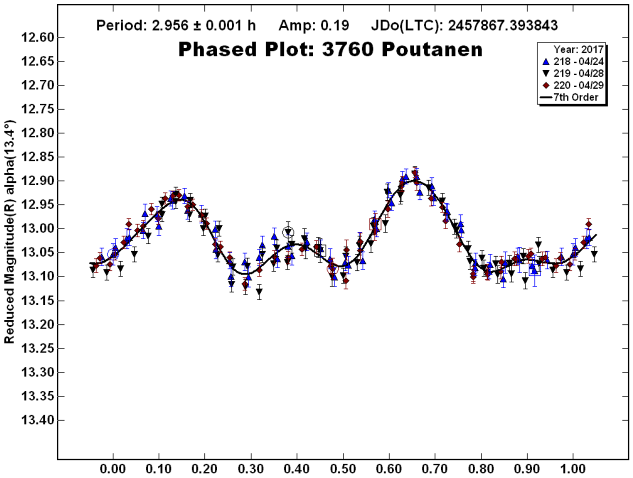
Photometric observations of the main-belt asteroids 3760 Poutanen and 14309 Defoy were performed in 2017 April-May. The data revealed a tri-modal lightcurve phased to a period of 2.956 ± 0.001 hours for 3760 Poutanen and a bimodal lightcurve phased to 3.391 ± 0.002 hours for 14309 Defoy.

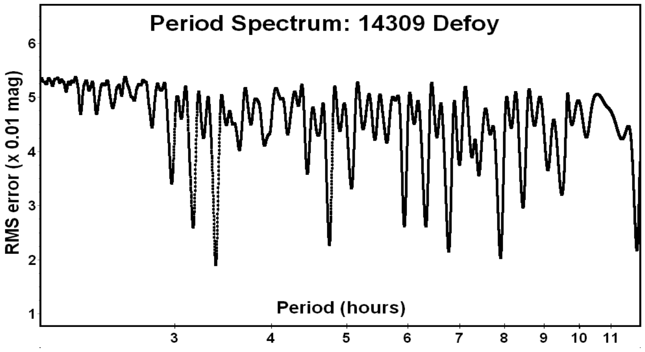
Lightcurve analysis we report here was performed using images taken at the Astronomical Observatory of the University of Siena (Italy). The equipment consisted of a 0.30-m *f*/5.6 Maksutov-Cassegrain telescope, SBIG STL-6303E NABG CCD camera, and clear filter; the pixel scale was 2.30 arcsec with 2x2 binning. Exposures were 300 seconds. The images were calibrated with dark and flat-field frames. *MPO Canopus* (Warner, 2017) was used to measure the images, do Fourier analysis, and produce the lightcurves. Table I lists the observation circumstances and results.

3760 Poutanen (1984 AQ) was discovered on 1984 January 8 by E. Bowell at Flagstaff. Its orbit has a semi-major axis of 2.532 AU, eccentricity 0.184, and period of 4.03 years (JPL, 2017). We observed this asteroid from 2017 April 23-30. The collaborative observations resulted in 3 sessions with a total of 172 data points. Our analysis found a tri-modal lightcurve phased to 2.956 ± 0.001 h with an amplitude of 0.19 ± 0.03 mag.



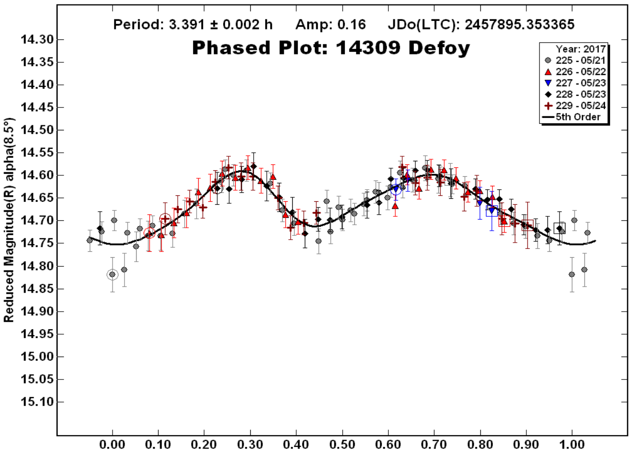


14309 Defoy (A908 SA, 1992 SU1) was discovered on 1908 September 22 by J. Palisa at Vienna. Its orbit has a semi-major axis of 2.605 AU, eccentricity 0.447, and period of 4.21 years (JPL, 2017). We observed Defoy on 2017 May 21-24. The collaborative observations resulted in 3 sessions with a total of 124 data points. We found a bimodal lightcurve with a synodic period of 3.391 ± 0.002 h and amplitude of 0.16 ± 0.02 mag.



Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
3760	Poutanen	04/23-30	172	13.8,11.2	231.5	13.7	2.956	0.001	0.19	0.03
14309	Defoy	05/21-24	124	8.7,8.2	245.5	10.0	3.391	0.002	0.16	0.02

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).



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LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2017 OCTOBER-DECEMBER

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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 2017 October-December.

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 2.5 million observations for more than 11500 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 = 15.3 and brighter.

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 asteroids 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.

An entry in bold italics is a near-Earth asteroid (NEA).

		Brightest			LCDB Data		
Number	Name	Date	Mag	Dec	Period	Amp	U
5964	1990 QN4	10 01.1	14.9	+2			
5189	**1990 UQ**	**10 01.5**	**14.2**	**-58**			
1182	Ilona	10 01.9	13.5	+13	29.8	0.98- 1.2	2
1422	Stromgrenia	10 03.9	14.6	+5	3.5	0.24-0.29	2
763	Cupido	10 04.1	14.0	+12	14.88	0.03	1
1134	Kepler	10 06.0	14.3	+15			
9513	1971 UN	10 07.1	15.0	+0			
25980	2001 FK53	10 07.3	14.8	+2			
916	America	10 09.0	12.9	+24	38.	0.28	1
3744	Horn-d'Arturo	10 11.0	14.6	+10	7.093	0.28-0.45	2
5561	Iguchi	10 11.2	14.8	+19	112.4	0.43	2
1283	Komsomolia	10 12.3	13.6	-2	96.	1.03	1+
2967	Vladisvyat	10 12.9	14.7	+1			
10357	1993 SL3	10 13.0	14.8	+12	2.762	0.05	2-
16009	1999 CM8	10 16.8	14.1	+1	16.7	0.54-0.65	2+
4576	Yanotoyohiko	10 17.4	15.0	+0			
16852	Nuredduna	10 18.9	14.9	+10			
1287	Lorcia	10 19.4	15.0	+9			
2884	Reddish	10 26.5	15.0	+12			
	2003 UV11	10 29.0	14.4	+5			
4605	Nikitin	10 30.2	15.0	+18			
1953	Rupertwildt	10 30.6	14.9	+12			
2123	Vltava	10 31.5	14.8	+16	34.	0.19-0.21	2
2597	Arthur	11 04.0	15.0	+14			
21766	1999 RW208	11 04.5	14.8	+18			
2908	Shimoyama	11 04.7	15.0	+20			
8484	1988 VM2	11 04.8	14.7	+10	2.548	0.15	2
1290	Albertine	11 06.5	14.8	+27			
1711	Sandrine	11 11.6	14.8	+1			
2052	Tamriko	11 13.0	14.1	+14	7.462	0.11-0.15	2
5049	Sherlock	11 14.0	14.8	+18			
666	Desdemona	11 14.8	12.4	+14	14.607	0.07-0.22	2+
1255	Schilowa	11 15.0	13.7	+20	29.536	0.09-0.15	2
444584	**2006 UK**	**11 15.7**	**14.5**	**+33**			
2430	Bruce Helin	11 17.5	13.9	+29	128.	0.60-0.61	2
4692	SIMBAD	11 23.1	15.0	+20			
163696	2003 EB50#	11 24.8	13.1	+27	62.4	0.73-1.43	2+
1883	Rimito	11 25.4	14.2	+7			
6484	Barthibbs	11 30.4	15.0	+9			
823	Sisigambis	11 30.8	12.9	+22	146.	0.7	2
2638	Gadolin	12 01.9	14.4	+20			
2790	Needham	12 03.9	14.9	+32			
868	Lova	12 06.0	13.0	+16	41.3	0.10-0.40	2
1599	Giomus	12 07.5	14.6	+28	6.46	0.04-0.40	1
2971	Mohr	12 08.0	14.7	+23			
2697	Albina	12 08.2	15.0	+24	16.587	0.16-0.16	2
529	Preziosa	12 09.3	13.7	+26	27.	0.56	2
4083	Jody	12 11.2	14.9	+2			
1181	Lilith	12 11.6	13.2	+23	15.04	0.11	2
1888	Zu Chong-Zhi	12 16.0	14.1	+20	15.9	0.28-0.50	2
3881	Doumergua	12 16.7	15.0	+28			
	2008 WM64	12 22.9	14.7	+29			
7496	Miroslavholub	12 23.4	14.3	+22	17.87	0.14	2
3030	Vehrenberg	12 25.1	15.0	+26	4.812	0.60	2
4690	Strasbourg	12 28.8	14.9	+36	69.2	0.75-0.80	2
2091	Sampo	12 30.0	14.2	+18	71.34	0.38	2

