THE MINOR PLANET BULLETIN

BULLETIN OF THE MINOR PLANETS SECTION OF THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

VOLUME 45, NUMBER 3, A.D. 2018 JULY-SEPTEMBER

LIGHTCURVE ANALYSIS FOR TWO NEAR-EARTH ASTEROIDS ECLIPSED BY EARTH'S SHADOW

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(Received 2018 March18)

Photometry was obtained from Great Shefford Observatory of near-Earth asteroids 2012 XE54 in 2012 and 2016 VA in 2016 during close approaches. A superfast rotation period has been determined for 2012 XE54 and H-G magnitude system coefficients have been estimated for 2016 VA. While under observation, 2012 XE54 underwent a deep penumbral eclipse by the Earth's shadow and 2016 VA also experienced a total eclipse by the Earth's shadow. The dimming due to the eclipses is modeled taking into account solar limb darkening.

Photometric observations of near-Earth asteroid 2012 XE54 were made at Great Shefford Observatory on two dates in 2012 December and for 2016 VA on 2016 November 1 using a 0.40-m Schmidt-Cassegrain and Apogee Alta U47+ CCD camera. All observations were made unfiltered and with the telescope operating with a focal reducer at *f*/6. The 1Kx1K, 13-micron CCD was binned 2x2 resulting in an image scale of 2.16 arc seconds/pixel. *Astrometrica* (Raab 2017) was used to measure photometry using APASS Johnson V band data from the UCAC4 catalogue. *MPO Canopus* (Warner, 2017) incorporating the Fourier algorithm developed by Harris (Harris et al., 1989) was used for rotational lightcurve analysis. *FindOrb* (Gray, 2017b) was used to generate data for eclipse calculations.

2012 XE54 was discovered as a 17th mag object on 2012 Dec 9 by the Catalina Sky Survey (Sarneczky et al., 2012), two days before passing Earth at 0.59 LD. By 2012 Dec 10, a message on the Minor Planet Mailing List indicated it would undergo an eclipse deep within the Earth's penumbral shadow a few hours before closest approach (Tricarico, 2012a). Images were obtained for 20 min on 2012 Dec 9 primarily for astrometry and then for 7h 10m starting at 21:34 UT on Dec 10 for photometry. 2012 XE54 was 16th mag and moving at 10″/min on the first date and brightened from 14th to 13th mag on the second date, accelerating from 90 to 320″/min during the close approach. The eclipse was observed, within minutes of the original prediction. Preliminary rotational and eclipse lightcurves were made available soon after the close approach (Birtwhistle, 2012; Birtwhistle, 2013; Miles, 2013) but it should be noted that a possible low amplitude 8.7 h period (Miles, 2013) has been discounted in this analysis.

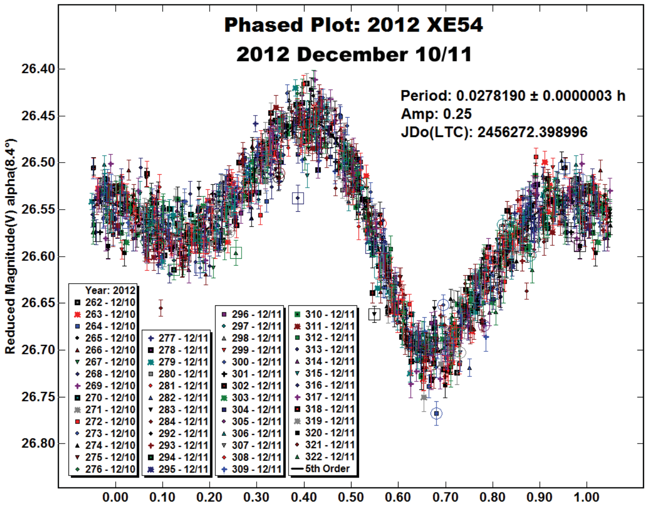
Several other near-Earth asteroids are known to have been eclipsed by the Earth's shadow, e.g. 2008 TC3 and 2014 AA (both before impacting Earth), 2012 KT42, and 2016 VA (this paper) but internet searches have not found any eclipse lightcurves. The asteroid lightcurve database (LCDB; Warner et al., 2009) lists a reference to an unpublished result for 2012 XE54 by Pollock (2013) without lightcurve details, but these have been provided on request and give the rotation period as 0.02780 ± 0.00002 h, amplitude 0.33 mag derived from 101 points over a period of 30 minutes for epoch 2012 Dec 10.2 UT at phase angle 19.5°, (personal correspondence; images by J. Pollock, reduction by P. Pravec) and this period agrees within the given errors with this paper. Wider searches have not revealed any other results.

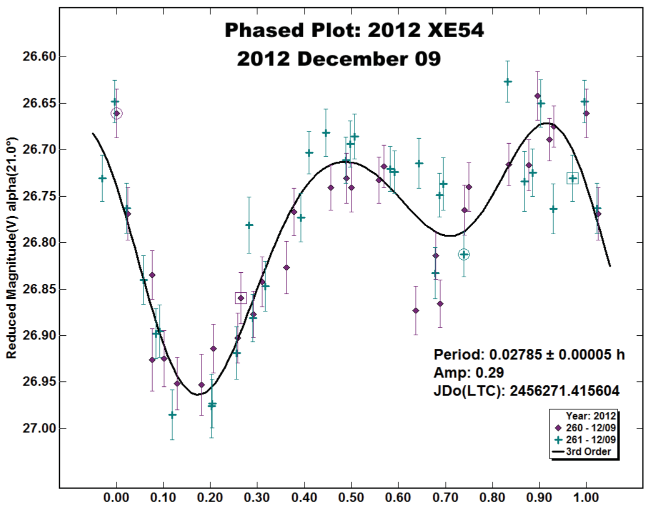
The telescope needed to be repositioned twice on the first night and 61 times on the second due to the large apparent motion against the sky. Each set of images from the 63 telescope fields was measured in *Astrometrica*. The JD, apparent V mag and SNr from the PhotReport.txt output file was then imported into separate sessions within *MPO Canopus* for lightcurve analysis.

The photometry from Dec 10/11 (excluding the 38 minutes during the eclipse) allowed the rotation period to be determined as 0.0278190 ± 0.0000003 h with an amplitude of 0.25 ± 0.02 magnitudes. Small adjustments were made to each *MPO Canopus* session to minimise the residuals of the lightcurve. During the 7 h 9 m it was under observation on Dec. 10/11, it completed 257 rotations. At that time the phase angle bisector was changing at a rate of 34°/day. Using the formula in Warner et al. (2009), the expected difference between the sidereal and synodic periods is estimated to be 0.0000030 h, an order of magnitude larger than the estimated error on the calculated synodic period.

Number	Name	Date	Exp. (s)	Exp. / Period	Min a/b
	2012 XE54	12/09	12	0.12	1.18
	2012 XE54	12/10	4,2,1	0.04	1.18

Table I. Ancillary information, listing the exposure times used (seconds), the fraction of the period represented by the longest exposure time (see Pravec et al., 2000), and the calculated minimum elongation of the asteroid.





An independent rotational lightcurve from the Dec 9 photometry at phase angle 21° produced a similar result, with period 0.02785 ± 0.00005 h and a slightly larger amplitude of 0.29, expected as an effect of the larger phase angle.

Exposure lengths were always less than the threshold ~18% of the rotation period where lightcurve smearing would start to affect the results (Table I).

2012 XE54 Eclipse. 42 images were taken during the eclipse ingress and 59 during egress; the minor planet was easily visible on each image. 2012 XE54 was only faintly recorded or was invisible on two images immediately before mid-eclipse and a further 12 images immediately after. The two images before the mid-eclipse were stacked together and the 12 images after were grouped into 3 sets of 4 and stacked using *Astrometrica*. Each of the resulting 4 stacked images allowed a magnitude to be measured near minimum light. Due to telescope positioning issues, no images were collected between 01:33:17 - 01:37:32 UT. Unity and phase corrections were made to all the apparent V magnitudes measured during the eclipse to produce individual estimates of H_0. The average of 29 measures immediately pre-eclipse plus 20 measures post-eclipse was taken as the zero-point for the evaluation of the eclipse fading.

The eclipse geometry was analysed using all available astrometry as a starting point (MPC 2018b) to calculate an orbit using *FindOrb*. Of the 193 measurements, 65 were then rejected due to either having large astrometric residuals or where timing errors were apparent. The formal error in the resulting geocentric ephemeris position for the moment of mid-eclipse is ±0.02 arcseconds in the plane of the sky, which equates to 44 meters at the distance of the minor planet. *FindOrb* was then used to generate detailed distance data and heliocentric and topocentric ecliptic co-ordinates, allowing the eclipse geometry to be modelled. The fraction of the solar surface visible from 2012 XE54 throughout the eclipse was calculated to determine the dimming in illumination and therefore depth of the eclipse. Limb darkening of the solar disk was calculated from

$$I = 0.436 + 0.72 * \mu - 0.16 * \mu^2$$

where I = Intensity, $\mu = \sqrt{(1 - (r/R)^2)}$, r = distance from the centre of the solar disk, and R = the solar radius (Youles, 2017). The relative intensity of the entire solar disk was determined from the sum of intensities calculated for a grid of points separated by 1 arc second horizontally and vertically. The sum of the intensities of the points visible from the minor planet, i.e. the uneclipsed area of the solar surface was also calculated. The fraction of the total intensity falling on the minor planet was then converted to magnitudes and plotted on Figure 1 as a solid red line, together with a grey dashed line of dimming with limb darkening not taken into account, i.e. assuming I = 1 uniformly across the disk.

An O-C plot of the observed magnitude drop minus modelled drop is given in figure 2 and shows the measured depth of the eclipse is ~0.5 magnitudes greater than the solar limb darkened prediction, though there are large measurement uncertainties around mid-eclipse when flux was at a minimum.

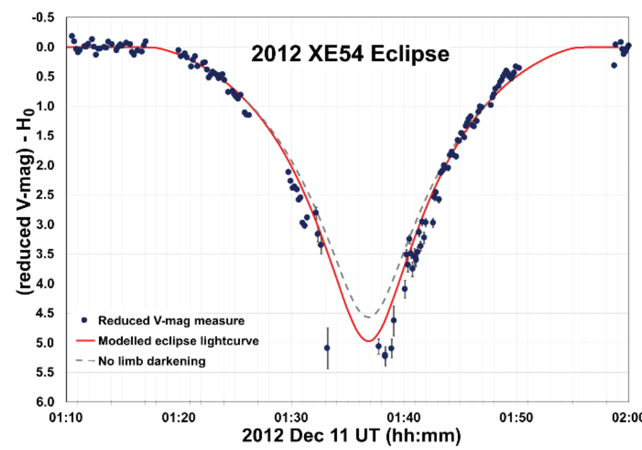


Figure 1

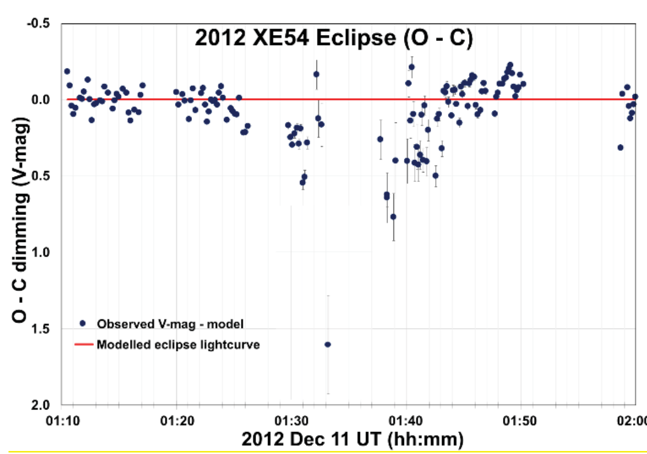


Figure 2

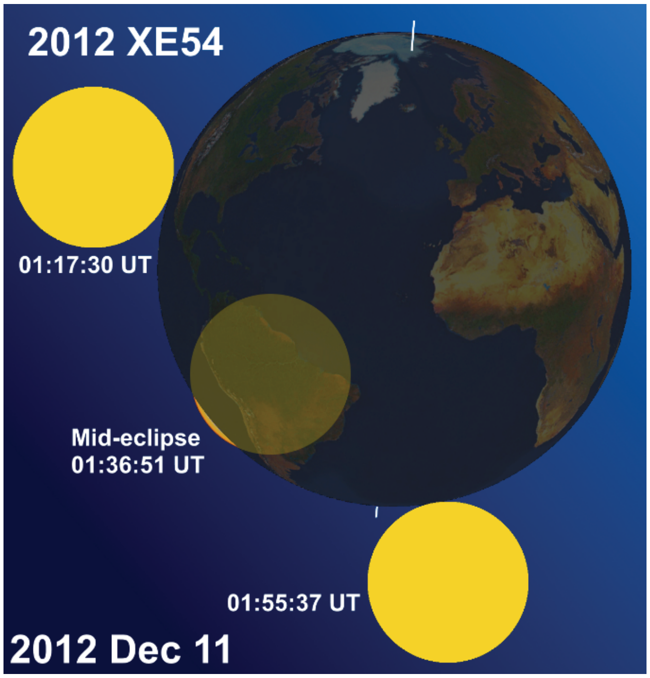


Figure 3

The calculations provide the following circumstances for the eclipse, all times are for 2012 December 11:

	Time (UT)	Geocentric distance (km)
1st contact:	01:17:30	473296
Mid-eclipse:	01:36:51	459892
4th contact:	01:55:37	447007
Duration:	38 m 07 s	
Magnitude:	0.9625	
Obscuration:	98.52%	

The maximum observed depth of the eclipse was 5.2 magnitudes.

Figure 3, inspired by graphics by Pasquale Tricarico (Tricarico 2012b), shows the view of the Earth's night side as seen from the minor planet at mid-eclipse, produced using *Guide* (Gray, 2017a) and from Ground track and Altitude data generated by *FindOrb*.

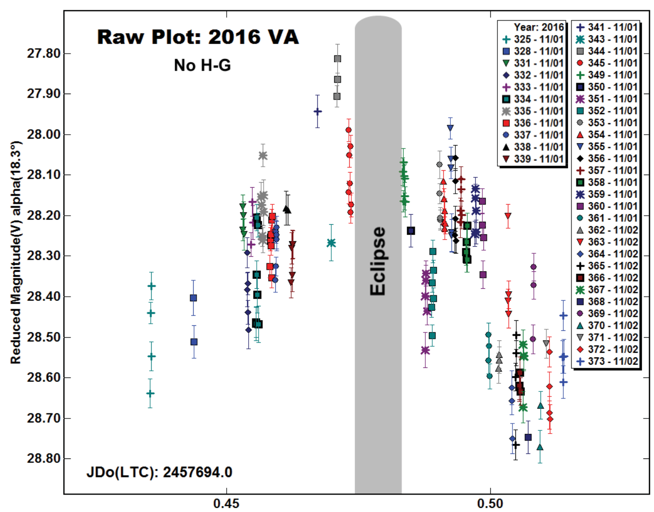
2016 VA was a one-night only target of opportunity, discovered by the Mt. Lemmon Survey on 2016 Nov 1 at 09:23 UT (Nishiyama et al., 2016), just 15 hours before passing Earth at 0.25 LD. Bill Gray posted a message on the Minor Planet Mailing List (Gray, 2016) that same day, before nightfall in the UK, indicating that it would probably run through the Earth's shadow between (roughly) 23:28 and 23:33 UT that night.

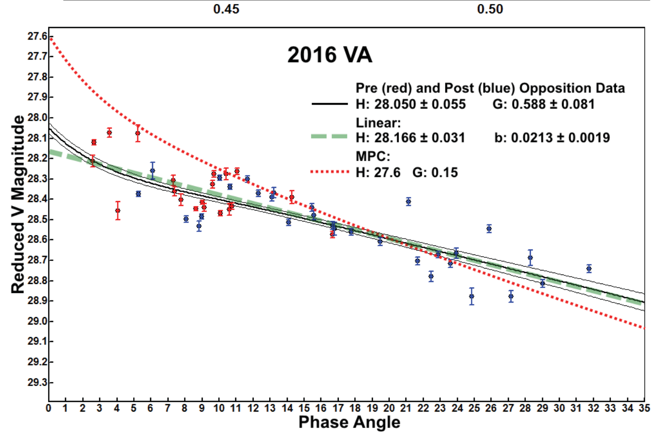
A preliminary eclipse lightcurve was made available soon after the close approach (Birtwhistle, 2016) but a search of the asteroid lightcurve database (LCDB; Warner et al., 2009) and wider searches did not reveal any other results.

Weather conditions were poor at Great Shefford with cloud interruptions during the approach, but 2016 VA was picked up at 22:23 UT at a distance or just 0.50 LD. At the time, it was 13th magnitude and moving at 650″/min. It was kept under observation for 2 hours, to within 15 minutes of closest approach and brightened to 12th mag. The extreme apparent speed necessitated 1- second exposures at the start to keep trailing short enough to be enclosed in the 13 arc second diameter annulus used for measurement in *Astrometrica*. Exposures were stepped down to 0.5s, then 0.3s and, for the last 35 minutes, reduced to 0.2s as the speed reached 2780″/min. The telescope was repositioned 60 times during the 2 hours, as the declination decreased from +30° to –21° and altitude from 60° to 20°.

Consequences of such short, sub-second exposures include catalogue star matching becoming an issue; there were not enough stars to allow a reduction in 3 of the 60 fields even though the asteroid was well recorded. Also, with reducing numbers of reference stars, weaker target images and increasing air mass, the accuracy of measured magnitudes also deteriorated. A further 5 fields provided no measurements during eclipse totality, leaving 52 fields providing some photometry of 2016 VA.

Cloud interference, mainly in the period before the eclipse caused extra scatter in some measurements and attempts to detect a rotation period were unsuccessful. It is expected that the rotation period is either >> 2 hours or has an amplitude < 0.2 magnitudes, or both. The raw lightcurve excludes all measurements during the eclipse and normalises the observed apparent magnitudes to a distance of 1 AU from both Earth and Sun without any phase effect correction applied. The curve indicated that ~0.5 magnitudes of probable phase related brightening occurred, centred around the minimum phase angle during eclipse.





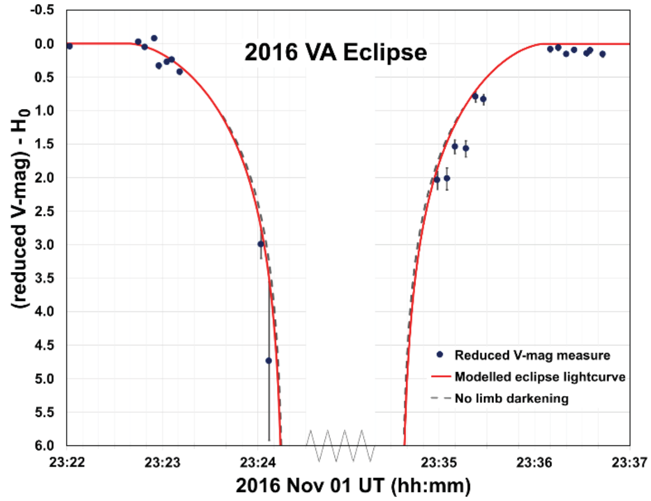
Conditions were occasionally poor over the 2 hours of observation. During that time, the phase angle changed from 17°

to 2° just before eclipse and then increased again to 32° afterwards. This allowed H-G parameters to be estimated, with the assumption that the lightcurve amplitude was <0.2 mags. Magnitude measurements were selected only where their estimated error was < 0.05, calculated from: $\sigma_{\text{magnitudes}} = 1.0857$ / SNr (Howell, 2000). After applying this filter, 11 of the 60 fields had no magnitude measurements while 41 of the fields did survive for further processing. The individual measured apparent V-mags were corrected to normalise to a standard distance of 1 AU from both Earth and Sun. Then the averages were calculated for all measures occurring in the same minute of time, along with the RMS of the associated errors. The reduced magnitudes, errors, and appropriate phase angles were entered into the *MPO Canopus* H-G calculator. The resulting $H_V = 28.050 \pm 0.055$ and $G_V = 0.588 \pm 0.081$ is plotted in the phase diagram as a solid line together with the MPC values of $H = 27.6$ and $G = 0.15$ (MPC 2018a) as a dotted line.

Belskaya and Shevchenko (2000) show that the slope (b) of the linear part of the phase curve, from phase angles from 5° up to 25°, has a strong correlation with albedo p_V, with the phase slope increasing linearly as albedo decreases. The phase curve of 2016 VA is, within the accuracy of measurement, linear through the complete range of phase angles of 2-32°, showing little opposition effect surge in brightness at small phase angles. The calculated phase slope $b = 0.0213 \pm 0.0019$ mag/° is plotted on the phase diagram as a dashed line; the phase slope/albedo dependency suggests a value of $p_V \approx 0.45 \pm 0.12$. This is consistent with but not confirmation of 2016 VA being an E-type asteroid.

It is noted that 2016 VA may be recoverable in late 2024 October. The JPL Small-Body Database Browser (JPL 2018) indicates another close approach on 2024 Nov 1.96 UT, with a nominal approach to 1.3 LD and time uncertainty of ± 5 h.

2016 VA Eclipse. A set of 7 images was obtained starting at 23:22:46 UT in the first 30 seconds following first contact, with <0.5 magnitudes of dimming apparent. After repositioning the telescope, the next set of 7 images started at 23:24:02 UT. The first two of those, separated by 5 seconds, show the asteroid fading fast, being 3 and 4.5 magnitudes fainter, respectively, than the pre-eclipse value. The remaining 5 exposures, taken from 23:24:12 to 23:24:29 UT were stacked together but showed no trace of 2016 VA. This is consistent with 2nd contact starting at 23:24:17 UT. The first of a set of 7 exposures taken after 3rd contact was started at 23:34:49 UT but, unfortunately, 2016 VA was out of the field of view. However, the next 6 exposures recorded a rapid brightening of 1.2 magnitudes in 29 seconds. Fourth contact occurred before the next set of images started at 23:36:10 UT. The penumbral stages of the eclipse were modelled as described for 2016 XE54 and indicate a much more rapid passage through the penumbra: 97 seconds from 1st to 2nd contact and 89 seconds from 3rd to 4th contact, with the total eclipse phase lasting 10 m 19 s.



2016 VA was 3.5x closer to Earth than 2012 XE54 at their respective mid-eclipse times. This can be seen in the Earth night side view diagrams where the Earth appears comparatively much larger (and therefore Sun apparently smaller) from 2016 VA. As viewed from the asteroid, the apparent diameter of the Earth increased by 9% during the eclipse as it continued towards its closest point at 2016 Nov 02 00:40 UT at a distance of 94,190 km. The formal uncertainty in geocentric ephemeris at mid-eclipse is ±0.29 arcseconds in the plane of the sky; this equates to 183 meters at the distance of the minor planet.

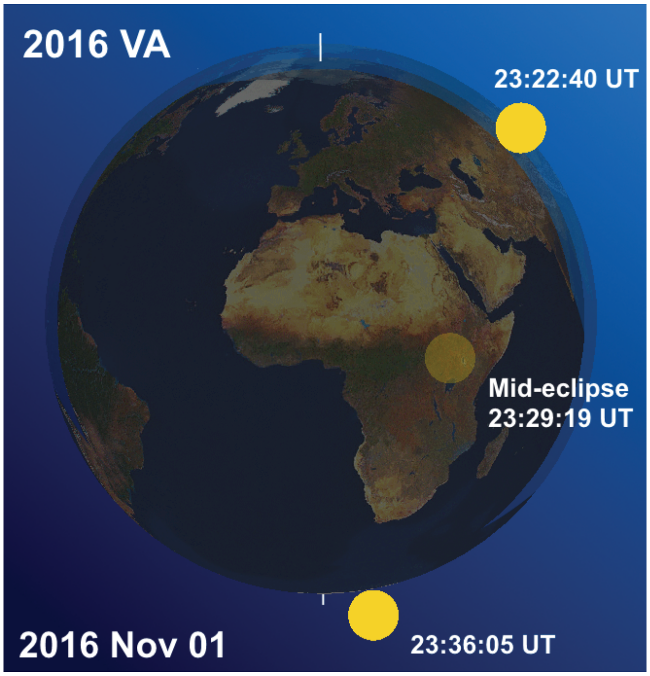
The following circumstances of the eclipse were calculated, all times are for 2016 November 1:

	Time (UT)	Geocentric distance (km)
First contact:	23:22:40	136815
Second contact	23:24:17	135336
Mid-eclipse:	23:29:19	130830
Third contact	23:34:36	126273
Fourth contact:	23:36:05	125029
Duration:	13 m 25 s	
Magnitude:	3.0349	
Obscuration:	100%	

The maximum observed depth of the eclipse was 4.7 magnitudes.

Number	Name	20yy mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E	Grp	Note
	2012 XE54	12/12/09	60	20.9	72	8	0.02785	0.00005	0.29	0.05	NEA	
	2012 XE54	12/12/10-11	1433	8.0,1.0,12.4	79	-1	0.0278190	0.0000003	0.25	0.02	NEA	
	2012 XE54	12/12/11	113	1.1,1.0,1.2	79	0					NEA	Ecl
	2016 VA	16/11/01	165	16.7,2.4,31.7	40	-1					NEA	
	2016 VA	16/11/01	15	2.4,2.3,4.9	40	-1					NEA	Ecl

Table II. Observing circumstances. 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). Ecl indicates observations made during penumbral phase of eclipse.



Acknowledgments

The author is indebted to Bill Gray and Pasquale Tricarico for their timely eclipse predictions and would also like to thank Joe Pollock and Petr Pravec for their 2012 XE54 results, Steve Harvey, Director of the Computing Section of the British Astronomical Association for help with eclipse magnitude calculations, and to Alan Harris for his much-appreciated help.

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LIGHTCURVE ANALYSIS FOR NEAR-EARTH ASTEROID 2012 TC4

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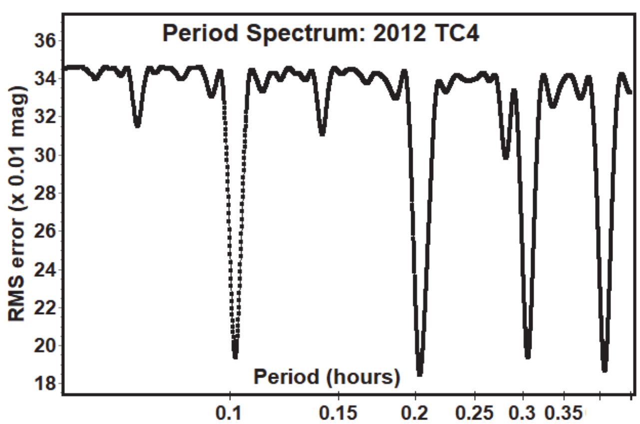
(Received: 2018 Jan 15)

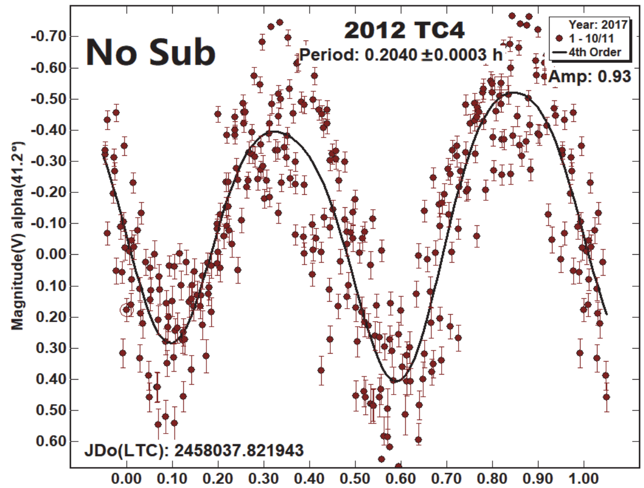
Lightcurves of near-Earth asteroid (NEA) 2012 TC4 were obtained at the Xingming Observatory (Code C42) on 2017 Oct.11. The absolute magnitude of the asteroid, H = 26.7, corresponds to a diameter of ~13 m. Analysis of the observations shows a bimodal solution with a synodic rotation period of 0.2040 ± 0.0003 h and lightcurve amplitude of 0.93 mag.

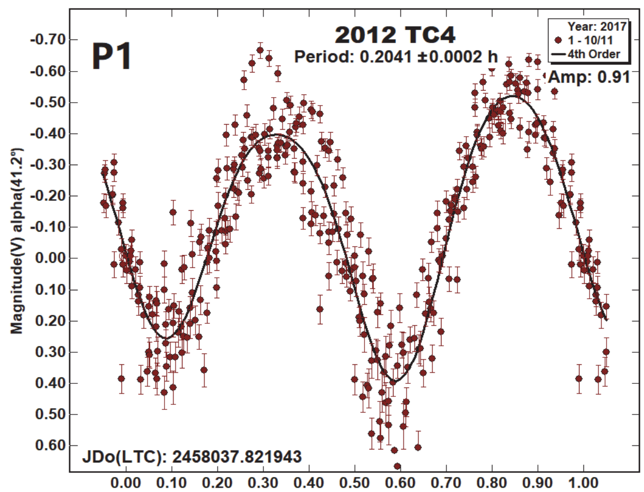
We observed the near-Earth asteroid (NEA) 2012 TC4 for one night, 2017 Oct 11, at Xingming Observatory using a 0.5-m *f*/4 reflector telescope with an unfiltered QHY11 CCD at 2x2 binning. Exposures were 2 sec. The image scale of was 1.8 arcsec/pixel. All images were calibrated using the standard procedure, including flat-correction, dark, and bias frames.

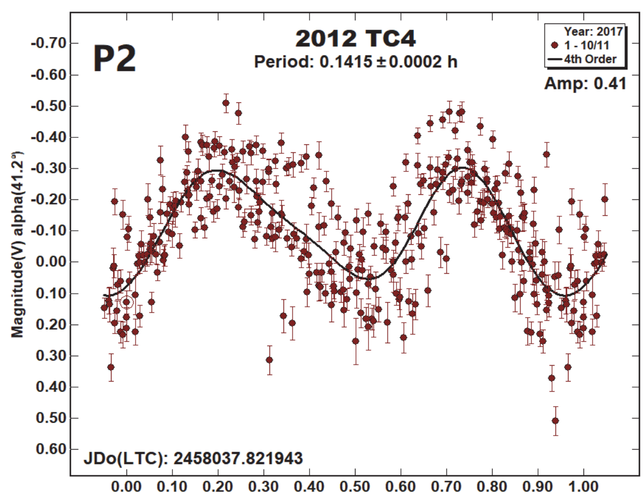
2012 TC4 is an NEA (*D* ~ 13m), was discovered in 2012 by Pan-STARRS in Hawaii. It approached near the Earth in 2012 and 2017 Oct 12 at a distance of 0.11 lunar distances. Previous rotation period results are from Warner (2013; 2018) and Polishook (2013), all of them near 0.204h. Because of bad weather and the faintness of the target, we only observed this NEA for only 1.5 hours on one night. Our initial analysis found a synodic period of $P = 0.2040 \pm 0.0003$ h with a large amplitude of $A = 0.93$ mag. The period and amplitude are consistent with the previously published results.



Using the dual-period search feature of *MPO Canopus*, we found a second period of $P_2 = 0.1415 \pm 0.0002$ h. This period is in excellent agreement with past results by Ryan, Pravec, and Warner as reported by Warner (2018). Because *MPO Canopus* is not good at analyzing data for tumbling asteroids, further analysis of the possible P_2 using another method is required.







Number	Name	yyyy/mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
	2012 TC4	2017/10/11	324	41.0,42.4	357	0	0.2040	0.0003	0.93	0.02

Table I. Observing circumstances and results. The phase angle (α) is given at the start and end of each date range. L PAB and B PAB are, respectively, the average phase angle bisector longitude and latitude (see Harris *et al.,* 1984).

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ROTATIONAL PERIOD DETERMINATION FOR 12 NEAR-EARTH ASTEROIDS

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(Received: 2018 Mar 3)

Rotational periods for 12 near-Earth asteroids (NEAs) were determined from lightcurves acquired at the Observatório Astronômico do Sertão de Itaparica (MPC Y28, OASI) between May 2016 and 2017 August.

CCD photometric observations of 12 NEAs were made at the Observatório Astronômico do Sertão de Itaparica (code Y28, OASI, Nova Itacuruba) between 2016 May and 2017 August. All images were obtained with the 1.0-m *f*/8 telescope (Astro Optik, Germany) of the IMPACTON project and a CCD Astra Apogee Instruments (2048x2048 pixels) that was binned 2x2. This configuration gave a field-of-view of 11.8x11.8 arcmin and an image scale of 0.343 arcsec/pix. All the observations were performed in the R filter with the exposure time varied depending on the asteroid's brightness and sky motion.

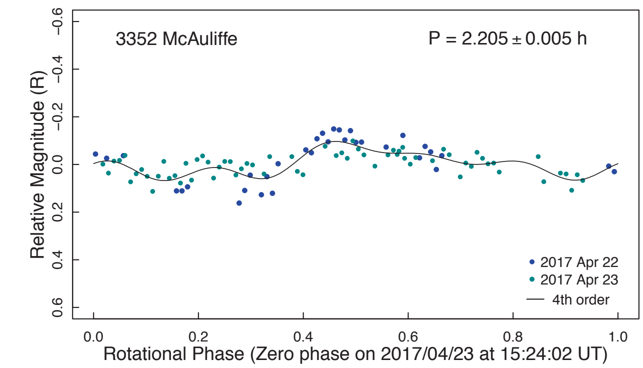
Data reduction was performed using *MaxIm DL* package following the standard procedures of flat-field correction and sky subtraction. Relative magnitudes were computed to obtain the lightcurves and the rotation periods were determined using a Fourier series analysis method (e.g. Harris et al., 1989). The lightcurve for each asteroid includes the best fit line and uses different colors to represent different nights.

The observational circumstances for each of the observed asteroids are given in Table I along with the results, which are discussed individually below. In this table we give for each obtained rotation period a reliability code (Warner et al., 2009).

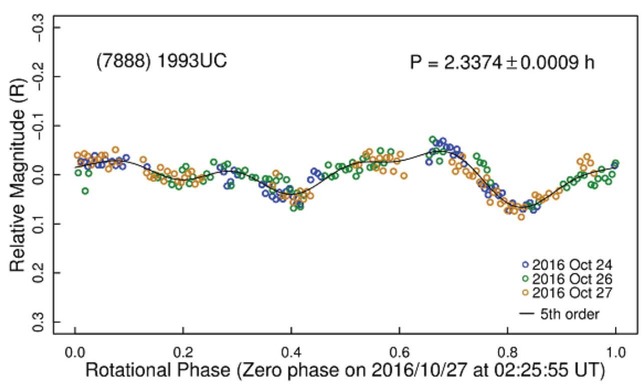
For some asteroids, the maximum lightcurve amplitude was used to estimate the a/b ratio for a triaxial ellipsoid asteroid shape with $a > b > c$ and rotation about the c-axis. This was achieved using the relation $\Delta m = 2.5\log(a/b)$, as given by Burns and Tedesco (1970), where Δm is the maximum lightcurve amplitude reached in the equatorial view.

It is worth mentioning that a search of the Asteroid Lightcurve Database (Warner *et al.*, 2009, or other resources) did not find any previously reported results for asteroids (138404) 2000 HA24, (250620) 2005 GE59, (370702) 2004 NC9, 2001 QE34, 2015 FO124.

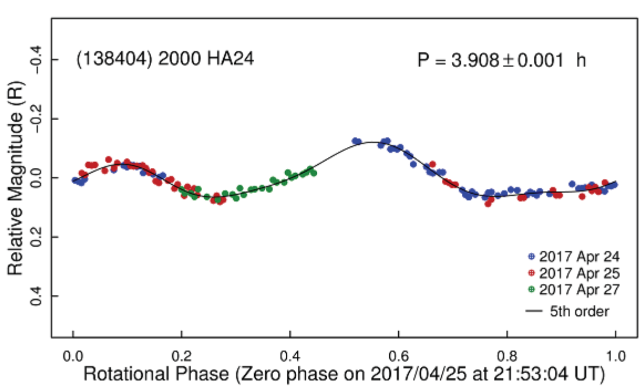
3352 McAuliffe. This is a suspected binary asteroid (Warner, 2012). It was observed for nearly four hours on two nights during 2017 April. The composite lightcurve fits a synodic period of P = 2.205 ± 0.005 h with an amplitude of A = 0.16 ± 0.01 mag. Previous results were reported by Howell (2012) and Warner (2012, 2017a, 2017b), who found rotational periods of 2.207 h, 2.206 h, 2.212 h and 2.2062 h, respectively.



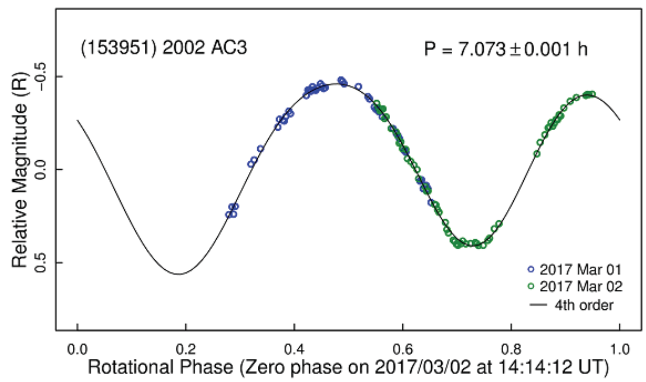
(7888) 1993 UC. Observations of this Amor asteroid were made for about six hours during three nights in 2016 October. The composite lightcurve fits a period of P = 2.3374 ± 0.0009 h using a 5th-order Fourier fit. It presents a small amplitude of 0.12 ± 0.01 mag and an asymmetric shape. Previous results include Pravec et al. (1996) and Warner (2017a), with rotational periods of 2.34 h and 2.337 h, respectively.



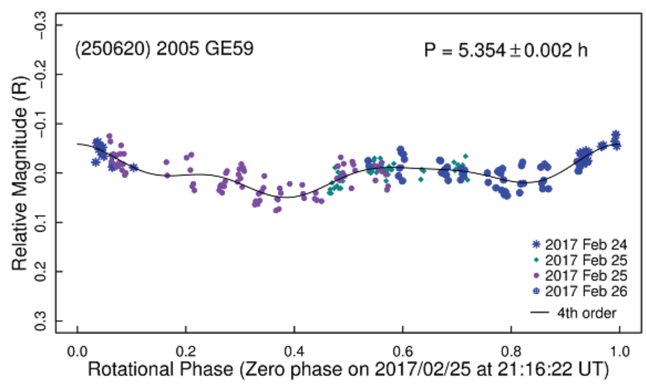
(138404) 2000 HA24. This potentially hazardous asteroid (PHA), member of the Apollo group was observed for nearly six hours on three nights during 2017 April. The composite lightcurve fits a period of P = 3.908 ± 0.001 h, using a 5th-order Fourier fit, with a small amplitude of 0.19 ± 0.01 mag. It is relatively well-covered and presents a low dispersion of the data.



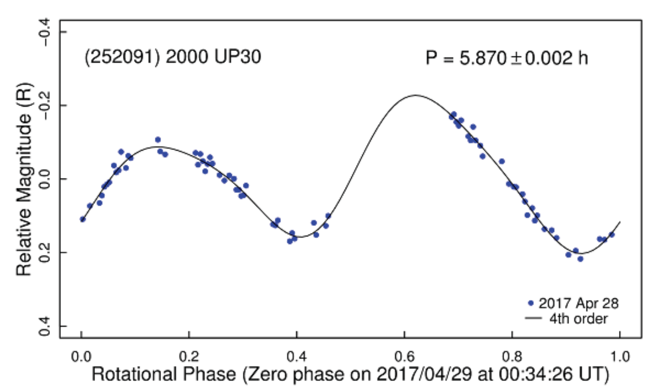
(153951) 2002 AC3. This NEA was observed for about five hours on two nights in 2017 March. The composite lightcurve with a 4th-order Fourier fit gives a period of 7.073 ± 0.001 h. Although not complete, the lightcurve has two maxima and minima and a high amplitude of A = 1.0 ± 0.01 mag. From this amplitude, we estimate a lower limit of a/b = 2.51, implying a quite elongated body. Warner (2017c) found a similar rotational period of 7.072 h.



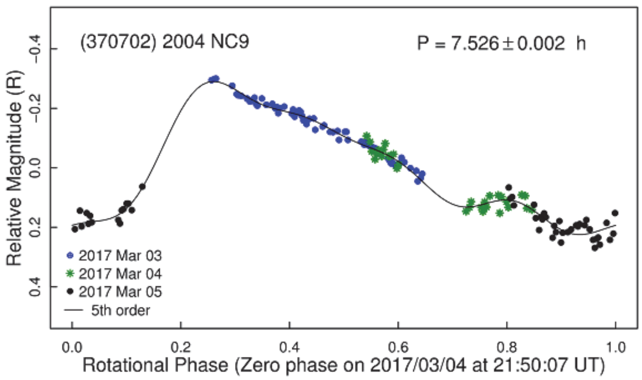
(250620) 2005 GE59. This Apollo class and PHA was observed for almost eight hours on three nights from 2017 February 24 to 26. The composite lightcurve fits a period of P = 5.354 ± 0.002 h with a small amplitude of A = 0.11 ± 0.02 mag. It was obtained with a 4th-order Fourier fit and shows some dispersion among the points.



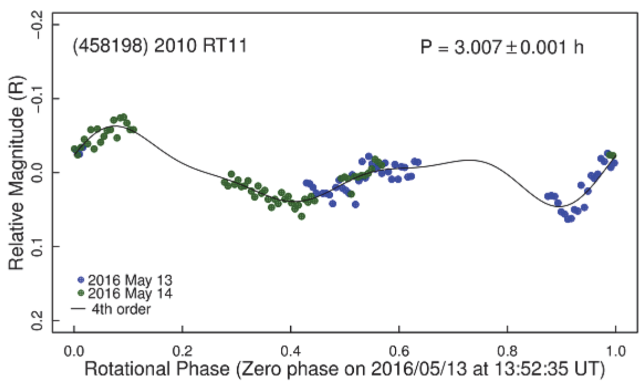
(252091) 2000 UP30. We observed this Apollo asteroid for more than four hours on just one night in 2017 April. The 4th-order Fourier fit to the data revealed a period of P = 5.870 ± 0.002 h. Although not complete, the lightcurve has two maxima and minima and an amplitude of 0.43 ± 0.02 mag. This suggests an elongated shape with $a/b \geq 1.49$. A previous result was reported by Warner (2017c), who found a rotational period of 5.44 h.



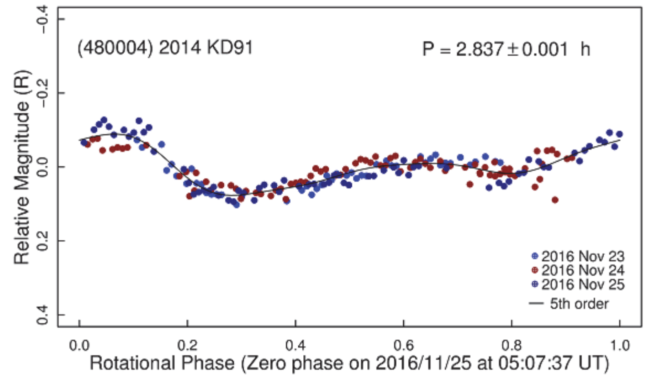
(370702) 2004 NC9. We observed this Amor asteroid for almost eight hours on three nights during 2017 March. The composite lightcurve fits a period of P = 7.526 ± 0.002 h with an amplitude of 0.52 ± 0.02 mag. Since the rotation period is not completely covered, we cannot trust the lightcurve shape around rotational phase 0.1-0.3. The composite lightcurve is asymmetric, with the primary maximum being much larger than the secondary. The high amplitude implies a/b ≥ 1.62, suggesting an elongated object.



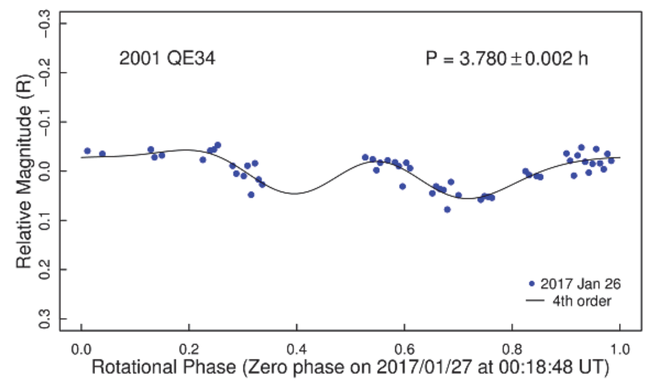
(458198) 2010 RT11. Observations of this Amor asteroid were made for about four hours on two nights on 2016 May 13-14. The composite lightcurve fits a period of P = 3.007 ± 0.001 h. It has a small dispersion and small amplitude (0.11 ± 0.02 mag), but has an incomplete coverage. A period of 1.75 h was found by Carbognani (2017) using just three hours of observation.



(480004) 2014 KD91. We observed this Amor asteroid for almost eight hours on three nights during 2016 November. The composite lightcurve fits a period of P = 2.837 ± 0.001 h. It is well-covered and presents a low dispersion of the data. The amplitude of 0.17 ± 0.02 mag may indicate an approximately spherical shape. Previous results were reported by Warner (2017a) and Carbognani (2017) who found 2.829 h and 2.837 h, respectively.



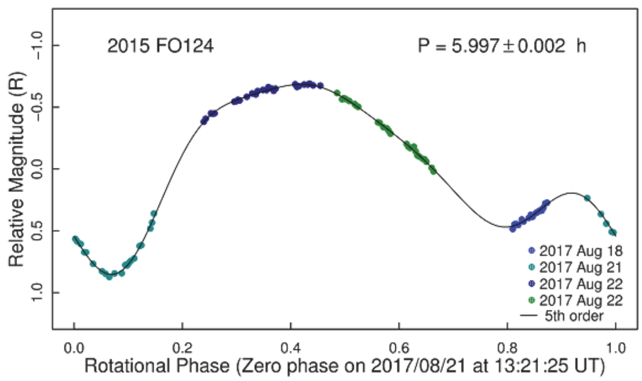
2001 QE34. Observations of this Apollo asteroid were made on January 2017 for about four hours. Since the weather was non-photometric, with occasionally passing clouds, only half of the frames obtained were useful. The derived synodic period is P = 3.780 ± 0.002 h with a small amplitude of A = 0.10 ± 0.02 mag.



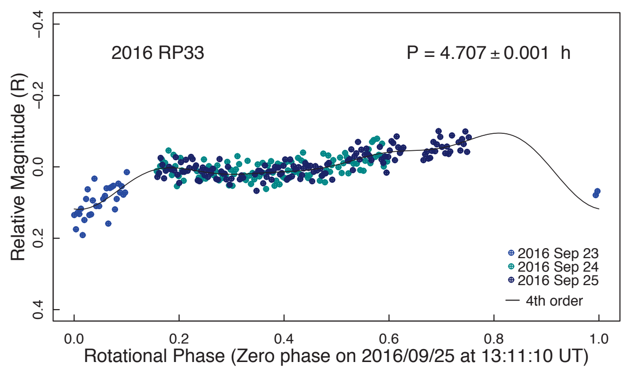
2015 FO124. This Apollo asteroid is the smallest object studied in our work (D ~ 157 m), assuming the average NEA albedo of 0.14 given by Mainzer et al. (2011). We observed this asteroid from 2016 August 18 to 22 for three hours each night. The composite lightcurve fits a period of P = 5.997 ± 0.002 h, although some rotational phases are not covered by the observations. This lightcurve is asymmetric and present a high amplitude of 1.54 mag, suggesting a quite elongated shape, with a/b ≥ 4.17.

Number	Name	yyyy mm/dd	Exp	Phase	L_{PAB}	B_{PAB}	Period	P.E	Amp	A.E.	U
3352	McAuliffe	2017 04/22-04/23	90	50.6,50.4	146	6	2.205	0.005	0.16	0.01	3
7888	1993 UC	2016 10/24-10/27	50	65.0,66.5	101	-40	2.337	0.001	0.12	0.01	3
138404	2000 HA24	2017 04/24-04/27	90	18.6,20.0	203	7	3.908	0.001	0.19	0.01	3
153951	2002 AC3	2017 03/01-03/02	70	28.7,29.4	162	-21	7.073	0.001	1.00	0.01	2
250620	2005 GE59	2017 02/24-02/26	30	45.5,42.7	146	-32	5.354	0.002	0.11	0.02	3
252091	2000 UP30	2017 04/28	90	38.7	182	2	5.870	0.002	0.43	0.02	2
370702	2004 NC9	2017 03/03-03/05	80	6.0,7.0	158	-4	7.526	0.002	0.52	0.02	2
458198	2010 RT11	2016 05/13-05/14	80	4.4,4.0	236	1.5	3.007	0.001	0.11	0.02	2
480004	2014 KD91	2016 11/23-11/25	90	44.2,46.2	45	-50	2.837	0.001	0.17	0.02	3
	2001 QE34	2017 01/26	90	10.2	120	-6	3.780	0.002	0.10	0.02	2
	2015 FO124	2017 08/18-08/22	120	17.3,25.0	318	-8	5.997	0.002	1.54	0.01	2
	2016 RP33	2016 09/23-09/25	50	6.0,9.0	358	4	4.707	0.001	0.22	0.02	2

Table I. Observing circumstances. Exp is average exposure time, seconds. The phase angle (α) is given at the start and end of each date range, unless it reached a minimum, which is the second of three values. If a single value is given, the phase angle did not change significantly and the average value is given. L_{PAB} and B_{PAB} are each the average phase angle bisector longitude and latitude. The U rating is our estimate and not necessarily the one assigned in the asteroid lightcurve database (Warner *et al.*, 2009).



2016 RP33. This Amor asteroid was observed for nearly six hours on three nights, 2016 September 23 to 25. The derived rotational period is $P = 4.707 \pm 0.001$ h with a small amplitude of $A = 0.22 \pm 0.02$ mag. Since the composite lightcurve presents some rotational phases not covered, the derived period is not conclusive. Warner (2017a) reported a rotational period of 4.682 h.



Acknowledgements

F.M., H.M, P.A. and E.R. would like to thank CAPES, FAPERJ and CNPq for supporting this work through diverse fellowships. Support by CNPq (305409/2016-6) and FAPERJ (E-26-201.213/2014) is acknowledged by D.L. The authors are grateful to the IMPACTON team, in particular, to A. Santiago, for the technical support at OASI.

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ROTATION PERIOD FOR THE POTENTIALLY HAZARDOUS ASTEROID 2018 AM12

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(Received: 2018 Feb 1)

The potentially hazardous asteroid 2018 AM12 was observed on 2018 January 16. The synodic period was found to be 0.2106 ±0.0013 h.

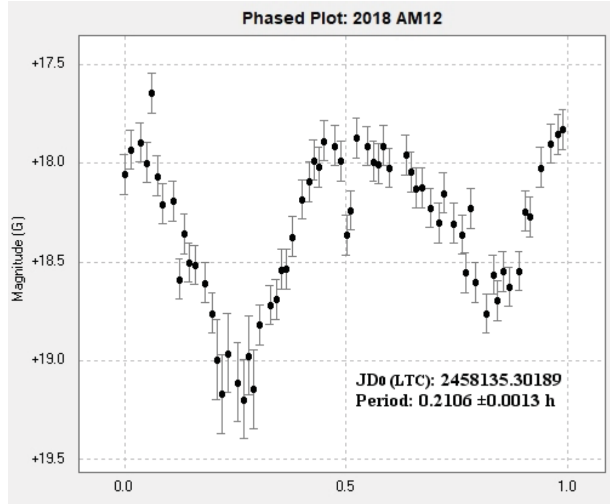
The near-Earth asteroid 2018 AM12 was discovered on 2018 January 15 by the Pan-STARRS1 survey and classified as a potentially hazardous asteroid (PHA). About 38 hours later, on 2018 January 16, we observed it remotely with the 0.8-meter f/3.0 Schmidt telescope at Calar Alto Observatory, Spain (MPC Z84).

The CCD camera used was a SBIG ST-10XME with 2184x1472 array of 6.8 micron pixels operated in un-binned mode. This configuration gave a field-of-view of 21.3x14.3 arcmin and an image scale of 0.58 arcsec per pixel. No filter was used. Due to the asteroid's rapid sky motion the exposure time was 30 s. The readout time was 25 s. Dark and flat-field frames could not be taken, because it is not yet implemented in the software for remote control.

The data reduction was done with *Astrometrica* using the Gaia DR-1 star catalogue. For the rotation period analysis the software *Peranso* was used, with the internal period analysis ANOVA method. The solution favored by the period spectrum resulted in a best value for the period of 0.2106 ±0.0013 h.

The asteroid was observed over a time span of 1.44 h, which corresponds to about 7 rotation periods. The periodic behavior is shown in the phased lightcurve. The Julian Date is light-time corrected, $JD_{0\ (LTC)}$ = 2458135.30189. The peak-to-peak amplitude is about 1.2 mag. The observational circumstances and results are summarized in Table I.

The object has an estimated absolute magnitude of approximately 21.4, which would correspond to a diameter between 150 meter and 300 meter, assuming a typical range of albedos. It is therefore possible that this asteroid could be larger than the ~200-meter spin barrier above which only very few fast rotators are known.



Acknowledgements

The work is funded by the Space Situational Awareness Programme of the European Space Agency (ESA), contract number 4000116155/15/D/AH (P2-NEO-VIII).

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Number	Name	2018 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
	2018 AM12	01/16	66	88.8	70	-17	0.2106	0.0013	1.2	0.1	NEA

Table I. Observing circumstances and results. Pts is the number of data points. L_{PAB} and B_{PAB} (phase angle bisector longitude and latitude) and the phase angle are given at approximate mid-time of the observations on 2018 January 16 at 20:00 UT. Grp is the asteroid family/group (Warner et al., 2009).

ROTATIONAL PERIOD DETERMINATION OF 16852 NUREDDUNA

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(Received: 2018 Feb 6)

The main-belt asteroid (16852) Nuredduna, was observed between October and December 2017. The synodic period is 6.3 ± 0.1 h.

Discovered in June 1995 at Steward Observatory, (16852) Nuredduna was selected for observation from the "*Lightcurve Photometry Opportunities: Oct-Dec 2017*" (Warner, 2017).

The observations of this main-belt asteroid lasted five nights between October and December 2017. The observations were carried out from F. Fuligni Observatory using a 0.35-m f/10 ACF telescope and SBIG ST8-XE CCD camera with Bessel clear filter and by Francesco Franceschini using a 9.25" f/6.3 reflector telescope equipped with Atik 314L+ CCD camera unfiltered. All images were dark and flat-field calibrated with *Maxim DL*. The lightcurve analysis has been performed with a differential photometry technique extrapolating the best polynomial of approximation of the observations, using the program *MPO Canopus* (Warner, 2012). The resulting synodic period is found to be P = 6.3 ± 0.1 h with an amplitude of A = 0.41 mag (Figure 1).

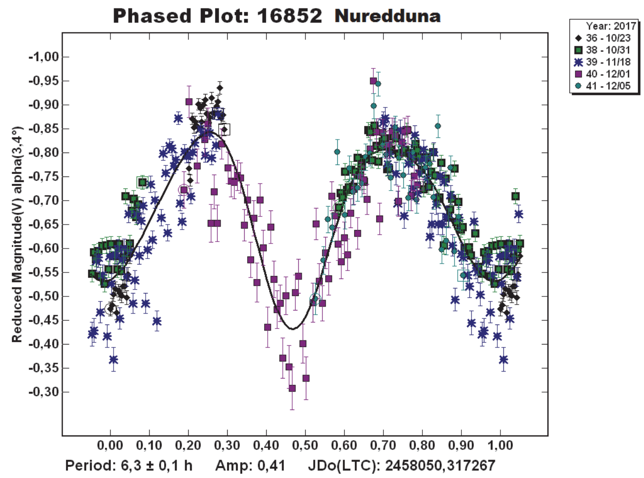

Figure 1. The lightcurve of 16852 Nuredduna with a period P = 6.3 ± 0.1 h, and an amplitude A = 0.41 mag.

Acknowledgement

We would like to thank Fernando Pierri, Simone Nodari and Samuele Piscitello for help in taking image frames and maintenance of the ATA observatory instruments.

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Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
16852	Nuredduna	10/23-12/05	321	2.8,24.5	25	1	6.3	0.1	0.41	0.02	BAP

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).

ASTEROID LIGHTCURVE ANALYSIS OF DATA FROM DUSTY FILES

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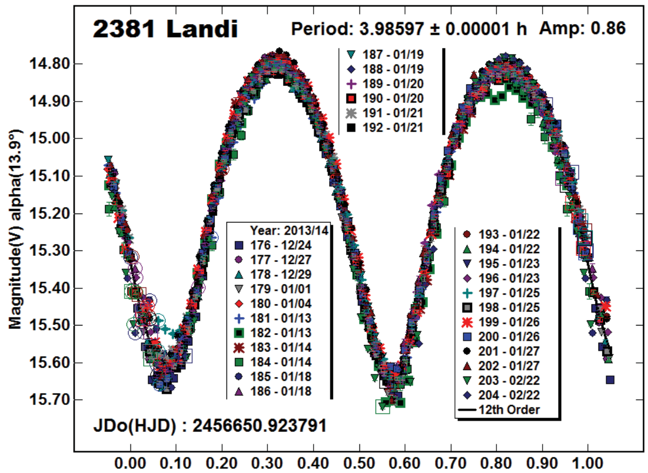
(Received: 2018 Feb 8)

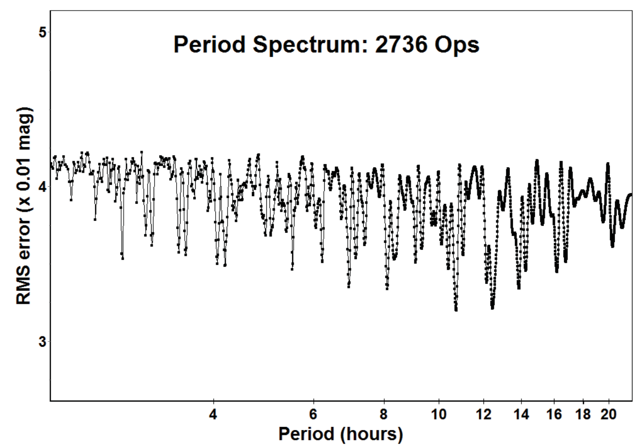
Lightcurves for 14 main-belt asteroids were obtained at the Barnes Ridge Observatory from 2013 October through 2017 November. Synodic rotation periods and amplitudes are found for 9 of the 14 main-belt asteroids. The nine are 2381 Landi: 3.98595 h, 0.86 mag; 2884 Reddish: 14.310 h, 0.90 mag; 4067 Mikhel'son: 2.24620 h, 0.15 mag; 4517 Ralpharvey: 3.60065 h, 0.31 mag; 5613 Eizaburo: 2.87538 h. 0.35 mag; 5976 Kalatajean: 4.55362 h 0.59 mag; 14309 Defoy: 3.3940 h, 0.17 mag; (18017) 1999 JC124: 3.0300 h, 0.18 mag; (31775) 1999 JN122: 4.3186 h, 0.10 mag. Of the remaining five asteroids 4336 Jasnicwicz has a possible period of 10 h; (6045) 1991 RG9 has a possible period of 12.3 h and periods of 2736 Ops, 2902 Westerlund and (12721) 1991 PB could not be calculated.

Photometric data for fourteen asteroids were obtained at Barnes Ridge Observatory located in northern California, USA, using a 0.43-m PlaneWave f/6.8 corrected Dall-Kirkham astrograph and Apogee U9 camera. The camera was binned 2x2 with a resulting image scale of 1.26 arcsec per pixel. All image exposures were 210-s taken through a photometric C filter. All images were obtained with *MaxIm DL* V5 driven by *ACP* V8 and analyzed using *MPO Canopus* v10.7 (Warner, 2011). The *MPO Canopus* Comp Star Selector feature was used to select comparison stars. All comparison stars and asteroid targets had an SNR at least 100.

2381 Landi. Data were collected from 2013 December 24 through 2014 February 22 resulting in 17 nights totaling 1504 data points. 2381 Landi was tracked through 361.12 revolutions from phase angles of -14.35 through 16.80 deg. A period of 3.98597 ± 0.00001 h was calculated with a peak-to-peak amplitude of 0.86 mag. The data were previously reported by Apostolovska et al. (2014), with a period of 3.986 ± 0.001 h, by Klinglesmith III et al. (2014) with a period of 3.986 ± 0.001 h, and by Stephens (2014) with a period of 3.985 ± 0.001 h. Observations at small phase angles allowed calculation of H-G values of H = 12.00 ± 0.04 and G = 0.14 ± 0.05.



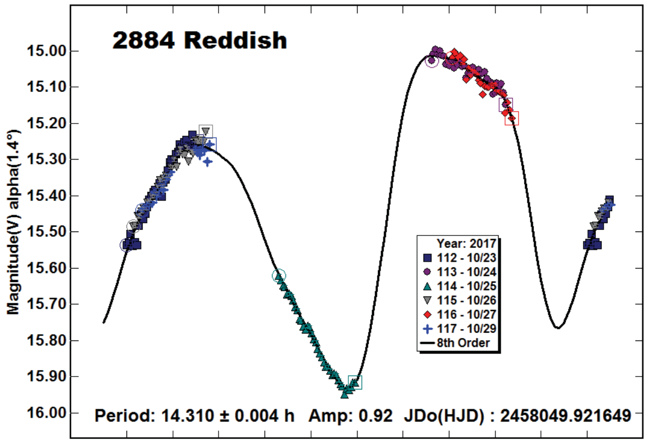
2736 Ops. Data were collected from 2017 July 19 through 25 resulting in 5 nights totaling 315 data points. A period could not confidently be calculated. The Period spectrum is shown below. The amplitude of the lightcurve variation from the raw data was under 0.2 magnitudes. A search of the Asteroid Lightcurve Database (and other resources) did not find any previously reported results for asteroid 2736. This asteroid clearly needs More Data.



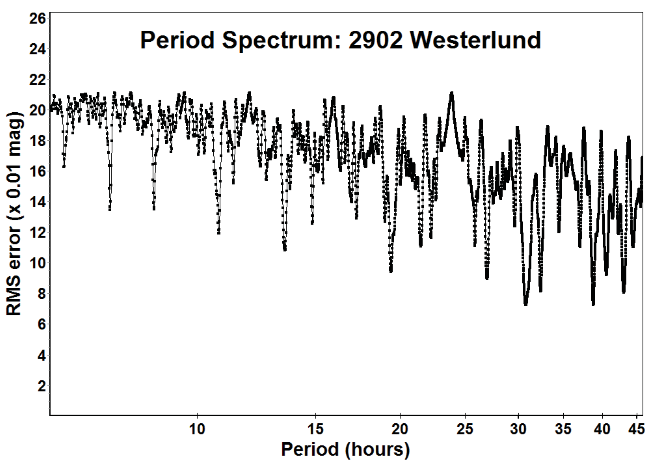
Number	Name	20yy mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp
2381	Landi	13/12/24-14/02/22	1504	-14.4,16.8	117.9	-9.4	3.98595	0.00001	0.86
2736	Ops	17/07/19-17/07/25	315	-	296.6	7.3	-	-	0.2
2884	Reddish	17/10/23-17/10/29	196	-	34.0	-0.4	14.310	0.004	0.90
2902	Westerlund	17/10/23-17/11/07	435	-	9.4	-1.8	-	-	0.7
4067	Mikhel'son	13/10/24-14/01/15	1667	6.8,24.2	58.5	8.0	2.24620	0.00003	0.15
4336	Jasniewicz	16/08/08-16/08/26	197	-	327.8	-4.4	-	-	0.2
4517	Ralpharvey	13/10/05-13/11/30	741	2.3,25.8	14.4	-1.2	3.60065	0.00003	0.30
5813	Eizaburo	17/08/29-17/10/27	967	5.4,23.8	341.4	6.4	2.87538	0.00002	0.35
5976	Kalatajean	17/05/02-17/05/21	322	9.2,17.0	205.2	-4.3	4.55362	0.00006	0.59
6045	1991 RG9	17/07/02-17/07/14	233	-3.7,6.5	282.8	4.7	12.345	0.004	1.00
12721	1991 PB	16/07/24-16/08/26	339	-	302.2	1.5	-	-	0.35
14309	Defoy	17/05/19-17/05/22	176	-8.5,-9.1	245.2	9.8	3.3940	0.0011	0.17
18017	1999 JC124	17/06/24-17/06/30	325	5.7,7.6	270.0	8.7	3.0300	0.0004	0.18
31775	1999 JN122	17/07/26-17/08/29	797	-3.9,17.8	307.2	5.9	4.3186	0.0002	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).

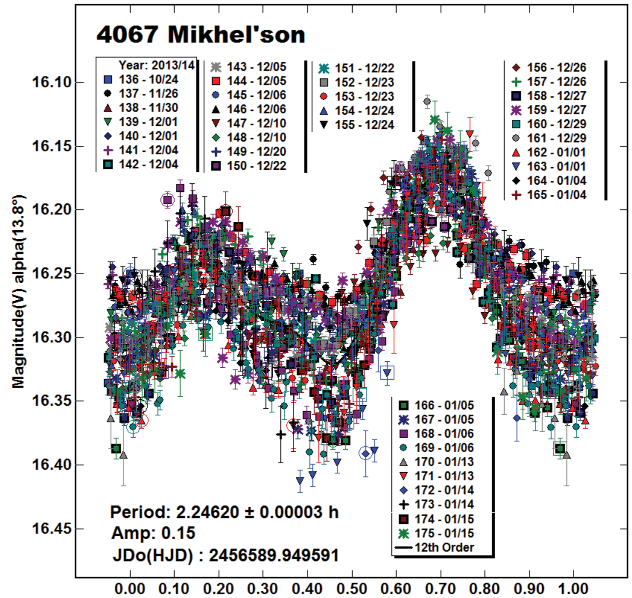
2884 Reddish. Data were collected from 2017 October 23 through 29 resulting in 6 nights totaling 196 data points. A period of 14.310 ± 0.004 h was calculated with a peak-to-peak amplitude of 0.92 mag. However, without additional data points at all peaks this period is suspect. A search of the Asteroid Lightcurve Database (and other resources) did not find any previously reported results for asteroid 2884.



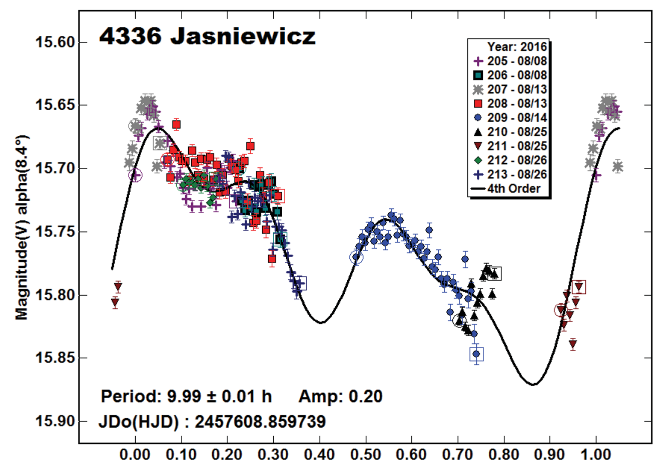
2902 Westerlund. Data were collected from 2017 October 23 through November 07 resulting in 12 nights totaling 435 data points. A period could not confidently be calculated. The amplitude of the lightcurve variation from the raw data was under 0.7 magnitudes. The Period spectrum is shown below. A search of the Asteroid Lightcurve Database (and other resources) did not find any previously reported results for asteroid 2902.

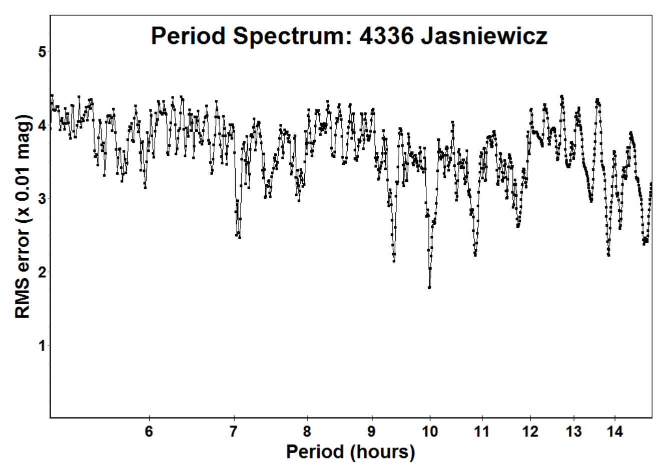


4067 Mikhel'son. Data were collected from 2013 October 24 through 2014 January 15 resulting in 22 nights totaling 1667 data points. A period of 2.24620 ± 0.00003 h was calculated with a peak-to-peak amplitude of 0.15 mag. 4067 Mikhel'son was tracked through 884.2 revolutions from phase angles of 6.8 through 24.2 deg. With minimum phase angle less than 7 degrees the H-G values were H = 13.04 ± 0.03 and G = 0.17 ± 0.03. A period of 2.2451 ± 0.0004 h has previously been reported by Alkema (2014).

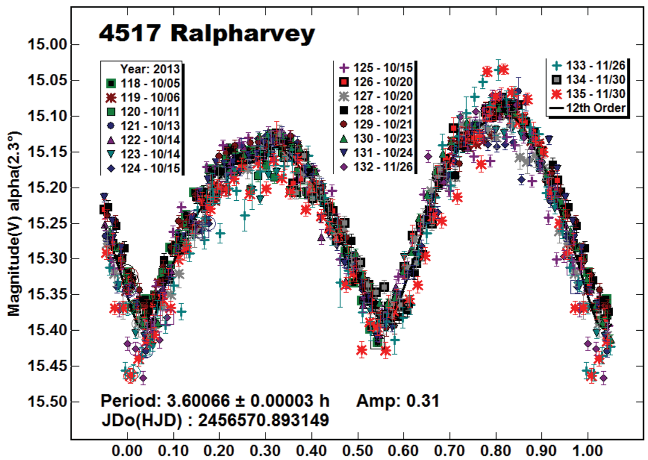


4336 Jasniewicz. Data were collected from 2016 August 8 through 26 resulting in 5 nights 197 data points. A possible period of 10 h was found on the period spectrum but there were not enough data points around the peaks to secure a period. The amplitude of the lightcurve variation from the raw data was under 0.2 magnitudes. The data were previously reported by Linville (2017) with no period and an amplitude of 0.04 mag but not found in the ALCDEF database.

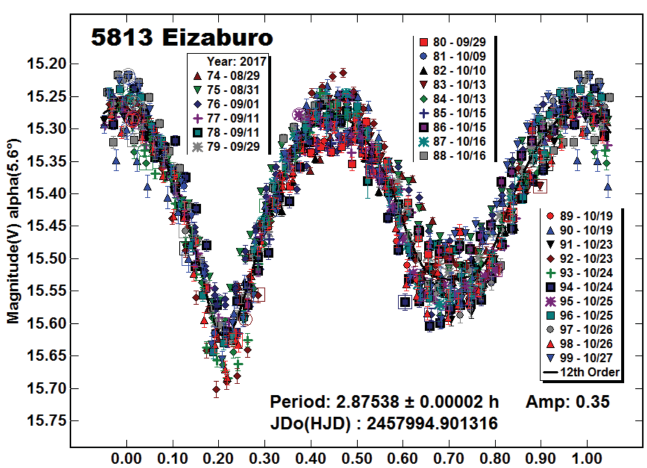




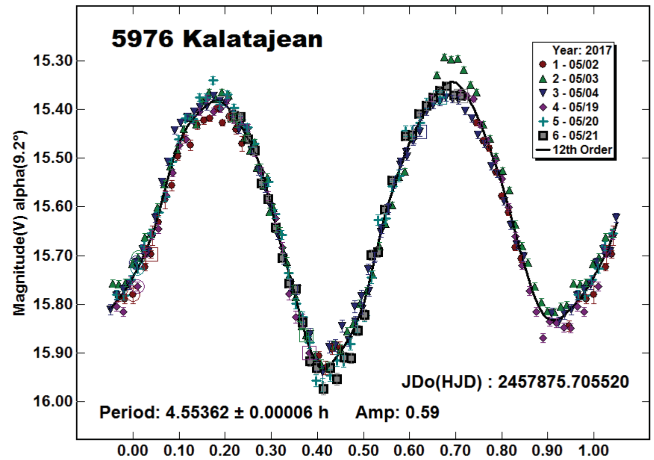
4517 Ralpharvey. Data were collected from 2013 October 5 through November 30 resulting in 12 nights totaling 741 data points. A period of 3.60066 ± 0.00003 h was calculated with a peak-to-peak amplitude of 0.31 mag. 4517 Ralpharvey was tracked through 372.8 revolutions from phase angles of 2.27 through 25.79 deg. Calculated H-G values were H = 13.91 ± 0.04 and G = 0.53 ± 0.08. "Sparse dense" data were found from the Palomar Transient Factory and reported by Waszczak et al, (2015). Waszczak data was found in the LCDB with a period of 3.601 h, amplitude of 0.21 mag.



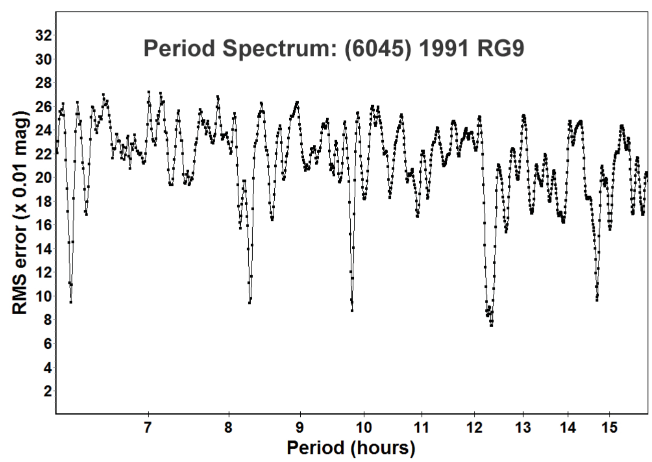
5813 Eizaburo. Data were collected from 2017 August 29 through October 27 resulting in 16 nights totaling 967 data points. A period of 2.87538 ± 0.00002 h was calculated with a peak-to-peak amplitude of 0.35 mag. 5813 Eizaburo was tracked from phase angles of 5.40 through 23.75 deg. Calculated H-G values were H = 12.96 ± 0.03 and G = 0.16 ± 0.03. The data were previously reported by Tomassini (2018) with a period of 2.93 ± 0.01 h and amplitude of 0.26 mag, by Salvaggio (2018) as a trimodal lightcurve with a period of 2.876 ± 0.002 h and amplitude of 0.32 ± 0.02 mag. Data were also found in the ALCDEF database reported by Benishek, (2018). Merging the Benishek data with that presented here resulted in a period of 2.87544 ± 0.00001 h with an amplitude of 0.35 mag.; a slight refinement of the original solution.



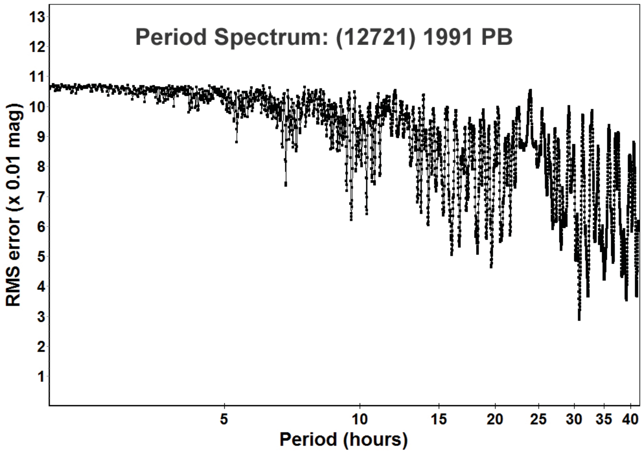
5976 Kalatajean. Data were collected from 2017 May 2 through 21 resulting in 6 nights totaling 322 data points. A period of 4.55362 ± 0.00006 h was calculated with a peak-to-peak amplitude of 0.59 mag. 5976 Kalatajean was tracked from phase angles of 9.20 through 17.01 deg. Since the minimum phase angle measured was 9.70, G was fixed at 0.150 resulting in H = 12.3 ± 0.1. A search of the Asteroid Lightcurve Database (or other resources) did not find any previously reported results for asteroid 5976.



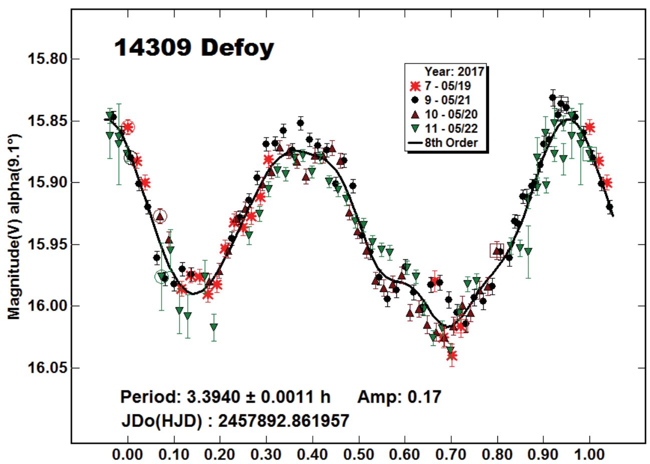
(6045) 1991 RG9. Data were collected from 2017 July 2 through 14 resulting in 5 nights totaling 233 data points. Possible periods are shown in the period spectrum. The most likely is 12.3 h. The peak-to-peak amplitude is approximately 1.0 mag. A search of the Asteroid Lightcurve Database (or other resources) did not find any previously reported results for asteroid 6045. More Data is definitely needed for 6045.



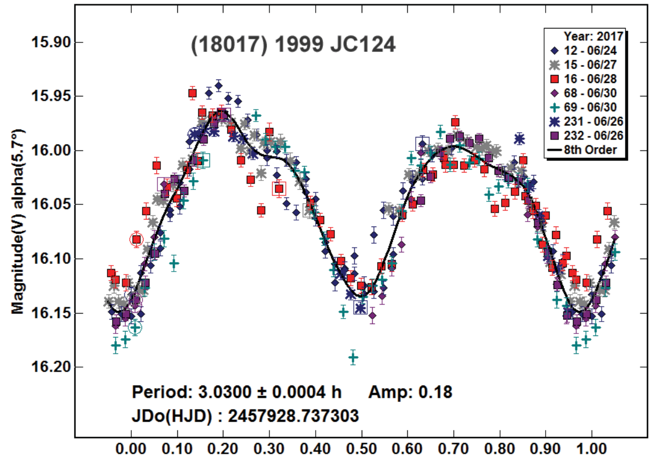
(12721) 1991 PB. Data were collected from 2016 July 24 through August 26 resulting in 7 nights totaling 339 data points. No reasonable period could be found from the period spectrum. The amplitude of the lightcurve variation from the raw data was under 0.35 magnitudes. A search of the Asteroid Lightcurve Database (or other resources) did not find any previously reported results for asteroid 12721.



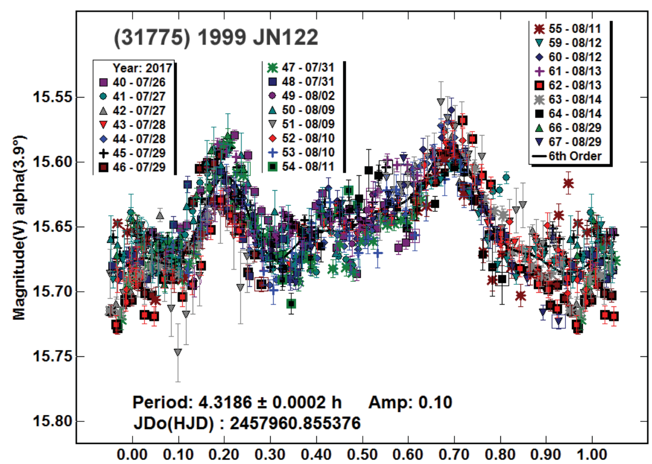
14309 Defoy. Data were collected from 2017 May 19 through 22 resulting in 4 nights totaling 176 data points. A period of 3.394 ± 0.001 h was calculated with a peak-to-peak amplitude of 0.17 mag. H-G values could not be calculated since there was such a short range of phase angles. The data were previously reported by Salvaggio (2017) with a period of 3.391 ± 0.002 h and amplitude of 0.16 ± 0.02 mag, and by Tomassini (2018) with a period of 3.4 ± 0.1 h and amplitude of 0.16. Both are in close agreement with data presented here.