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." Use the on-line query form for the LCDB

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

to get more details about a specific 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 must 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 difficult. Refer to Harris *et al.* (1989; *Icarus* **81**, 365-374) 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.

The International Astronomical Union (IAU) has adopted a new system, $H\text{-}G_{12}$, introduced by Muinonen *et al.* (2010; *Icarus* **209**, 542-555). However it will be some years before it becomes the general standard and, furthermore, it is still in need of refinement. That can be done mostly through having more data for more asteroids, but only if there are data at very low and moderate phase angles. Therefore, we strongly encourage observers to obtain data for these objects not only at very low phase angles, but to follow them well before and/or after opposition, *i.e.*, out to phase angles of 15-30 degrees.

Num	Name	Date	α	V	Dec	Period	Amp	U
846	Lipperta	01 06.5	0.16	14.0	+22	1641.	0.30	2
158	Koronis	01 14.7	0.20	12.8	+21	14.218	0.28-0.43	3
212	Medea	01 25.7	0.30	12.2	+20	10.283	0.03-0.16	3
54	Alexandra	01 30.8	0.25	12.0	+18	7.024	0.10-0.31	3
177	Irma	02 04.0	0.40	13.2	+17	13.856	0.24-0.37	3
103	Hera	02 10.3	0.28	11.5	+15	23.740	0.35-0.45	3
924	Toni	02 13.8	0.39	13.7	+12	19.437	0.1 -0.24	3
379	Huenna	03 01.4	0.16	13.9	+07	14.141	0.07-0.12	3
243	Ida	03 02.8	0.21	13.6	+07	4.634	0.40-0.86	3
269	Justitia	03 02.9	0.30	13.2	+08	33.128	0.14-0.25	3
16	Psyche	03 03.2	0.30	10.3	+08	4.196	0.03-0.42	3
33	Polyhymnia	03 10.1	0.22	13.8	+05	18.608	0.13-0.21	3
589	Croatia	03 16.9	0.12	13.4	+01	24.821	0.16-0.25	2+
356	Liguria	03 20.1	0.37	11.8	-01	31.82	0.22	3-
77	Frigga	03 28.5	0.21	12.2	-03	9.012	0.07-0.20	3
332	Siri	04 09.9	0.31	13.5	-07	8.007	0.10-0.35	3
258	Tyche	04 19.5	0.26	12.6	-11	10.041	0.09-0.43	3
104	Klymene	05 13.9	0.22	13.2	-19	8.984	0.26-0.3	3
886	Washingtonia	05 21.4	0.21	13.9	-21	9.001	0.12	3
1319	Disa	05 27.2	0.36	13.4	-22	7.080	0.26-0.27	3
116	Sirona	05 28.2	0.17	11.2	-22	12.028	0.42-0.55	3
394	Arduina	05 29.6	0.18	12.8	-22	16.53	0.28-0.54	3
596	Scheila	05 30.6	0.32	11.7	-21	15.848	0.06-0.10	3
346	Hermentaria	06 21.9	0.13	10.8	-23	28.43	0.07-0.20	2
691	Lehigh	06 22.2	0.31	13.4	-24	12.891	0.12-0.16	2+
40	Harmonia	06 23.4	0.23	9.3	-23	8.910	0.13-0.36	3
767	Bondia	06 27.2	0.38	13.8	-24			
539	Pamina	06 27.6	0.19	13.3	-23	13.903	0.10-0.22	3
1784	Benguella	06 29.1	0.08	14.0	-23			
10	Hygiea	06 29.8	0.21	9.1	-24	27.630	0.09-0.33	3
1112	Polonia	07 21.7	0.34	14.0	-21	82.5	0.20	2
382	Dodona	08 09.1	0.19	12.8	-15	4.113	0.39-0.42	3
271	Penthesilea	09 08.6	0.38	13.3	-05	18.787	0.33	3
120	Lachesis	09 10.1	0.34	12.1	-04	46.551	0.14-0.22	3
107	Camilla	09 13.3	0.17	12.0	-03	4.844	0.32-0.53	3
994	Otthild	09 26.6	0.30	12.6	+02	5.95	0.09-0.15	2+

Num	Name	Date	α	V	Dec	Period	Amp	U
184	Dejopeja	10 07.1	0.32	12.9	+06	6.455	0.25-0.3	3
122	Gerda	10 07.4	0.22	12.3	+05	10.685	0.10-0.26	3
186	Celuta	10 07.9	0.13	10.7	+06	19.842	0.4 -0.55	3
658	Asteria	10 10.1	0.39	13.9	+08	21.034	0.22-0.32	3
435	Ella	10 16.9	0.11	12.1	+09	4.623	0.30-0.45	3
207	Hedda	10 18.6	0.27	12.5	+09	30.098	0.09-0.11	3
24	Themis	10 19.9	0.06	11.5	+10	8.374	0.09-0.14	3
964	Subamara	10 25.4	0.19	14.0	+12	6.868	0.11-0.25	3
673	Edda	10 29.4	0.32	13.8	+14	22.340	0.12-0.21	3
154	Bertha	10 30.3	0.12	12.2	+14	25.224	0.04-0.20	3
300	Geraldina	11 06.9	0.04	13.8	+16	6.842	0.15-0.32	3
188	Menippe	11 23.2	0.12	12.9	+20	11.98	0.28	3-
823	Sisigambis	11 30.8	0.40	13.0	+22	146.	0.05-0.7	2
1181	Lilith	12 11.7	0.21	13.3	+23	15.04	0.13	2
1663	van den Bos	12 13.1	0.19	13.9	+23	740.	0.80	3-
199	Byblis	12 17.2	0.34	13.6	+22	5.220	0.05-0.15	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

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.

Included in the list below 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 three 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 longitudes differ 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 an on-going project.

Favorable apparitions are in bold text. NEAs are in italics.

		Brightest			LCDB Data		
Num	Name	Date	Mag	Dec	Period	Amp	U
2647	Sova	10 02.8	14.6	+11	9.366	0.23-0.35	3
851	Zeissia	10 03.3	14.4	+1	9.34	0.38-0.53	3
1107	Lictoria	10 04.7	14.0	-5	8.5616	0.16-0.30	3
1309	Hyperborea	10 06.2	14.4	+8	13.88	0.34-0.41	3
658	**Asteria**	**10 10.1**	**13.9**	**+8**	**21.034**	**0.22-0.28**	**3**
607	Jenny	10 18.1	14.3	+23	8.521	0.17-0.26	3
224	Oceana	10 18.3	12.1	+14	9.401	0.09-0.14	3
1426	Riviera	10 18.6	14.8	+20	4.4044	0.30-0.31	3
7505	**Furusho**	**10 18.9**	**13.0**	**-3**	**4.14**	**0.52-0.75**	**3**
66146	***1998 TU3***	***10 23.8***	***12.0***	***-36***	***2.375***	***0.07-0.15***	***3***
159	Aemilia	10 24.8	12.3	+3	24.476	0.17-0.24	3
554	Peraga	10 25.6	11.2	+17	13.7128	0.11-0.28	3
1100	Arnica	10 26.3	14.5	+14	14.535	0.09-0.28	3
663	Gerlinde	10 28.7	14.1	+21	10.251	0.19-0.35	3
895	Helio	10 29.9	12.8	+41	9.347	0.10-0.23	3
558	Carmen	11 01.9	13.1	+3	11.387	0.2-0.31	3
111	Ate	11 03.3	11.2	+23	22.072	0.08-0.18	3
300	**Geraldina**	**11 07.0**	**13.8**	**+16**	**6.8423**	**0.13-0.32**	**3**
987	Wallia	11 07.4	13.3	+30	10.0813	0.11-0.36	3
1028	**Lydina**	**11 08.3**	**13.7**	**+13**	**11.68**	**0.22- 0.7**	**3**
905	**Universitas**	**11 09.9**	**12.9**	**+19**	**14.238**	**0.22-0.33**	**3**
972	**Cohnia**	**11 11.0**	**12.6**	**+28**	**18.472**	**0.19-0.21**	**3**
420	Bertholda	11 11.1	13.0	+20	11.04	0.24-0.29	3
454	Mathesis	11 13.9	13.1	+21	8.378	0.20-0.37	3
2144	**Marietta**	**11 17.6**	**14.8**	**+15**	**5.489**	**0.40-0.44**	**3-**
1590	Tsiolkovskaja	11 19.8	14.5	+18	6.731	0.10- 0.4	3
2228	**Soyuz-Apollo**	**11 22.2**	**14.6**	**+17**	**5.3846**	**0.4-0.54**	**3-**
151	Abundantia	11 23.7	12.5	+24	9.864	0.15-0.20	3
1443	Ruppina	11 24.7	14.9	+18	5.88	0.27-0.35	3
775	Lumiere	11 30.3	14.3	+32	6.103	0.19-0.28	3
608	Adolfine	11 30.8	14.7	+32	8.3458	0.16-0.37	3
535	Montague	12 01.1	12.5	+19	10.2482	0.18-0.25	3
126	Velleda	12 05.1	12.1	+26	5.3672	0.07-0.22	3
359	Georgia	12 05.4	12.5	+32	5.537	0.16-0.54	3
909	Ulla	12 05.9	14.0	-2	8.73	0.08-0.24	3
653	Berenike	12 06.6	13.6	+8	12.4886	0.03-0.11	3
326	Tamara	12 07.8	13.5	+49	14.445	0.10-0.27	3
1741	Giclas	12 08.6	14.9	+24	2.943	0.10-0.15	3
388	Charybdis	12 11.4	12.9	+32	9.516	0.14-0.25	3
1096	Reunerta	12 11.5	14.1	+23	13.036	0.20-0.39	3
217	Eudora	12 12.2	14.4	+8	25.272	0.08-0.31	3
59	Elpis	12 12.5	11.3	+9	13.69	0.07-0.42	3
295	**Theresia**	**12 13.8**	**12.8**	**+24**	**10.73**	**0.11-0.22**	**3-**
1072	**Malva**	**12 16.5**	**13.9**	**+33**	**10.08**	**0.17-0.17**	**3**
1113	Katja	12 17.8	13.1	+41	18.465	0.08-0.17	3
980	Anacostia	12 18.9	11.4	+32	20.117	0.05-0.21	3
840	Zenobia	12 21.6	14.7	+24	5.565	0.08-0.28	3
1848	Delvaux	12 22.3	15.0	+25	3.637	0.57-0.69	3
1084	Tamariwa	12 22.7	14.9	+18	6.1961	0.25-0.42	3
781	Kartvelia	12 23.2	14.8	+4	19.04	0.16-0.28	3-
1304	Arosa	12 23.9	13.9	+26	7.7478	0.13-0.38	3
954	Li	12 26.4	14.8	+22	7.207	0.11-0.25	3
1116	Catriona	12 28.9	13.0	+51	8.832	0.09-0.20	3
772	Tanete	12 29.0	13.0	+48	17.258	0.07-0.18	3
114	Kassandra	12 29.1	11.4	+16	10.7431	0.23-0.25	3
8256	Shenzhou	12 29.2	14.6	+36	3.395	0.30-0.31	3
779	Nina	12 29.5	11.8	+26	11.186	0.06-0.32	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 the Minor Planet Center observing tools

In particular, monitor NEAs 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 (through Dr. Benner's email listed above) if you get data. The team may not always be observing the target but 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" 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.

About YORP Acceleration

Many, if not all, of the targets in this section are near-Earth asteroids. These objects are particularly sensitive to YORP acceleration. YORP (Yarkovsky–O'Keefe–Radzievskii–Paddack) is the asymmetric thermal re-radiation of sunlight that can cause an asteroid's rotation period to increase or decrease. High precision lightcurves at multiple apparitions can be used to model the asteroid's *sidereal* rotation period and see if it's changing.

It usually takes four apparitions to have sufficient data to determine if the asteroid rotation rate is changing under the influence of YORP. So, while obtaining a lightcurve at the current apparition may not result in immediately seeing a change, the data are still critical in reaching a final determination. This is why observing asteroids that already have well-known periods can still be a valuable use of telescope time. It is even more so when considering BYORP (binary-YORP) among binary asteroids where that effect has stabilized the spin so that acceleration of the primary body is not the same as if it would be if there were no satellite.