(18017) 1999 JC124. Data were collected from 2017 June 24 through 30 resulting in 5 nights totaling 325 data points. A period of 3.0300 ± 0.0004 h was calculated with a peak-to-peak amplitude of 0.18 mag. (18017) 1999 JC124 was tracked from phase angles of 5.71 through 7.60 deg .Since the phase angles are clustered around 7 deg. H-G values were not calculated. A search of the Asteroid Lightcurve Database (or other resources) did not find any previously reported results for asteroid 18017



(31775) 1999 JN122. Data were collected from 2017 July 26 through August 29 resulting in 13 nights totaling 797 data points. A period of 4.3186 ± 0.0002 h was calculated with a peak-to-peak amplitude of 0.10 mag. (31775) 1999 JN122 was tracked from phase angles of -3.87 through 17.78 deg. Calculated H-G values were H = 14.05 ± 0.01 and G = 0.24 ± 0.02. The data were previously reported by Salvaggio (2018) with a period of 4.319 ± 0.001 h and amplitude of 0.12 ± 0.02 mag.



Acknowledgements

I would like to thank Brian Warner for his help through private emails.

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ROTATIONAL PERIOD DETERMINATION FOR ASTEROID 5798 BURNETT

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(Received: 2018 Feb 9)

Photometric observations for the main-belt asteroid 5798 Burnett were taken from 2017 September 9 to 2017 October 13, totaling 267 images. The rotational period was determined as 7.482 ± .001 h.

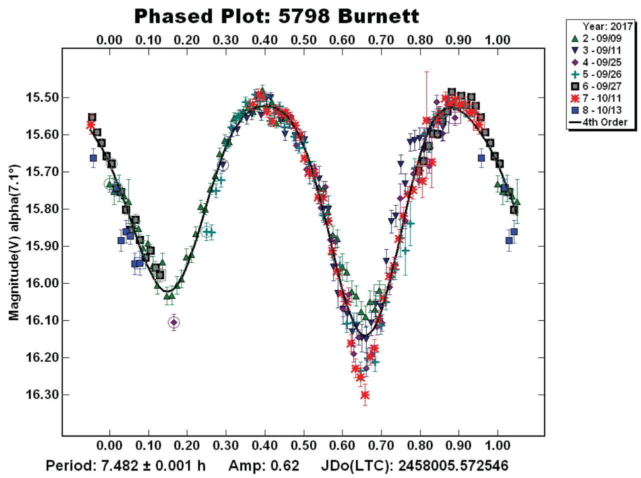
5798 Burnett, a main-belt asteroid, was discovered by S.J. Bus at Palomar Observatory (MPC Database, 2017). This asteroid was chosen as a target for measurement through the Lightcurve Database (LCDB; Warner *et al.*, 2009). This search showed no previously reported results for Burnett's rotational period.

Observations reported here were made at the Phillips Academy Observatory (code I12) over the course of 7 nights from 2017 September to October in order to measure the rotational period of this asteroid. All observations were made with an Andor Tech iKon DW436 camera, producing images with a resolution of 2048x2048 pixels, with each square pixel measuring 13.5 microns in width, and having an overall image scale of 0.87 arcseconds per pixel. The telescope used was a 40-m *f*/8 Ritchey-Chrétien telescope produced by DFM Engineering.

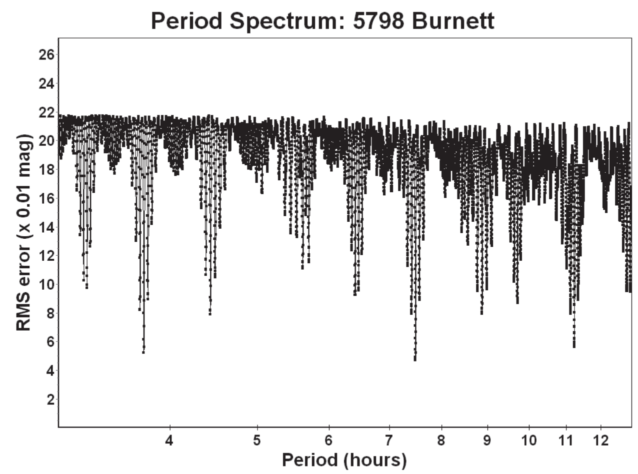
All images were 300 second guided exposures, taken through a luminance filter. Each was corrected with corresponding bias, dark, and luminance flat-field frames. The images for 9/10 and 9/11 were calibrated using *Maxim DL* (2016). All other images sets were similarly calibrated using *AstroImageJ*. After calibration, photometric analysis was performed using *MPO Canopus* (Warner, 2010) with comparison stars chosen to have approximately solar color. Resultant magnitude values for the asteroid given by this process were plotted using *MPO Canopus* (Warner, 2010). For a few sets, several data points were removed for images taken close to dawn as the increasing background sky brightness resulted in exceedingly large uncertainty. Additionally, a few data points were removed due to passing clouds or poor tracking. Two sessions required zero-point adjustments of 0.09 and -0.12 mag. A Fourier analysis (FALC; Harris et al., 1989) was performed in *MPO Canopus* (Warner, 2013) to produce a period-fitted graph (Figure 1).

Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp	Exp
5798	Burnett	09/09-10/13	267	7.11,18.28	340	11.3	7.482	0.001	0.62	0.05	MBA	300

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). Exp is exposure time, seconds.



The best rotational period for 5798 Burnett was then determined as 7.482 ± 0.001 h with an amplitude of 0.62 mag. The period spectrum is shown in Figure 2.



Acknowledgements

Research at the Phillips Academy Observatory is supported by the Israel Family Foundation. Funding for the Andor Tech camera was generously provided by the Abbot Academy Association and the Taylor family.

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LIGHTCURVES FOR ASTEROIDS 2022 WEST AND 18301 KONYUKHOV

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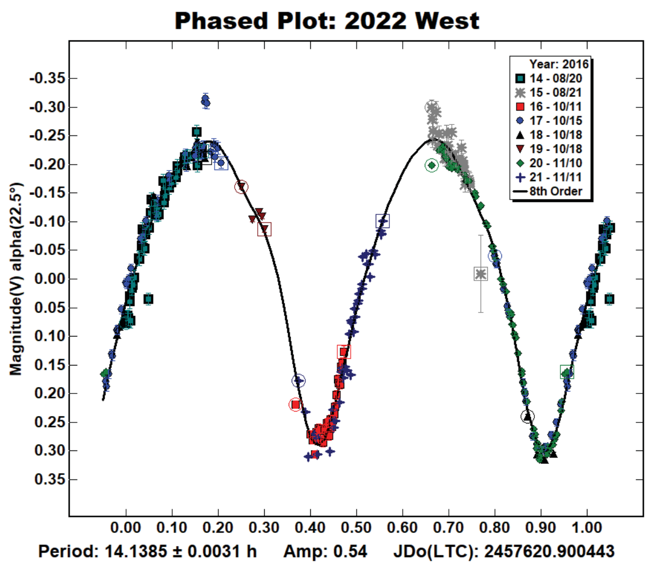
(Received: 2018 Feb 12)

We report photometric analysis of two main-belt asteroids observed at the Observatorio Astronomico Nacional in the Sierra San Pedro Martir, Baja California, México. For 18301 Konyukhov, our derived intrinsic rotation period is 2.6667 ± 0.0003 h with an amplitude of 0.16 mag. To the best of our knowledge, this is the first lightcurve reported for this asteroid. In the case of 2022 West, our derived intrinsic rotation period is 14.1385 ± 0.0031 h with an amplitude of 0.54 mag.

The Mexican effort to achieve coordinated simultaneous photometric observations of asteroids is embodied by the Mexican Asteroid Photometric Campaign (hereafter CMFA). Since 2015, more than 10 asteroids have been photometrically observed and analyzed (Sada et al 2016; 2017; 2018). In this work, we present photometric data of two main-belt asteroids supplemental to the 2016 CMFA. These objects were observed in the period 2016 August-November as targets of opportunity at the Observatorio Astronómico Nacional at San Pedro Mártir (hereafter OAN-SPM; MPC 679) in Baja California, México. The observations were carried out with the 0.84-m *f*/15 Ritchey-Chretien telescope. We used a 2048×2048 pix^2 E2V-4240 cryogenic CCD operating at a temperature of -110 °C. The images were generally binned 2 × 2 with a final field of view of 7.6 × 7.6 arcmin^2. All observations were unfiltered. The observed images were processed using standard *IRAF* routines in order to correct them for nightly bias, dark current and flat-field effects. We used *MPO Canopus* (V9.5.0.14, BDW Publishing, 2017) to carry out differential photometric measurements and lightcurve analysis.

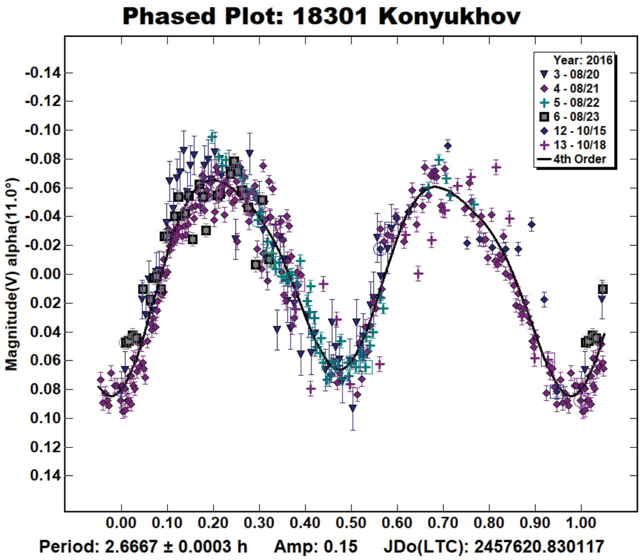
2022 West (1938 CK) was discovered on 1938 Feb 7 by K. Reinmuth. It is a main-belt asteroid with H = 11.6 (JPL, 2017a). 2022 West was reported by Franco and Marchini (2017) to have a rotation period of 14.14 ± 0.01 h. In this work, 2022 West was observed on seven nights in 2016 (Aug 20-21; Oct 11,15, and 18; Nov 10-11). During analysis, the Oct 18 observations were treated as two separate sessions because two different sets of bright and comparison stars were used. A total of 287 data points were used to construct its lightcurve. Based on this curve, we derived an intrinsic rotation period of 14.1385 ± 0.0031 h with an amplitude of 0.54 mag. In this case, the period is 3.2 times more precise than previous works because this asteroid was observed over a longer period of time.



18301 Konyukhov (1979 QZ9) was discovered on 1979 Aug 27 by N.S. Chernykh and was named after the Russian traveler Fyodor Fyodorovich Konyukhov. It is an outer main-belt asteroid with H = 13.4 (JPL, 2017a). The asteroid was observed at the OAN-SPM on six nights in 2016 (Aug 20-23; Oct 15, 18). During analysis, the Aug 22 observations were treated as two separate sessions because the asteroid passed in front of a bright star. A total of 395 data points were used to construct its lightcurve. From this curve, we derived an intrinsic rotation period of 2.6667 ± 0.0003 h with an amplitude of ~0.17 mag. This period is in the range of a typical asteroid in the main-belt. According to the JPL Small-Body Database (JPL, 2017b) there is a total of 1738 observations (all types) since 1979. However, as far as we know, there is no photometry or lightcurve data reported in the literature.

Number	Name	2016 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2022	West	08/20-11/11	287	22.5,10.2	28	3	14.1385	0.0031	0.54	0.04	MB
18301	Konyukhov	08/20-10/18	395	10.9,12.7	312	1	2.6667	0.0003	0.15	0.02	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), which values were extracted from *https://ssd.jpl.nasa.gov/horizons.cgi#top*. Grp is the asteroid family/group (Warner *et al.*, 2009).



Acknowledgements

The results presented in this report are based upon observations carried out at the Observatorio Astronómico Nacional on the Sierra San Pedro Mártir (OAN-SPM), Baja California, México. IRAF is distributed by the National Optical Astronomy Observatory, which is operated by the Association of Universities for Research in Astronomy (AURA) under a cooperative agreement with the National Science Foundation.

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ASTEROID PHOTOMETRY FROM THE PRESTON GOTT OBSERVATORY

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(Received: 2018 Feb 20)

Asteroid rotation period and amplitude results obtained at the Preston Gott Observatory during 2017 November are reported.

During the U.S. Thanksgiving week of 2017 November, I was able to spend several nights using the Preston Gott Observatory of the Texas Tech University. Located about 20 km north of Lubbock, the main instrument is a 0.5-m *f*/6.8 Dall-Kirkam Cassegrain. An SBIG STL-1001E CCD was used with this telescope. Also used were several 0.3-m Schmidt-Cassegrain telescopes with SBIG ST9XE CCD's. All images were unfiltered and were reduced with dark frames and sky flats.

Image analysis was accomplished using differential aperture photometry with *MPO Canopus*. Period analysis was also done in *MPO Canopus*, which implements the algorithm developed by Alan Harris (Harris et al., 1989). Differential magnitudes were calculated using reference stars from the USNO-A 2.0 and UCAC4 catalogs.

Results are summarized in the table below, and the lightcurve plots are presented at the end of the paper. The data and curves are presented without additional comment except where circumstances warrant.

2036 Sheragul. Observations of this asteroid were made on four nights as part of an ongoing project to model its shape. The derived rotation period of 5.4138 h is in close agreement with that found in previous studies (Clark, 2004; Clark, 2011; Clark, 2015b).

3015 Candy. Observations of this asteroid were made on two nights as part of an ongoing project to model its shape. The derived rotation period of 4.6214 h is in general agreement with that found in previous studies. However, due to clouds the data is insufficient to check for any increase in the rotation period as indicated in previous observations (Clark, 2007; Clark, 2011; Clark, 2015a; Clark, 2016).

7857 Lagerros. This asteroid was observed on only one night. However, the observations covered two full rotations of the asteroid thus the derived period should be fairly accurate.

(43148) 1999 XB106. Despite four nights of observation, the scatter in the data precluded any reasonable period determination. The result presented here is as a guide for future observations.

Acknowledgments

I would like to thank Dr. Nural Akchurin and Dr. Robert Morehead for allowing the use of the Preston Gott Observatory for this work, and Brian Warner for all of his work with the program *MPO Canopus* and for his efforts in maintaining the "CALL" website.

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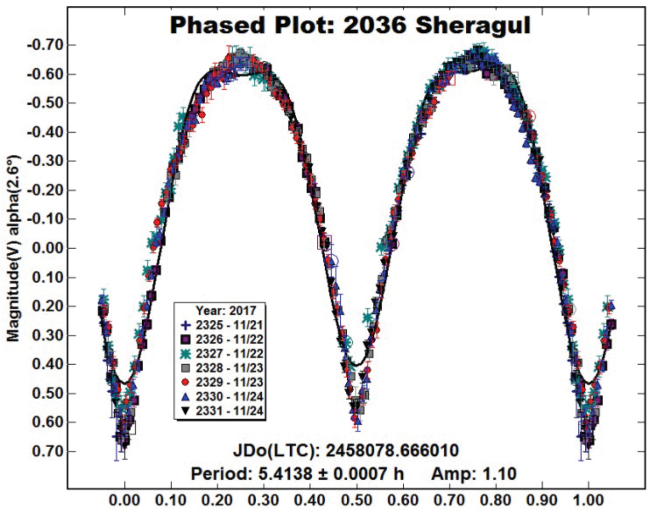
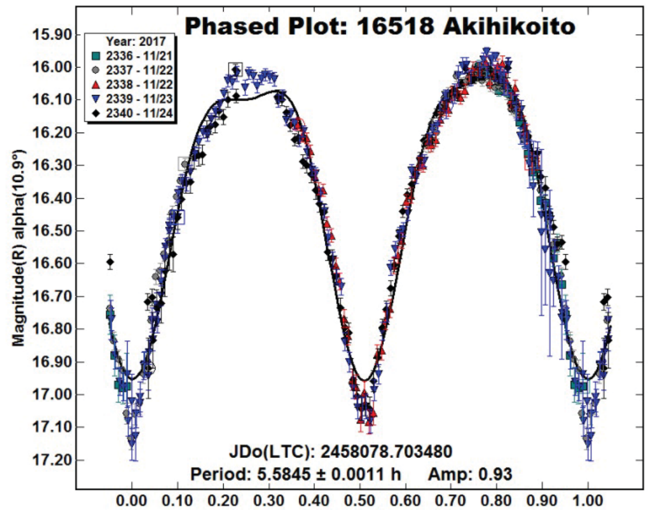
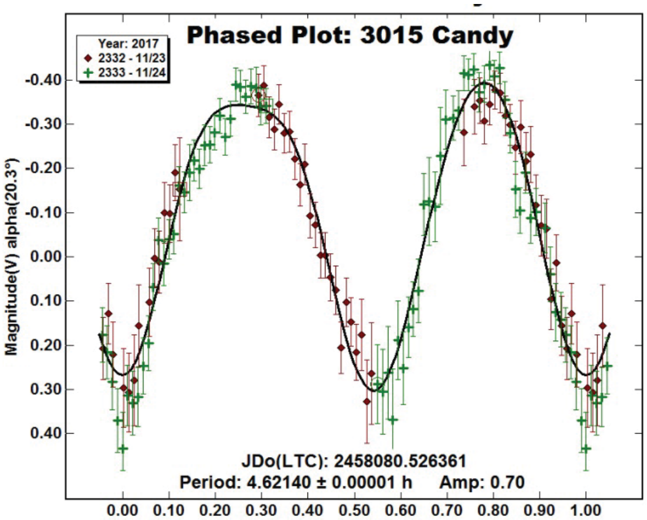
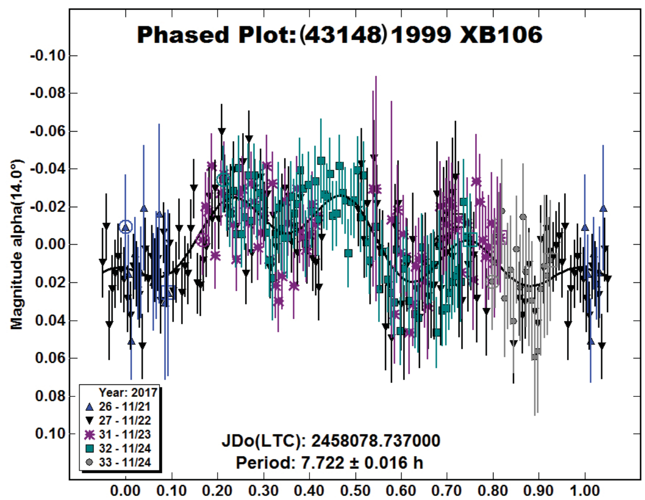
Number	Name	2017 mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2036	Sheragul	11/21-11/24	2.6,3.2	58	5	5.4138	0.0007	1.10	0.02	FLOR
3015	Candy	11/23-11/24	20.1,20.3	349	-12	4.62140	0.00001	0.70	0.05	MB-O
7857	Lagerros	11/24	10.8	48	-16	3.0769	0.0001	0.17	0.02	MB-O
16518	Akihikoito	11/21-11/24	10.7,12.2	44	-7	5.5845	0.0011	0.93	0.05	FLOR
43148	1999 XB106	11/21-11/24	14.0,13.8	59	-18	-	-	0.05	-	MB-O
85799	1998 VV50	11/21-11/24	11.4,13.1	44	-6	3.797	0.003	0.28	0.10	FLOR

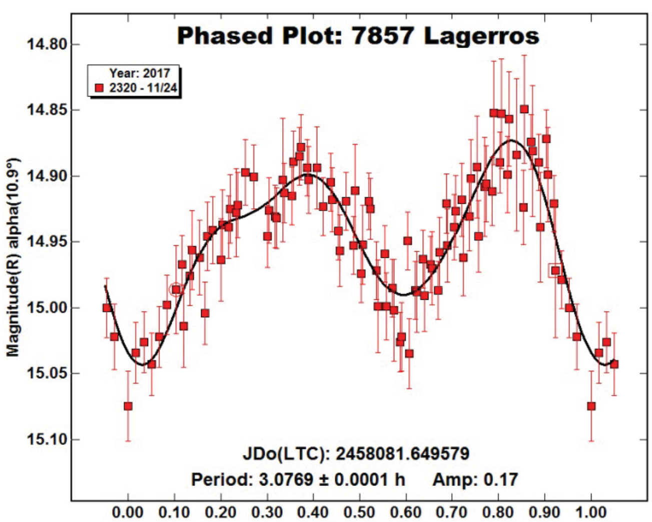
Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984). Grp is the asteroid family/group (Warner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

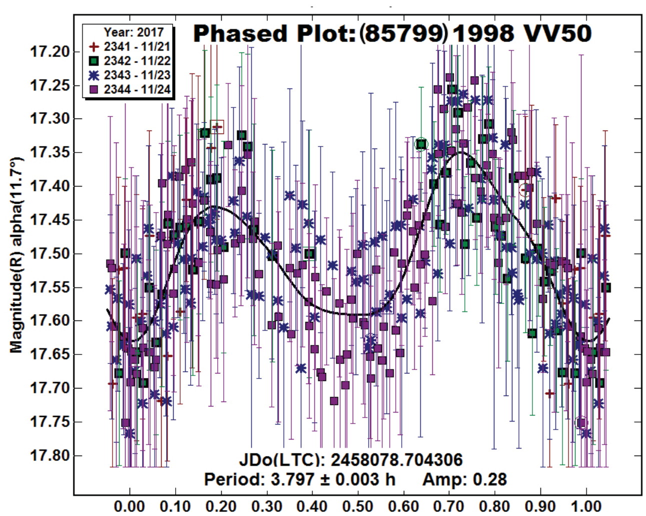

Phased Plot: 2036 Sheragul
Magnitude(V) alpha(2.6°)
Year: 2017
2325 - 11/21
2326 - 11/22
2327 - 11/22
2328 - 11/23
2329 - 11/23
2330 - 11/24
2331 - 11/24
JDo(LTC): 2458078.666010
Period: 5.4138 ± 0.0007 h Amp: 1.10


Phased Plot: 16518 Akihikoito
Magnitude(R) alpha(10.9°)
Year: 2017
2336 - 11/21
2337 - 11/22
2338 - 11/22
2339 - 11/23
2340 - 11/24
JDo(LTC): 2458078.703480
Period: 5.5845 ± 0.0011 h Amp: 0.93


Phased Plot: 3015 Candy
Magnitude(V) alpha(20.3°)
Year: 2017
2332 - 11/23
2333 - 11/24
JDo(LTC): 2458080.526361
Period: 4.62140 ± 0.00001 h Amp: 0.70


Phased Plot: (43148) 1999 XB106
Magnitude alpha(14.0°)
Year: 2017
26 - 11/21
27 - 11/22
31 - 11/23
32 - 11/24
33 - 11/24
JDo(LTC): 2458078.737000
Period: 7.722 ± 0.016 h


Phased Plot: 7857 Lagerros
Magnitude(R) alpha(10.9°)
Year: 2017
2320 - 11/24
JDo(LTC): 2458081.649579
Period: 3.0769 ± 0.0001 h Amp: 0.17


Phased Plot: (85799) 1998 VV50
Magnitude(R) alpha(11.7°)
Year: 2017
2341 - 11/21
2342 - 11/22
2343 - 11/23
2344 - 11/24
JDo(LTC): 2458078.704306
Period: 3.797 ± 0.003 h Amp: 0.28

NEAR-EARTH ASTEROID (297418) 2000 SP43: LIGHTCURVE AND COLOR PHOTOMETRY

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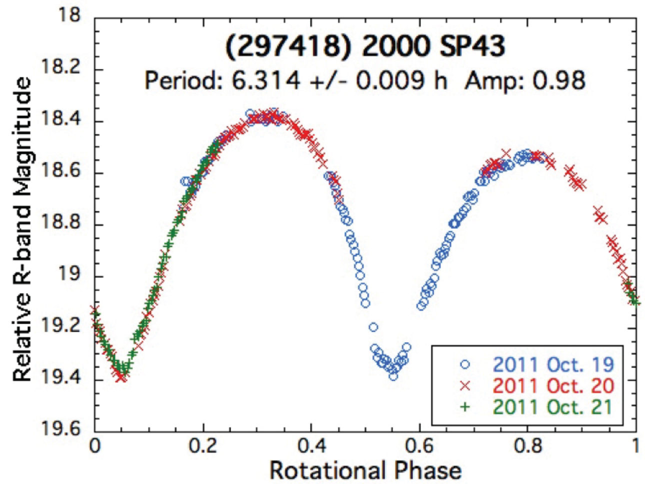
Photometry of the Aten near-Earth asteroid (297418) 2000 SP43 was obtained on three nights in 2011 October with the University of Arizona Kuiper 1.54-m telescope. Lightcurve analysis yielded a rotation period of 6.314 ± 0.009 h and amplitude of 0.98 magnitudes. Broadband filter photometry found the following colors: B-V = +0.80, V-R = +0.50 and V-I = +0.85. These colors are consistent with an S-type taxonomy and agree with the results published in Hicks et al. (2011).

The near-Earth asteroid (297418) 2000 SP43 (henceforth 2000 SP43) is an Aten with a semi-major axis of 0.811 AU, eccentricity of 0.467 and inclination of 10.4°. The Minor Planet Center finds an absolute magnitude of 18.5 and Minimum Orbit Intercept Distance (MOID) of 0.019 AU, making 2000 SP43 a potentially hazardous asteroid (PHA). It was discovered by the Lincoln Laboratory Near Earth Asteroid Research (LINEAR) survey on 2000 September 25 at magnitude 16.5 to 16.9. At the time of discovery, it was located ~0.08 AU from Earth. The asteroid experiences relatively close approaches to Earth every 2-3 years. During the close approach in late 2011, 2000 SP43 passed within 0.139 AU of Earth.

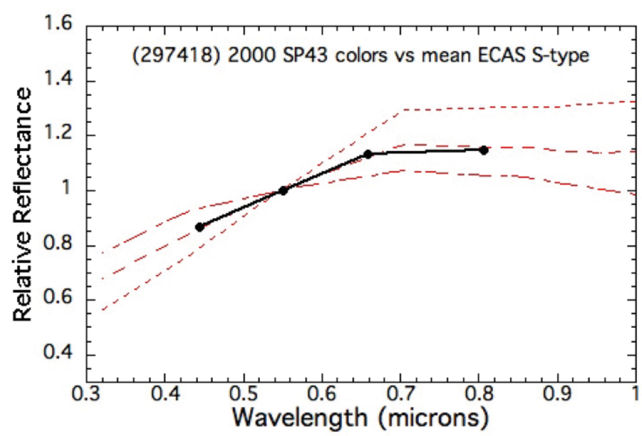
CCD photometric lightcurve observations of 2000 SP43 were acquired on 2011 October 19-21 with the University of Arizona Kuiper 1.54-m telescope and the Montreal 4K imager (better known as the "Mont4K"). The Mont4K consists of a Fairchild CCD486 4096x4097 detector with 15 μm pixels. Images were binned 3x3, which yielded an effective plate scale of 0.45 arc seconds per pixel.

Data reduction included the standard procedure of zero subtraction and use of flat field images produced from the data and twilight images. All data reduction was done within the *IRAF* IMRED and DIGIPHOT packages. Lightcurve photometry was conducted with a Harris R filter on all three nights. Harris B, Harris V, and Arizona I filter images were also obtained on the night of October 19. Zero points and extinction coefficients were determined by observing multiple stars in SA113 from Landolt (1992) at air masses from 1.1 to 2.5 per filter per night. A variable circular aperture of 2 times the measured FWHM of each image was used to compensate for seeing variations. Sky background was measured with a circular aperture of radius 20 pixels and width of 5 pixels. Petr Pravec's Asteroid Lightcurve (ALC) software (version 0.96) was used for lightcurve analysis.

The observations on 2011 October 19 consist of 130 *R*-band measurements obtained over a span of 4.2 h. On October 20, 154 *R*-band images were acquired over 4.6 h. On the final night, October 21, 73 *R*-band images were collected over 1.5 h. The asteroid was at an average heliocentric distance 1.17 AU and geocentric distance of 0.21 AU. The phase angle ranged from 32.5° to 34.1° during the observations. The photometry conducted on these three nights yielded a rotation period of 6.314 ± 0.009 h and amplitude of 0.98 magnitudes.



BVI filter photometry was interspersed between the *R* filter photometry obtained on October 19. The color photometry yielded a *B-V* of +0.80 ± 0.05, *V-R* of +0.50 ± 0.04 and *V-I* of +0.85 ± 0.09. These colors are consistent with an S-type taxonomy and agree with the results of Hicks et al. (2011), who found 2000 SP43's spectrum to be similar to an Sr taxonomy.



VRI colors of 2000 SP43 compared with high, low and mean ECAS colors from Zellner et al. (2009).

Acknowledgements

We would like to thank the University of Arizona Observatories for allowing use of their facility. We are also grateful to Petr Pravec for providing his ALC software for lightcurve photometry analysis.

Number	Name	2011 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
297418	2000 SP43	10/19-10/21	357	32.5,34.1	12	19	6.314	0.009	0.98	0.03	NEA

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).

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LIGHTCURVE ANALYSIS AND ROTATION PERIOD FOR 6838 OKUDA

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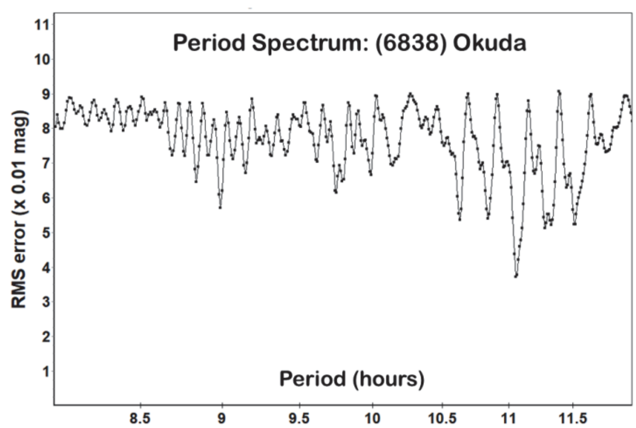
From 2018 January 24 to 2018 Feb 16, CCD images were taken with the aim to measure the rotation period of 6838 Okuda. The data analysis gives a best fit lightcurve period of 11.0537 ± 0.0012 hours. We note that other period solutions may be possible.

6838 Okuda is a main-belt asteroid discovered at Nachi-Katsuura on 1995 October 30 by Y. Shimizu and T. Urata. It is named in honor of Toyozo Okuda, director of International Latitude Observatory at Mizusawa, Japan. The diameter of this asteroid is about 11 km while the orbital period is approximately 1576 days. The geometric albedo is 0.264 (JPL, 2018).

CCD photometric observations of 6838 Okuda were performed in a period ranging from 2018 January 23 to February 16 with the purpose of evaluating the lightcurve and rotation period. There was a rotation period already reported (Pligge et al., 2011) to be confirmed for this asteroid at the time of the observations. Photometric measurements were carried out by means of observations with a 0.3-m *f*/4 Newton telescope and a Moravian KAF-1603 ME CCD camera with a 1536x1024 array of 9-micron pixels. A clear filter was used.



A total of 304 lightcurve data points were collected in 11 observing sessions with exposure times ranging from 240 to 300 s. All images were astrometrically aligned and dark and flat-field corrected. *MPO Canopus* (Warner, 2016) was used to measure the magnitudes, perform Fourier analysis, and produce the final lightcurve. In particular, data were reduced in *MPO Canopus*

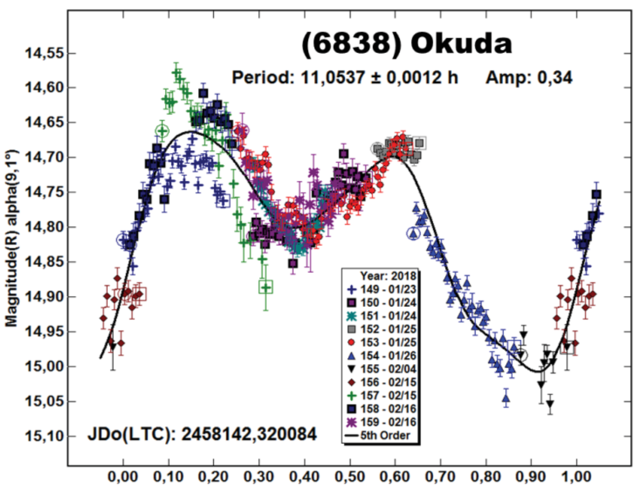
Number	Name	2018 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Exp
6838	1995 UD9	01/23-02/16	304	8.9-17.4	117	-15	11.0537	0.0012	0.34	0.02	240-300

Table I. Observing circumstances and results. 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). Exp is exposure range, seconds.

using differential photometry. Night-to-night zero point calibration was accomplished by selecting up to five comparison stars with near-solar colors using the "comp star selector" feature. The CMC-15 star catalog was used for determining the comparison star magnitudes. The "StarBGone" routine within *MPO Canopus* was used to subtract stars that occasionally merged with the asteroid during the observations. *MPO Canopus* was also used for rotation period analysis. The software employs a FALC Fourier analysis algorithm developed by Harris (Harris et al., 1989). After accumulating 11 sessions, we found a period of 11.0537 ± 0.0012 h. The lightcurve has an asymmetrical shape and amplitude of 0.34 mag. Table I gives the observing circumstances and results.

The period spectrum shows that other solutions are possible. Even if other periods cannot be rejected, the suggested one is considered the more stable solution (i.e., with lowest RMS). The period found is different from 8.983 h proposed by (Pligge et al., 2011). The data were forced to fit the period close to 9 hours, but the result was less convincing than the period of 11.0537 ± 0.0012 h adopted in this paper.

These results clearly call for further investigations in the future so that a definitive solution can be found.



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LIGHTCURVE ANALYSIS OF MINOR PLANETS 1132 HOLLANDIA, 1184 GAEA, 1322 COPPERNICUS, 1551 ARGELANDER, AND 3230 VAMPILOV

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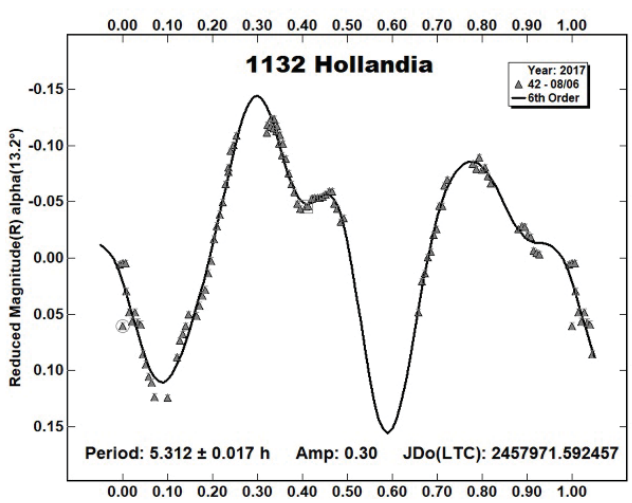
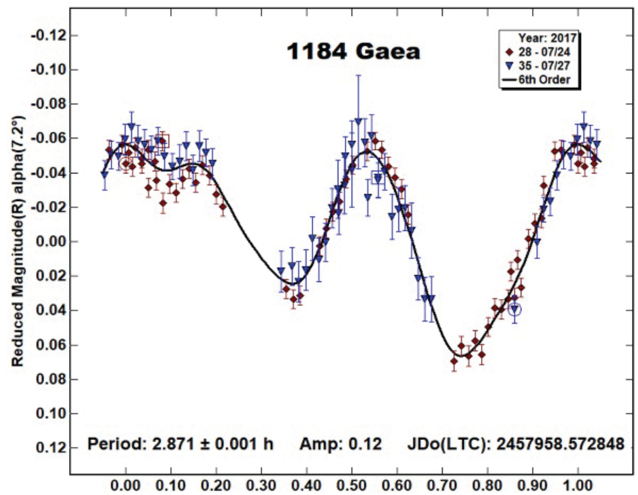
Photometric observations of 5 main-belt asteroids were obtained during three nights from 2017 July 24 to 2017 August 6, using the SARA-South telescope located at Cerro Tololo Inter-American Observatory in Chile.

We report results of photometric observations obtained with the Southeastern Association for Research in Astronomy (SARA) consortium 0.6m telescope located at Cerro Tololo Inter-American Observatory in Chile. A detailed description of the instrumentation and setup can be found in Keel et al. (2016). The data were calibrated using MaximDL and photometric analysis was performed using MPO Canopus (Warner, 2017). The targets were selected to take advantage of the long winter nights and their accessibility from the southern hemisphere. Utilizing the asteroid lightcurve database (LCDB; Warner et al., 2009a) we searched for asteroids that fulfilled these criteria and had a high uncertainty in their rotational periods. This allowed us to maximize the impact of the three nights available to us.

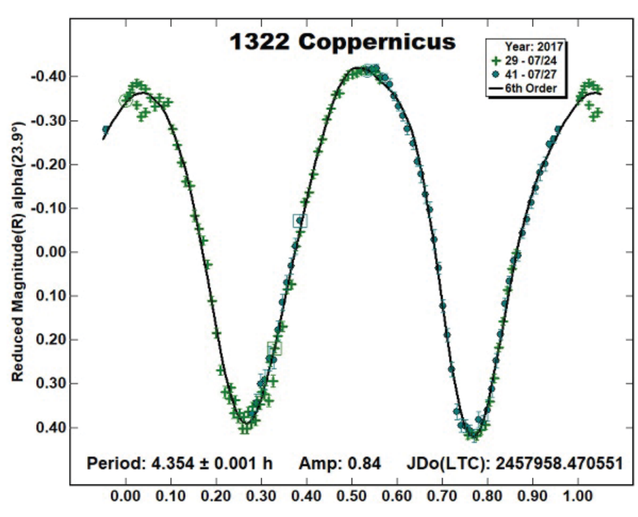
1132 Hollandia. This main-belt asteroid was observed during a single night. Our analysis yields a rotational period of 5.312 ± 0.017 h with an amplitude of 0.30 mag. This is in excellent agreement with two previous publications by Sauppe et al. (2007, 5.326 h) and Clarke (2014, 5.360 h). The asteroid was observed for approximately 7.5 h, therefore we were able to cover more than one rotational cycle of the object during a single night leading to overlapping data points and a high confidence level in the reported period. Another previously reported period of 5.568 ± 0.005 h by Behrend (2003) cannot be supported by our data.



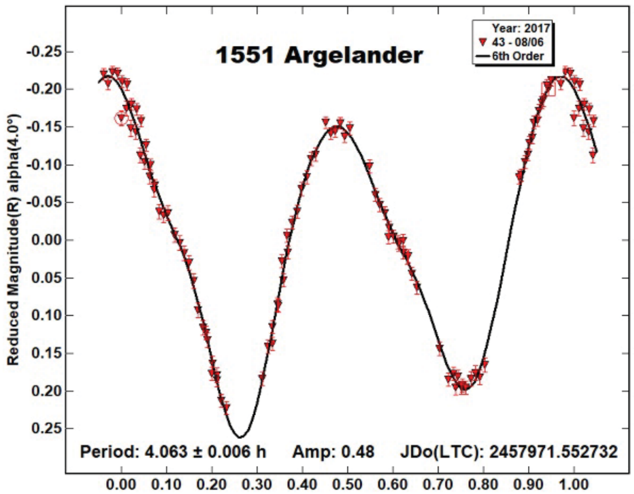
1184 Gaea. was observed over a period of two nights. We derived a rotational period of 2.871 ± 0.001 h with an amplitude of 0.12 mag. We observed the asteroid for approximately 6h the first night and 4.5 h the second night, therefore covering more than a whole rotation during each night. This again leads us to high confidence in our derived period and makes it possible to exclude other similar periods. Sauppe et al. (2007) were unable to find a rotational period for 1184 Gaea. The only previous published rotational period by Behrend (2011) of 2.94 ± 0.06 is in good agreement with our result.