Asteroid	Period	Amp	App	Last	R SNR
3122 Florence **NEA,PHA, Bin?**	**2.36**	**0.12** **0.27**	**7**	**2016**	**56900 A** **3240 G**
(5189) 1990 UQ NEA	-	0.78	-	-	2006 A 117 G
1989 VB **NEA,PHA**	**16**	**0.32**	**1**	**1997**	**79900 A** **4500 G**
2329 Orthos NEA	4.6	-	1	2017	468 A 27 G
2014 UR116 **NEA**	**-**	**-**	**-**	**-**	**312 A** **18 G**
(171576) 1999 VF11 **NEA,PHA**	**-**	**0.08**	**-**	**-**	**8290 A** **471 G**
(66146) 1998 TU3 NEA	2.375	0.07 0.15	5	2010	813 G 46 A
2003 UV11 **NEA,PHA**	**-**	**-**	**-**	**-**	**4290 A** **244 G**
1989 UP **NEA,PHA**	**6.98**	**1.16**	**1**	**1989**	**612 A** **35 G**
(190208) 2006 AQ NEA, Bin?	182.	0.25	1	2014	271 A 15 G
(162004) 1991 VE NEA	13.48	1.08 1.11	2	2014	35 A
(457768) 2009 KN4 NEA	-	-	-	-	14 A
(99907) 1989 VA NEA	2.51	0.22 0.40	2	1997	23 A
3361 Orpheus NEA	3.53	0.22 0.32	3	2013	890 A 51 G
(138852) 2000 WN10 NEA,PHA	4.46	0.38 0.44	3	2015	23 A
(444584) 2006 UK **NEA**	**-**	**-**	**-**	**-**	**2210 A** **1260 G**
(333888) 1998 ST4 NEA	-	-	-	-	16 A
(163696) 2003 EB50 **NEA,PHA**	**62.**	**0.73** **0.83**	**3**	**2017**	**4160 A** **238 G**
3200 Phaethon **NEA,PHA**	**3.60**	**0.07** **0.34**	**10**	**2016**	**1120 A** **639 G**
(140158) 2001 SX169 NEA	-	-	-	-	343 A 20 G
(276703) 2004 BL11 NEA	-	-	-	-	16 A
(418849) 2008 WM64 **NEA,PHA**	**-**	**-**	**-**	**-**	**1760 A** **100 G**
(294739) 2008 CM NEA	3.05	0.18 0.49	2	2015	21 A

Table I. Summary of radar-optical opportunities in 2017 Oct-Dec. Data from the asteroid lightcurve database (Warner *et al.*, 2009; *Icarus* **202**, 134-146). If no period is given, 4 hours was assumed to calculate the radar SNR.

To help focus efforts in YORP detection, Table I gives a quick summary of this quarter's radar-optical targets.

The family or group for the asteroid is given under the number name. Also under the name will be additional flags such as "PHA" for Potentially Hazardous Asteroid or "Bin" to indicate the asteroid is a binary (or multiple) system. If followed by "?" it means that the asteroid is a suspect but not confirmed binary. The period is in hours and, in the case of binary, for the primary. The Amp column gives the known range of lightcurve amplitudes. The App columns gives the number of different apparitions at which a lightcurve period was reported while the Last column gives the year for the last reported period. The "R SNR" column indicates the estimated radar SNR using the tool at

http://www.naic.edu/~eriverav/scripts/radarscript.php

The estimate in Table I is based on using the Arecibo (A) or Goldstone (G) radar. The estimate uses the current MPCORB absolute magnitude (*H*), a period of 4 hours if it's not known, and the approximate minimum Earth distance during the three-month period covered by this paper.

If the SNR value is in bold text, the object was found on the radar planning pages listed above. Otherwise, the search tool at

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

was used to find known NEAs that were V < 18.0 during the quarter. An object was placed on the list only if the estimated radar SNR > 10. This would produce a very marginal signal, not enough for imaging, but might allow improving orbital parameters.

3122 Florence (Oct-Dec, *H* = 14.1, PHA)

Pravec et al. (1998) found a period of 2.358 h. Warner (2016) reported it as a suspected binary after finding a second period of 10.36 h with an amplitude of 0.07 mag. No signs of mutual events were seen, however. If the second period is real, it might also be due to low-level tumbling. The SNRs for the radar teams are going to be extremely large and so they are planning hi-res imaging.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	17 34.4	+73 25	0.22	1.02	13.6	78.2	89	95	+0.77	+31
10/11	17 04.8	+75 21	0.29	1.04	14.1	74.4	89	85	-0.67	+33
10/21	16 48.7	+76 46	0.34	1.06	14.4	69.7	91	89	+0.02	+33
10/31	16 44.7	+78 19	0.39	1.10	14.6	64.6	94	99	+0.79	+33
11/10	16 53.7	+80 23	0.43	1.14	14.7	59.4	99	78	-0.59	+32
11/20	17 25.9	+83 10	0.47	1.19	14.8	54.1	103	101	+0.02	+29
11/30	19 21.8	+86 21	0.50	1.24	14.9	48.8	109	87	+0.82	+27
12/10	00 55.0	+86 00	0.53	1.30	15.0	43.7	115	85	-0.53	+23
12/20	02 57.8	+80 55	0.56	1.36	15.1	39.0	120	114	+0.03	+19
12/30	03 41.9	+74 41	0.61	1.42	15.2	35.3	124	61	+0.86	+15

(5189) 1990 UQ (Oct, $H = 17.9$)

Southern Hemisphere observers get the best opportunities for this 0.8 km NEA. There is no period in the LCDB. Watch for unusual lightcurve shapes during the early part of the month, when the phase angle is large and shadowing effects may come into play.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	22 52.7	-57 33	0.07	1.03	14.3	60.1	116	47	+0.77	-53
10/04	23 42.5	-45 00	0.08	1.06	14.4	47.3	129	39	+0.96	-67
10/07	00 05.1	-35 50	0.10	1.08	14.7	38.9	137	51	-0.98	-77
10/10	00 17.7	-29 18	0.12	1.10	15.0	33.4	143	81	-0.77	-82
10/13	00 25.9	-24 31	0.15	1.12	15.3	29.9	146	116	-0.44	-84
10/16	00 31.6	-20 54	0.17	1.14	15.6	27.7	148	150	-0.15	-82
10/19	00 36.0	-18 02	0.19	1.17	15.9	26.5	149	158	-0.01	-80
10/22	00 39.5	-15 42	0.22	1.19	16.2	25.8	149	128	+0.05	-78
10/25	00 42.5	-13 45	0.25	1.21	16.5	25.6	148	95	+0.24	-76
10/28	00 45.3	-12 04	0.27	1.23	16.7	25.7	147	62	+0.51	-75

1989 VB (Oct, $H = 19.8$, PHA)

Wisniewski et al. (1997) reported a period of 16 h. The estimated diameter is about 325 m, making it likely that the period is about 2 hours or more. Unfortunately, the NEA hovers near the galactic plane for most of October.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	05 34.0	-43 08	0.02	1.00	14.2	81.0	98	106	+0.77	-32
10/03	05 50.2	-25 37	0.02	1.00	14.4	80.0	99	103	+0.91	-24
10/05	05 59.2	-12 28	0.03	1.01	14.8	78.7	100	86	+0.99	-17
10/07	06 04.9	-03 12	0.03	1.01	15.1	77.1	101	62	-0.98	-12
10/09	06 08.7	+03 23	0.04	1.01	15.4	75.3	103	36	-0.86	-8
10/11	06 11.4	+08 11	0.04	1.01	15.6	73.3	104	12	-0.67	-5
10/13	06 13.3	+11 48	0.05	1.01	15.9	71.2	106	25	-0.44	-3
10/15	06 14.6	+14 37	0.06	1.02	16.1	69.1	108	51	-0.24	-1
10/17	06 15.4	+16 51	0.06	1.02	16.2	66.8	110	77	-0.08	+0
10/19	06 15.8	+18 41	0.07	1.02	16.4	64.5	112	103	-0.01	+1