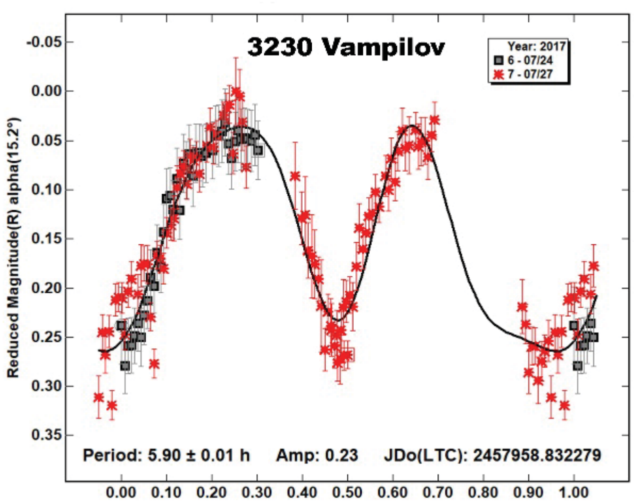
1322 Coppernicus. We observed 1322 Coppernicus on two nights for approximately 6h and 3.5h respectively. At the time of our observations three prior rotational periods had been reported for this asteroid. Wisniewski (1991) measured a period of 3.967 h based on sparse data. Behrend (2006) published two sets of data with very small amplitudes and a period of 5.375 h and 5.37 h respectively. We obtained a rotational period of 4.354 ± 0.001 h with an amplitude of 0.86 mag. Independent from us another group observed and measured the rotational period of 1322 Coppernicus a month prior to us (Noschese et al. (2018)). Their derived rotational period of 4.354 ± 0.005 hours agrees perfectly with ours. Noschese et al. provide a smaller amplitude of 0.76 mag compared to the one presented here, but their last data set (2017-June-23) seems to suggest a larger amplitude than the Fourier fit, in agreement with our measurements.



1551 Argelander. This asteroid was observed on a single night for approximately 8h. We measured a rotational period of 4.063 ± 006 h with an amplitude of 0.48 mag. Our observations span almost two complete rotations of the asteroid. This is in excellent agreement with two previous measurements based on sparse data (Waszczak et al. (2015), Ďurech at al. (2016)).



3230 Vampilov. This asteroid was observed over an interval of two nights. We derived a rotational period of 5.90 ± 0.01 h with an amplitude of 0.23 mag. We observed the asteroid for approximately 2h the first night and 6 h the second night. Waszczak et al. (2015) derived a period of 6.141 ± 0.0015 h, based on sparse data. This period does not provide a good fit to our data.



Acknowledgements

One of the authors (A.B.) would like to acknowledge support from the NASA/Florida Space Grant Consortium Summer Research Scholarship program.

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Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1132	Hollandia	08/06	95	13.3	331.2	-9.6	5.312	0.017	0.30	0.02	MB-M
1184	Gaea	07/24-07/27	106	7.2, 7.8	295.3	-12.9	2.871	0.001	0.12	0.02	MB-M
1322	Coppernicus	07/24-07/27	142	24.1, 25.1	268.0	15.8	4.354	0.001	0.86	0.02	MB-I
1551	Argelander	08/06	102	4.1	320.0	-2.7	4.063	0.006	0.48	0.02	MB-I
3230	Vampilov	07/24-07/27	140	15.2, 14.5	319.4	-18.8	5.90	0.01	0.23	0.02	MB-O

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).

ROTATION PERIOD DETERMINATION FOR 460 SCANIA

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A 142 day photometric campaign on minor planet 460 Scania 2017 Oct. 15 – 2018 March 6 reveals a synodic rotation period of 164.1 ± 0.1 hours, amplitude 0.37 ± 0.03 magnitudes. A search with simultaneous dual period software found no evidence of tumbling above 0.1 magnitudes.

The only previously published rotation period for minor planet 460 Scania is 9.55 hours based on a fragmentary lightcurve (Behrend, 2005). A more comprehensive study was launched 2017 Oct. 15 and continued until 2018 March 6 for a total of 58 sessions. Pilcher at Organ Mesa observatory used a 0.35-m f/10 Meade LX200 GPS Schmidt-Cassegrain (SCT) telescope and SBIG STL-1001E CCD. Benishek at Sopot Observatory used a 0.35-m f/6.3 Meade LX200 GPS SCT and SBIG ST-8XME CCD. The exposures for both observers used a clear filter and were unguided. Calibration stars for all sessions are solar colored stars with Sloan r' magnitudes from the Carlsberg Meridian Circle 15 (CMC15) catalog, and adjusted to the Johnson R magnitude system by R = r'-0.22. This catalog is internally consistent usually within 0.05 magnitudes but occasionally somewhat larger inconsistencies are found. A single period lightcurve (Fig. 1) is plotted with *MPO Canopus* software with no adjustments of instrumental magnitudes. Best fit is to 164.22 ± 0.02 hours and amplitude near 0.4 magnitudes. Single period software cannot determine whether observed scatter up to 0.1 magnitudes on some nights is caused by magnitude errors in the CMC15 catalog or partially by tumbling.

P. Pravec (personal communication) used simultaneous dual period software to search for evidence of tumbling. No second period could be found with amplitude greater than the 0.1 magnitude maximum errors in the calibration star magnitudes. Adjustment of instrumental magnitudes of individual sessions to best fit produced a very smooth lightcurve (Fig. 2) when phased to a period 164.1 ± 0.1 hours, amplitude 0.37 magnitudes.

We conclude that the synodic rotation period of 460 Scania is 164.1 ± 0.1 hours, amplitude near 0.37 magnitudes, with no evidence of tumbling.

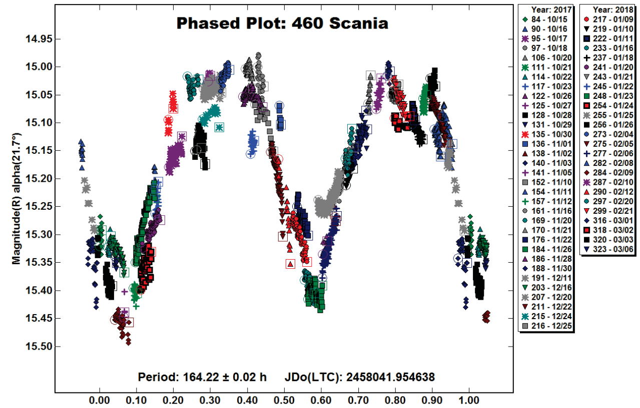

Figure 1. Lightcurve of 460 Scania obtained with MPO Canopus single period software and no adjustments of instrumental magnitudes.

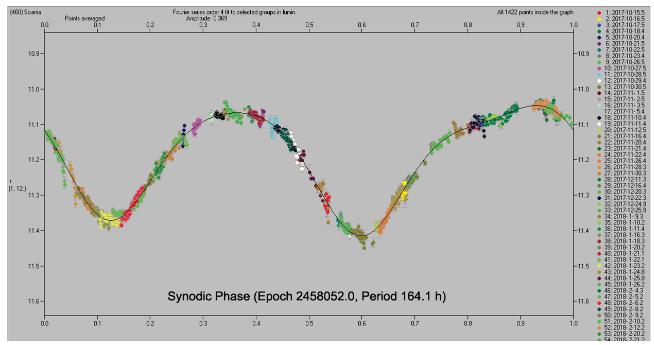

Figure 2. Lightcurve of 460 Scania obtained with simultaneous dual period software and adjustment of instrumental magnitudes to best fit.

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Number	Name	yyyy/mm/dd	Pts	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.
460	Scania	2017/10/15-2018/03/06	7088	21.7, 2.5, 21.0	89	-5	164.1	0.1	0.37	0.03

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).

LIGHTCURVE ANALYSIS OF 216 KLEOPATRA

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CCD images (I_c filter) of the asteroid 216 Kleopatra were obtained over four sessions from 2017 August to September. A folded lightcurve was produced and the synodic period, P = 5.3856 h, was calculated.

Minor planet 216 Kleopatra is an M-type member of the main belt that was discovered by J. Palisa in 1880. It provides an interesting target for study due to its dumbbell shape, 217 km x 94 km x 71 km (Ostro *et al*., 2000), which can result in a large lightcurve (LC) amplitude suitable for investigation by telescopes with a modest aperture. In this case the minimum to maximum peak amplitude of A = 0.48 mag was near the middle of the range of 0.12-1.22 mag typically observed for this system.

The equipment used at UnderOak Observatory included a focal reduced (*f*/6.42) 0.28-m Schmidt-Cassegrain telescope with a thermoelectrically cooled SBIG ST-8XME CCD camera. A total of 469 images were taken over four sessions from 2017 August 6 to September 11. Light frames were taken through an I_c filter using 75-s exposures, during which the CCD camera was operated between –5 and –10 °C.

Image acquisition (raw lights, darks, flats) was performed with *TheSkyX Pro* while calibration and registration was performed with *AIP4WIN* (Berry and Burnell, 2006). Further data reduction was carried out with *MPO Canopus* (Warner, 2008) using at least two non-varying comparison stars to generate lightcurves by differential aperture photometry. Data were light-time corrected but not reduced to standard magnitudes.

Table I summarizes the observational parameters and results. *MPO Canopus* provided a period solution for the folded data sets using Fourier analysis (FALC; Harris et al., 1989). The calculated synodic period of 5.3856 ± 0.0001 h is generally in good agreement with the most recently published rotational periods (Alton, 2009; Kaasalainen and Viikinkoski, 2012; Shevchenko et al., 2014) as well as with other unpublished lightcurve data (2010, 2015 and 2017) referenced at the JPL Solar System Dynamics website (*http://ssd.jpl.nasa.gov/sbdb.cgi*).

Acknowledgements

Many thanks to the staff who support the SAO/NASA Astrophysics Data System, the JPL Small-Body Database Browser, and the asteroid lightcurve database (LCDB; Warner et al., 2009), all of which were essential to locating relevant data and literature references.

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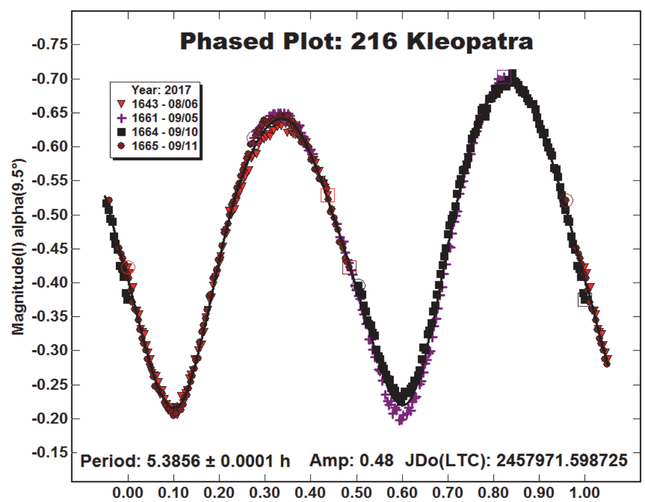

Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
216	Kleopatra	08/06-09/11	469	9.5-19.2	303	16	5.3856	0.0001	0.48	0.02	MB-O

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).

PHOTOMETRIC OBSERVATIONS OF MAIN-BELT ASTEROIDS 1968 MEHLTRETTER, 2681 OSTROVSKIJ & 3431 NAKANO

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Lightcurves for three mid-belt asteroids were obtained from Flarestar Observatory (MPC171) and Znith Observatory in 2017 and 2018. These asteroids were selected from the Collaborative Asteroid Lightcurve Link (CALL) website. No reported observations were available to deduce their rotation periods prior to this research.

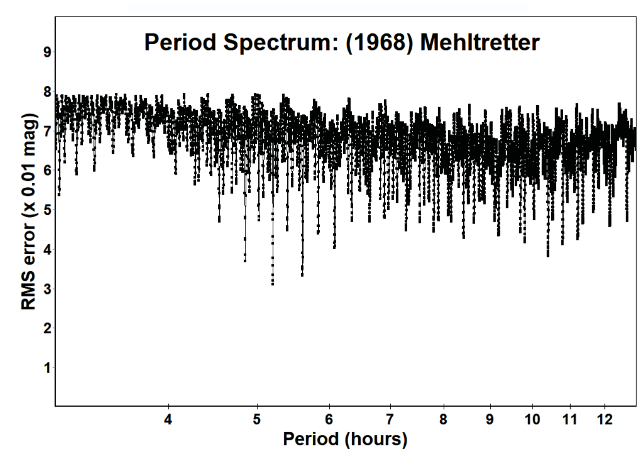
In between the months of October 2017 and March 2018, photometric observations of three main-belt asteroids were carried out from two observatories located in Malta (Europe). Observations of asteroids 1968 Mehltretter & 2681 Ostrovskij were obtained from Flarestar Observatory (MPC171). Observations of 3431 Nakano were obtained from Znith Observatory through a 0.20-m *f*/10 Schmidt-Cassegrain (SCT) equipped with a Moravian G2-1600 CCD camera. Flarestar Observatory utilized a Moravian G2-1600 camera at 1x1 binning mode with a resultant pixel scale of 0.99” per pixel while Znith operated at a pixel scale of 1.17” per pixel using the same binning mode. All cameras were operated at sensor temperature of -15°C and images were dark subtracted and flat-fielded.

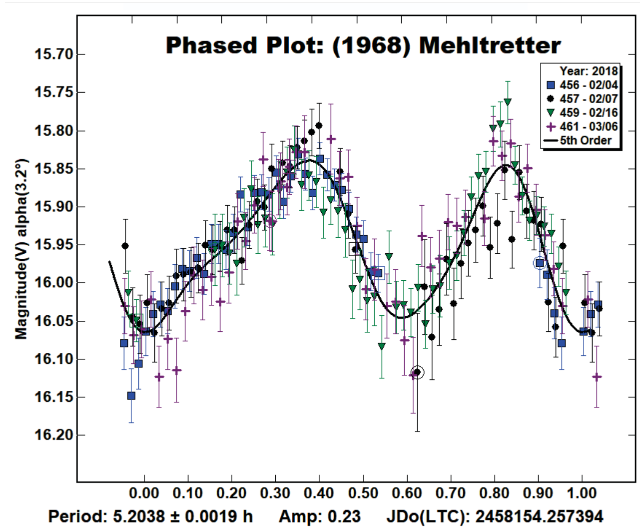
Both telescopes and cameras were controlled remotely from a nearby location via *Sequence Generator Pro* (Binary Star Software). Photometric reduction, lightcurve construction and analyses were derived through *MPO Canopus* software (Warner, 2017). Differential aperture photometry was utilised and photometric measurements were derived through the use of MPO Canopus. The Comparison Star Selector (CSS) that utilized comparison stars of near-solar color was used by the same software. All measurements were taken from the MPOSC3 Catalog that is based on the 2MASS catalog (*http://www.ipac.caltech.edu/2mass*) with magnitudes converted from J-K to BVRI (Warner, 2007).

The three asteroids for this research have been selected through the CALL website as maintained by Warner (2016).

1968 Mehlgretter. This main-belt asteroid that was discovered on 1932 January 29 by Reinmuth, K. at Heidelberg. The asteroid orbits the sun with a semi-major axis of 2.734 AU, eccentricity 0.112, and period of 4.53 years (JPL, 2018). The JPL Small-Bodies Database Browser lists the diameter of 1968 Mehltretter as 13.154 km ± 0.277 km based on an absolute magnitude H = 11.7.

Observations were conducted from Flarestar Observatory and were carried out on 4 nights from 2018 February 4 to March 6. Results indicate a synodic period of 5.2038 ± 0.0019 h and amplitude of 0.23 ± 0.05 mag There were no previous entries in the LCDB for this asteroid.



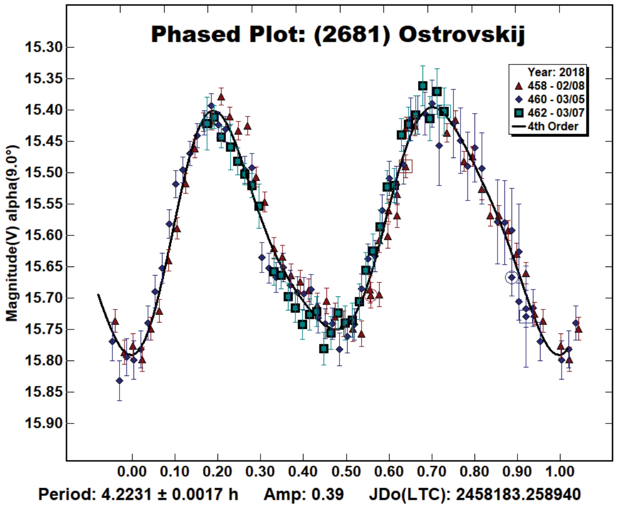


2681 Ostrovskij. This main-belt asteroid that was discovered on 1975 November 02 by Smironva, T. at Nauchnyj Russia. This 13.29 km asteroid has an absolute magnitude (H) of 12.3 and orbits the sun with a semi-major axis of 2.747 AU, eccentricity 0.1896, and period of 4.55 years (JPL, 2018).

Number	Name	yyyy /mm/ dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Group
1968	Mehltretter	2018 02/04-03/06	189	2.9,14.1	130	05	5.2038	0.0019	0.23	0.05	MB-M
2681	Ostrovskij	2018 02/08-03/07	143	9.0,6.4	155	06	4.2231	0.0017	0.39	0.02	MB-M
3431	Nakano	2017 10/14-12/22	258	6.3,19.2	013	13	9.0563	0.0021	0.20	0.04	MB-M

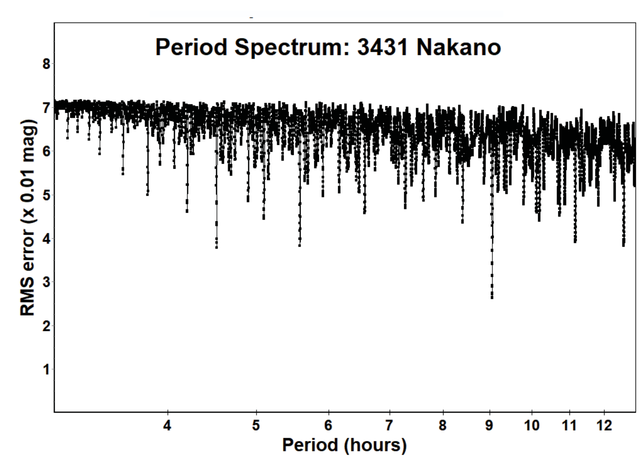
Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984). Grp is the asteroid family/group (Warner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

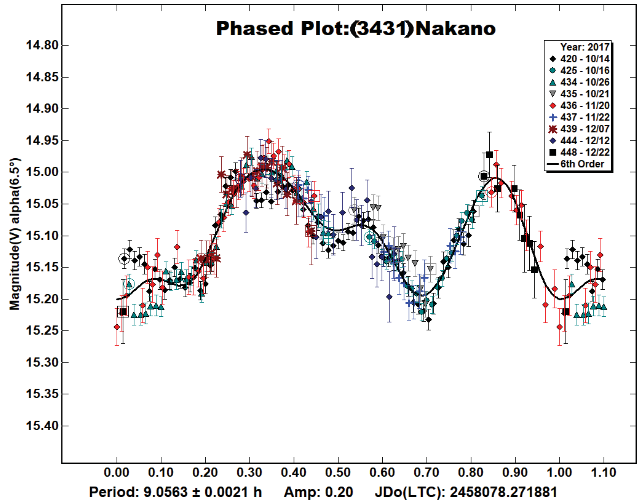
Observations were conducted from Flarestar Observatory on 3 nights from 2018 February 08 to March 07 10. The derived lightcurve indicates a synodic period of 4.2231 ± 0.0017 h and amplitude of 0.39 ± 0.02 mag. No previous entries in the LCDB database were found for this asteroid.



3431 Nakano. Nakano is a main-belt asteroid that was discovered on 1984 August 24 by Seki, T. at the at the Geisei Observatory in Kōchi, Japan. This asteroid was named was named after the Japanese astronomer Nakano Shuichi (1947-). 3431 Nakano orbits the sun with a semi-major axis of 3.095 AU, eccentricity 0.0472, and period of 5.45 years (JPL, 2018). The JPL Small-Bodies Database Browser (JPL, 2018) lists the diameter of 1637 Swings as 44.30 km ± 0.142 km based on an absolute magnitude H = 10.6.

3431 Nakano was observed from Znith Observatory on 9 nights starting on the night of 2017 October 14/15 at 19:16UT and ending on the night of 2017 December 22 at 21:11UT. Our results yielded a synodic period of 9.0563 ± 0.0021h and amplitude of 0.20 ± 0.04 mag. The Lightcurve Database 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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ROTATION PERIOD DETERMINATIONS FOR 50 VIRGINIA, 142 POLANA, AND 597 BANDUSIA

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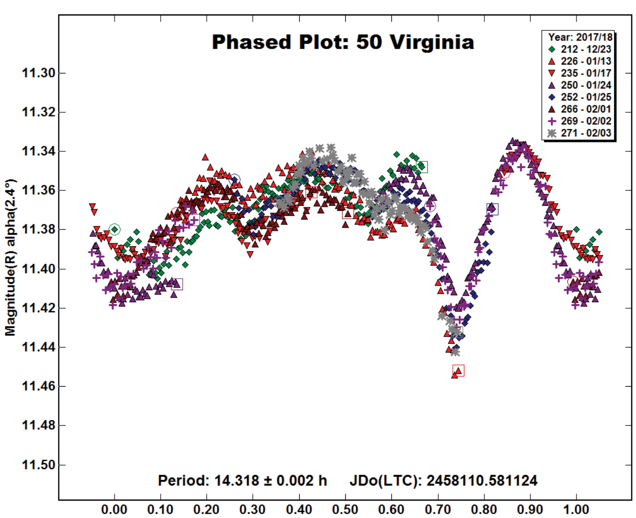
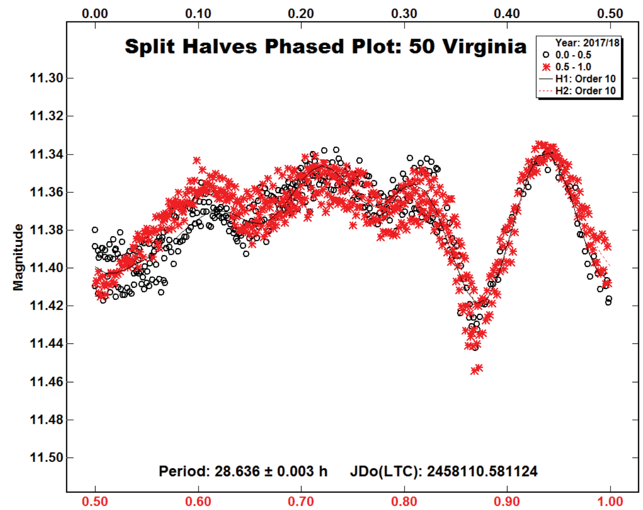
Synodic rotation periods and amplitudes are reported for 50 Virginia 14.318 ± 0.002 hours, 0.09 ± 0.01 magnitudes; 142 Polana 9.762 ± 0.002 hours, 0.17 ± 0.01 magnitudes; 597 Bandusia 7.6643 ± 0.0001 hours, 0.38 ± 0.02 magnitudes. The rotational spin vector of 597 Bandusia may be within 20 degrees of celestial longitude 30 degrees or 210 degrees, celestial latitude 0 degrees.

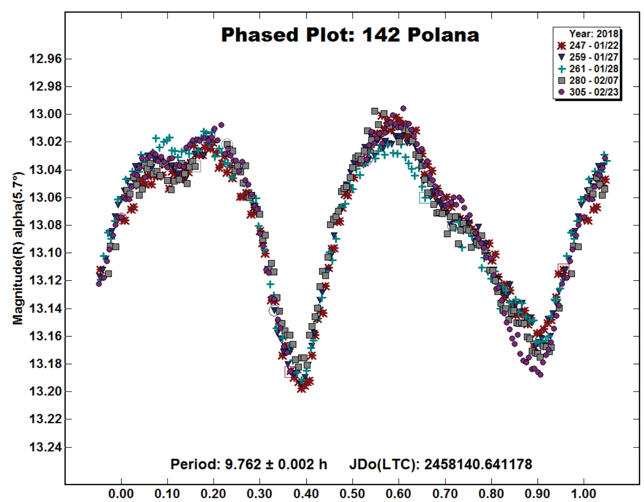
Observations to obtain the data used in this paper were made at the Organ Mesa Observatory with a 0.35-meter Meade LX200 GPS Schmidt-Cassegrain (SCT) and SBIG STL-1001E CCD. Exposures were 60 seconds, unguided, with a clear filter. Photometric measurement and lightcurve construction is with *MPO Canopus* 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.

50 Virginia. Warner et al. (2009, updated 2018 Mar. 7) list three previously published rotation periods within 0.005 hours of 14.315 hours and consider this period to be secure. New observations were made by the author on 8 nights 2017 Dec. 23 – 2018 Feb. 3 to contribute to lightcurve inversion modeling. They provide a fit to an irregular lightcurve with period of 14.318 ± 0.002 hours, amplitude 0.09 ± 0.01 magnitudes, and considerable variation in lightcurve shape with changing phase angle. A split halves plot phased to the double period 28.636 hours shows that variations within each half of the plot are greater than between halves of the plot, strong evidence against the double period. The 14.318 hour period found in this study is consistent with several previously reported results.





142 Polana. Previously published rotation periods are by Dotto et al. (1992), 9.770 hours; and by Barucci et al. (1994), 9.764 hours. New observations on 5 nights 2018 Jan. 22 – Feb. 23 provide a good fit to a bimodal lightcurve with period 9.762 ± 0.002 hours, amplitude 0.17 ± 0.01 magnitudes. This period is in excellent agreement with both previously published periods.

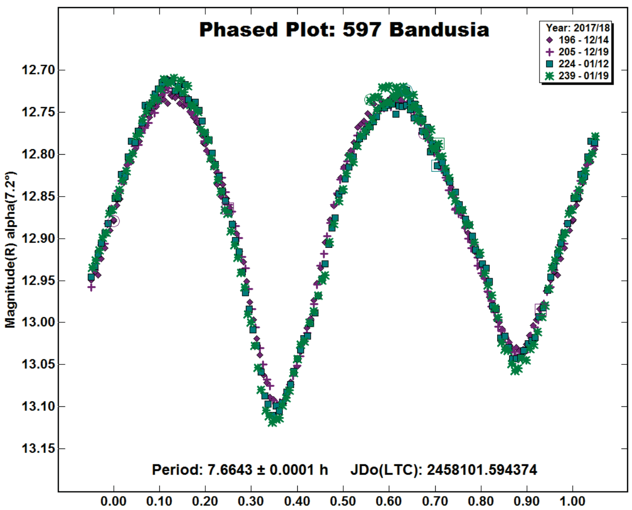


597 Bandusia. Previously published period determinations, are by Behrend (2002), period 11.50 hours, amplitude 0.11 magnudes at celestial longitude 207 degrees; Garlitz (2013), period 15.340 hours, amplitude 0.06 magnitudes at celestial longitude 30 degrees; and by Polakis (2018), period 7.6636 hours, amplitude 0.36 hours at celestial longitude 92 degrees at the same opposition as the study in this report. New lightcurves obtained on 4 nights 2017 Dec. 14 – 2018 Jan. 19 provide an extremely precise fit to a bimodal lightcurve with period 7.6643 ± 0.0001 hours, amplitude 0.38 ± 0.02 magnitudes near celestial longitude 92 degrees. It is noteworthy that this is in excellent agreement with Polakis (2018) at the same opposition. The 11.50 hour period by Behrend (2002) is an alias at 3/2 of the period obtained in this study and the 15.340 hour period by Garlitz is an alias with double the period obtained in this study. The relationships between celestial longitude at observation and amplitude provide considerable constraint on the location of the rotational pole. Celestial longitude and latitude, respectively, of the rotational spin vector are probably within 20 degrees of 30 degrees or 210 degrees, 0

Number	Name	yyyy/mm/dd	Pts	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.
50	Virginia	2017/12/23-2018/02/03	2796	2.4, 18.5	90	-4	14.318	0.002	0.09	0.01
142	Polana	2018/01/22-2018/02/23	2038	5.7, 2.7, 10.7	133	-1	9.762	0.002	0.17	0.01
597	Bandusia	2017/12/14-2018/01/19	1808	7.2, 6.2, 11.8	92	14	7.6643	0.0001	0.38	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, 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).

degrees. This places the observations in 2017/2018 at longitude 92 degrees at nearly equatorial aspect and the maximum possible amplitude. The small amplitudes reported by Behrend (2002) and by Garlitz (2013) make finding the period difficult, in these cases leading to commensurability alias periods that were resolved by the large amplitude and presumably near-equatorial aspect measurements in this current study.



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NEAR-EARTH ASTEROID LIGHTCURVE ANALYSIS AT CS3-PALMER DIVIDE STATION: 2018 JANUARY-APRIL

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(Received: 2018 Apr 13)

Lightcurves for 28 near-Earth asteroids (NEAs) obtained at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2018 January-April were analyzed for rotation period and signs of satellites or tumbling. In addition, re-examination of data for 2014 UR taken in 2014 shows that the rotation period is 0.2300 h and not the 2.37 h that was originally reported.

CCD photometric observations of 28 near-Earth asteroids (NEAs) were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2018 January-April. In addition, re-examination of data obtained in 2014 of the NEA 2014 UR showed that the period was 0.2300 h and not 2.37 h as originally reported (Warner, 2015).

Table I lists the telescope/CCD camera combinations that were used. 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 cause a 0.1-0.3 mag 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 APASS (Henden et al., 2009) or CMC-15 (Munos, 2017) 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).

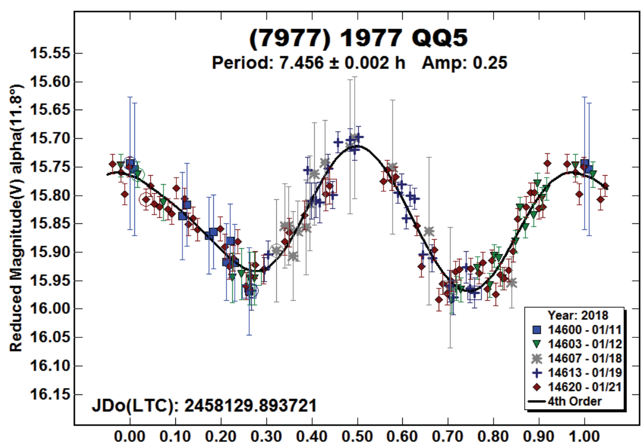
The nightly zero points for the APASS and CMC-15 catalogs are generally consistent to about ±0.05 mag or better, but occasionally reach > 0.1 mag. There is a systematic offset among the catalogs so, whenever possible, the same catalog is used for all observations of a given asteroid. Period analysis is done with *MPO Canopus*, which implements the FALC algorithm 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 (rΔ) to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. Unless otherwise stated, the magnitudes were normalized to the phase angle in parentheses using *G* = 0.15. The X-axis is the rotational phase, ranging from –0.05 to +1.05.

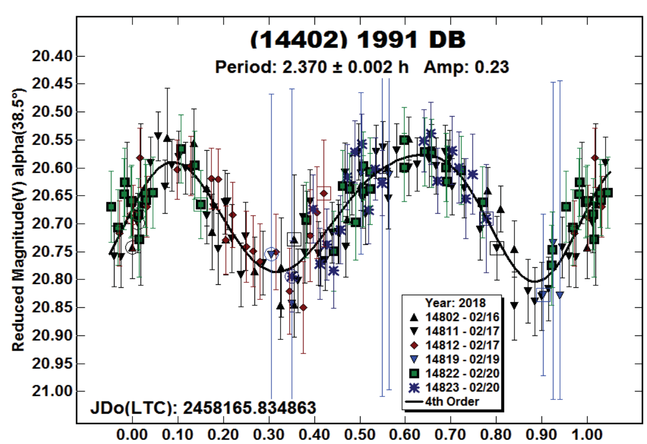
If the plot includes an amplitude, e.g., "Amp: 0.65", this is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*.

For the sake of brevity, only some of the previously reported results may be referenced in the discussions on 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 Bibcode, is also available for download. Readers are strongly encouraged, when possible, to cross-check with the original references listed in the LCDB.

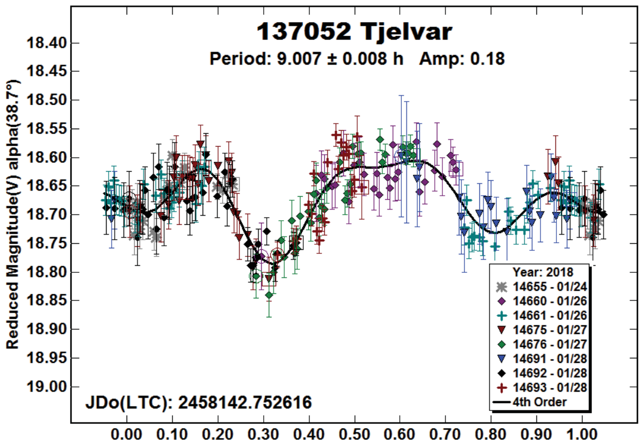
(7977) 1977 QQ5 is a 3 km NEA that was observed in mid-January. The period of 7.456 h is in good agreement with earlier results by Pravec et al. (1998web; 7.457 h) and Waszczak et al. (2015; 7.462 h).



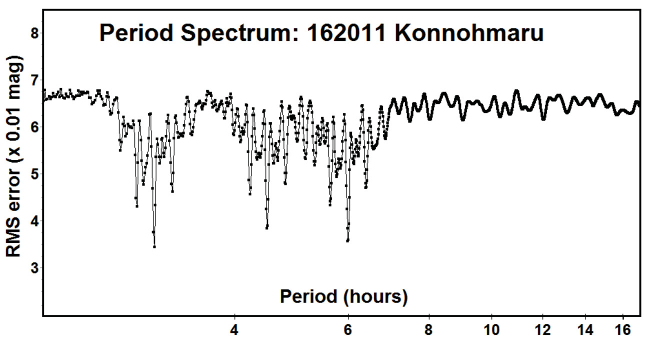
(14402) 1991 DB. Pravec et al. (2000) found a period of 2.2656 h based on observations in 2000 while Durkee (2011) and Behrend (2009) found periods near 3.57 h based on data obtained in 2009. The period of 2.370 h based on the CS3-PDS observations is in better agreement with the Pravec et al. (2000) result.

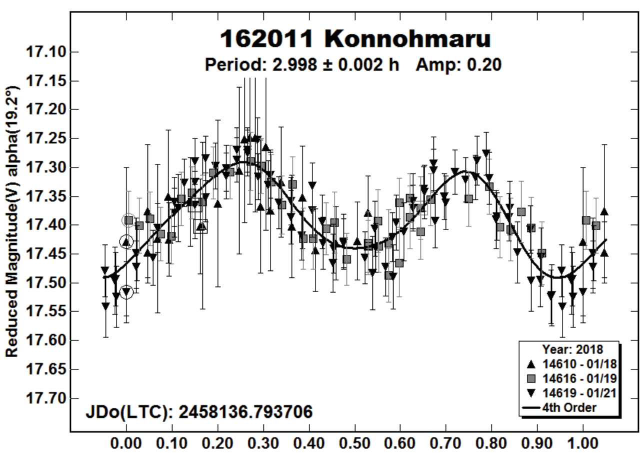


137052 Tjelvar has an estimated diameter of 1.2 km. Skiff (2011) found a period of 9.02 h. This is in good agreement with the 9.007 h given here.



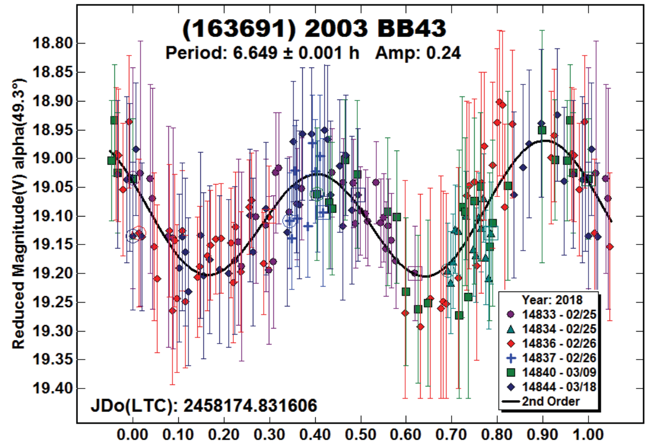
162011 Konnohmaru. This appears to be the first reported rotation period for this 1.5 km NEA. The period spectrum favors three possibilities. In most cases, the amplitude would favor a bimodal solution (Harris et al., 2014), which gives a period of 2.998 h.



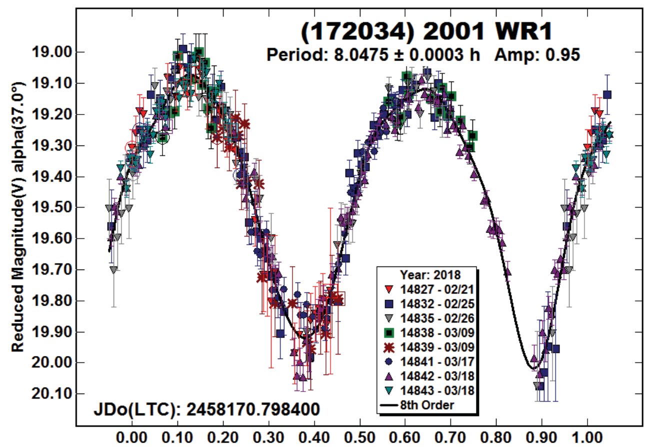


(163691) 2003 BB43. By default, an NEA is assumed to have an albedo of $p_V \sim 0.2$. However, WISE (Mainzer et al., 2011) and Nugent et al. (2015) found an average value of 0.025, which leads to a diameter of about 3.2 km if $H = 17.1$. If the default albedo is used, then the diameter is $D \sim 1.1$ km.

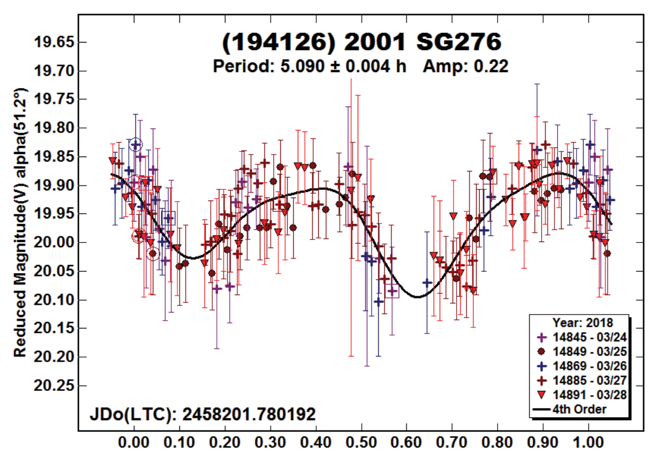
This may be the first reported rotation period. The solution is not fully secure, mostly because the error bars rival the lightcurve amplitude. The asteroid is V 19-22 at most oppositions. The next good chance is 2033 Feb, when it is V = 16.9 at +31° declination.



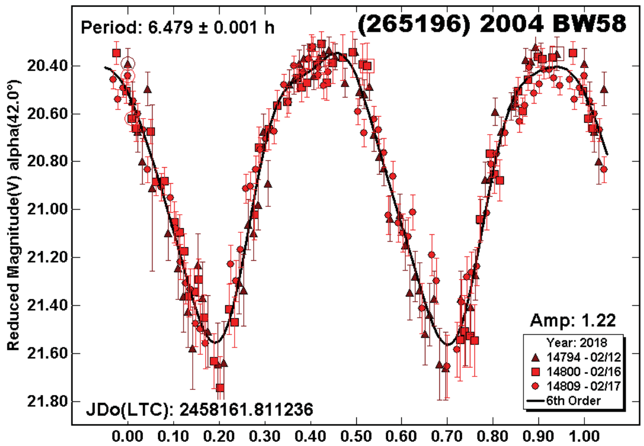
(172034) 2001 WR1. Nugent et al. (2015; 2016) give a diameter of 0.64 km. There were no previous LCDB lightcurve entries. The next apparition within reach of backyard telescopes is 2027 Oct.



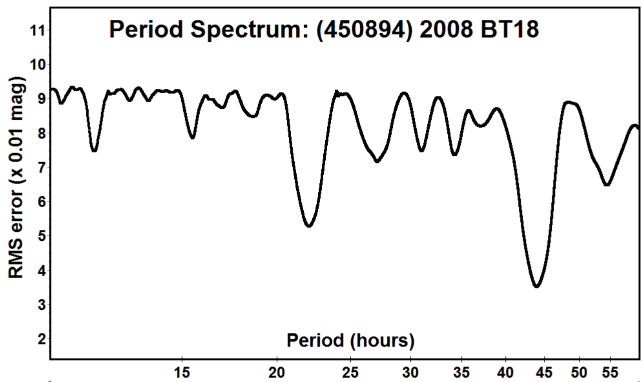
(194126) 2001 SG276. This 860 meter NEA was a target for Arecibo radar in 2018 April. The results, if any, were not available at the time of writing. This is apparently the first reported rotation period for the asteroid.

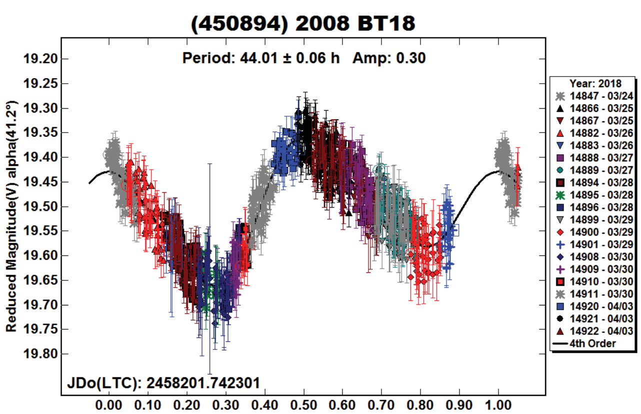


(265196) 2004 BW58. This is another apparent newcomer to the LCDB for its rotation period. WISE (Mainzer et al., 2012) found $p_V = 0.310$ and effective diameter of 0.36 km. Using the usually assumed albedo of 0.20, the diameter expands to about 0.5 km.



(450894) 2008 BT18. While the period spectrum and lightcurve for the adopted period of 44.01 h may not seem extraordinary, there is more to the story.



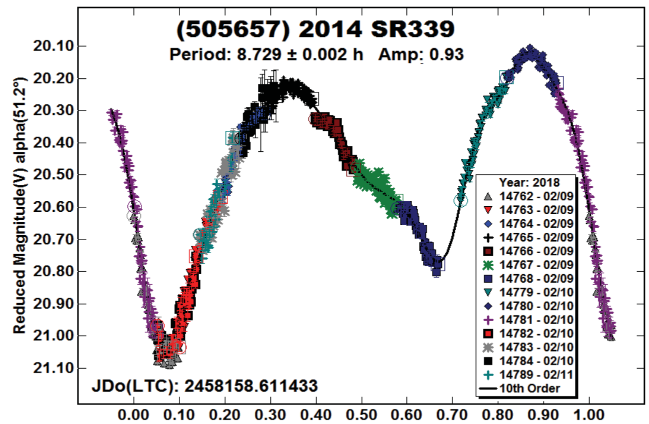


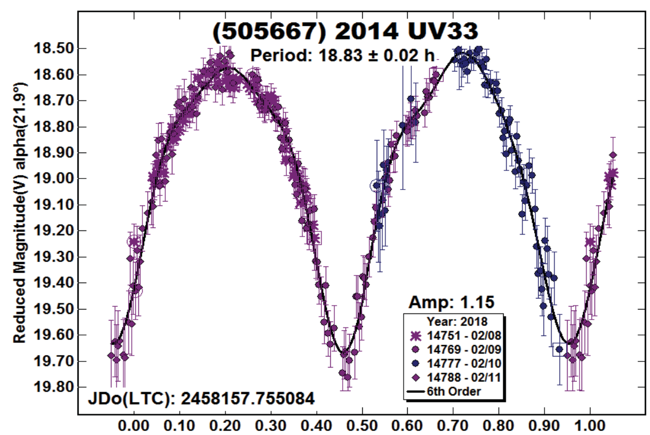
Using Arecibo radar, Benner et al. (2008a) found this to be a binary asteroid with diameters of about 0.6 km and > 200 meters. Pravec et al. (2008web) found a period of 2.5702 h and reported what may have been attenuations due to a satellite.

Alan Harris and Lance Benner (personal communications) used "back of the envelope calculations" and found that an orbital period of about 44 hours for the satellite was plausible, as was the lightcurve amplitude of 0.30 mag. These current results might be interpreted as the primary being viewed nearly pole-on and the long-period lightcurve is the rotation of an elongated satellite with its rotation period likely tied to its orbital period.

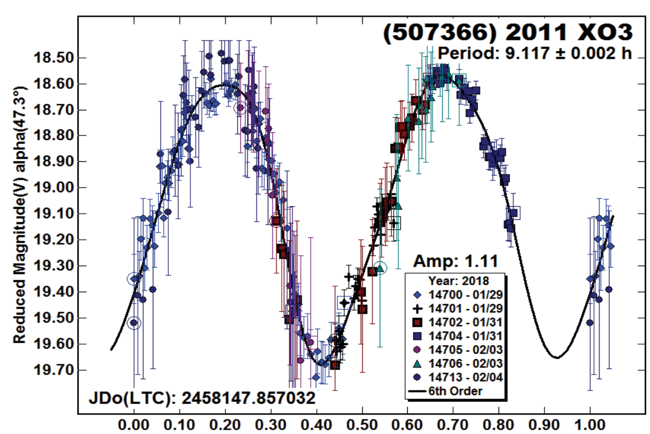
A dual period search with *MPO Canopus* found a period of 2.55 h, in reasonable agreement with Pravec et al. (2008). However, the lightcurve amplitude was 0.02 mag while the RMS fit was 0.04 mag, leaving essentially no confidence in the result.

(505657) 2014 SR339, (505667) 2014 UV33. There were no previous lightcurve results found in the LCDB for these two NEAs. For 2014 SR339, Nugent et al. (2015) found an albedo of $p_V = 0.07$ and $D = 0.97$ km. The usually assumed albedo of 0.20 and $H = 18.6$ from the MPCORB file give 0.57 km. This is an example of how using assumed values for albedo and/or class based on orbital group or family can lead to significantly different (and possibly wrong) results.

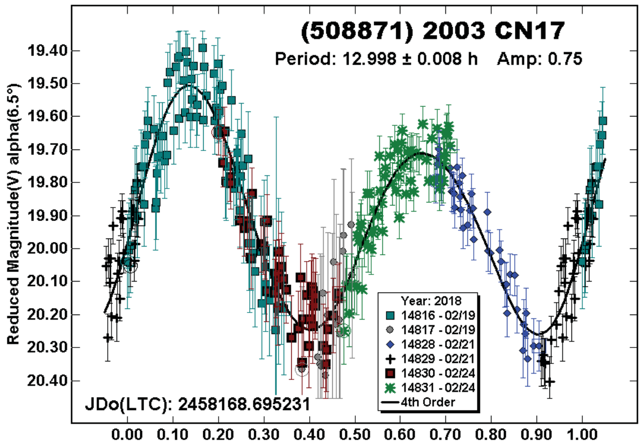


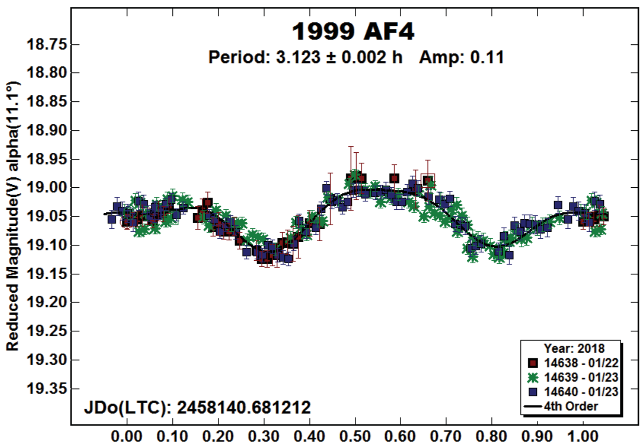


(507366) 2011 XO3. Behrend (2018) found a period of $P > 12$h for 2011 XO3. The data from CS3-PDS led to a bimodal lightcurve with a period of 9.117 h and amplitude of 1.11 mag. Even at a phase angle of 47°, the amplitude virtually assures a bimodal lightcurve (Harris et al., 2014).

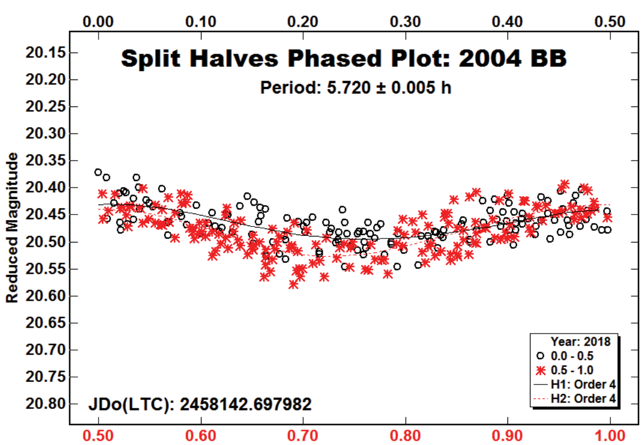


(508871) 2003 CN17, 1999 AF4. These two NEAs are new entries into the LCDB. The estimated diameters are 0.49 and 0.62 km, respectively.



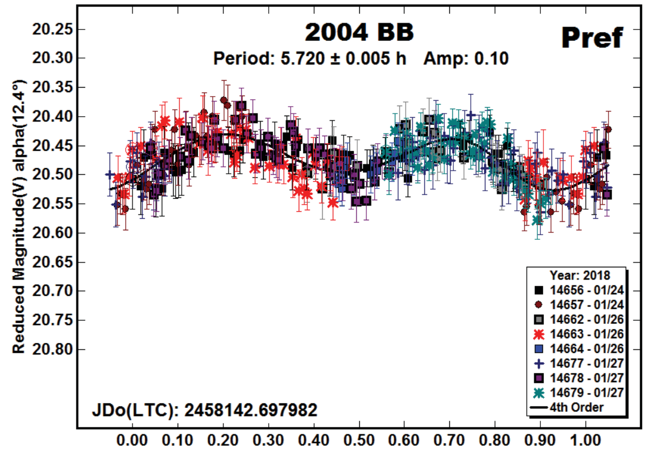


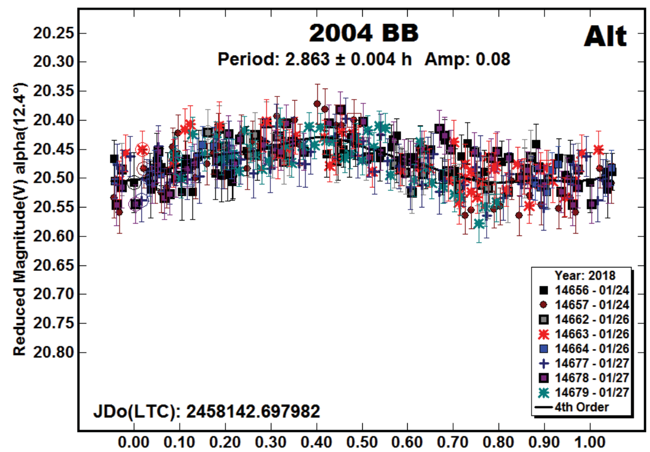
2004 BB. Pravec et al. (2018web) reported a period of 2.8756 h but the double-period could not be formally excluded. A period of 5.720 h, with a bimodal lightcurve, is preferred from the CS3-PDS data by virtue of having a lower RMS Fourier fit. In addition, the "split halves" plot also favored the longer period.



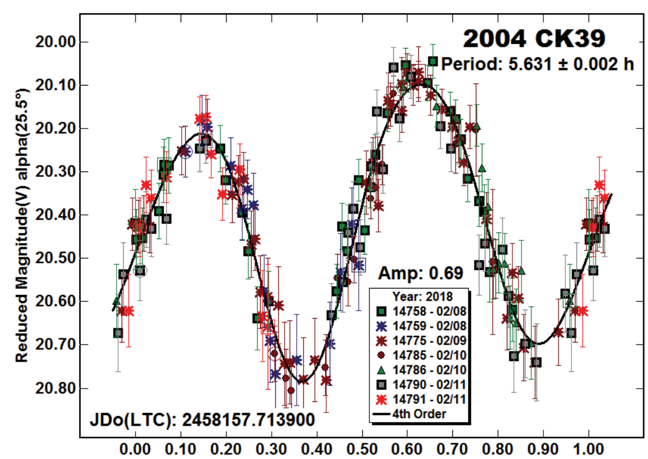
In the split-halves plot, the second half of a lightcurve phased to a given period is superimposed over the first half. If the two halves are essentially the same, then either the full or half-period is possible. In this case, the two halves seem to be sufficiently different to adopt the longer, bimodal solution.

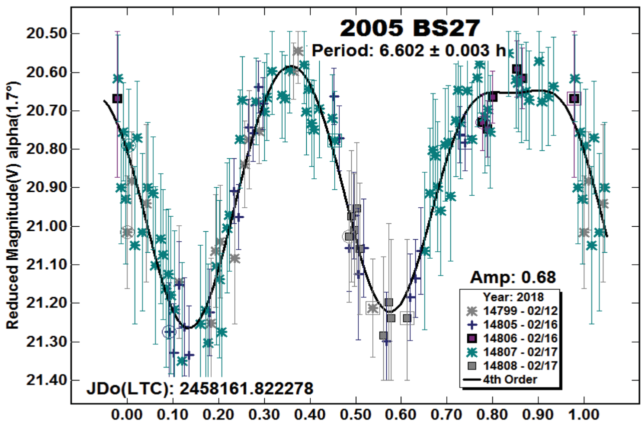
Still, the half-period with a monomodal lightcurve cannot be formally excluded. As discussed by Harris et al. (2014), either solution is possible.



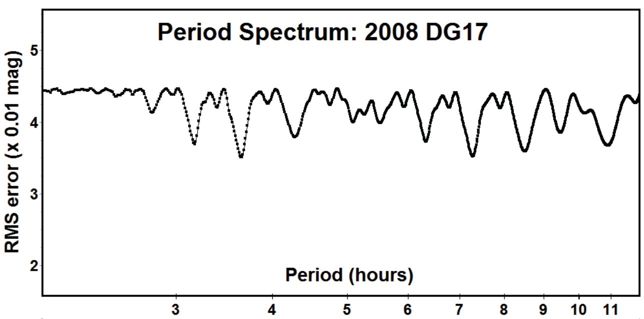


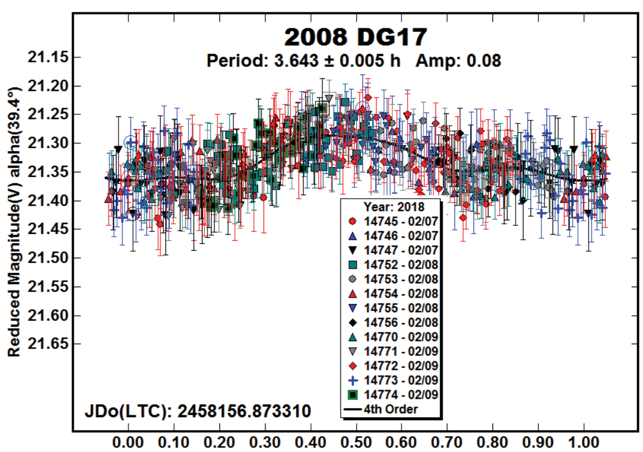
2004 CK39, 2005 BS27. Both of these NEAs are new to the LCDB. The estimated sizes are 490 and 250 meters, respectively. Unlike 2004 BB, both period solutions are considered secure because of the large amplitudes at low to modest phase angles (see Harris et al., 2014).





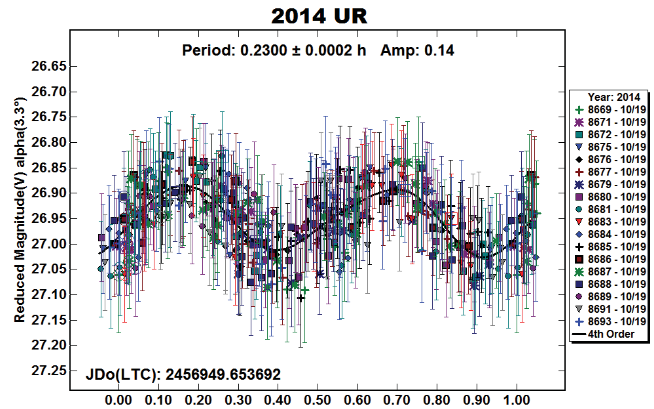
2008 DG17. Radar observations (*http://www.naic.edu/~pradar/; http://www.jpl.nasa.gov/asteroidwatch*) showed that this asteroid is a binary. The primary was D ~ 0.38 km and P ~ 2.8 h with a somewhat longer period possible. The CS3-PDS data led to a monomodal lightcurve with a period of 3.643 h. The double-period at 7.280 h cannot be formally excluded.



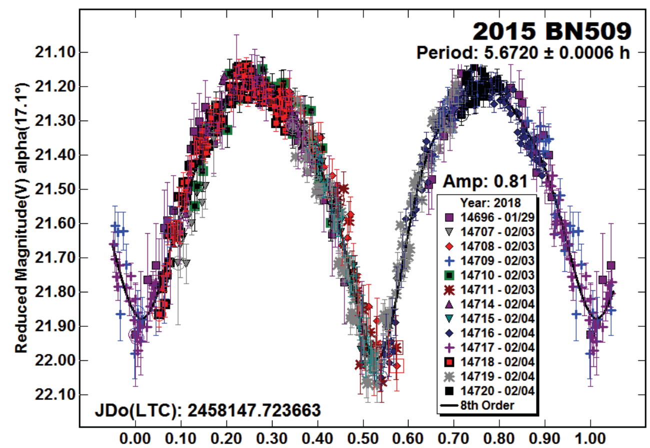


2014 UR. This 15 meter NEA was worked by the author in 2014 shortly after discovery (Warner, 2015). Analysis at that time found a period of 2.37 h, which seem contradicted by reports from those getting astrometry images and reported that they could see 0.5 magnitude jumps over just a few seconds.

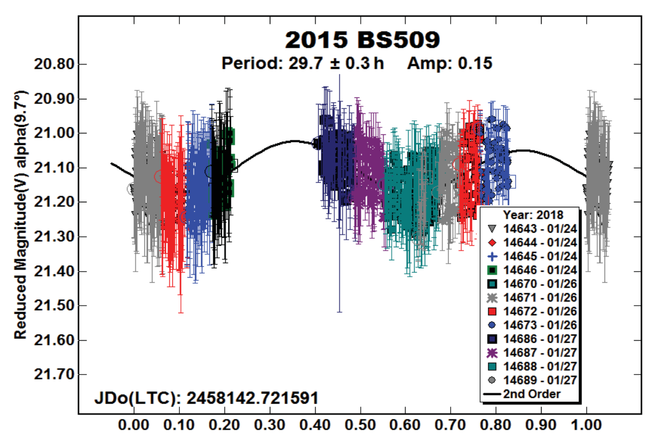
Marina Brozovic (personal communications) called attention to radar results obtained and analyzed by Patrick Taylor in 2014 that indicated a period of about 0.25 h was more likely. The 2014 lightcurve data were re-examined and were found to have a weak solution near 0.25 hours. After data smoothing to reduce the net noise, it was possible to get a solution of 0.2300 h. The new period spectrum showed only periods < 0.5 h and no signs of 2.37 h found in the initial analysis.

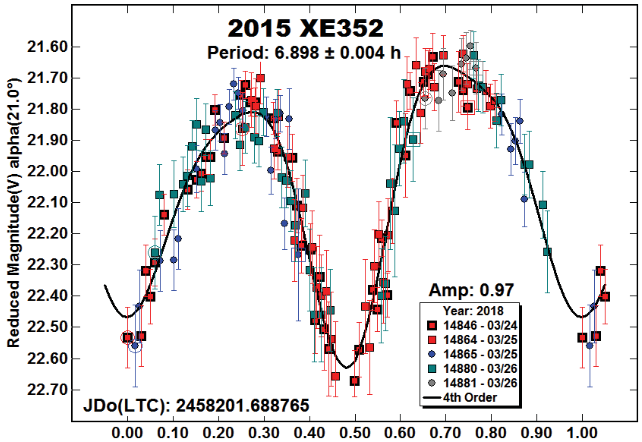


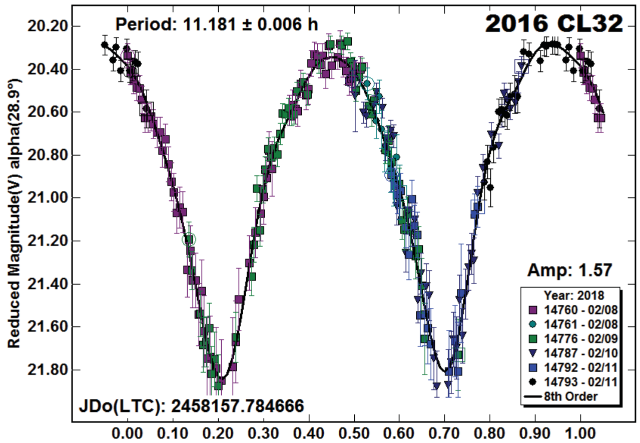
2015 BN509 was worked by the author in 2017 (Warner, 2017). The new analysis shows a very similar period with an amplitude 0.2 mag lower than in 2017. Pravec et al. (2018web) reported a similar period of 5.681 h.



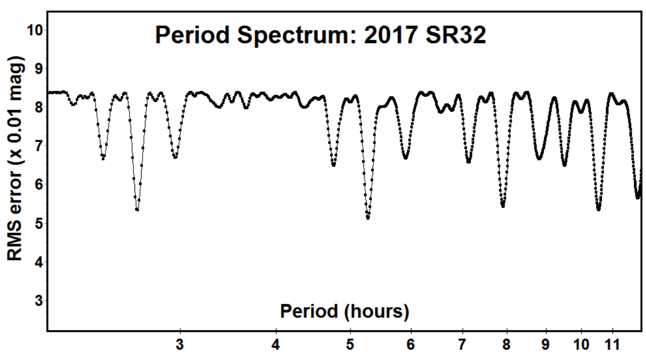
2015 BS509, 2015 XE352, 2016 CL32. There were no previous lightcurve entries in the LCDB for any of these three NEAs. 2015 BS509 has an estimated diameter of 270 meters. It was within reach of the CS3 scopes for too short a time to get a definitive solution, but a long period seems likely. On the other hand, the solution for 2015 XE352 is considered secure given the large amplitude and relatively low phase angle (see Harris et al., 2014). The estimated diameter is 200 meters. The result for 2016 CL32 is secure for the same reasons as for 2015 XE352. The estimated diameter for 2016 CL32 is 400 meters.





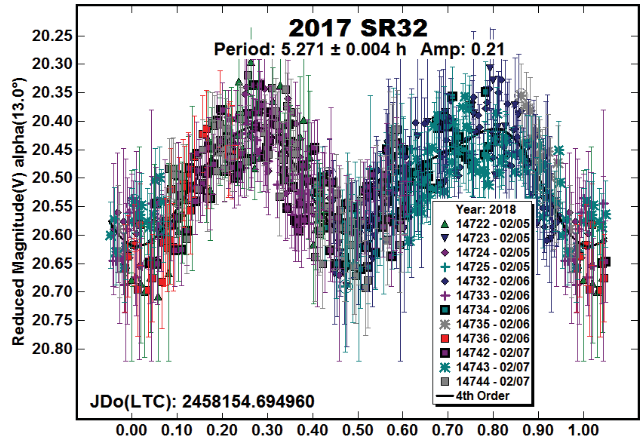


2017 SR32 has an estimated diameter of 400 meters. The SNR was not ideal during the observations even though it was V ~ 16.2 at the time. The moon being at waning gibbous phase was part of the reason, as was the shortened exposures of 60 sec required because of the sky motion of 10 arcsec/min.



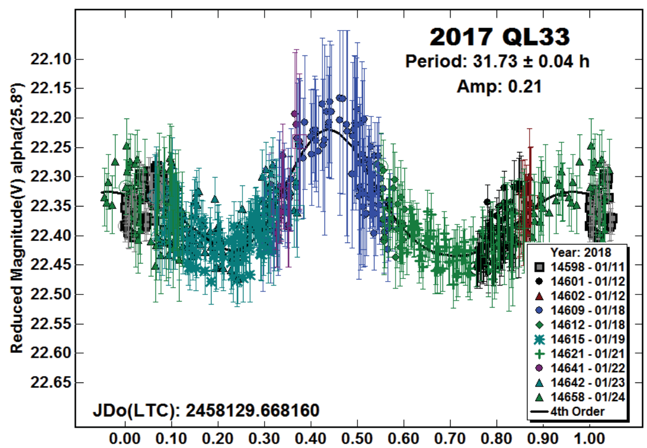
Fortunately, each observing run spanned almost 8 hours, meaning that more than one cycle of the adopted period was covered. However, as the period spectrum shows, the solution was not unique. The first three prominent minimums correspond to periods of about 2.6, 5.3, and 8 hours. These represent, respectively, a monomodal, bimodal, and trimodal lightcurve.

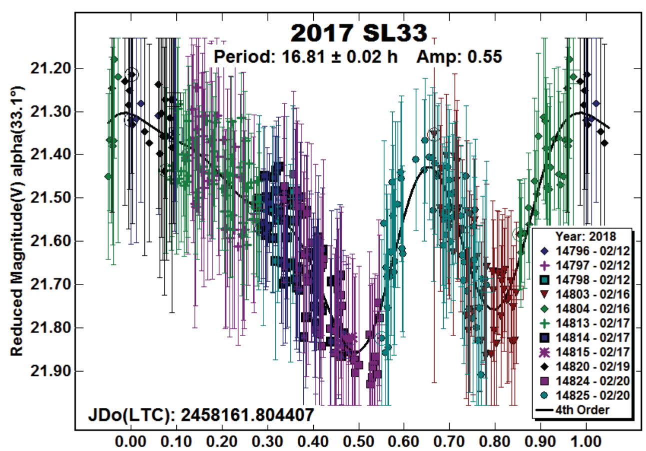
There is often the temptation to adopt a bimodal solution since it represents, in general, the lightcurve that is generated by regularly-shaped elongated body at low phase angles (Harris et al., 2014). The amplitude of 0.21 mag is almost at the cross-over point where one can safely assume a bimodal lightcurve. However, the noisy data make this assumption less certain.



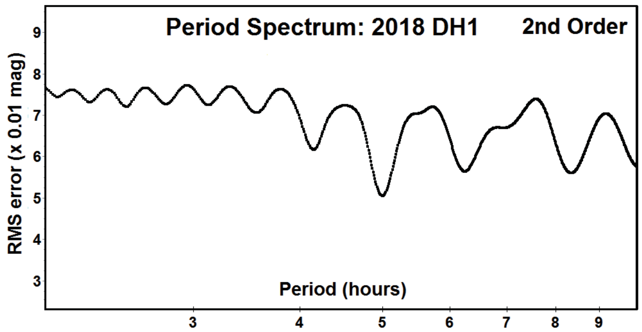
2017 QL33, 2017 SL33. There were no previous entries of any kind in the LCDB for these two NEAs. 2017 QL33 has an estimated diameter of 170 meters while 2017 SL33 has an estimate diameter of 330 meters.

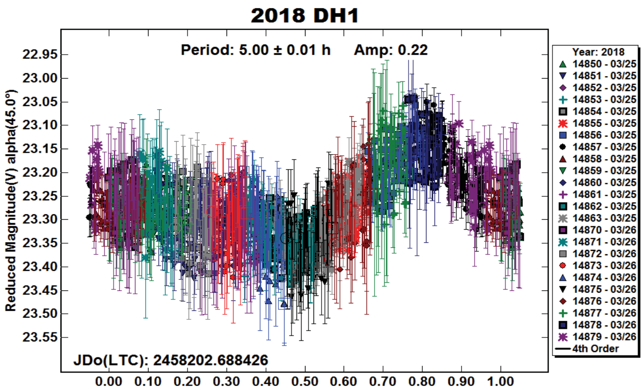
Neither period solution is secure, least of which is that for 2017 SL33, where the error bars almost rival the 0.55 mag amplitude and the lightcurve shape is highly asymmetric.



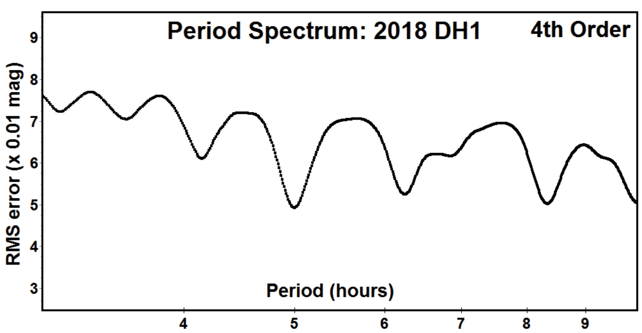


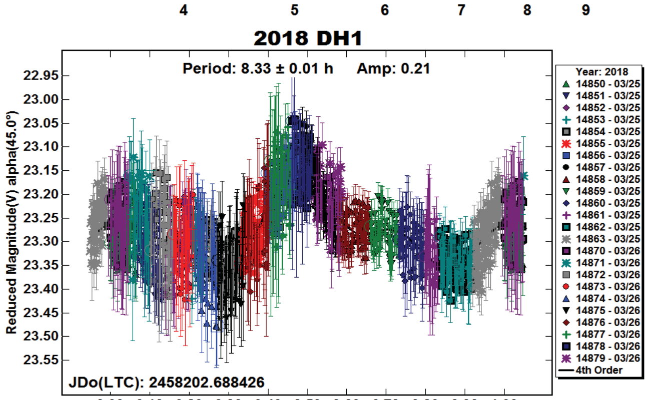
2018 DH1. This was a case where the number of harmonic orders used in the Fourier analysis changed the result significantly. This is shown in the two period spectra, one for a 2nd order and one for a 4th order fit. Because of the low SNR data, a second order fit was tried first since it isn't as prone to "latch onto noise." This gave a period of 5.00 h and amplitude 0.22 mag. The lightcurve, however, shows an unusual shape, which might be attributed to shadowing effects at the 45° phase angle.



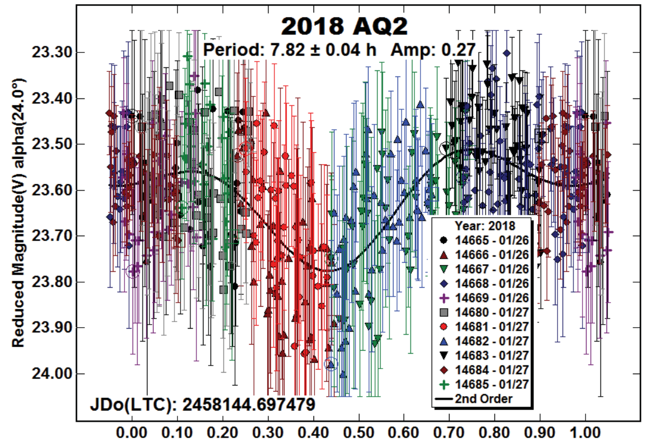


When going to the higher order analysis, the solution comes out as 8.33 h and similar amplitude of 0.21 mag. The lightcurve is a little more plausible, having a nearly symmetrical bimodal shape. The two periods have an almost exact 5:3 ratio, which casts doubt on both solutions since an integral ratio often implies that one period is a harmonic of the other. For this paper, the shorter period is adopted while also acknowledging that the longer period cannot be formally excluded.

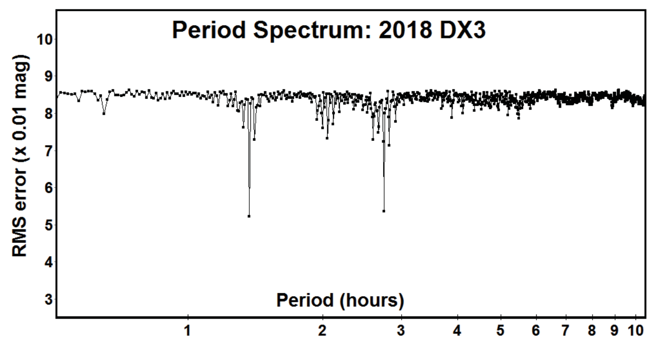


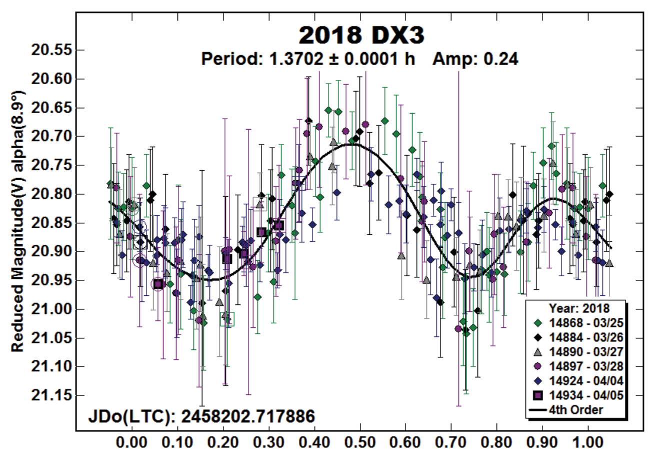


2018 AQ2 was faint and fast. Making things worse was that the estimated diameter made P < 2.2 h, even < 1.0 h, a possibility. These factors dictated short exposures that led to low SNR. There are indications of a period in the data, but with the error bars so large, exceeding the amplitude of the purported lightcurve, the period solution is not much more than a guess.



2018 DX3. The observations in late March clearly indicated a short period, as confirmed by the period spectrum. Assuming a bimodal shape, this gave P = 1.37 h. This is a bit unusual for an object with an estimated diameter of 300 meters. Generally objects need to be about 170 meters or smaller to have a good chance of being a superfast rotator, i.e., P < 2.2 h.





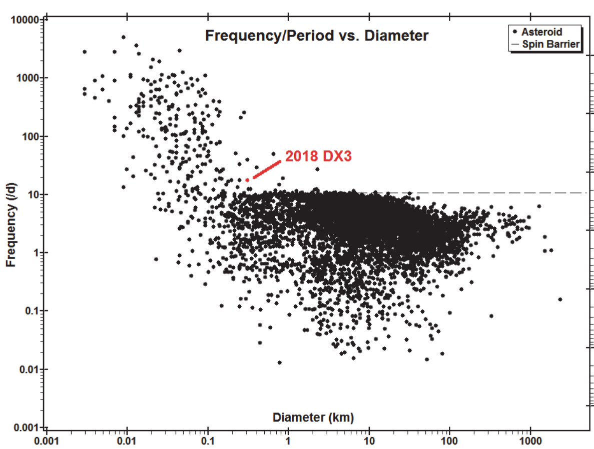
Because of a nearly full moon close to the asteroid's sky position, 2018 DX3 was taken off the observing list with hopes of observing it again after full moon and so the SNR would be higher. The observations on April 4 and 5 showed no reason to

Number	Name	2018 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
7977	1977 QQ5	01/11-01/21	131	11.8,7.6	119	-12	7.456	0.002	0.25	0.02
14402	1991 DB	02/16-02/20	158	38.5,39.9	177	0	2.370	0.002	0.23	0.03
137052	Tjelvar	01/24-01/28	230	38.7,43.2	136	33	9.007	0.008	0.18	0.02
162011	Konnohmaru	01/18-01/21	142	19.3,17.1	142	7	2.998	0.002	0.20	0.02
163691	2003 BB43	02/25-03/18	168	49.3,58.4	194	46	6.649	0.001	0.24	0.04
172034	2001 WR1	02/21-03/18	348	37.0,10.3	179	15	8.0475	0.0003	0.95	0.03
194126	2001 SG276	03/24-03/28	143	51.2,50.7	202	35	5.090	0.004	0.22	0.02
265196	2004 BW58	02/16-02/17	188	38.2,37.2	170	18	6.479	0.001	1.22	0.05
450894	2008 BT18	03/24-04/03	897	41.2,60.3	183	32	44.01	0.06	0.30	0.03
505657	2014 SR339	02/10-02/11	744	48.3,47.3	115	2	8.729	0.002	0.93	0.03
505667	2014 UV33	02/08-02/11	270	22.0,19.9	157	10	18.83	0.02	1.15	0.03
507366	2011 XO3	01/29-02/04	228	47.3,50.4	169	-4	9.117	0.002	1.11	0.03
508871	2003 CN17	02/19-02/24	281	6.5,0.0,10.4	103	-3	12.998	0.008	0.75	0.05
	1999 AF4	12/31-12/31	191	0.0,0.0,0.0	0	0	3.123	0.002	0.11	0.01
	2004 BB	01/24-01/27	317	12.4,6.8	130	-4	[A]5.720	0.005	0.10	0.02
	2004 CK39	02/08-02/11	161	25.5,26.8	150	18	5.631	0.002	0.69	0.04
	2005 BS27	02/16-02/17	125	4.6,6.1	144	-2	6.602	0.003	0.68	0.04
	2008 DG17	02/05-02/09	495	42.3,37.4	161	7	3.643	0.005	0.08	0.01
	2014 UR	[14]10/19-10/19	382	6.7,6.7	24	3	0.2300	0.0002	0.14	0.02
	2015 BN509	01/29-02/04	595	17.1,14.7,50.4	149	1	5.672	0.0006	0.81	0.03
	2015 BS509	01/24-01/27	712	9.5,4.5	129	-1	29.7	0.3	0.15	0.03
	2015 XE352	03/24-03/26	152	21.1,24.9	171	6	6.898	0.004	0.97	0.05
	2016 CL32	02/08-02/11	219	29.0,25.9	157	14	11.181	0.006	1.57	0.04
	2017 SR32	02/05-02/07	638	13.1,15.8	143	7	5.271	0.004	0.21	0.03
	2017 QL33	01/11-01/24	586	25.8,11.4	123	9	31.73	0.04	0.21	0.03
	2017 SL33	02/16-02/20	371	28.8,26.6	166	10	16.81	0.02	0.55	0.06
	2018 DH1	03/25-03/26	1340	46.6,61.1	189	28	5.00	0.01	0.22	0.03
	2018 AQ2	01/26-01/27	483	24.3,27.7	131	14	7.82	0.04	0.27	0.08
	2018 DX3	03/25-04/05	800	8.9,6.9	188	5	1.3702	0.0001	0.24	0.03

Table II. Observing circumstances. [A](Period): preferred period of an ambiguous solution. [yy](Dates): data are from the year 20YY. 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.

expect a dramatically different result and so confirmed and somewhat refined the short period.

The location of the asteroid is shown in the familiar frequency-diameter plot taken from LCDB data. This shows that, while a bit unusual, 2018 DX3 is not an overt outlier.



Acknowledgements

PDS observations, analysis, and publication are self-funded. Work on the asteroid lightcurve database (LCDB) is funded by National Science Foundation grant 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.

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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ASTEROID LIGHTCURVE ANALYSIS AT CS3-PALMER DIVIDE STATION: 2018 JANUARY-APRIL

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Lightcurves for six main-belt asteroids were obtained at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2018 January-April. Two of the asteroids were *targets of opportunity*, i.e., in the field of planned targets, which demonstrates a good reason for data mining images.

CCD photometric observations of six main-belt asteroids were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2018 January-April. Table I lists the telescope/CCD camera combinations that were used. All the cameras use the KAF-1001E blue-enhanced CCD chip 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 cause a 0.1-0.3 mag 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 APASS (Henden et al., 2009) or CMC-15 (Munos, 2017) 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, 2007b).

The nightly zero points for the APASS and CMC-15 catalogs are generally consistent to about ±0.05 mag or better, but occasionally reach > 0.1 mag. There is a systematic offset among all three catalogs so, whenever possible, the same catalog is used for all observations of a given asteroid. Period analysis is done with *MPO Canopus*, which implements the FALC algorithm by Harris (Harris *et al.,* 1989).