2329 Orthos (Oct-Jan, $H = 14.6$)

The estimated diameter is 3.4 km. Warner (2017) reported a period of about 4.6 h based on observations in 2017 Feb and May.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/10	21 11.1	-77 30	0.20	1.02	13.9	78.6	90	113	-0.77	-34
10/20	01 02.8	-64 54	0.29	1.10	14.3	60.9	105	108	+0.00	-52
10/30	01 40.6	-54 25	0.39	1.19	14.8	50.7	111	59	+0.70	-61
11/09	01 55.3	-46 59	0.51	1.29	15.4	44.3	115	101	-0.70	-67
11/19	02 04.3	-41 00	0.63	1.38	15.9	40.0	116	117	+0.00	-70
11/29	02 12.1	-35 46	0.76	1.48	16.3	37.1	115	43	+0.73	-71
12/09	02 20.0	-31 02	0.90	1.57	16.8	35.0	114	120	-0.64	-70
12/19	02 28.7	-26 41	1.04	1.67	17.2	33.5	111	107	+0.01	-68
12/29	02 38.2	-22 41	1.20	1.76	17.6	32.3	107	33	+0.77	-65
01/08	02 48.6	-19 00	1.36	1.85	17.9	31.3	103	142	-0.59	-62

2014 UR116 (Oct, $H = 14.6$, PHA)

There is no period in the LCDB for this 350 m NEA.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/15	07 25.4	+53 16	0.07	1.01	16.9	79.9	96	48	-0.24	+26
10/16	06 27.2	+54 41	0.08	1.02	16.7	70.5	105	66	-0.15	+18
10/17	05 33.5	+54 23	0.08	1.03	16.6	62.0	114	84	-0.08	+11
10/18	04 48.6	+52 57	0.09	1.05	16.5	54.6	121	102	-0.03	+5
10/19	04 13.1	+50 56	0.10	1.06	16.6	48.1	128	118	-0.01	+0
10/20	03 45.5	+48 44	0.11	1.07	16.6	42.6	133	132	+0.00	-5
10/21	03 24.0	+46 32	0.11	1.08	16.7	37.9	138	143	+0.02	-9
10/22	03 07.1	+44 29	0.12	1.10	16.8	33.8	142	149	+0.05	-12
10/23	02 53.5	+42 36	0.13	1.11	16.9	30.3	146	148	+0.10	-15
10/24	02 42.5	+40 53	0.14	1.12	17.0	27.3	149	141	+0.16	-17

(171576) 1999 VP11 (Oct, $H = 18.6$, PHA)

Skiff et al. (2012) were not able to find a period from data obtained in 2008. The amplitude at the time was about 0.08 mag. The estimated diameter is about 340 meters.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/22	17 25.0	-16 58	0.02	0.99	14.9	125.8	53	28	+0.05	+10
10/23	20 34.2	-28 25	0.02	1.00	12.6	84.8	94	59	+0.10	-34
10/24	22 40.1	-26 50	0.02	1.01	12.6	59.4	119	76	+0.16	-61
10/25	23 34.9	-23 49	0.03	1.02	13.1	48.4	130	77	+0.24	-72
10/26	00 02.4	-21 45	0.05	1.03	13.6	43.0	135	72	+0.32	-78
10/27	00 18.4	-20 23	0.06	1.04	14.1	40.1	138	65	+0.41	-80
10/28	00 28.9	-19 25	0.07	1.05	14.4	38.2	139	56	+0.51	-81
10/29	00 36.3	-18 41	0.08	1.06	14.8	37.1	140	47	+0.61	-81
10/30	00 41.8	-18 07	0.09	1.07	15.1	36.3	141	37	+0.70	-81
10/31	00 46.1	-17 40	0.11	1.08	15.3	35.8	141	27	+0.79	-80

(66146) 1998 TU3 (Oct-Nov, $H = 14.5$)

This is one of the larger targets this quarter, the diameter being about 3.7 km. The NEA has been observed at several apparitions. The period of about 2.37 h and low amplitudes in the past make it a good candidate for being a binary asteroid. High-precision observations with dense coverage over 1-3 cycles for at least 3-4 consecutive nights will maximize the chances of finding a satellite.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	03 55.9	-08 13	0.23	1.16	13.3	43.7	127	104	+0.77	-43
10/06	03 47.1	-12 31	0.21	1.15	13.0	40.5	132	43	-1.00	-46
10/11	03 33.1	-17 48	0.18	1.14	12.6	37.7	136	50	-0.67	-52
10/16	03 11.6	-24 11	0.16	1.12	12.3	36.7	138	114	-0.15	-58
10/21	02 39.5	-31 26	0.14	1.10	12.1	39.0	136	138	+0.02	-66
10/26	01 53.5	-38 43	0.13	1.08	12.1	45.5	129	89	+0.32	-73
10/31	00 52.9	-44 35	0.13	1.06	12.2	55.6	118	44	+0.79	-73
11/05	23 43.5	-47 40	0.13	1.04	12.6	67.4	105	79	-0.99	-66
11/10	22 37.1	-47 50	0.14	1.01	13.0	79.3	93	141	-0.59	-57
11/15	21 41.8	-46 00	0.15	0.98	13.6	90.6	80	116	-0.12	-48

2003 UV11 (Oct, $H = 19.5$, PHA)

There is no reported lightcurve period for this 370 m NEA. The large range of phase angles makes this an excellent opportunity to find reliable H and G parameters, i.e., absolute magnitude and phase slope parameter, respectively.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/15	02 44.3	+12 20	0.24	1.22	17.7	17.1	159	101	-0.24	-42
10/17	02 39.4	+12 11	0.21	1.20	17.3	14.9	162	129	-0.08	-43
10/19	02 32.7	+11 58	0.18	1.17	16.8	12.2	166	157	-0.01	-44
10/21	02 23.3	+11 39	0.15	1.14	16.3	8.8	170	175	+0.02	-45
10/23	02 09.4	+11 09	0.12	1.12	15.6	4.3	175	148	+0.10	-47
10/25	01 47.6	+10 18	0.10	1.09	14.9	2.7	177	119	+0.24	-50
10/27	01 09.8	+08 35	0.07	1.06	14.6	13.3	166	86	+0.41	-54
10/29	23 56.3	+04 35	0.05	1.03	14.4	33.2	145	44	+0.61	-56
10/31	21 38.4	-03 52	0.04	1.01	14.9	70.0	108	21	+0.79	-39

1989 UP (Oct-Nov, $H = 20.8$, PHA)

The estimated diameter is only 200 meters. This would make it a possible candidate for being a superfast rotator, i.e,. $P < 2$ hours. However, Wisniewski et al. (1997) found this to have a period on the slower side of average, 6.98 h.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/10	02 17.7	-06 04	0.14	1.13	17.7	20.1	157	45	-0.77	-61
10/14	02 35.4	-05 22	0.12	1.10	17.4	21.5	156	95	-0.33	-57
10/18	02 59.3	-04 09	0.10	1.08	17.0	23.6	154	140	-0.03	-52
10/22	03 32.3	-02 09	0.08	1.07	16.7	27.3	151	164	+0.05	-44
10/26	04 18.8	+01 00	0.07	1.05	16.4	33.7	144	139	+0.32	-33
10/30	05 22.5	+05 27	0.06	1.03	16.4	44.1	134	109	+0.70	-17
11/03	06 40.3	+10 25	0.05	1.02	16.6	57.7	120	75	+0.98	+2
11/07	07 57.6	+14 13	0.06	1.01	17.1	70.9	106	35	-0.89	+21
11/11	09 00.6	+16 12	0.07	1.00	17.8	80.5	96	8	-0.48	+36
11/15	09 46.7	+16 57	0.08	0.99	18.3	86.0	89	50	-0.12	+46

(190208) 2006 AQ (Oct-Dec, *H* = 18.2)