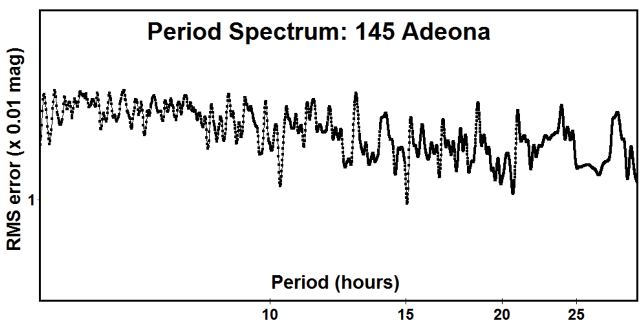
In the lightcurves below, the "Reduced Magnitude" is Johnson V as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distance by applying $-5*\log(r\Delta)$ to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid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

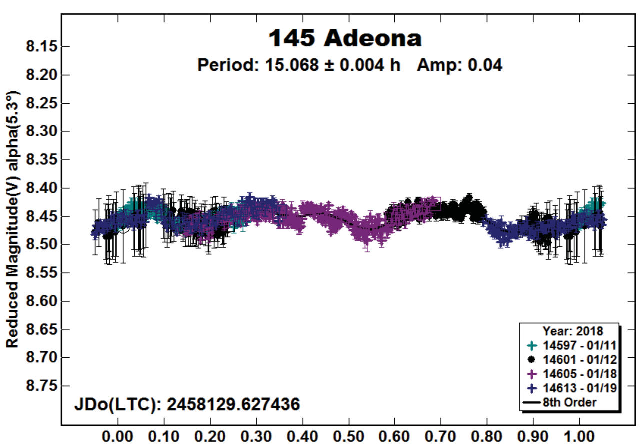
If the plot includes an amplitude, *e.g.*, "Amp: 0.65", this is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*.

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 Bibcode, is also available for download. Readers are strongly encouraged, when possible, to cross-check with the original references listed in the LCDB.

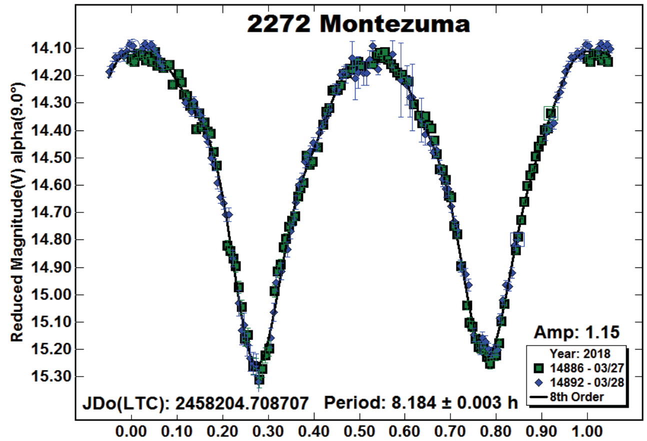
145 Adeona is a 150 km member of the Eunomia group. The first reliable (LCDB U > 1+) rotation period was reported by Burchi et al. (1985), who found a period of 8.1 h. Behrend (2004) found a period of 8.301 h, but that was with a noisy data set and low amplitude lightcurve. Stephens (2009) and Pilcher (2010) found highly reliable results (U = 3) of 15.086 h and 15.017 h, respectively.

The observations at CS3-PDS were made at the request of Josef Hanus, who was updating a shape and spin axis model for the asteroid. The period of 15.068 h found from the CS3-PDS data is in good agreement with Stephens (2009) and Pilcher (2010).

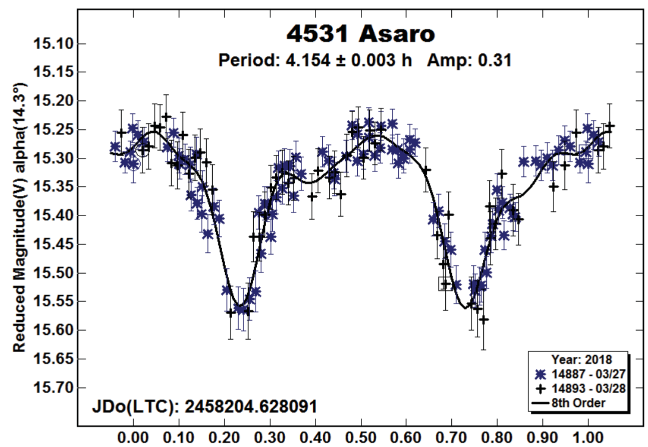




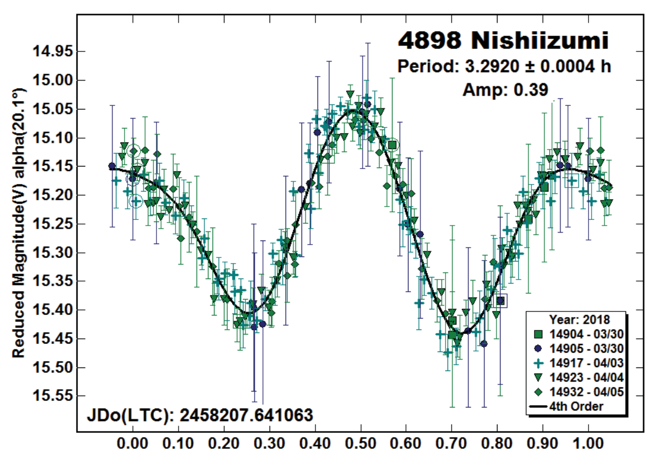
2272 Montezuma. This is a Hungaria asteroid that was observed at three previous apparitions by Stephens et al. (2014), Stephens (2017), and Warner (2012b), all of whom reported a period of 8.180-8.183 h. The period of 8.184 h found from the most recent CS3 data is in excellent agreement with those earlier findings.



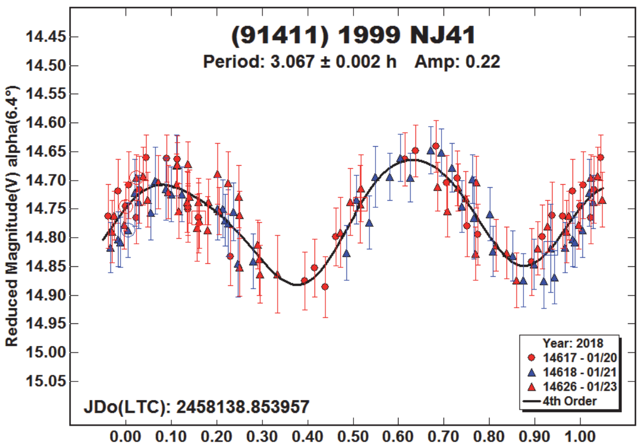
4531 Asaro. The data obtained in 2018 March was the fifth time that the Hungaria asteroid had been observed by the author. The previous results (Warner, 2013; 2015a; 2015b) ranged from 4.118-4.16 h. The period of 4.154 h reported here is in good agreement.



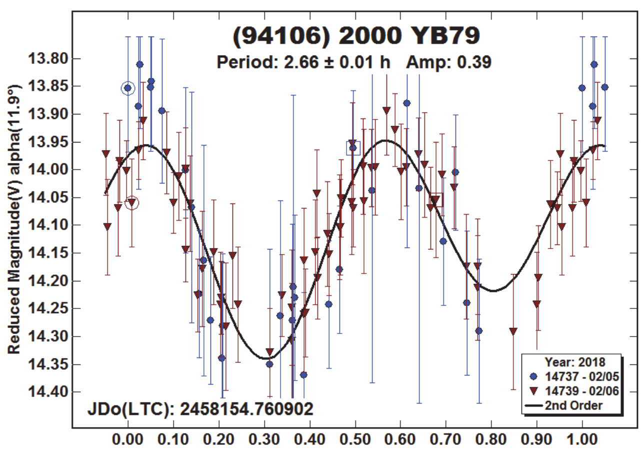
4898 Nishiizumi. This is another Hungaria member that was observed so that data could be used in lightcurve inversion to improve a previously found shape and spin axis. Previous results by the author, Warner (2007a; 2012b; 2015c), are in close agreement with the most recent result of 3.2920 h. The amplitude, A = 0.39 mag, was the largest by at least 0.1 mag, indicating the most equatorial view of the asteroid to-date.



(91411) 1999 JN41. This 4.4 km Eunomia asteroid was a *target of opportunity*, one that was in the same field as the planned target. There were no previous lightcurve results in the LCDB. The period of 3.067 h is considered secure.



(94106) 2000 YB79 is a 12 km outer main-belt asteroid that was serendipitously wandering through the field of a planned target. It was V ~ 18, so the SNR was low. However, it was possible to get a reliable solution because of the large amplitude.



Acknowledgements

Observations, analysis, and publication are self-funded. Work on the asteroid lightcurve database (LCDB) was funded by National Science Foundation grant AST-1507535.

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 based in part 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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Number	Name	2018 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Group
145	Adeona	01/11-01/19	1069	5.3,6.8	112	10	15.068	0.004	0.04	0.01	EUN
2272	Montezuma	03/28-03/28	244	8.8,8.8	193	11	8.184	0.003	1.15	0.02	H
4531	Asaro	03/28-03/28	142	14.7,14.7	172	12	4.154	0.003	0.31	0.02	H
4898	Nishiizumi	03/30-04/05	209	20.1,22.8	162	5	3.2920	0.0004	0.39	0.03	H
91411	1999 NJ41	01/20-01/23	111	6.4,7.2	112	10	3.067	0.002	0.22	0.02	EUN
94106	2000 YB79	02/05-02/06	91	11.9,11.6	166	13	2.66	0.01	0.39	0.04	MB-O

Table II. Observing circumstances and results. The phase angle (α) is given at the start and end of each date range. 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). EUN: Eunomia; H: Hungaria; MB-O: outer main-belt.

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2018 AJ: A TUMBLING NEAR-EARTH ASTEROID

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CCD photometric observations of the near-Earth asteroid 2018 AJ were made during its close approach (4.7 lunar distances) to Earth in 2018 January. Analysis of data obtained over three nights shows that the asteroid is in a state of non-principal axis rotation (NPAR, "tumbling") with possible periods of 0.6722 ± 0.0006 h and 0.986 ± 0.002 h. The lightcurve observations alone could not determine which period is that of rotation and the other of precession nor whether or not the corresponding rotation frequencies are the actual or a linear combination of the true values.

The near-Earth asteroid 2018 AJ was discovered by the Mt. Lemmon survey on 2018 Jan 5 (JPL, 2018). Shorty after, orbit calculations showed that the asteroid would approach the Earth at a minimum distance of about 4.7 lunar distances on Jan 23 around 12:23 UT.

The CCD photometric observations at CS3-PDS from Jan 22-24 were made using a 0.35-m *f*/9.1 Schmidt-Cassegrain and SBIG STL-1001E camera with a KAF blue-enhanced chip (1024x1024x24μ pixels). The resulting image scale was 1.5 arcsec/pixel. No filter was used given the 15-20 sec exposures that were required due to rapid sky motion.

Measurements were made using *MPO Canopus* using master dark and flat-field frames. The Comp Star Selector utility in *MPO Canopus* found up to five comparison stars of near solar-color for differential photometry. Comp star magnitudes were taken from the APASS catalog (Henden et al., 2009). The session-to-session zero points for the catalog were generally consistent to ≤ 0.05 mag or better. The data were light-time corrected and adjusted for changing distances and geometry before period analysis.

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

Number	Name	2018 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
	2018 AJ	01/22	114	24.5,24.9	133	6	0.737	0.006	0.88	0.05
	2018 AJ	01/23	672	32.8,35.4	140	1	1.0081	0.0004	0.98	0.03
	2018 AJ	01/24	226	44.2,47.2	147	-4	1.0077	0.0008	1.15	0.05
	2018 AJ	**01/23**	**672**	**32.8,35.4**	**140**	**1**	**0.6722**	**0.0002**	**1.09**	**0.05**
	2018 AJ	**01/23**					**0.986**	**0.002**		
	2018 AJ	**01/24**	**226**	**44.2,47.2**	**147**	**-4**	**0.6725**	**0.0006**	**1.26**	**0.05**
	2018 AJ	**01/24**					**0.982**	**0.005**		

Table I. Observing circumstances. The phase angle (α) is given at the start and end of each date's observations. L_{PAB} and B_{PAB} are each the average phase angle bisector longitude and latitude (see Harris *et al.*, 1984). The results in normal text are by Warner using single-period analysis. The results in bold are by Pravec using software with a dual-period search feature capable of handling tumbling asteroids. In each case, the first line gives what is called P1 and the second line gives P2. See the text for more information.

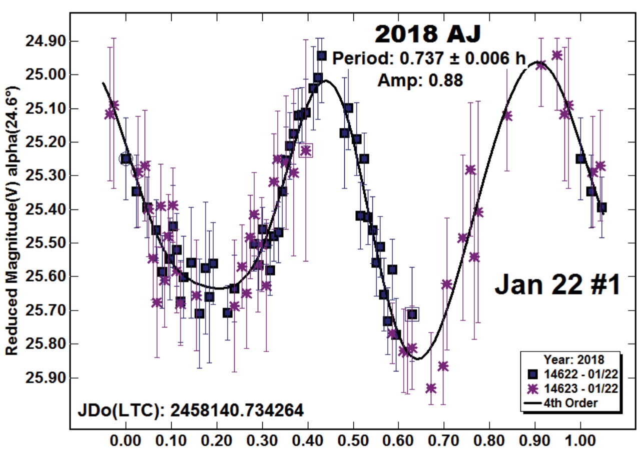
–5*log (rΔ) to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the given phase angle, e.g., alpha(6.5°), using $G = 0.15$, unless otherwise stated. The X-axis is the rotational phase ranging from –0.05 to 1.05.

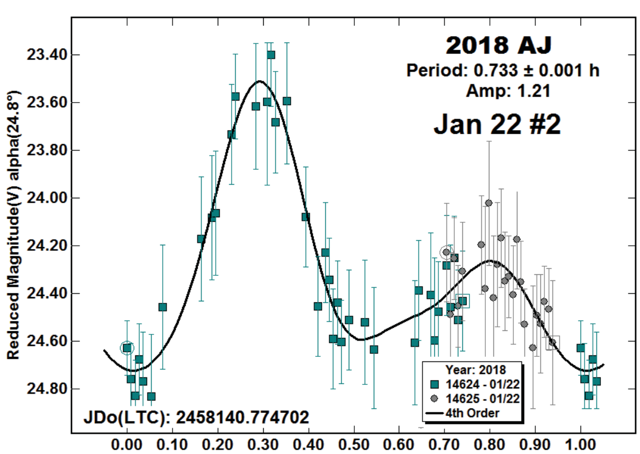
The amplitudes given in the lightcurves, e.g., "Amp: 0.65", is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*.

First order period analysis was done with *MPO Canopus*, which implements the FALC algorithm by Harris (Harris *et al.,* 1989). However, this program cannot handle non-additive multiple periods such as found with tumbling asteroids (Pravec et al., 2005; 2010). Final period analysis was performed by Pravec and will be discussed below.

Observations and Single-Period Analysis

2018 Jan 22. The first observations at CS3-PDS were made on Jan 22 under marginal conditions that forced an early end of the observations. A total of 114 observations were accumulated over 2.5 h. Because of a large gap between two sets of observations, Warner analyzed each set separately for a single-period solution.

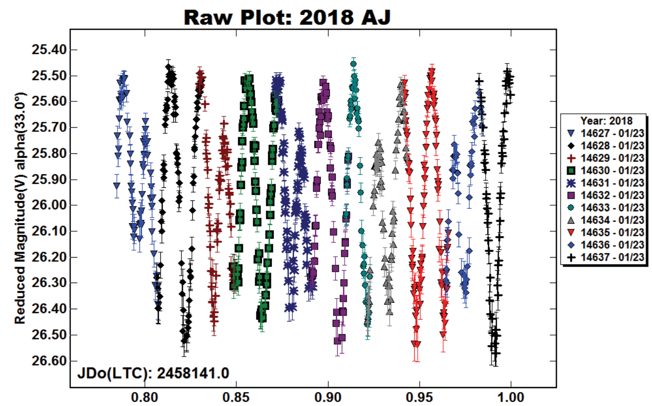


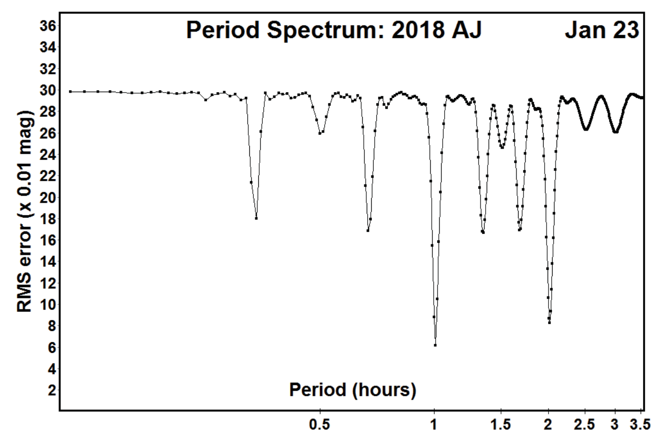


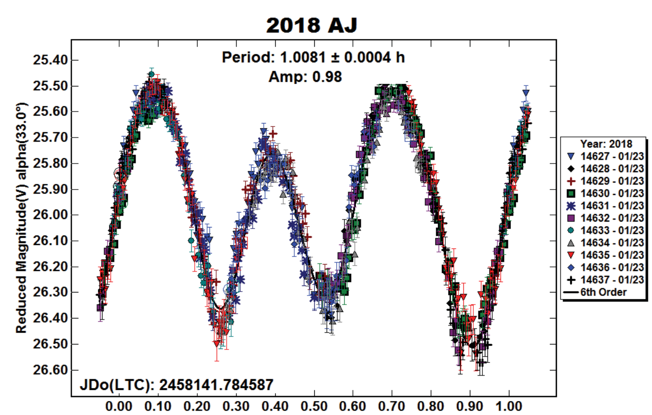
On the same night, radar observations were made at the Arecibo radar facility in Puerto Rico (Patrick Taylor, personal communications). Very preliminary analysis at the time indicated a period of about 45 minutes, a 2:1 elongation, and hints of tumbling.

2018 Jan 23. The night of Jan 23 saw much better observing conditions. A total of 672 observations were made over a period of about five hours. The raw plot of the data, i.e., magnitude versus time, showed a large amplitude and clear cyclical pattern with very short period, but the maximums and minimums did not exactly repeat.

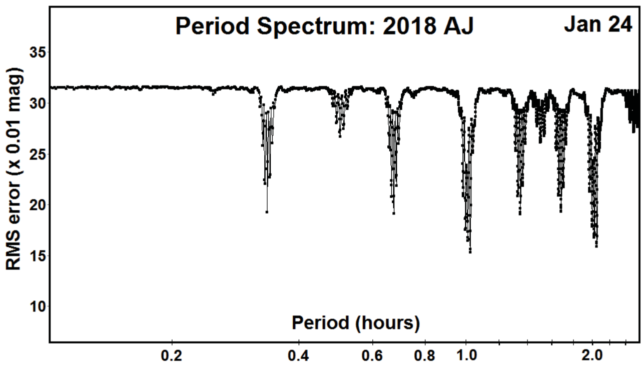
The single-period analysis by Warner found a good fit to a trimodal lightcurve with a period of 1.0081 h. However, as discussed below, this represented a physically-improbable solution (Harris et al., 2014).

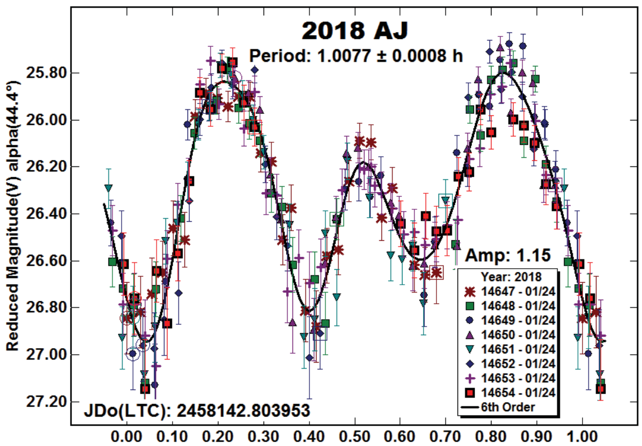






2018 Jan 24. This was the last night that observations could be made at CS3-PDS because of a combination of incoming weather and the asteroid fading. A total of 226 observations were made over a span of six hours.





A comparison of the phased plots from Jan 23 and Jan 24 shows a significant change in the shape of the lightcurves and amplitude. The larger amplitude on Jan 24 was to be expected as the phase angle increased from about 34° to 45° between the two nights. The smaller data set on Jan 24 produced a period spectrum with less well-defined minimums but still in good agreement with the one from Jan 23.

Tumbling Analysis

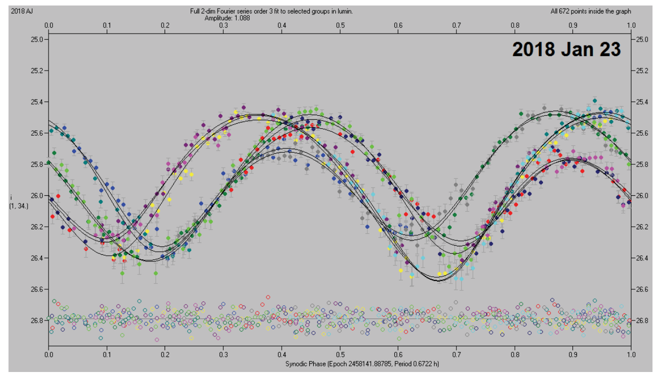
As discussed by Harris et al. (2014), the trimodal lightcurves for 2018 AJ on Jan 23-24 represent physically improbable, if not impossible, solutions. Specifically, at relatively low phase angles, a lightcurve with an amplitude of about 1 mag can be generated only by a (nearly) symmetrical and regular body. This was covered in the first part of their paper. In the closing section, they examined the case of 2010 RC130, which also produced a reasonably good fit to a single period with a large amplitude and also had a complex lightcurve shape. In that case, the complex curve was the result of two, similar periods (rotation and precession) that nearly repeated after an integer ratio of cycles. The data for 2018 AJ were pointing in the same direction.

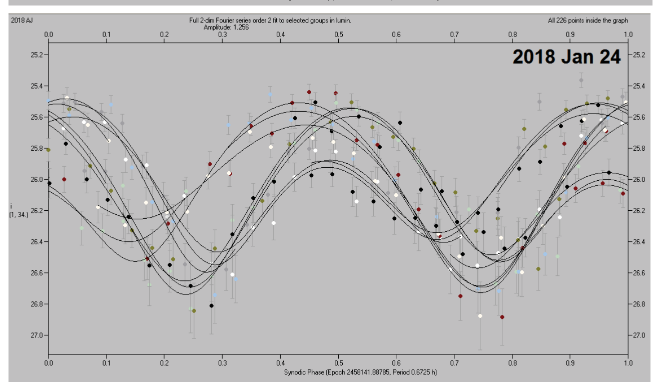
The dual-period search feature of *MPO Canopus* cannot properly analyze tumbling asteroids. Therefore, the CS3-PDS data were sent to Pravec for his analysis using custom software with the needed capabilities.

The details of analysis and nature of tumbling asteroids is beyond the scope of this paper. We strongly recommend Pravec et al. (2005) as essential reading on the topic. Follow-up work in Pravec et al. (2014) should also be the reading list since it revises estimates of the "damping time" of tumbling asteroids. This is the time it takes for an asteroid to go from tumbling to single-axis ("normal") rotation.

The results of Pravec's analysis are shown below. Because of the substantial change in viewing aspect between Jan 23 and 24, the data set for each night was handled separately. As might be expected, the plots are not simple curves but a composite of a number of curves that follow the complex change in the asteroid's brightness during its tumbling action.

For Jan 23, Pravec found $P_1 = 0.6722 \pm 0.0002$ h and $P_2 = 0.986 \pm 0.002$ h with a full range amplitude (based on the Fourier curves) of 1.09 ± 0.05 mag; the results for Jan 24 were $P_1 = 0.6725 \pm 0.0006$ h and $P_2 = 0.982 \pm 0.005$ h with a full range amplitude of 1.26 ± 0.05 mag. Statistically, the two period sets are the same.





The increase in amplitude from Jan 23 to 24 is expected because the phase angle increased from about 34° to 46° (Zappala et al., 1990). Using their formula to correct the amplitude to 0° phase angle gives *A(0)* ~ 0.54 mag. In turn, this gives a lower limit of *a/c* ~ 1.6 if assuming a simple ellipsoid with *a* being the longest axis and *c* the shortest.

There are two important uncertainties about these results. The first is that it is not possible to attribute one period or the other to rotation and the other to precession. It *may* be possible to use radar data in a model combining all data to determine which period is that of rotation. The second uncertainty is whether or not these results are the true periods of rotation and precession. A tumbler's lightcurve is the result of a linear sum of two frequencies (Pravec et al., 2005). With the available data, we cannot say if the two frequencies determined here represent the true values or they are integral multiples of the true frequencies. Here again, radar and/or other additional data might provide more definitive results.

Acknowledgements

Observations at CS3 are self-funded. Work on the asteroid lightcurve database (LCDB) by Warner was funded by National Science Foundation grant AST-1507535. He also gratefully acknowledges a Shoemaker NEO Grant from the Planetary

Society (2007), which was used to purchase of one the telescopes 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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Zappala, V., Cellini, A., Barucci, A.M., Fulchignoni, M., Lupishko, D.E. (1990). "An analysis of the amplitude-phase relationship among asteroids." *Astron. Astrophys*. **231**, 548-560.

LIGHTCURVE ANALYSIS OF HILDA ASTEROIDS AT THE CENTER FOR SOLAR SYSTEM STUDIES: 2018 JANUARY-FEBRUARY

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(Received: 2018 Apr 13)

Lightcurves for five Hilda asteroids were obtained at the Center for Solar System Studies (CS3) from 2018 January-February: 361 Bononia, 1902 Shaposhnikov, 3415 Danby, (20038) 1992 UN5, and (20628) 1999 TS40.

CCD photometric observations of five Hilda asteroids were made at the Center for Solar System Studies (CS3) from 2018 January-February. This is another installment of an on-going 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 (Yarkovsky–O'Keefe–Radzievskii–Paddack) 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 APASS (Henden et al., 2009) or CMC-15 (*http://svo2.cab.inta-csic.es/vocats/cmc15/*) 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).

Number	Name	2018 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
361	Bononia	01/26-01/28	606	8.0,7.4	147	12	13.835	0.007	0.17	0.01
1902	Shaposhnikov	01/28-02/09	379	8.5,6.6	168	13	20.988	0.006	0.31	0.02
3415	Danby	01/28-02/06	219	8.2,6.3	164	-2	5.675	0.001	0.35	0.03
20038	1992 UN5	01/28-02/07	258	7.6,7.2	136	23	6.941	0.002	0.28	0.02
20628	1999 TS40	02/10-03/24	340	4.6,4.1,4.9	229	3	68.1	0.1	1.04	0.10

Table III. Observing circumstances. The phase angle (α) is given at the start and end of each date range. L_{PAB} and B_{PAB} are each the average phase angle bisector longitude and latitude (see Harris *et al.*, 1984).

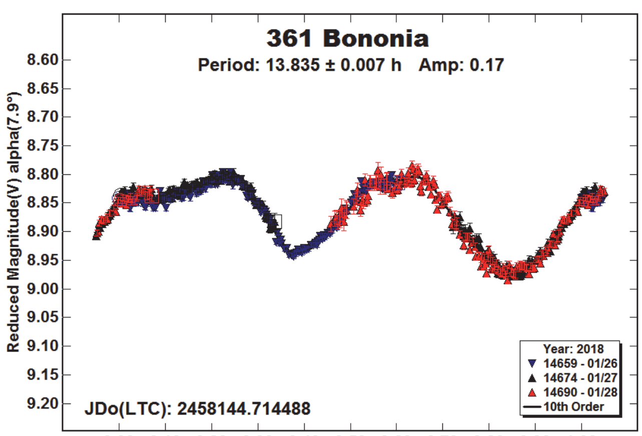
The nightly zero points for the APASS and CMC-15 catalogs are generally consistent to about ±0.05 mag or better, but occasionally reach >0.1 mag. There is a systematic offset among all the catalogs so, whenever possible, the same catalog is used for all observations of a given asteroid. Period analysis is done with *MPO Canopus*, which implements the FALC algorithm 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 phase angle in the parentheses using $G = 0.15$, unless otherwise stated. The X-axis is the rotational phase ranging from –0.05 to 1.05.

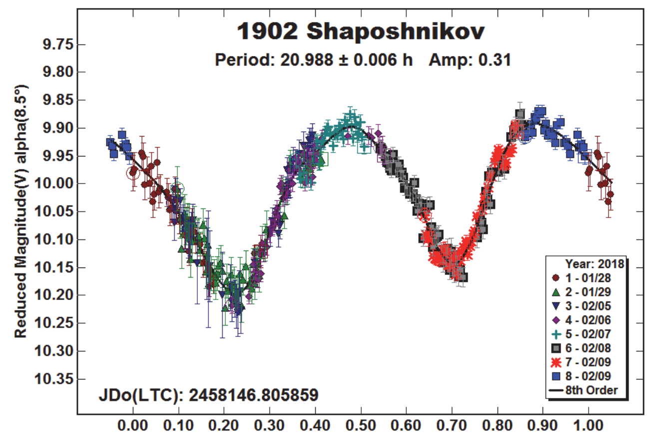
If the plot includes an amplitude, *e.g.*, "Amp: 0.65", this is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*.

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 Bibcode, is also available for download. Readers are strongly encouraged to obtain, when possible, the original references listed in the LCDB for their work.

361 Bononia. Binzel and Sauter (1992) reported a period of 13.83 ± 0.02 h for this 140 km Hilda. The only other publically available results are from Hanus et al. (2016) who presented a shape and spin axis model with a sidereal period of 13.80634 h, and Warner et al. (2017a) who found 13.79 h. The result of 13.835 h is the longest of these all but still in good agreement.

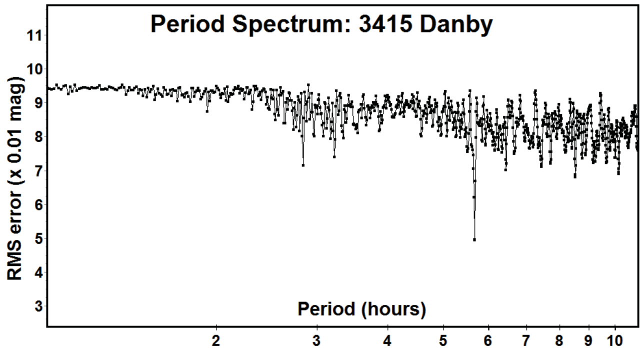


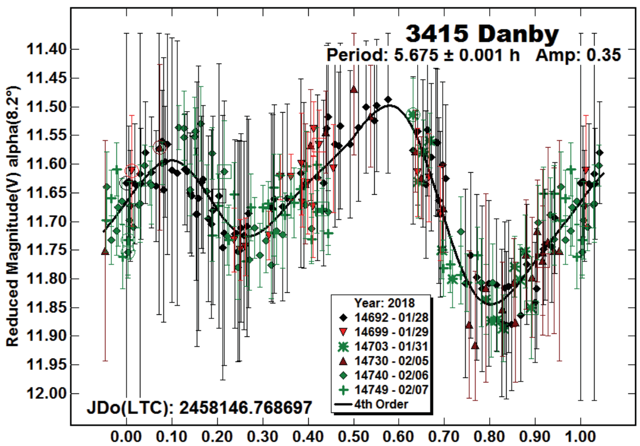
1902 Shaposhnikov has an estimated diameter of about 97 km. The average reported albedo is $p_V \sim 0.035$ (e.g., AKARI, Usui et al., 2011). This is a little lower than the average albedo for Hildas in the LCDB ($p_V = 0.046$) when considering only those that were determined and not assumed values. Hanus et al. (2016) found a sidereal rotation period of 20.9959 h. Warner et al. (2017b) found a synodic period of 20.987 h. Our latest result is almost exactly the same.



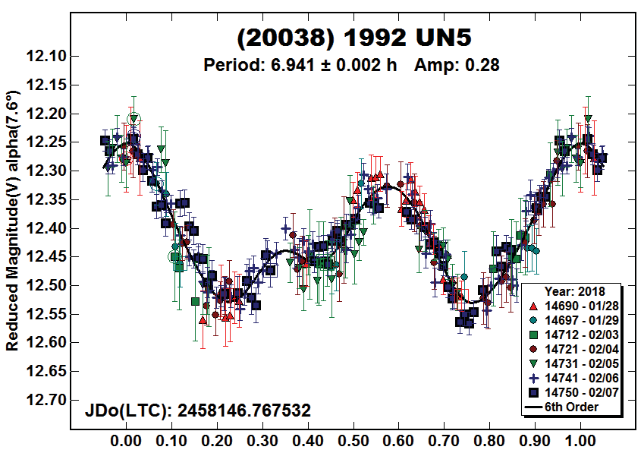
3415 Danby. There are numerous previous results for Danby, which has an estimated diameter of 32 km. Dahlgren et al. (1998) found a period of 2.851 h. Warner (2008) found a doubled period of 5.666 h, as did Behrend (2007, 2015; 5.6706 h). When Warner et al. (2017a) observed Danby in 2016, they found the shorter period: 2.837 h. On re-examining Warner's 2007 data, the original result was changed to 2.834 h. However, both of these were stated to be ambiguous solutions, with the double period of about 5.6 h being almost as likely.

The 2018 observations were hampered by low SNR data (large error bars). Were it not for the large amplitude, by far the largest reported to-date, we would not have been able to give a reliable solution. At this point, we believe a period of 5.675 h is the most likely since the amplitude almost demands a bimodal lightcurve (Harris et al., 2014) and not the quadramodal lightcurves often associated with the 2.8 h solutions. Still, the period cannot be said to be definitively solved and future observations are planned.

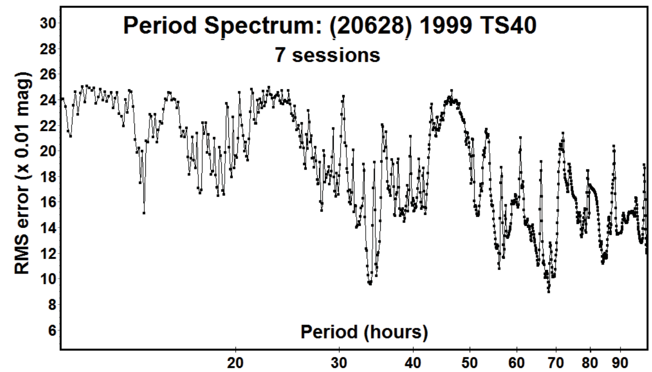


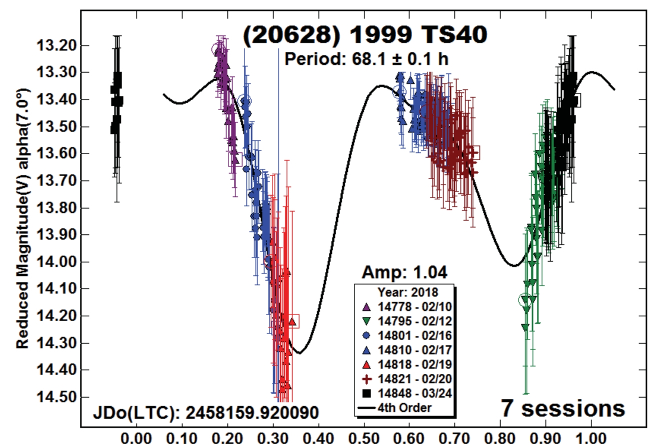


(20038) 1992 UN5. Previous results include Polishook (2011, 6.9 h) and Warner et al. (2017a, 6.944 h). Our period of 6.941 h is in close agreement with our earlier result.

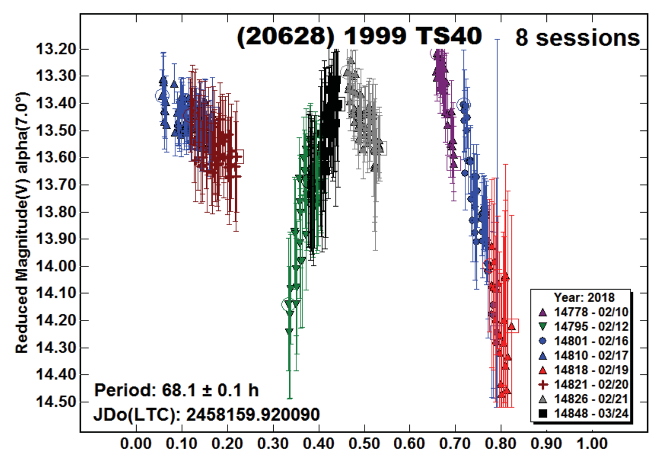


(20628) 1999 TS40. A limited data set of poor quality was all that could be managed for this 18 km Hilda. Using seven of eight sessions (Feb 21 was excluded), the period spectrum showed a very indecisive result, with two possible solutions near 35 hours and 70 hours. Given the apparent large amplitude (see Harris et al., 2014), a bimodal solution was found with a period of 68.1 h, but this can hardly be considered reliable.





When the eighth session (Feb 21) was added to the analysis and the period forced to 68.1 h, it's clear that the Feb 21 session does not fit well with the rest of the data. A period search using all eight sessions covering the same range as in the period spectrum given here was essentially identical.



The ill-fitting lightcurve lends itself to the possibility that the asteroid is tumbling (see Pravec et al., 2005). However, based on even a set of shorter times to go from tumbling to normal rotation (see Pravec et al., 2014), 1999 TS40 is not a likely candidate for tumbling. However, rules of thumb are not rigorous and there are examples in the LCDB where an asteroid should be tumbling but is not and when it should not be tumbling but it is.

MPO Canopus cannot properly analyze tumbling asteroids. However, even if it could, the data set is far too sparse to make even an initial attempt at analysis using software with the needed capabilities. One possibility is that *MPO Canopus* is locking onto a dominant period in the data set that maybe one of the periods of non-principal rotation (NPAR, "tumbling") or that it is finding a "beat frequency", i.e., a period that is nearly an integral ratio of the actual tumbling periods.

The best step towards resolving the mystery is to observe the asteroid under more favorable conditions and involve observers at well-separated longitudes. Looking ahead, the 2023 and 2025 apparitions will be the next ones with V < 18.0.

Acknowledgements

Observations at CS3 are self-funded by the authors. Work on the asteroid lightcurve database (LCDB) by Warner was funded by National Science Foundation grant AST-1507535. The authors gratefully acknowledge Shoemaker NEO Grants from the Planetary Society (2007, 2013). 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. It was also based on data from the 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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LIGHTCURVE AND SYNODIC ROTATION PERIOD OF THE NEAR-EARTH ASTEROID (475967) 2007 JF22

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(Received: 2018 Apr 5)

CCD photometric observations of near-Earth asteroid (475967) 2007 JF22 were made by the authors in 2018 March and April. Analysis of the data found a bimodal lightcurve with a period of P = 25.60 ± 0.01 h and amplitude A = 1.19 ± 0.05 mag.

The near-Earth asteroid (475967) 2007 JF22 with an Amor-type orbit was discovered on 2007 January 8 at Socorro by the Lincoln Near-Earth Asteroid Research (LINEAR) project. A review of the asteroid lightcurve database (LCDB; Warner et al., 2009) and other sources found no previously reported rotation period.

The 2018 apparition of 2007 JF22 was the only one between 1995 and 2050 when the asteroid was V < 17.0. This made it a rare opportunity for photometric observations with typical 0.3-0.4-m backyard telescopes.

Independent observations by Benishek were started on 2018 March 27 at Sopot Astronomical Observatory in Serbia and by Warner on 2018 March 29 at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS). Warner used a 0.35-m *f*/9.1 Schmidt-Cassegrain telescope (SCT) equipped with a Finger Lakes ML-1001E CCD; the image scale was 1.45 arcsec/pixel. Benishek used a 0.35-m *f*/6.3 SCT with SBIG ST-8XME CCD binned 2x2. The image scale was 1.66 arcsec/pixel. The observations were unfiltered to maximize SNR.

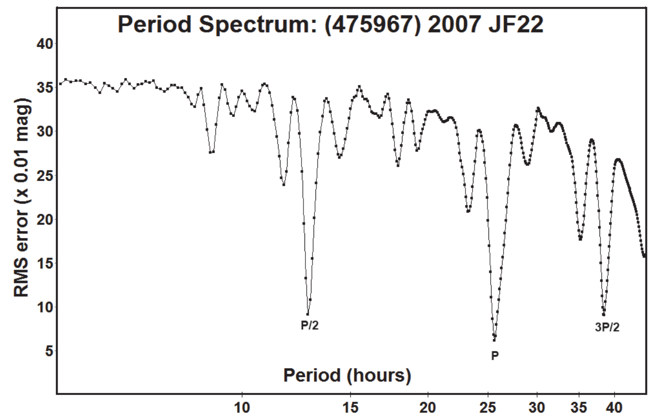
From each independent set, the period seemed to be about 25 hours, which would make it very hard for a single station to cover the entire lightcurve in a reasonable amount of time. Benishek appealed for help and we formed a collaboration. Our observatories are well-separated in longitude, which is important when trying to find the period for an object with a period nearly commensurate with an Earth day.

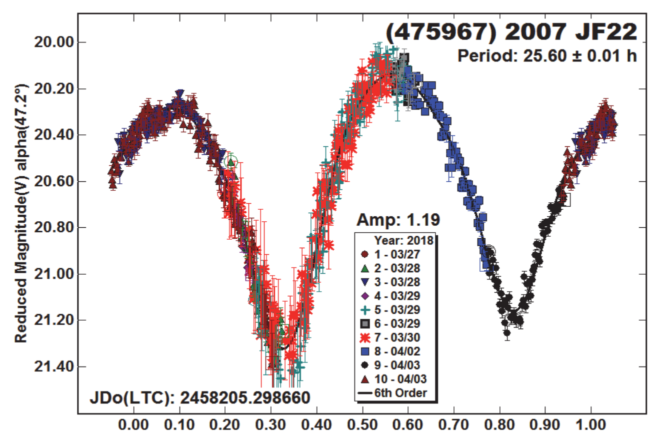
At the end of observations on 2018 April 3, we had a total of 10 data sets (*sessions*), four of which were by Warner (sessions 5-7, 10) and six were by Benishek (sessions 1-4, 8-9).

MPO Canopus software (Warner, 2018) was used for data sharing, photometric measurements, lightcurve construction and period analysis. *MPO Canopus* allows differential aperture photometry with up to five comparison stars of near solar color (0.5 ≤ B-V ≤ 0.9) using the Comparison Star Selector (CSS) feature. To achieve a satisfactory consistency level of magnitude zero-points for individual data sets, the Johnson V magnitudes from the AAVSO Photometric All-Sky Survey catalog (APASS; Henden et al., 2009) were used for calibration of field comparison stars. Subsequent zero-point adjustments mostly required adjustments of only a few hundredths of a magnitude to find a global minimum RMS for the Fourier model.

Both authors performed period analysis on the overall data and obtained consistent results. The lightcurve plot and period spectrum shown here were made by Warner.

In the lightcurve, the "Reduced Magnitude (V)" represents Johnson V magnitude corrected to a unity distance by applying –5*log (rΔ) to the measured sky magnitudes. The quantities r and Δ are the Sun-asteroid and Earth-asteroid distances in astronomical units, respectively. The magnitudes were normalized to the phase angle given in parenthesis using a value for the slope parameter of G = 0.15.





Since the solar phase angle changed by only 2° during the span of observations, the lightcurve showed no noticeable changes in amplitude or shape.

The period spectrum shows three prominent RMS minimums. Given the amplitude of the lightcurve, the only realistic solution was a bimodal lightcurve (Harris et al., 2014). This corresponds to a solution of P = 25.60 ± 0.01 h.

Number	Name	Points	2018 mm/dd	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
475967	2007 JF22	654	03/27-04/03	44.3,42.2	179	39	25.60	0.01	1.19	0.05	NEA

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).

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NEW LIGHTCURVE AND ROTATION PERIOD DETERMINATION FOR 1884 SKIP

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(Received: 2018 Apr 10)

New densely-sampled CCD observations of the main-belt asteroid 1884 Skip carried out from 2017 November to 2018 January yielded a synodic rotation period of P = 2.89484 ± 0.00005 h.

Prior to our work the only previous synodic rotation period determination for the main-belt (Phocaea group) asteroid 1884 Skip was by Di Martino et al. (1994), who reported a value of 3.079 h, associated with a bimodal lightcurve obtained from photoelectric measurements made over four nights in 1992 March. The asteroid lightcurve database (LCDB; Warner et al. 2009), rated the result U = 3, meaning the result was secure.

Despite the highly-assessed reliability, Benishek started photometric observations on 2017 Nov 1 at Sopot Astronomical Observatory in Serbia to verify this result. After the first few nights, it was noted that the earliest data showed a discrepancy (attenuation), which was presumed to be a possible indication of a binary companion. In order to increase the data collection efficiency, Benishek invited Rowe of RMS Observatory in Ohio, USA to join the observations and a collaboration was established.

The first data set at RMS Observatory was obtained on 2017 Nov 22. Benishek used an *f*/6.3 0.35-m Schmidt-Cassegrain telescope (SCT) equipped with a SBIG ST-8XME CCD camera operating in 2x2 binning mode. The image scale was 1.66 arcsec/pixel. Rowe used an *f*/7.6 0.35-m SCT with an Atik One 6.0 CCD camera operating in 3x3 binning mode; this gave an image scale of 1.05 arcsec/pixel. The exposures were unfiltered an unguided for both observers.

While the lightcurve and rotational period could have been established with much less data, the observations were continued until 2018 Jan 6 in anticipation of detecting additional attenuations. None were seen. It was concluded that the one apparent deviation was most likely an instrumental and/or reduction artefact and the defective data were excluded. A total of 14 individual data sets ("sessions") were obtained, of which 9 were by Rowe and 5 by Benishek.

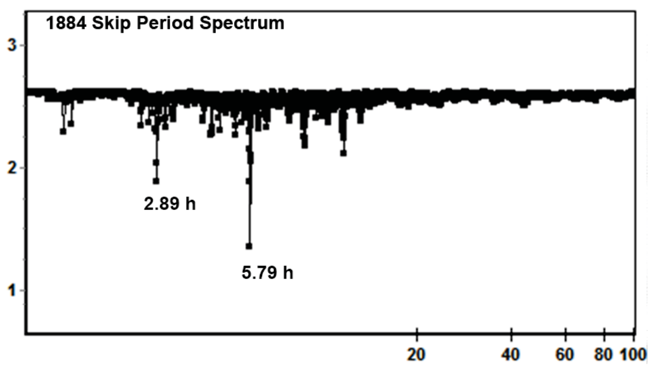
MPO Canopus software (Warner, 2016) was used for data sharing, photometric measurements, lightcurve construction, and period analysis. MPO Canopus allows differential photometry with up to five comparison stars of near solar color (0.5 ≤ B-V ≤ 0.9) using the Comparison Star Selector feature. All sessions were calibrated

Number	Name	2017/18/mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
1884	Skip	11/11-01/06	1026	16.2,30.3	44	27	2.89484	0.00005	0.08	0.02	PHO

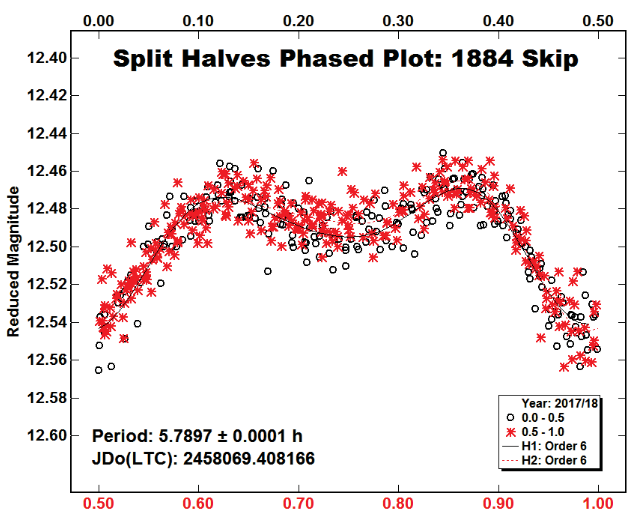
Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L PAB and B PAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et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

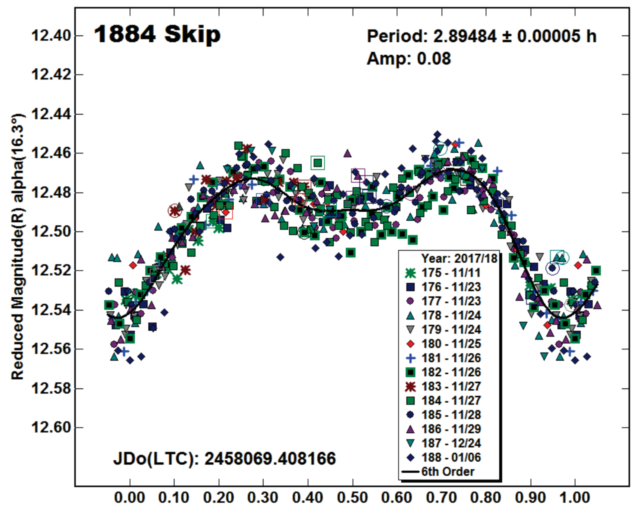
to Cousins R magnitudes using R = r′ – 0.22, where r′ is the Sloan r′ magnitude found in the Carlsberg Meridian Catalog 15 (VizieR, 2018). This generally ensures satisfactory levels of magnitude zero-point consistency within 0.05 mag. Subsequent zero-point adjustments are required only in the exceptional cases to find minimum RMS residual for the Fourier model.

In the composite lightcurve plot shown below, "Reduced Magnitude (R)" represents the Cousins R magnitudes corrected to unity distance by applying –5*log (rΔ) to the measured sky magnitudes. The quantities r and Δ are the Sun-asteroid and Earth-asteroid distances in astronomical units, respectively. The magnitudes were normalized to the phase angle given in parenthesis using a value for the slope parameter of G = 0.15. To simplify the lightcurve, the large data set was binned in groups of two with time difference not exceeding 15 minutes.



Period analysis using the total combined data set yields a period spectrum with several prominent, harmonically related solutions of which 2.89 h and 5.79 h (twice 2.89 h) are the most distinguished by their low RMS values. Since the amplitude of the lightcurve is quite small (A = 0.08 mag), these periods appear equally possible. However, a split-halves plot using the 5.79 h period shows two almost identical halves, which rules out the 5.79 h period as the likely solution.





It should be kept in mind that the solution found from the observations in the 1992 apparition (Di Martino et al., 1994) corresponds to a lightcurve with a distinct bimodal shape with a period of period of 3.079 h and 0.20 mag amplitude. This is very close to the newly found period of 2.89 h.

The small amplitude and almost monomodal lightcurve shape seen in the 2017 apparition can be interpreted as a result of the change of viewing direction toward more nearly polar aspect. Thus, the 1992 observations at low solar phase angles (~ 4-6.5 degrees) are significantly in favor of the shorter period of 2.89 h. Therefore, we adopt a period of P = 2.89484 ± 0.00005 h as the correct one.

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LIGHTCURVE ANALYSIS FOR ELEVEN MAIN-BELT MINOR PLANETS

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(Received: 2018 Apr 10 Revised: 2018 May 6)

Synodic rotation periods were determined for eleven main-belt asteroids: 494 Virtus, 49.427 ± 0.022 h; 613 Ginevra, 12.906 ± 0.009 h; 645 Agrippina, 54.130 ± 0.033 h; 777 Gutemberga, 12.838 ± 0.006 h; 783 Nora, 55.53 ± 0.08 h; 927 Ratisbona, 12.986 ± 0.003 h; 1031 Arctica, 24.904 ± 0.016 h; 1587 Kahrstedt, 7.971 ± 0.001 h; 4528 Berg, 3.5626 ± 0.0004 h; 4628 Laplace, 9.016 ± 0.003 h; and 7430 Kogure, 335.9 ± 0.8 h. All the data have been submitted to the ALCDEF database.

CCD photometric observations of eleven main-belt asteroids were performed at Command Module Observatory (MPC V02) in Tempe. Images were taken using a 0.32-m *f*/6.7 Modified Dall-Kirkham telescope, SBIG STXL-6303 CCD camera, and a ‘clear’ glass filter. Exposure time for all the images was 2 minutes. The image scale after 2x2 binning was 1.76 arcsec/pixel. Table I shows the observing circumstances and results.

Images were calibrated using a dozen bias, dark, and flat frames. Flat-field images were made using an electroluminescent panel. Image calibration and alignment was performed using *MaxIm DL* software.

The data reduction and period analysis were done using *MPO Canopus* (Warner, 2017). The 45′x30′ field of the CCD typically enables the use of the same field center for three consecutive nights. In these fields, the asteroid and three to five comparison stars were measured. Comparison stars were selected with colors within the range of 0.5 < B-V < 0.95 to correspond with color ranges of asteroids. In order to reduce the internal scatter in the data, the brightest stars of appropriate color that had peak ADU counts below the range where chip response becomes nonlinear were selected. The *MPO Canopus* internal star catalogue was useful in selecting comp stars of suitable color and brightness.

Comp star magnitudes were derived from a combination of CMC15 (Muiñoz et al. 2014), APASS DR9 (Munari et al. 2015), and GAIA1 G (Sloan r′ = G + 0.066 for stars of asteroidal color) catalogues to set the zero-points each night. In most regions the Sloan r′ data sources for brighter stars yielded very similar magnitudes (within about 0.05 mag total range), so mean values rounded to 0.01 mag precision were used.

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.

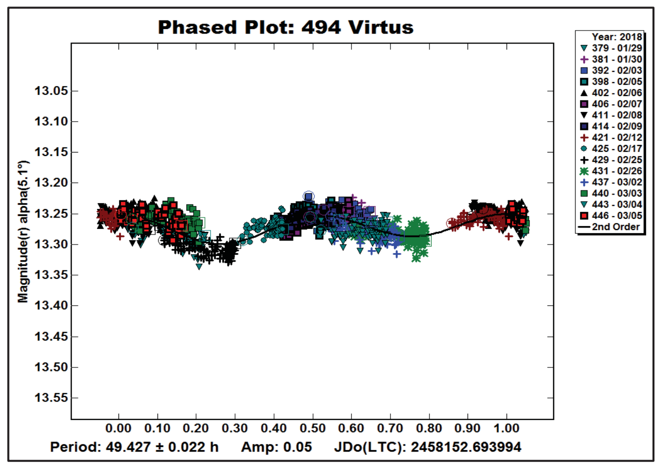
A 9-pixel (16 arcsec) diameter measuring aperture was used for asteroids and comp stars. It was typically necessary to employ star subtraction to remove contamination by field stars. For the asteroids described here, I note the RMS scatter on the phased lightcurves, which gives an indication of the overall data quality including errors from the calibration of the frames, measurement of the comp stars, the asteroid itself, and the period-fit. Period determination was done using the *MPO Canopus* Fourier-type FALC fitting method (cf. Harris et al., 1989). Phased lightcurves show the maximum at phase zero. Magnitudes in these plots are apparent, and scaled to by *MPO Canopus* to the first night.

In most cases, asteroids were selected from the CALL website (Warner, 2011) using the criteria of magnitude greater than 14.5 and quality of results, U, less than 3–.

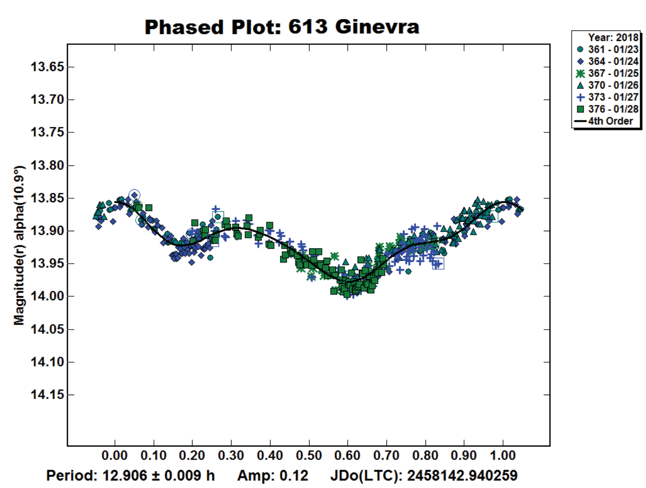
The asteroid lightcurve database (LCDB; Warner et al., 2009) was consulted to locate previously published results. All of the new data for these eleven asteroids may be found in the ALCDEF database (*http://alcdef.org*).

494 Virtus. This outer-belt asteroid was discovered in 1902 by Max Wolf at Heidelberg. Four rotation periods between 5 and 6 h were found in the LCDB, most recently that of Hamanowa (2009), who found 5.57 ± 0.003 h.

On 16 nights in 2018 January through March, 1244 data points were gathered to obtain a period of 49.427 ± 0.022 h, greatly disagreeing with all previously published results. The amplitude is only 0.05 ± 0.02 mag; the RMS scatter on the fit shown in the phased plot is 0.015 mag.



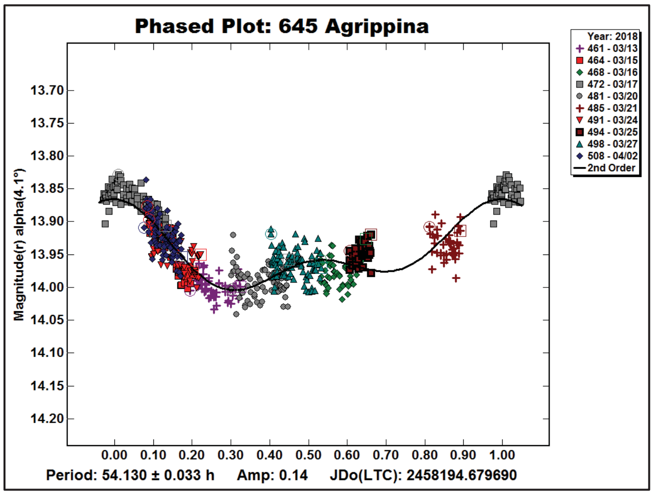
613 Ginevra. August Kopff discovered this asteroid at Heidelberg in 1906. Several periods appear in the LCDB. Gil-Hutton (1998) and Kaminski (2009) both calculated 16.45 h, Saylor (2012) found 16.9 ± 0.1 h, while Ferrero (2012) computed 13.024 ± 0.001 h.



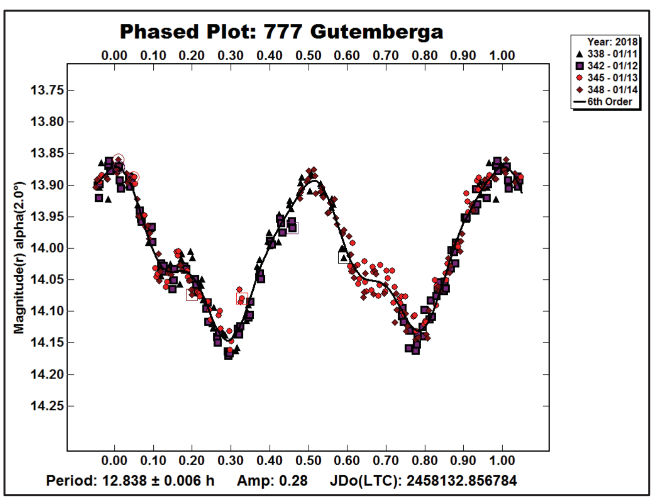
A total of 462 images were obtained on six nights in 2018 January, resulting in a period solution of 12.906 ± 0.009 h. This result is similar to Ferrero's period. The amplitude is 0.12 ± 0.01 mag. The RMS scatter on the fit is 0.013 mag.

645 Agrippina is an outer-belt asteroid that was discovered in 1907 by Joel Metcalf at Taunton. Binzel (1987) found a period of 32.6 h, while the period calculation of Behrend (2004) yielded 34.39 ± 0.05 h.

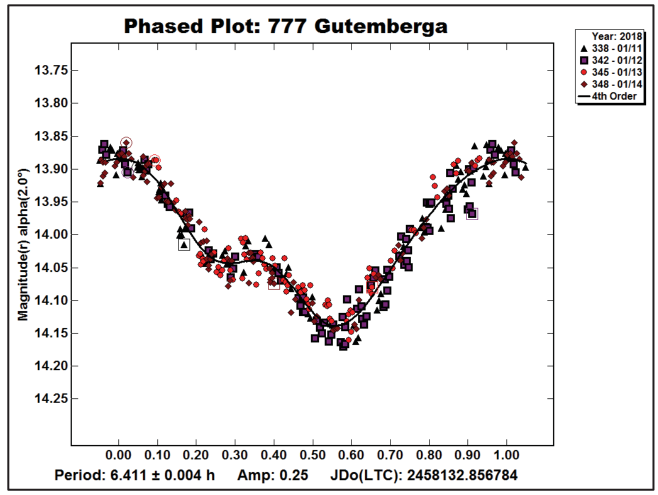
In 2018 March and April, 664 points were obtained on 10 nights, resulting in a rotation period of 54.130 ± 0.033 h, disagreeing with previous assessments. The full amplitude is 0.14 ± 0.02 mag; the RMS scatter of the fit is 0.023 mag.

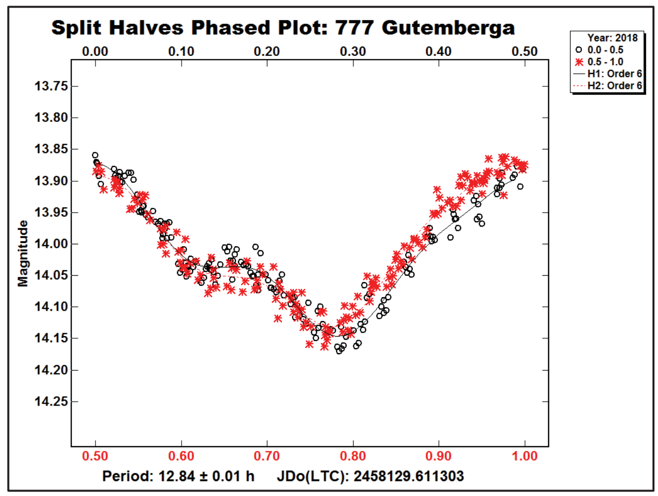


777 Gutemberga was discovered by Franz Kaiser at Heidelberg in 1914. The two published periods are those of Nickel (2011) and Waszczak (2015) who found 12.88 h and 12.849 ± 0.0081 h, respectively.

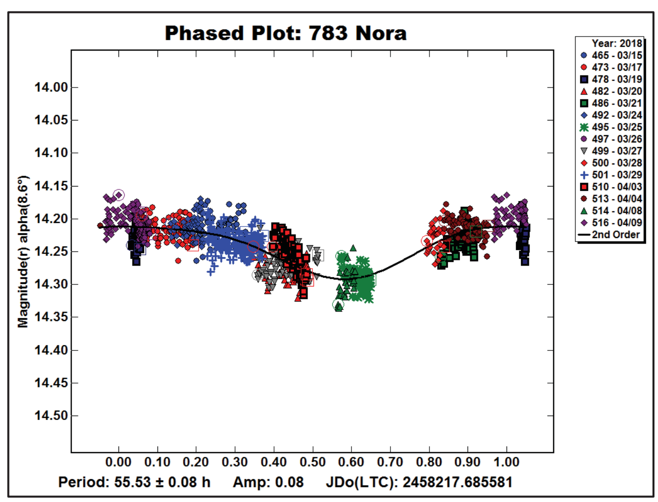


Four nights in 2018 January with 508 observations were sufficient to determine a bi-modal rotation period of 12.838 ± 0.006 h, in accordance with previously published results. The "Split Halves" feature of *MPO Canopus* was used to determine if a single-mode solution was preferred. That period solution is 6.411 ± 0.004 h and cannot be ruled out, despite the bi-modal solution having the better fit. The amplitude of the bi-modal curve is 0.28 ± 0.02 mag, with an RMS error on the fit of 0.017 mag. The single-mode curve has an amplitude of 0.25 ± 0.02 mag, and an RMS error of 0.019 mag.





783 Nora is an inner-belt asteroid with moderately high inclination. It was discovered at Vienna by Johann Palisa in 1914. Florczak (1997) obtained a period of 34.4 ± 0.5 h, and Behrend (2007) shows 9.6 h.



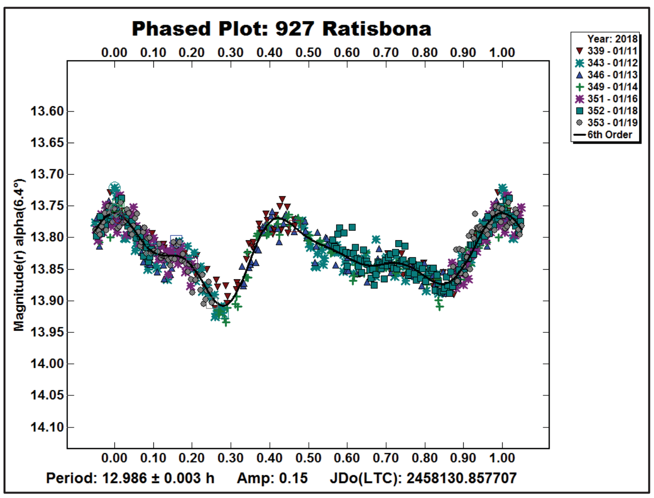
Number	Name	2017/mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
494	Virtus	01/29-03/05	1244	5.1,3.3,9.7	139	9	49.427	0.022	0.05	0.02	MB-O
613	Ginevra	01/23-01/28	462	10.9,9.2	151	5	12.906	0.009	0.12	0.01	MB-O
645	Agrippina	03/13-04/02	664	4.1,10.8	162	2	54.130	0.033	0.14	0.02	MB-O
777	Gutemberga	01/11-01/14	508	2.0,3.1	106	-1	12.838	0.006	0.28	0.02	MB-O
783	Nora	03/15-04/09	1056	8.6,4.9,7.4	189	9	55.53	0.08	0.08	0.02	MB-I
927	Ratisbona	01/11-01/19	687	6.4,7.1	110	17	12.986	0.003	0.15	0.02	MB-O
1031	Arctica	01/23-02/17	948	10.9,16.4	102	-20	24.904	0.016	0.20	0.02	MB-O
1587	Kahrstedt	01/29-02/08	523	8.4,4.2	143	7	7.971	0.001	0.17	0.02	MB-I
4528	Berg	02/27-03/12	342	9.5,3.2	177	2	3.5626	0.0004	0.26	0.05	MB-I
4628	Laplace	01/11-01/14	316	7.7,6.6	125	-7	9.016	0.003	0.38	0.03	MB-M
7430	Kogure	02/10-03/30	1094	3.2,23.2	141	-4	335.9	0.8	0.57	0.10	MB-M

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). Grp is the asteroid family/group (Warner et al., 2009).

On 14 nights in 2018 March and April, 1056 images were taken. The period solution of 55.53 ± 0.08 h differs from the two published values. The RMS scatter on the fit is 0.020 mag. The amplitude is 0.08 ± 0.02 mag.

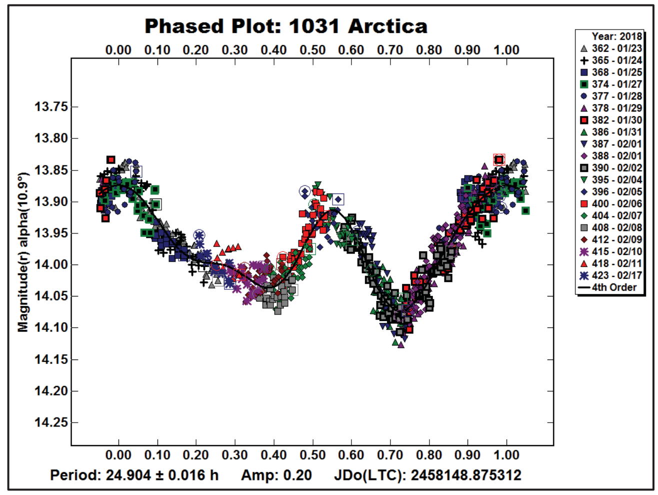
927 Ratisbona was discovered in 1920 by Max Wolf at Heidelberg. Only one rotation period appears in the LCDB: that of Behrend (2004), who shows a result of 12.9938 ± 0.0007 h.

Almost 690 images of 927 Ratisbona were accrued on seven nights in 2018 January. The period of 12.986 ± 0.003 h agrees with Behrend's determination. The amplitude is 0.15 ± 0.02 mag, and the RMS error on the fit is 0.015 mag.



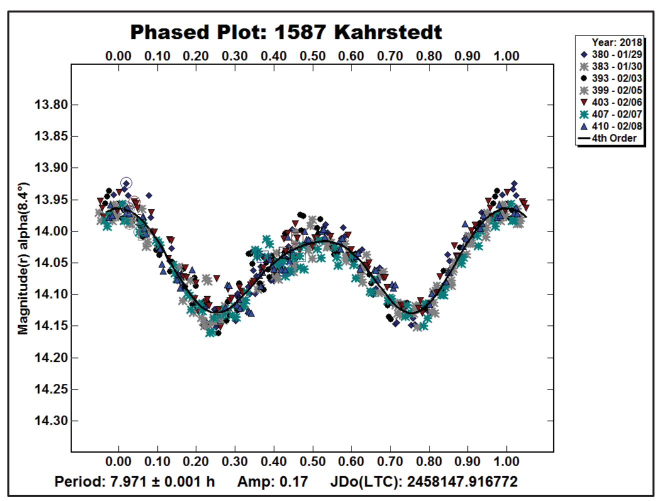
1031 Arctica. This high-inclination asteroid was discovered in 1924 by Sergey Belyavskij at Simeis. The three published periods belong to Behrend (2005 and 2016) and Di Martino (1995), all of which are 51.0 h.

Due to a rotation period that is nearly commensurate with that of the Earth, 19 nights in 2018 January and February and 948 images were required to obtain an adequate solution. The computed period is 24.904 ± 0.016 h, which disagrees with published results. The amplitude is 0.20 ± 0.02 mag., and the RMS scatter of the fit is 0.023 mag.



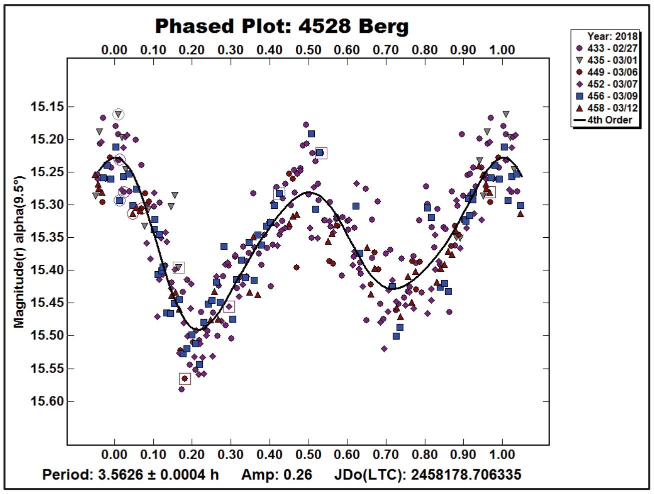
1587 Kahrstedt is another Heidelberg discovery, identified by Karl Reinmuth in 1933. Behrend (2004) determined a period of 7.93 ± 0.001 h, and Waszczak (2015) published 9.562 ± 0.0037 h.

Observations of 1587 Kahrstedt were conducted on seven nights in 2018 January and February, during which 523 data points were obtained. The computed period of 7.971 ± 0.001 h is in good agreement with Behrend's result. The amplitude of the lightcurve is 0.17 ± 0.02 mag. The fit has an RMS scatter of 0.018 mag.



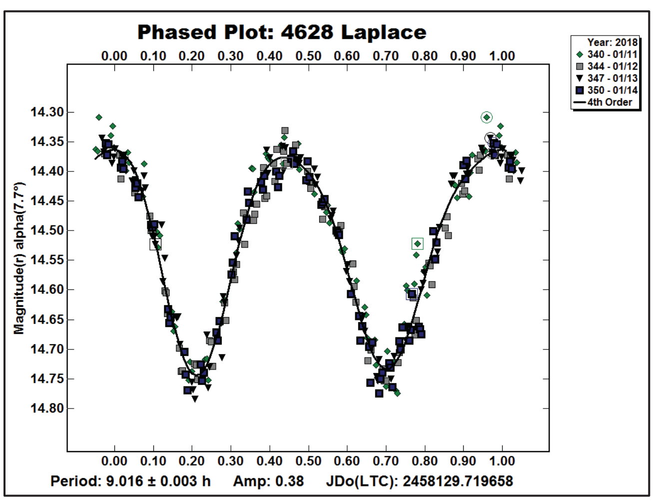
4528 Berg. Edward Bowell discovered this inner-belt asteroid in 1983 at Lowell. Two rotation period analyses were conducted: Behrend (2006) found a period of 3.5163 ± 0.0004 h and Stetcher (2015) shows a similar result of 3.47 ± 0.44 h.

4528 Berg was imaged on seven nights in 2018 February and March, during which 342 data points were gathered. The period is 3.5626 ± 0.0004 h, which agrees with previous determinations, and the amplitude is 0.26 ± 0.05 mag. The asteroid was near the faint limit for my urban site, so the RMS scatter on the fit of 0.046 mag. is greater than desired.



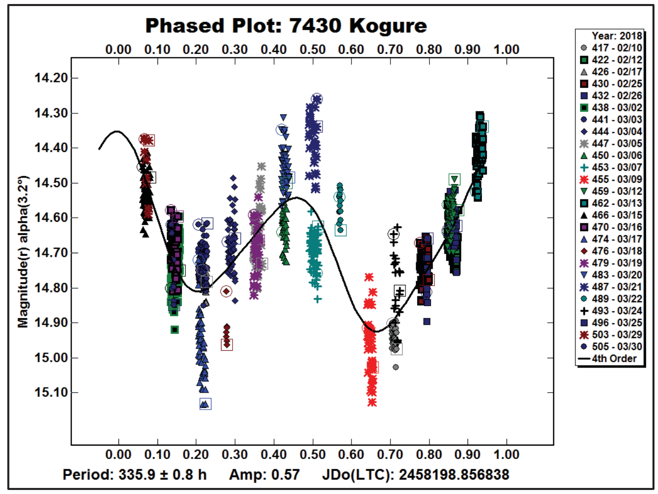
4628 Laplace was discovered in 1986 by Eric Elst at Rozhen. Angeli (1996) determined a period of 9.011 h while Behrend (2004) computed 11.105 ± 0.003 h.

The asteroid's short period required only four nights in 2018 January for a good solution of 9.016 ± 0.003 h., in good agreement with Angeli. The amplitude is 0.38 ± 0.03, and RMS scatter of the fit is 0.027 mag.



7430 Kogure. This high-inclination asteroid was discovered in 1993 by amateur astronomers Kin Endate and Kazuro Watanabe. The LCDB shows no entries for this asteroid.

On 26 nights running from 2018 February through March, 1094 observations of 7430 Kogure were taken. The 48-day observation interval covered less than 3.5 rotations of the asteroid, whose period is 335.9 ± 0.8 h. The poor alignment between data points at similar phases suggests that the minor planet is tumbling, although inadequate data exist to determine the tumbling period. The lightcurve amplitude is 0.57 ± 0.10 mag. RMS scatter of the fit is 0.097 mag., which is significant relative to the amplitude.



Acknowledgments

The author would like to express his gratitude to Brian Skiff for his indispensable mentoring in data acquisition and reduction. Thanks also go out to Brian Warner for support of his *MPO Canopus* software package.

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LIGHTCURVES FOR 1318 NERINA, 1342 BRABANTIA, 1981 MIDAS, AND 3951 ZICHICHI

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(Received: 2018 Apr 10)

Photometric observations of four main-belt asteroids were made in order to acquire lightcurves for shape/spin axis models. For 1318 Nerina, the synodic rotation period is 2.5277 ± 0.0001 h, amplitude 0.06 mag. For 1342 Brabantia, the synodic rotation period is 4.1751 ± 0.0001 h, amplitude 0.18 mag. For 1981 Midas, the synodic rotation period is 5.20 ± 0.01 h, amplitude 0.93 mag. For 3951 Zichichi, the synodic rotation period is 3.3953 ± 0.0004 h, amplitude 0.25 mag.

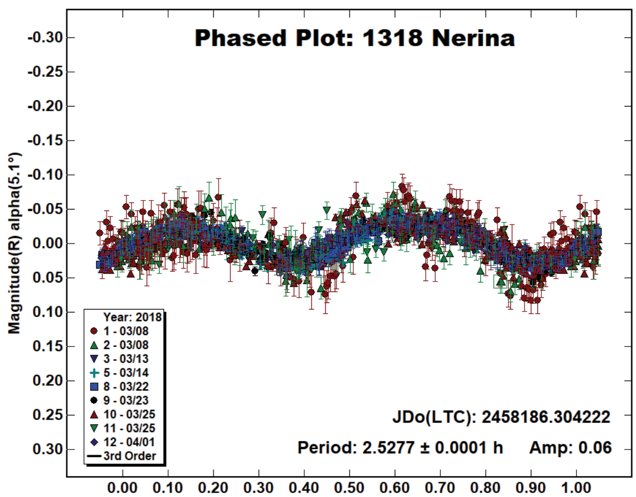
Collaborative observations were made inside the UAI (Italian Amateur Astronomers Union) group in order to observe asteroids listed in the Shape/Spin Modeling Opportunities section from the "Lightcurve Photometry Opportunities: 2018 January-March" (Warner et al., 2018). The CCD observations were made in 2018 January-March using the instrumentation described in the Table I. Lightcurve analysis was done 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 the CMC15 catalogue, distributed with *MPO Canopus*. Table II shows the observing circumstances and results.

1318 Nerina is an S-type inner main-belt asteroid discovered on 1934 March 24 by C. Jackson at Johannesburg. Collaborative observations of this asteroid were made over five nights. We derive a synodic period of P = 2.5277 ± 0.0001 h with an amplitude A = 0.06 ± 0.01 mag. The period is consistent with the

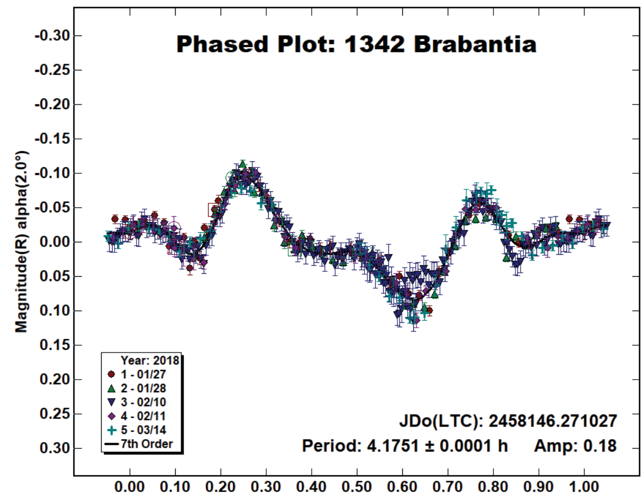
Observatory (MPC code)	Telescope	CCD	Filter	Asteroids
Univ. Siena (K54)	0.30-m MCT *f*/5.6	SBIG STL-6303e (bin 2x2)	Rc	1342,3951
M57 (K38)	0.30-m RCT *f*/5.5	SBIG STT-1603	C	1318,3951,1981
Iota Scorpii(K78)	0.40-m RCT *f*/8	SBIG STXL-6303e (bin 2x2)	Rc	1342,3951
Eurac (C62)	0.20-m NRT *f*/4	QHY9 MAG Z-9 (bin 2x2)	Rc	1318
Vegaquattro (K41)	0.30 SCT *f*/3.4	SBIG ST7XME	C	1318
Tavolaia (A29)	0.40-m NRT *f*/5	DTA EL- 4710F	C	1318
San Marcello Pistoiese (104)	0.60-m NRT *f*/4	Apogee Alta	C	1318
G.Pascoli (K63)	0.40-m NRT f/3.2	QHY22	C	1318
GiaGa (203)	0.28-m SCT f/10	SBIG ST8XME	C	1318

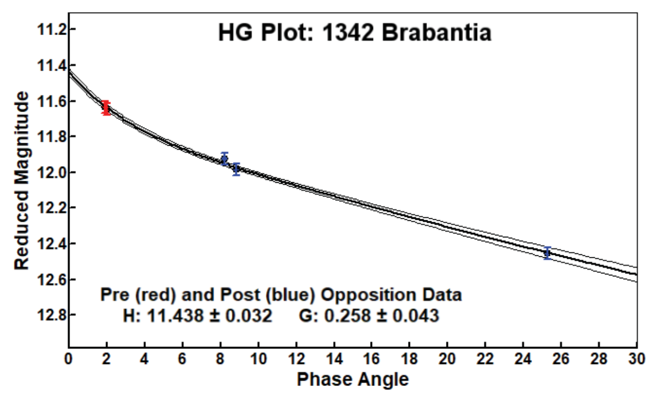
Table I. Observing Instrumentations. MCT: Maksutov-Cassegrain, NRT: Newtonian Reflector, SCT: Schmidt-Cassegrain. RCT: Ritchey-Chretien.

previously published results in the asteroid lightcurve database (LCDB; Warner et al., 2009).