This asteroid needs an extensive campaign involving observers at well-separated longitudes producing high-precision photometry. Warner (2014) reports this as a possible “very wide binary”, one where the primary period is very long (182 h, *A* = 0.25 mag) with a short period (2.62 h, *A* = 0.08 mag) lightcurve superimposed. Confirmation, or not, of the initial discovery is needed. Be careful about using a combined data set that spans more than a month or so. Changes in the lightcurve due to changing viewing aspect could lead to false conclusions.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	02 32.2	+29 32	0.28	1.23	17.2	31.2	141	95	+0.77	-28
10/11	03 10.2	+36 55	0.22	1.18	16.7	34.1	139	39	-0.67	-18
10/21	04 10.0	+45 02	0.19	1.13	16.4	39.9	133	141	+0.02	-5
10/31	05 43.2	+51 08	0.16	1.09	16.3	47.9	125	103	+0.79	+11
11/10	07 35.4	+51 07	0.16	1.07	16.4	56.0	116	36	-0.59	+27
11/20	09 03.1	+45 21	0.16	1.06	16.6	61.3	110	122	+0.02	+42
11/30	09 55.6	+37 57	0.18	1.06	16.8	62.5	108	119	+0.82	+52
12/10	10 24.6	+31 16	0.19	1.07	16.9	59.9	110	25	-0.53	+58
12/20	10 38.7	+25 56	0.21	1.09	17.0	54.4	116	132	+0.03	+60
12/30	10 41.8	+21 53	0.23	1.13	17.0	46.6	124	100	+0.86	+60

(162004) 1991 VE (Nov, *H* = 18.2)

Pravec et al. (2012) and Warner (2015) both report a period of about 13.5 h for this 700 meter NEA.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
11/05	20 07.5	-38 54	0.19	0.96	17.9	94.8	74	115	-0.99	-31
11/07	20 48.3	-35 41	0.20	0.98	17.7	87.7	81	134	-0.89	-38
11/09	21 22.4	-32 03	0.21	1.00	17.7	81.3	87	153	-0.70	-45
11/11	21 50.4	-28 23	0.22	1.02	17.7	75.8	92	166	-0.48	-50
11/13	22 13.2	-24 55	0.24	1.04	17.7	71.1	96	157	-0.28	-55
11/15	22 32.0	-21 45	0.26	1.06	17.8	67.1	99	138	-0.12	-58
11/17	22 47.5	-18 55	0.28	1.08	17.9	63.8	101	118	-0.02	-60
11/19	23 00.7	-16 24	0.31	1.10	18.0	61.1	103	98	+0.00	-62
11/21	23 11.9	-14 11	0.33	1.12	18.1	58.8	105	78	+0.06	-63
11/23	23 21.6	-12 12	0.35	1.13	18.3	57.0	106	57	+0.18	-64

(457768) 2009 KN4 (Oct-Dec, *H* = 18.3)

The estimated diameter is 650 meters; there is no lightcurve period listed in the LCDB. The large phase angles in October could make lightcurve analysis difficult because of deep shadowing effects.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/20	18 28.0	+19 47	0.21	0.97	18.1	90.4	77	72	+0.00	+14
10/25	19 03.8	+26 38	0.20	0.99	17.8	84.6	84	49	+0.24	+9
10/30	19 46.6	+33 13	0.20	1.02	17.5	77.3	91	57	+0.70	+4
11/04	20 36.4	+38 47	0.20	1.04	17.4	69.4	100	83	+1.00	-1
11/09	21 31.0	+42 38	0.21	1.07	17.3	61.5	108	113	-0.70	-6
11/14	22 25.8	+44 32	0.23	1.11	17.3	54.3	115	128	-0.19	-11
11/19	23 16.1	+44 44	0.25	1.14	17.4	48.1	121	114	+0.00	-15
11/24	23 59.3	+43 49	0.28	1.17	17.6	43.1	126	81	+0.25	-18
11/29	00 35.0	+42 16	0.32	1.21	17.8	39.3	129	44	+0.73	-21
12/04	01 04.3	+40 30	0.35	1.25	18.0	36.6	131	56	-1.00	-22

(99907) 1989 VA (Oct-Dec, *H* = 17.9)

Pravec et al. (1997) reported a period of 2.5 h. That’s 20 years ago. It often gets brighter than V = 17.0, so it’s curious that it has not been observed since, except that the U = 3 rating in the LCDB lead observers to believe that additional data were not needed.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/10	06 45.1	+39 18	0.38	1.11	18.3	63.0	97	33	-0.77	+16
10/17	06 29.3	+36 15	0.32	1.13	17.8	57.2	107	74	-0.08	+12
10/24	06 04.5	+31 42	0.27	1.15	17.2	49.0	119	162	+0.16	+5
10/31	05 27.0	+24 20	0.22	1.16	16.4	37.3	135	100	+0.79	-6
11/07	04 35.2	+12 39	0.19	1.16	15.6	22.1	154	15	-0.89	-23
11/14	03 33.7	-02 28	0.18	1.16	15.4	17.9	159	128	-0.19	-44
11/21	02 34.6	-15 53	0.20	1.15	16.1	33.4	140	121	+0.06	-64
11/28	01 48.0	-24 27	0.24	1.13	16.9	47.7	122	38	+0.63	-77
12/05	01 15.2	-29 10	0.29	1.11	17.5	57.8	108	86	-0.97	-84
12/12	00 53.1	-31 45	0.34	1.08	18.0	65.1	97	148	-0.33	-85

3361 Orpheus (Oct-Nov, *H* = 19.0)

Wisniewski (1991), Polishook (2012), and Skiff (2013) all reported a period of about 3.5 h for this 0.5 km NEA. If caught early on, mid-October, here is another excellent chance to find *H*-*G* parameters.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/15	02 20.3	+09 49	0.21	1.20	16.7	12.5	165	108	-0.24	-47
10/20	02 15.3	+07 41	0.18	1.17	16.2	8.0	171	175	+0.00	-50
10/25	02 07.8	+04 50	0.15	1.15	15.7	6.6	172	122	+0.24	-53
10/30	01 57.5	+01 02	0.13	1.12	15.6	12.0	166	58	+0.70	-58
11/04	01 43.5	-04 00	0.11	1.09	15.4	21.0	157	18	+1.00	-64
11/09	01 24.3	-10 46	0.09	1.07	15.3	32.8	144	96	-0.70	-72
11/14	00 57.0	-19 45	0.08	1.04	15.3	47.8	129	159	-0.19	-83
11/19	00 16.0	-31 12	0.07	1.01	15.5	66.4	110	108	+0.00	-81
11/24	23 10.6	-43 48	0.06	0.99	16.0	88.3	88	45	+0.25	-64
11/29	21 28.6	-53 25	0.06	0.96	17.2	111.1	65	63	+0.73	-45

(138852) 2000 WN10 (Nov, *H* = 20.2, PHA)

The estimated diameter of this NEA is 270 meters. Pravec et al. (2011), Skiff et al. (2009), and Warner (2016) all found a period of about 4.46 h. To date, the amplitude has been fairly large, at least 0.38 mag. Will it be so this time around?

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
11/01	05 33.8	-57 16	0.15	1.03	18.7	73.2	98	84	+0.87	-33
11/04	04 45.4	-52 37	0.14	1.04	18.3	66.0	107	69	+1.00	-40
11/07	04 02.2	-46 02	0.13	1.05	18.0	57.9	116	68	-0.89	-48
11/10	03 26.0	-37 50	0.13	1.07	17.7	49.5	125	91	-0.59	-56
11/13	02 56.8	-28 45	0.13	1.08	17.6	41.8	133	124	-0.28	-62
11/16	02 33.7	-19 41	0.14	1.10	17.5	35.7	140	152	-0.06	-65
11/19	02 15.7	-11 20	0.15	1.11	17.6	32.2	143	142	+0.00	-65
11/22	02 01.7	-04 05	0.16	1.12	17.8	31.0	144	109	+0.11	-61
11/25	01 51.0	+01 59	0.18	1.13	18.1	31.6	143	73	+0.34	-58
11/28	01 42.7	+07 00	0.20	1.15	18.4	33.2	141	35	+0.63	-54

(444584) 2006 UK (Oct-Nov, *H* = 20.2)

There is no period reported in the LCDB. The estimated diameter is 270 meters, so it’s probable that the period is going to be more than 2 hours.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/25	02 36.3	+29 24	0.21	1.20	18.1	16.2	160	133	+0.24	-28
10/28	02 32.6	+29 55	0.19	1.17	17.7	15.0	162	99	+0.51	-28
10/31	02 27.4	+30 28	0.16	1.15	17.3	14.3	163	63	+0.79	-28
11/03	02 19.9	+31 08	0.13	1.12	16.8	14.5	164	28	+0.98	-28
11/06	02 08.6	+31 58	0.10	1.09	16.4	16.3	162	35	-0.95	-28
11/09	01 49.8	+33 04	0.08	1.06	15.9	20.5	158	77	-0.70	-28
11/12	01 13.5	+34 31	0.06	1.04	15.3	29.1	149	120	-0.38	-28
11/15	23 43.7	+35 00	0.03	1.01	14.7	49.0	130	143	-0.12	-26
11/18	20 07.6	+17 59	0.02	0.98	15.6	101.7	77	78	+0.00	-8

(333888) 1998 ST4 (Oct-Dec, *H* = 16.4)

At 1.6 km, this is one of the larger NEAs in this quarter’s collection. The rotation period is unknown.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	00 24.8	+23 11	0.60	1.58	17.0	12.6	160	66	+0.77	-39
10/11	00 16.3	+22 07	0.53	1.51	16.6	12.6	161	77	-0.67	-40
10/21	00 07.8	+20 03	0.47	1.43	16.4	16.8	155	142	+0.02	-42
10/31	00 02.1	+17 06	0.42	1.37	16.3	23.6	147	30	+0.79	-44
11/10	00 01.5	+13 35	0.39	1.31	16.3	31.3	137	120	-0.59	-48
11/20	00 08.0	+09 52	0.37	1.25	16.3	38.7	128	110	+0.02	-52
11/30	00 22.6	+06 17	0.35	1.20	16.3	45.3	120	13	+0.82	-56
12/10	00 45.6	+03 05	0.34	1.17	16.3	50.6	114	152	-0.53	-60
12/20	01 16.7	+00 24	0.33	1.14	16.3	54.3	110	91	+0.03	-62
12/30	01 55.4	-01 37	0.33	1.13	16.3	56.2	108	29	+0.86	-60

(163696) 2003 EB50 (Oct-Dec, *H* = 16.4, PHA)

Warner observed this NEA at three apparitions (2013, 2015, 2017). The data from 2013 led to a period of 27 h with the possibility of tumbling. The data from 2015 and 2017 resulted in a period of about 62.5 h with large amplitudes and no obvious signs of tumbling. High-precision observations with dense observations every night (at least 10-15 spread out over 6 or more hours, not a handful over 1-2 hours) will be needed. Long period objects, especially if there is a possibility of tumbling, need a healthy amount of data and lots of patience.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	12 55.9	-51 05	0.56	0.76	18.1	98.3	48	93	+0.77	+12
10/11	12 30.5	-54 47	0.46	0.77	18.1	105.5	48	111	-0.67	+8
10/21	11 51.1	-55 58	0.35	0.82	17.9	110.3	50	56	+0.02	+6
10/31	10 58.4	-53 13	0.25	0.88	17.3	110.6	56	118	+0.79	+6
11/10	09 48.0	-41 51	0.16	0.95	15.9	101.2	70	62	-0.59	+9
11/20	08 04.1	-02 23	0.09	1.03	13.6	63.1	112	129	+0.02	+15
11/30	05 54.7	+44 14	0.14	1.11	13.5	25.9	151	74	+0.82	+9
12/10	04 21.6	+55 42	0.24	1.19	14.9	27.4	146	89	-0.53	+4
12/20	03 37.6	+57 28	0.36	1.28	16.0	30.9	138	126	+0.03	+1
12/30	03 22.3	+57 12	0.49	1.36	16.9	32.9	131	43	+0.86	+0

3200 Phaethon (Oct-Dec, H = 14.6, PHA)

Period determinations of about 3.6 hours go back at least two decades. Hanus et al. (2016) derived a shape and spin axis model for the asteroid. That does not mean you should neglect this 5 km NEA. Additional data can help find YORP acceleration and/or improve the quality of the current pole solution.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	06 30.2	+33 25	1.57	1.88	18.3	32.1	91	145	+0.77	+11
10/11	06 41.9	+33 40	1.36	1.80	17.9	33.2	99	18	-0.67	+13
10/21	06 52.1	+33 58	1.15	1.72	17.5	33.9	106	119	+0.02	+15
10/31	07 00.3	+34 25	0.93	1.62	16.9	34.0	114	119	+0.79	+17
11/10	07 05.5	+35 07	0.72	1.51	16.2	33.3	123	27	-0.59	+18
11/20	07 04.9	+36 18	0.52	1.40	15.3	31.4	133	146	+0.02	+18
11/30	06 50.9	+38 37	0.33	1.27	13.9	27.1	144	84	+0.82	+16
12/10	05 34.0	+44 07	0.15	1.12	11.6	19.1	158	79	-0.53	+6
12/20	22 29.4	+00 49	0.09	0.96	13.0	103.4	72	53	+0.03	-46

(140158) 2001 SX169 (Nov-Dec, H = 18.3)

There is no period in the LCDB for this NEA. The WISE survey (Mainzer et al., 2011) found a diameter of 566 meters. Using H = 18.2, they found an albedo of $p_V = 0.289$.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
11/01	04 44.2	+14 38	0.45	1.39	18.4	23.4	146	75	+0.87	-20
11/08	04 41.8	+13 36	0.38	1.34	17.8	19.3	153	28	-0.80	-21
11/15	04 35.4	+12 15	0.32	1.29	17.2	14.4	161	124	-0.12	-23
11/22	04 23.9	+10 29	0.26	1.24	16.5	10.0	167	147	+0.11	-26
11/29	04 05.6	+08 05	0.21	1.19	16.0	11.3	166	57	+0.73	-31
12/06	03 38.1	+04 45	0.17	1.14	15.7	21.2	155	54	-0.92	-39
12/13	02 56.7	-00 01	0.13	1.09	15.6	37.2	138	158	-0.24	-49
12/20	01 54.5	-06 49	0.11	1.03	15.6	59.9	115	98	+0.03	-65
12/27	00 24.5	-15 12	0.09	0.98	16.2	90.2	85	18	+0.57	-77

(276703) 2004 BL11 (Dec, H = 19.2)

The effective diameter of this NEA is about 0.5 km. There is no period reported in the LCDB. Unfortunately, the asteroid stays close to the galactic plane, meaning dense star fields and difficulties getting good photometry.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
12/20	07 14.9	-32 41	0.18	1.09	17.5	51.3	120	127	+0.03	-10
12/21	07 02.0	-29 55	0.19	1.10	17.5	47.7	124	129	+0.07	-11
12/22	06 50.5	-27 15	0.19	1.11	17.5	44.3	128	127	+0.12	-12
12/23	06 40.3	-24 42	0.20	1.12	17.6	41.2	131	121	+0.19	-13
12/24	06 31.2	-22 17	0.21	1.14	17.6	38.5	134	113	+0.27	-14
12/25	06 23.1	-20 00	0.22	1.15	17.6	36.0	137	103	+0.36	-15
12/26	06 15.8	-17 52	0.23	1.16	17.7	33.9	139	92	+0.46	-16
12/27	06 09.3	-15 52	0.24	1.17	17.8	32.0	141	80	+0.57	-16
12/28	06 03.4	-14 00	0.25	1.19	17.8	30.5	142	67	+0.67	-17
12/29	05 58.1	-12 15	0.26	1.20	17.9	29.1	144	54	+0.77	-17

(418849) 2008 WM64 (Dec-Jan, H = 20.7, PHA)

This NEA has no reported period in the LCDB. The diameter is estimated to be about 215 meters.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
12/15	08 45.7	-39 38	0.08	1.01	17.9	73.1	102	86	-0.10	+2
12/17	08 37.5	-31 55	0.07	1.01	17.2	66.3	110	105	-0.02	+6
12/19	08 26.4	-19 17	0.05	1.01	16.3	55.2	122	130	+0.01	+11
12/21	08 10.9	+01 30	0.04	1.02	15.4	37.9	141	162	+0.07	+18
12/23	07 48.4	+29 26	0.04	1.02	14.8	23.0	156	150	+0.19	+24
12/25	07 14.2	+53 40	0.05	1.02	15.4	30.9	148	113	+0.36	+25
12/27	06 20.6	+68 24	0.06	1.03	16.3	42.6	135	86	+0.57	+22
12/29	05 00.2	+75 55	0.08	1.03	17.1	50.4	126	69	+0.77	+20
12/31	03 22.0	+78 53	0.09	1.03	17.7	55.4	120	62	+0.93	+18
01/02	01 56.7	+79 18	0.11	1.04	18.2	58.7	116	67	+1.00	+17

(294739) 2008 CM (Nov-Dec, H = 15.2)

The period of this NEA is close to 3.0 h; the synodic period has varied about 0.05 h on either side. The estimated diameter is about 1.1 km. As often happens with NEAs, the phase angles during an apparition are very large and the solar elongations not so much so.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
11/01	13 56.0	+52 53	0.52	0.93	18.5	81.5	68	125	+0.87	+62
11/11	13 21.1	+47 34	0.46	0.93	18.3	83.5	69	57	-0.48	+69
11/21	12 47.8	+39 15	0.40	0.95	18.0	84.0	72	91	+0.06	+78
12/01	12 16.2	+26 58	0.35	0.97	17.7	81.7	78	136	+0.90	+82
12/11	11 44.3	+10 13	0.31	1.01	17.3	75.8	87	7	-0.43	+67
12/21	11 09.1	-09 20	0.30	1.06	17.1	67.0	97	126	+0.07	+46
12/31	10 27.7	-27 06	0.32	1.11	17.1	58.2	106	96	+0.93	+26

INDEX TO VOLUME 44

IN THIS ISSUE

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

Number	Name	EP	Page
46	Hestia	8	294
118	Peitho	8	294
131	Vala	31	317
213	Lilaea	17	303
314	Rosalia	64	350
333	Badenia	8	294
341	California	13	299
356	Liguria	8	294
397	Vienna	30	316
431	Nephele	8	294
459	Signe	59	345
594	Mireille	13	299
596	Scheila	3	289
611	Valeria	59	345
612	Veronika	31	317
901	Brunsia	59	345
939	Isberga	59	345
1016	Anitra	59	345
1022	Olympiada	25	311
1084	Tamariwa	64	350
1115	Sabauda	13	299
1117	Reginita	21	307
1369	Ostanina	35	321
1504	Lappeenranta	13	299
1602	Indiana	25	311
1656	Suomi	3	289
1696	Nurmela	35	321
1748	Mauderli	45	331
1758	Naantali	64	350
1845	Helewalda	64	350
1911	Schubart	18	304
1917	Cuyo	49	335
1926	Demiddelaer	13	299
1967	Menzel	59	345
1980	Tezcatlipoca	49	335
1990	Pilcher	1	287
1998	Titius	35	321
2042	Sitarski	18	304
2142	Landau	20	306
2329	Orthos	49	335
2383	Bradley	18	304
2501	Lohja	25	311
2504	Gaviola	22	308
2544	Gubarev	64	350
2572	Annschnell	35	321
2920	Automedon	26	312
2959	Scholl	45	331
3000	Leonardo	18	304
3022	Dobermann	3	289
3028	Zhangguoxi	64	350
3193	Elliot	35	321
3254	Bus	45	331
3266	Bernardus	3	289
3290	Azabu	45	331
3709	Polypoites	26	312
3760	Poutanen	68	354
3892	Dezso	63	349
4008	Corbin	35	321
4060	Deipylos	26	312
4068	Menestheus	26	312
4404	Enirac	23	309
4464	Vulcano	35	321
4490	Bambery	3	289
4833	Meges	26	312
4974	Elford	18	304
5215	Tsurui	64	350
5471	Tunguska	18	304
5653	Camarillo	49	335
5879	Almeria	49	335
6009	Yuzuruyoshii	59	345
6063	Jason	39	325
6107	Osterbrock	35	321
6493	Cathybennett	3	289
6674	Cezanne	3	289
6921	Janejacobs	35	321
7174	Semois	45	331
7247	Robertstirling	35	321
7888	1993 UC	49	335
8130	Seeberg	45	331
8443	Svecica	1	287
8679	Tingstäde	18	304
9829	Murillo	45	331
10041	Parkinson	2	288
11395	1998 XN77	26	312
11398	1998 YP11	49	335
13186	1996 UM	35	321
13504	1988 RV12	45	331
14309	Defoy	68	354
14339	Knorre	63	349
15440	1998 WX4	26	312
15527	1999 YY2	26	312
15540	2000 CF18	45	331
16206	2000 CL39	18	304
16562	1992 AV1	3	289
17014	1999 CY96	3	289
20713	1999 XA32	64	350
22058	2000 AA64	45	331
23481	1991 GT4	64	350
24495	2001 AV1	33	319
24691	1990 RH3	18	304
27000	1998 BO44	3	289
27097	1998 UM26	3	289
51122	2000 HN35	3	289
52586	1997 PB	3	289
56473	2000 GY108	3	289
68348	2001 LO7	49	335
100926	1998 MQ	49	335
106589	2000 WN107	49	335
132450	2002 HT1	3	289
138404	2000 HA24	24	310
141056	2001 XV4	49	335
143404	2003 BD44	49	335
163696	2003 EB50	49	335
190166	2005 UP156	38	324
215588	2003 HF2	49	335
222073	1999 HY1	49	335
247259	2001 RT98	3	289
332660	2008 WL7	12	298
388838	2008 EZ5	49	335
418094	2007 WV4	49	335
427643	2003 VF1	49	335
441987	2010 NY65	49	335
474179	1999 VS6	49	335
474231	2001 HZ7	49	335
475665	2006 VY13	49	335
484795	2009 DE47	49	335
	2005 GL9	49	335
	2010 VB1	41	327
	2011 ED78	49	335
	2014 JO25	41	327
	2014 KF91	49	335
	2017 CS	49	335
	2017 FH101	49	335
	2017 GM4	49	335
	2017 JA2	49	335
	2017 MC1	49	335

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* * * * *

The deadline for the next issue (45-1) is October 15, 2017. The deadline for issue 45-2 is January 15, 2018.