1342 Brabantia is an X-type inner main-belt asteroid, discovered on 1935 February 13 by H. Van Gent at Johannesburg. Collaborative observations of this asteroid were made over four nights. We derive a synodic period of P = 4.1751 ± 0.0001 h with an amplitude A = 0.18 ± 0.02 mag, consistent with the previously published results in the LCDB. For each lightcurve, we measured the half peak-to-peak R mag and deriving the V mag by adding the color index V-R = 0.41 ± 0.02 (Franco and Sergison, 2011). Using the H-G Calculator function of *MPO Canopus*, we derive H = 11.44 ± 0.03 mag and G = 0.26 ± 0.04. This values are close to previously published results (LCDB; Warner et al., 2009).

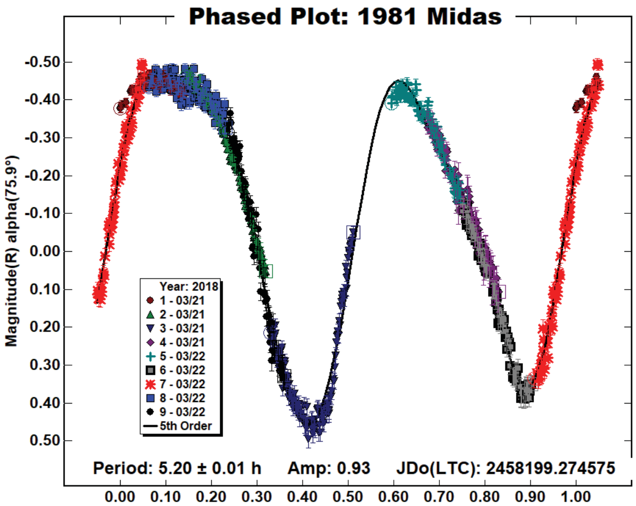




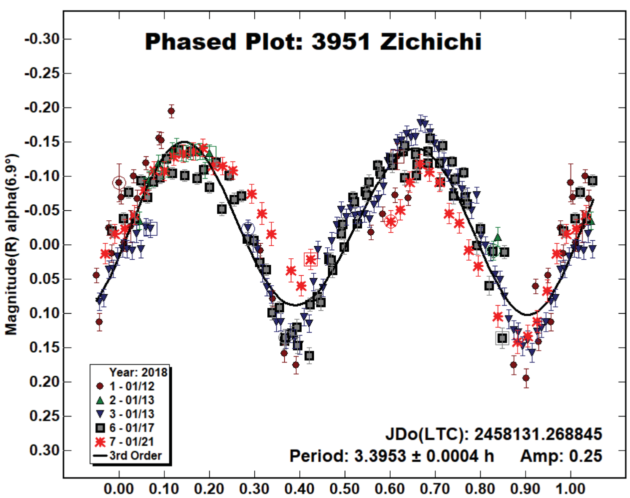
1981 Midas is a V-type Amor NEA discovered on 1973 March 6 by C. Kowal at Palomar. Observations of this asteroid were made over two nights. We derive a synodic period of P = 5.20 ± 0.01 h with an amplitude A = 0.93 ± 0.04 mag, close to the previously published results reported in the LCDB.

Number	Name	2017 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E	Amp	A.E.
1318	Nerina	03/08-04/01	1185	5.1,15.6	169	4	2.5277	0.0001	0.06	0.01
1342	Brabantia	01/27-03/14	370	1.9,25.2	130	-2	4.1751	0.0001	0.18	0.02
1981	Midas	03/21-03/22	857	75.9,84.0	136	4	5.20	0.01	0.93	0.04
3951	Zichichi	01/12-01/21	236	6.8,11.8	102	-2	3.3953	0.0004	0.25	0.02

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).



3951 Zichichi is an S-type inner main-belt asteroid discovered on 1986 February 13 at the Osservatorio San Vittore in Bologna. Collaborative observations of this asteroid were made over four nights. The lightcurve shows some attenuation events due to the binary nature of this asteroid. We derive a synodic period of P = 3.3953 ± 0.0004 h with an amplitude A = 0.25 ± 0.02 mag, consistent with the previously published results in the LCDB.



Acknowledgements

Some observing sessions and preliminary data analysis of the asteroid 1342 Brabantia were attended by a group of high school students involved in an interesting vocational guidance project about astronomy at the Astronomical Observatory of the University of Siena (DSFTA, 2018). From Liceo “A. Avogadro” (Abbadia San Salvatore): P. Bachiorrini, V. Barni, G. Cappelletti, E. Forti, R. Fé, M. Giuliano, G. Lori, G. Magini, M. Marchetti, C. Monaci, Y. Perugini, M. Sbrilli, F. Scussel. From Liceo “G. Galilei” (Siena): N. Aurigi, E. Dringoli, E. Messina, M. Sonno, G. Vagheggini. From Liceo “Sacro Cuore di Gesù” (Siena): A. Ahmed, A. Hu, S. Infante, M. Manetti, A. Muti Pizzetti. From Liceo “E. S. Piccolomini” (Siena): S. Schintu.

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ROTATION PERIOD DETERMINATION FOR 2079 JACCHIA AND 3394 BANNO

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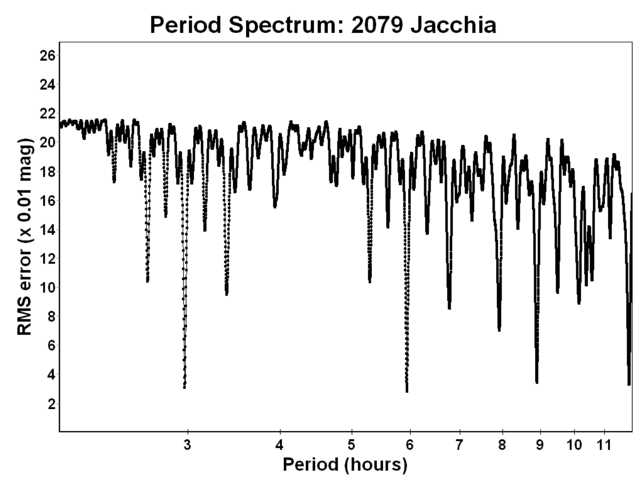
(Received: 2018 Apr 11)

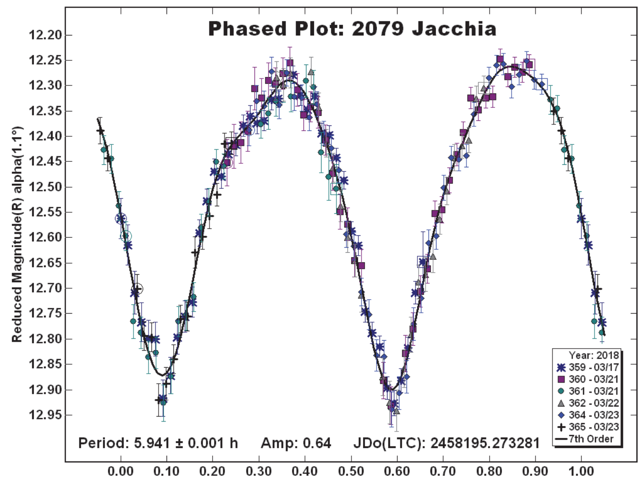
Photometric observations of two main-belt asteroids were conducted from the Astronomical Observatory of the University of Siena (Italy) in order to determine their synodic rotation periods. For 2079 Jacchia we found a period of 5.941 ± 0.001 h with an amplitude of 0.64 ± 0.02 mag, for 3394 Banno we found a period of 7.324 ± 0.001 h with an amplitude of 0.22 ± 0.02 mag.

CCD photometric observations of two main-belt asteroids were carried on in 2018 March at the Astronomical Observatory of the University of Siena (K54). We used a 0.30-m f/5.6 Maksutov-Cassegrain telescope, a SBIG STL-6303E CCD camera, and clear filter. The pixel scale was 2.30 arcsec when binned at 2x2 pixels. All exposures were 300 sec. Data processing and analysis were made with MPO Canopus (Warner, 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 through 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. 2079 Jacchia and 3394 Banno were reported as lightcurve photometry opportunities for 2018 January-March in the Minor Planet Bulletin (Warner *et al.*, 2018).

2079 Jacchia was discovered on February 23, 1976 at Oak Ridge Observatory (until 1981 Harvard College's Agassiz Station). The principal observers are R.E. McCrosky, C.-Y. Shao, G. Schwartz, and J.H. Bulger, and it was dedicated to the Italian-American astronomer Luigi Jacchia. It is a main-belt asteroid with the semi-major axis of 2.599 AU, eccentricity 0.077, inclination 13.261 degrees and an orbital period of 4.19 years. Its absolute magnitude is H = 12.6 (JPL, 2018; MPC, 2018). The WISE satellite infrared radiometry survey (Masiero *et al.*, 2014) found an optical albedo of p_V = 0.24 ± 0.04; with an absolute magnitude H = 12.5, a diameter D = 8.55 ± 0.32 km is derived. Observations of this asteroid were conducted on four nights, collecting 193 data points. The period analysis shows a clear bimodal solution for the rotational period P = 5.941 ± 0.001 hours with an amplitude A = 0.64 ± 0.02 magnitudes.

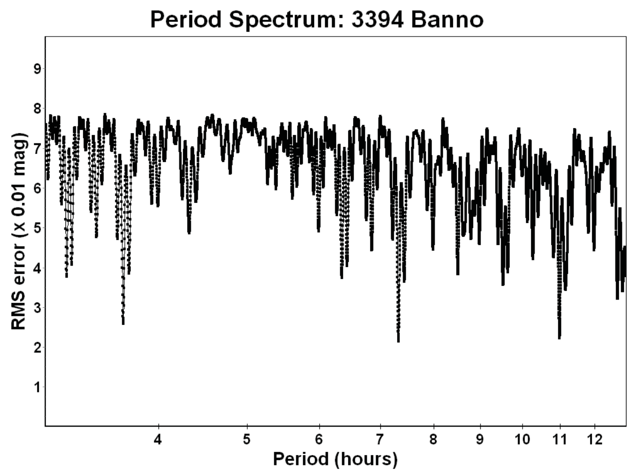


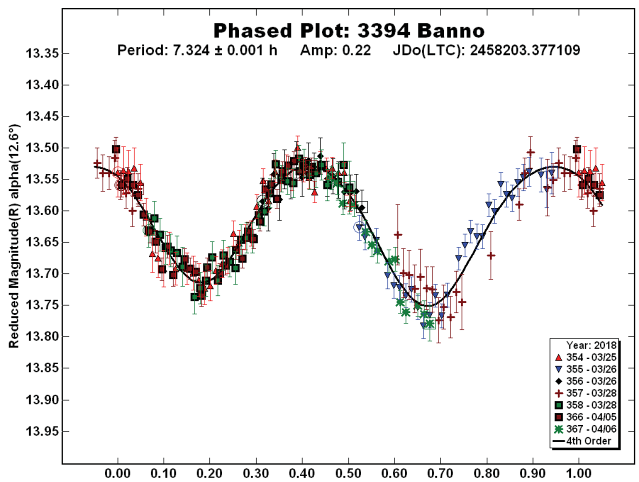


3394 Banno was discovered on February 16, 1986 by Inoda, S. and Urata, T. at Karasuyama and it was dedicated to the Japanese astronomer Yoshiaki Banno. It is a main-belt asteroid with the semi-major axis of 2.317 AU, eccentricity 0.197, inclination 7.09 degrees and an orbital period of 3.53 years. Its absolute magnitude is H = 13.1 (JPL, 2018; MPC, 2018). The WISE satellite infrared radiometry survey (Masiero *et al.*, 2011) found an optical albedo of p_V = 0.271 ± 0.025; with an absolute magnitude H = 12.9 a diameter D = 6.298 ± 0.132 km is derived. Bus and Binzel (2002) observed 3394 Banno during Phase II of the Small Main Belt Asteroid Spectrographic Survey (SMASS II) and assigned a spectral classification of S. Observations of this asteroid were conducted on four nights, collecting 194 data points. The period analysis shows a clear bimodal solution for the rotational period P = 7.324 ± 0.001 hours with an amplitude A = 0.22 ± 0.02 magnitudes.

Number	Name	2018/mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
2079	Jacchia	03/17-03/24	193	1.0,4.1	175	-1	5.941	0.001	0.64	0.02
3394	Banno	03/25-04/06	194	12.7,6.0	204	1	7.324	0.001	0.22	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).





Acknowledgements

Edoardo Bucalo, Denise Cocchiarella and Bianca Nardi, students of the course in Physics and Advanced Technologies at the Department of Physical Sciences, Earth and Environment (DSFTA, 2018), looked after the observations and the writing of this article during their internship activities at the Astronomical Observatory of the University of Siena, and appear deservedly as authors. Furthermore all the authors want to thank a group of high school students from Liceo "Sacro Cuore di Gesù" (Siena), involved in an interesting vocational guidance project about astronomy at the Astronomical Observatory of the University of Siena. They attended some observing sessions and participated in data analysis: A. Ahmed, A. Barbieri, N. Bellaccini, F. Bisconti, F. Capra, L. Casprini, L. Cencioni, K. Dickhaus, T. Galardi, A. Gennari, F. Grosso, A. Hu, S. Infante, N. Innocenti, L. Lacommare, M. Manetti, A. Muti Pizzetti, T. Paccagnini, S. Pannacci, F. Seri, E. Stanghellini, G. Zei.

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LIGHTCURVE ANALYSIS AND ROTATIONAL PERIOD DETERMINIATION FOR ASTEROIDS 1491 BALDUINUS AND 2603 TAYLOR

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(Received: 2018 Apr 13 Revised: 2018 Apr 17)

Photometric observations of asteroids 1491 Balduinus and 2603 Taylor were made from 2017 December to 2018 February. 1491 Balduinus was found to have a rotational period 15.315 ± 0.003 h with amplitude 0.40 mag; 2603 Taylor was found to have rotational period 3.905 ± 0.001 h with amplitude 0.27 mag.

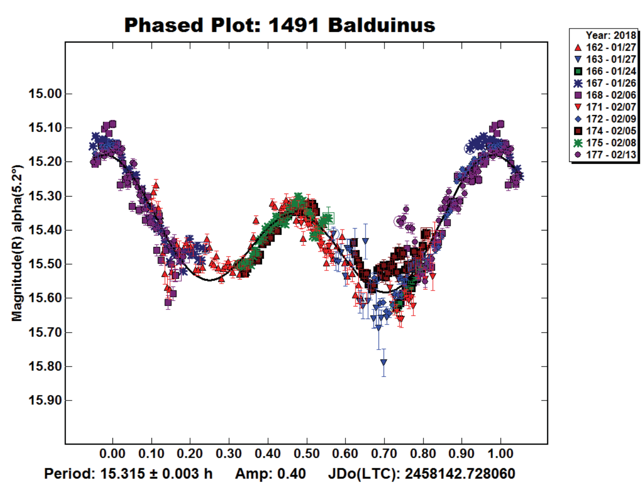
The rotational periods of asteroids 1491 Balduinus and 2603 Taylor were determined as part of a high school astronomy research course at Phillips Academy. The primary image sets used in the analysis of these two asteroids were taken from the Phillips Academy Observatory (PAO) with a 0.40-m *f*/8 Ritchey-Chrétien telescope by DFM Engineering. Images were taken with an Andor Tech iKon DW436 camera with a 2048x2048 array of 13.5-micron pixels. The resulting image scale was 0.86 arcseconds per pixel. All images were dark- and flat-field corrected, unbinned, and guided. The images were calibrated with *AstroimageJ* software (Collins et al., 2017). Additional image sets of 1491 Balduinus were obtained using purchased time on remote telescopes from the iTelescope network. The time was purchased to extend the coverage of 1491 Balduinus and to demonstrate to the group of high school students the impact of incorporating data from a variety of longitudes in a period determination. Details of iTelescope equipment configurations are included in the table below.

Coauthors Klinglesmith and Briggs also contributed data to improve the composite lightcurve of 1491 Balduinus. A Celestron C14 with a SBIG STL1001E CCD at Etscorn Campus Observatory was used by Klinglesmith. The image is 1024x1024 pixels. Pixel size used was 24 microns, which corresponds to 1.25 arcsec per pixel. Exposure times were 6 minutes with a clear filter. Imagery was reduced with *MPO Canopus* version 10.7.11.1. Observations by Briggs at FOAH Observatory near Magdalena, New Mexico, are made possible by the currently installed telescope system owned by Christian Pérez of Sweden. The imaging system is a 16-inch f/9 Ritchey–Chrétien reflector and field-flattening corrector built by RCOS, working with an SBIG STX 16803 CCD camera having a 4096x4096 array. The mounting is a Paramount ME by Software Bisque. FOAH Observatory is a dark-sky location at an altitude of 1981 meters and operates in association with the nearby Astronomical Lyceum and the local Magdalena Astronomical Society.

Site	Telescope	CCD Camera
Mahill, NM, USA	iT-05 0.25 m f/3.4 HFF	SBIG ST-10XME
Mahill, NM, USA	iT-21 0.43 m f/6.8 CDK	FLI-PL6303E
Nerpio, Spain	iT-18 0.32-m f/8.0 CDK	SBIG-STXL-6303E
Auberry, CA,USA	IT-24 0.61-m f/6.5 CDK	FLI-PL09000

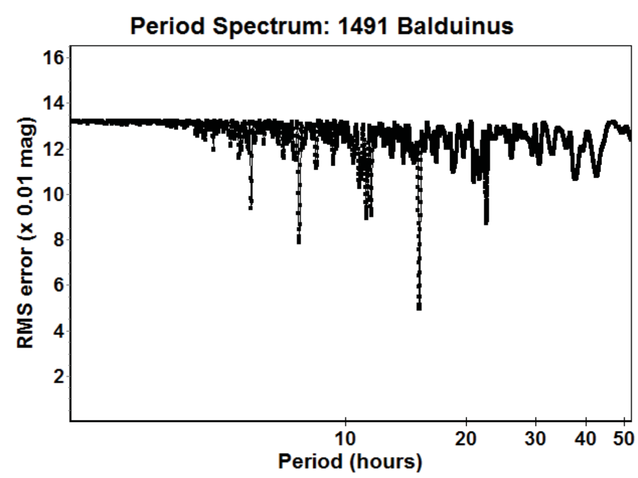
MPO Canopus was used to make photometric measurements of the asteroids as well as to generate the final lightcurves and period spectra. Comparison stars were chosen to have near solar color using the Comp Star Selector tool in *MPO Canopus*. Data merging and period analysis were also done with *MPO Canopus* using an implementation of the Fourier analysis algorithm of Harris (Harris *et al.*, 1989). The combined data sets were analyzed by the authors.

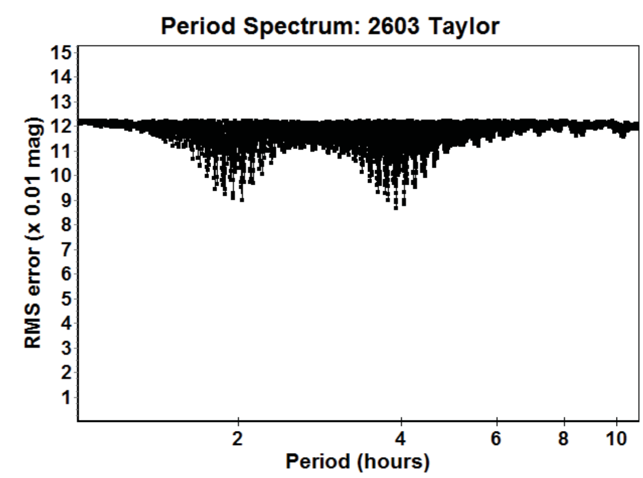
1491 Balduinus was chosen from the CALL website by a group of Phillips Academy students last year, but it was not measured. Although it did not appear on the CALL website this year, the students decided to measure it. The resulting bimodal lightcurve curve shows a period of 15.315 ± 0.003 hours, with amplitude of 0.40±0.1 magnitudes. The period spectrum, also included here, strongly favors this result. A search of the asteroid lightcurve database (Warner *et al.*, 2009) did not reveal previously reported lightcurve results for this asteroid.



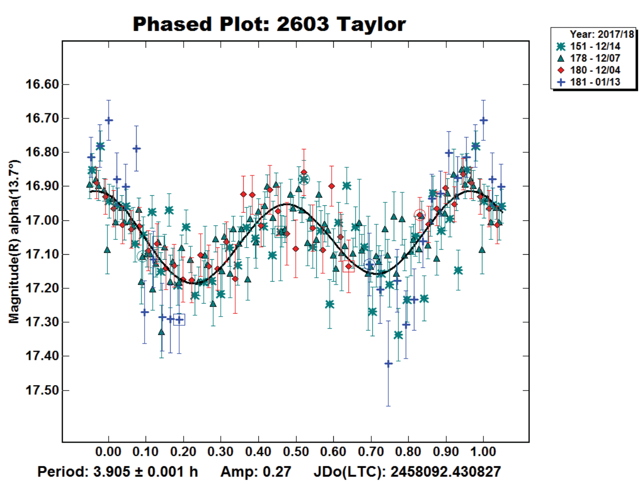
Number	Name	2017/2018 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	TxC
1491	Balduinus	01/24-02/13	580	3.6,11.2	115.5	1.1	15.315	0.003	0.40	0.1	C
2603	Taylor	12/04-01/13	499	10.4,19.5	47.7	1.1	3.905	0.001	0.27	0.1	SC

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). TxC is the taxonomic class as found in the LCDB (Warner *et al.*, 2009).





2603 Taylor was chosen from the CALL website. The lightcurve for 2063 Taylor contains data points solely collected from the Phillips Academy Observatory and is based on four sessions. Several additional imaging sessions were attempted after January 13, but by this time the asteroid had dimmed sufficiently that the resulting data were very noisy. The resulting bimodal lightcurve curve shows a period of 3.905 ± 0.001 hours with amplitude of 0.27 ± 0.1 mag. The period spectrum, also included here, favors this result but does not rule out other possibilities. Additional observations should be undertaken better constrain the period. A search of the asteroid lightcurve database (Warner *et al.*, 2009) did not reveal previously reported lightcurve results for this asteroid.



Acknowledgements

Research at the Phillips Academy Observatory is supported by the Israel Family Foundation, and funding for the Andor Tech camera was generously provided by the Abbot Academy Association. The Etscorn Campus Observatory operations are supported by the Research and Economic Development office of New Mexico Institute of Mining and Technology (NMIMT). Instrumental resources at FOAH Observatory are being supplied by Christian Pérez of Sweden.

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GENERAL REPORT OF POSITION OBSERVATIONS BY THE ALPO MINOR PLANETS SECTION FOR THE YEAR 2017

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Observations of positions of minor planets by members of the Minor Planets Section in calendar year 2017 are summarized.

During the year 2017 a total of 2514 observations of 648 different minor planets were reported by members of the Minor Planets Section. Of these, 2265 are approximate visual positions denoted V, and 249 are CCD images denoted C not measured at the time of writing.

The summary lists minor planets in numerical order, the observer and telescope aperture (in cm), UT dates of the observations, and the total number of observations in that period. When a significant departure from the predicted magnitude was noted, it is stated following the column for the number of positions. The year is 2017 in each case.

Positional observations were contributed by the following observers:

Observer, Instrument	Location	Planets	Positions
Faure, Gerard 5 cm binoculars at Nahe Island, Seychelles 35 cm Meade S-C, 20 cm Celestron Olympus E-M10 CCD	Col d'Arlezier,	17	40V, 70 C
Harvey, G. Roger 81 cm Newtonian, 38 cm Celestron SC	Concord, North Carolina, USA	557	1851V
Hubbell, Jerry 15 cm f/8 refractor +CCD	Wilderness, VA USA	23	46C
Pryal, Jim 20 cm f/10 SCT	Ellensburg, WA USA Ravensdale, WA USA	14	69V
Rayon, Jean-Michel 20 cm Vixen R200SS 35 cm Orion XX14G Sony A6000 CCD	Meylan and Col de L'Arzelier, France	7	133C
Werner, Robert 20 cm Celestron	Pasadena, CA USA	55	305V

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2017) (V unless otherwise stated)	NO. OBS.
3 Juno	Werner, 20	Jul 23-31	5
5 Astraea	Werner, 20	Jul 23-31	3
6 Hebe	Werner, 20	Jul 23-31	5
7 Iris	Faure, 5	Nov 20-21	2
	Werner, 20	Oct 12-25	10
10 Hygiea	Pryal, 20	Jun 25-29	4
	Werner, 20	Jul 23-Aug 13	7
12 Victoria	Werner, 20	Apr 15-May 2	5
16 Psyche	Werner, 20	Mar 17-Apr 2	7
20 Massalia	Harvey, 81	Dec 19	3
24 Themis	Werner, 20	Oct 13-24	5
25 Phocaea	Werner, 20	Jul 22-31	5
26 Proserpina	Werner, 20	Mar 17-Apr 2	6
27 Euterpe	Werner, 20	May 21-24	3
29 Amphitrite	Hubbell, 15	Mar 17	2C
	Werner, 20	Mar 17-Apr 2	7
30 Urania	Werner, 20	May 22-24	2
40 Harmonia	Werner, 20	Jul 22-Aug 13	8
41 Daphne	Werner, 20	Mar 17-Apr 2	7
42 Isis	Werner, 20	Oct 16-25	5
44 Nysa	Werner, 20	Oct 12-26	10
48 Doris	Werner, 20	Oct 16-26	7
52 Europa	Werner, 20	May 21-24	3
63 Ausonia	Werner, 20	Apr 15-May 2	5
64 Angelina	Werner, 20	Sep 26-Oct 26	10
80 Sappho	Werner, 20	May 21-24	2
82 Alkmene	Werner, 20	Mar 24-Apr 1	3
88 Thisbe	Werner, 20	Mar 29-May 2	7
89 Julia	Werner, 20	Oct 12-25	9
93 Minerva	Werner, 20	May 21-24	3
105 Artemis	Werner, 20	Apr 15-May 2	5
150 Nuwa	Hubbell, 15	Mar 20	2C
186 Celuta	Werner, 20	Sep 25-Oct 26	13
192 Nausikaa	Werner, 20	Mar 24-Apr 2	5
196 Philomela	Werner, 20	May 21-24	3
202 Chryseis	Werner, 20	May 1-2	2
211 Isolda	Pryal, 20	Nov 25	2
216 Kleopatra	Werner, 20	Jul 22-Aug 13	7
219 Thusnelda	Werner, 20	Jul 22-Aug 1	6
230 Athamantis	Werner, 20	Apr 21-May 2	4
241 Germania	Werner, 20	Sep 24-28	5
243 Ida	Hubbell, 15	Mar 17	2C
261 Prymno	Pryal, 20	Jul 29-30	2
264 Libussa	Werner, 20	Sep 27-Oct 25	5
270 Anahita	Werner, 20	Jul 22-Aug 13	8
337 Devosa	Werner, 20	Sep 25-27	3
344 Desiderata	Pryal, 20	Sep 27-28	3
	Werner, 20	Sep 26-Oct 22	4
354 Eleonora	Pryal, 20	Sep 27-28	3
364 Isara	Pryal, 20	Oct 14-15	2
	Werner, 20	Oct 17-23	3
356 Liguria	Hubbell, 15	Mar 20	2C
379 Huenna	Hubbell, 15	Mar 17	2C
409 Aspasia	Werner, 20	Apr 15-May 2	5
416 Vatican	Werner, 20	Apr 15-May 2	6
532 Herculina	Werner, 20	Oct 16-25	6
554 Peraga	Werner, 20	Oct 13-26	10
595 Polyxena	Pryal, 20	Oct 14-15	2
639 Latona	Pryal, 20	Jul 29-30	3
704 Interamnia	Werner, 20	Oct 12-26	10
712 Boliviana	Werner, 20	Oct 13-25	7
804 Hispania	Werner, 20	Sep 25-27	3
882 Swetlana	Faure, 35	Sep 20	2
1096 Reunerta	Harvey, 81	Dec 12	3

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2017) (V unless otherwise stated)	NO. OBS.
1193 Africa	Faure, 20	Apr 19-20	2
1246 Chaka	Pryal, 20	Jul 31	3
1564 Srbija	Hubbell, 15	Mar 20	2C
1788 Kiess	Harvey, 81	May 16	3
1804 Chebotarev	Faure, 35	Oct 26	11 (1V, 10C)
1864 Daedalus	Faure, 20	Apr 19	5
1901 Moravia	Harvey, 81	Dec 11	3
2032 Ethel	Harvey, 81	Apr 2	3
2073 Janacek	Harvey, 81	Sep 14	3
2124 Nissen	Harvey, 81	Oct 16	3
2142 Landau	Harvey, 81	Mar 23	3
2164 Lyalya	Harvey, 81	Aug 18	3
2168 Swope	Harvey, 81	Dec 10	6
2216 Kerch	Hubbell, 15	Mar 17	2C
2230 Yunnan	Harvey, 81	Dec 10	6
2330 Outake	Harvey, 81	Mar 24	3
2401 Aehlita	Harvey, 81	Nov 20	3
2503 Liaoning	Harvey, 81	Oct 6	3
2529 Rockwell Kent	Harvey, 81	Jun 26	3
2570 Porphyro	Harvey, 81	Sep 17	3
2579 Spartacus	Harvey, 81	Nov 25	3
2595 Gudiachvili	Harvey, 81	Aug 20	3
2603 Taylor	Harvey, 81	Nov 14	3
2624 Samitchell	Harvey, 81	Sep 19	3
2694 Pino Torinese	Harvey, 81	May 3	3
2706 Borovsky	Harvey, 81	Nov 25	3
2723 Gorshkov	Harvey, 81	Oct 16	3
2739 Taguacipa	Harvey, 81	Aug 18	3
2780 Monnig	Harvey, 81	May 16	3
2782 Leonidas	Harvey, 81	Sep 17	3 0.5f@16.3
2785 Sedov	Harvey, 81	Sep 19	3
2806 Graz	Harvey, 81	Nov 17	3
2818 Juvenalis	Harvey, 81	Mar 24	3
2833 Radishchev	Harvey, 81	Jul 22	3
2860 Pasacentennium	Faure, 35	Sep 20	2
2876 Aeschylus	Harvey, 81	Apr 2	3
2894 Kakhovka	Harvey, 81	Dec 12	3
2900 Lubos Perek	Harvey, 81	Oct 21	3
2901 Bagehot	Harvey, 81	Apr 1	3 0.4f@16.4
2902 Westerlund	Harvey, 81	Oct 16	3
2907 Nekrasov	Harvey, 81	Oct 17	3
2936 Nechvile	Harvey, 81	Mar 24	3 0.5f@16.3
2970 Pestalozzi	Harvey, 81	Dec 10	3
2982 Muriel	Harvey, 81	Apr 3	3
2985 Shakespeare	Harvey, 81	Nov 17	3
2986 Mrinalini	Harvey, 81	Oct 15-16	3
3006 Livadia	Harvey, 81	Oct 21	3
3008 Nojiri	Harvey, 81	Dec 19	3
3016 Meuse	Harvey, 81	Oct 27	3
3023 Heard	Harvey, 81	Mar 23	3
3025 Higson	Harvey, 81	Nov 14	3
3122 Florence	Faure, 20	Sep 12	6
	Harvey, 38	Sep 28	6
	Pryal, 20	Aug 31-Sep 11	16
	Rayon, 20	Sep 19-21	4C
	Werner, 20	Sep 7-10	8
3135 Lauer	Harvey, 81	Dec 11	3
3154 Grant	Harvey, 81	Nov 18	3
3158 Anga	Harvey, 81	Nov 18	3 0.5f@15.9
3159 Prokof'ev	Harvey, 81	Sep 17	3
3160 Angerhofer	Harvey, 81	Sep 20	3
3186 Manuilova	Harvey, 81	Oct 15	3
3200 Phaethon	Pryal, 20	Dec 11-15	9
	Werner, 20	Dec 12-18	14
3202 Graff	Harvey, 81	Sep 14	3
3215 Lapko	Harvey, 81	Dec 11	3
3217 Seidelmann	Harvey, 81	Sep 19	3
3263 Bligh	Harvey, 81	Dec 14	3
3297 Hong Kong	Harvey, 81	Nov 18	3
3316 Hertzberg	Harvey, 81	Mar 24	3
3328 Interpostia	Harvey, 81	Nov 17	3
3336 Grygar	Harvey, 81	Oct 15	3 0.5f@16.2
3344 Modena	Harvey, 81	Nov 18	3
3354 McNair	Harvey, 81	Aug 18	3
3361 Orpheus	Harvey, 81	Oct 21	6
3368 Duncombe	Harvey, 81	Nov 18	3
3369 Freuchen	Harvey, 81	Oct 15-16	3
3373 Koktebelia	Hubbell, 15	Mar 20	2C
3378 Susanvictoria	Harvey, 81	Oct 25-27	3
3399 Kobzon	Harvey, 81	Sep 16	3
3420 Standish	Harvey, 81	Mar 24	3
3422 Reid	Harvey, 81	Apr 27	3
3424 Nusl	Harvey, 81	Dec 12	3 0.3f@16.1
3456 Etiennemarey	Harvey, 81	Sep 17	3
3479 Malaparte	Harvey, 81	Sep 17	3
3491 Fridolin	Harvey, 81	Oct 20	3
3501 Olegiya	Harvey, 81	Nov 18	3
3557 Sokolsky	Harvey, 81	Sep 23	3
3594 Scotti	Harvey, 81	Sep 17	3
3602 Lazzaro	Harvey, 81	Dec 11	3
3604 Berkhuijsen	Harvey, 81	Mar 24	3
3610 Decampos	Harvey, 81	Oct 17	3
3620 Platonov	Harvey, 81	Sep 18	3
3707 Schroter	Harvey, 81	Sep 17	3
3715 Stohl	Harvey, 81	Oct 20	3
3716 Petzval	Harvey, 81	Aug 20	3
3719 Karamzin	Harvey, 81	Nov 24	3

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2017)	NO. OBS. (V unless otherwise stated)
3722 Urata	Faure, 35	Sep 20	2
	Rayon, 20	Sep 21	2C
3727 Maxhell	Harvey, 81	Jun 26	3
3751 Kiang	Harvey, 81	Sep 16	3
3756 Ruscannon	Harvey, 81	Sep 18	3
3783 Morris	Harvey, 81	Nov 11	3
3809 Amici	Harvey, 81	Oct 20	3
3845 Neyachenco	Harvey, 81	Oct 27	3
3849 Incidentia	Harvey, 81	Nov 17	3
3862 Agekian	Harvey, 81	Sep 19	3
3869 Norton	Harvey, 81	Dec 11	3
3897 Louhi	Harvey, 81	Jul 20	0.5b@15.8
3902 Yoritomo	Harvey, 81	Jul 20	3
3903 Kliment Ohridski	Harvey, 81	Sep 20	3
3916 Maeva	Harvey, 81	Dec 14	3
3927 Feliciaplatt	Harvey, 81	Jun 27	3
3978 Klepesta	Harvey, 81	Oct 17	3
4018 Bratislava	Harvey, 81	Nov 18	3 0.3f@16.2
4032 Chaplygin	Harvey, 81	Sep 16	3
4045 Lowengrub	Harvey, 81	Oct 15-16	3
4053 Cherkasov	Harvey, 81	Dec 12	3
4084 Hollis	Harvey, 81	Nov 17	3
4101 Ruikou	Harvey, 81	Oct 28	3
4109 Anokhin	Harvey, 81	Sep 19	3
4133 Heureka	Harvey, 81	Mar 23	3 0.7f@16.0
4137 Crabtree	Harvey, 81	Sep 24	3
4177 Kohman	Harvey, 81	Sep 18-20	4
4248 Ranald	Harvey, 81	Dec 12	4
4250 Perum	Harvey, 81	Aug 18	3
4307 Cherepashchuk	Harvey, 81	Sep 18	3
4328 Valina	Harvey, 81	Oct 17	3
4368 Pillmore	Harvey, 81	Sep 21	3
4379 Snelling	Harvey, 81	Sep 18	3
4418 Fredfranklin	Harvey, 81	Apr 27	3 0.4f@16.2
4444 Escher	Harvey, 81	Sep 24	3
4450 Royclarke	Harvey, 81	Oct 15-16	3
4470 Sergeev-Censkij	Harvey, 81	Sep 19	3
4546 Franck	Harvey, 81	Oct 17	3
4551 Cochran	Harvey, 81	Aug 18	3
4560 Klyuchevskij	Harvey, 81	Oct 27	3
4609 Pizarro	Harvey, 81	Jun 27	3
4610 Kajov	Harvey, 81	Dec 15	3
4651 Wongkwancheng	Hubbell, 15	Mar 20	2C
4701 Milani	Harvey, 81	Oct 18	3
4752 Myron	Harvey, 81	Nov 17	3
4759 Aretta	Harvey, 81	Aug 25	3
4765 Wasserburg	Harvey, 81	Dec 15-19	9
4772 Frankdrake	Harvey, 81	Oct 25-27	3
4786 Tatianina	Harvey, 81	Apr 27	3
4789 Sprattia	Harvey, 81	Sep 18	3
4824 Stradonice	Harvey, 81	Nov 11	3
4825 Ventura	Harvey, 81	Nov 14	3
4830 Thomascooley	Harvey, 81	May 16	3
4850 Palestrina	Harvey, 81	Oct 20	3
4880 Tovstonogov	Harvey, 81	May 3	3
4890 Shikanosima	Harvey, 81	Apr 27	3
4900 Maymelou	Harvey, 81	Apr 27	3
4903 Ichikawa	Harvey, 81	Oct 27	3
4922 Leshin	Harvey, 81	Nov 20	3
4929 Yamatai	Harvey, 81	May 16	3
4938 Papadopoulos	Harvey, 81	Nov 14	3 0.4f@16.3
5040 Rabinowitz	Faure, 35	Sep 20	2
5045 Hoyin	Harvey, 81	Nov 18	3
5049 Sherlock	Harvey, 81	Nov 14	3
5063 Monteverdi	Harvey, 81	Oct 20	3
5066 Gerrard	Harvey, 81	May 20	6
5068 Cragg	Harvey, 81	Oct 21	3
5074 Goetzoertel	Harvey, 81	Nov 11	3
5110 Belgirate	Harvey, 81	Dec 11	3
5115 Frimout	Harvey, 81	Oct 17	3
5132 Maynard	Harvey, 81	Sep 19	3
5156 Golant	Harvey, 81	Sep 17	3
5185 Alerossi	Harvey, 81	Dec 12	3
5227 Bocacara	Harvey, 81	Jun 26	3
5232 Jordaens	Harvey, 81	Sep 15	3
5263 Arrius	Harvey, 81	Nov 20	3
5289 Niemela	Harvey, 81	Sep 16	3
5307 Paul-Andre	Harvey, 81	Oct 18	3
5308 Hutchison	Harvey, 81	Sep 17	3
5379 Abehiroshi	Harvey, 81	May 3	3
5409 Saale	Harvey, 81	Nov 17	3
5418 Joyce	Harvey, 81	Sep 17	3
5456 Merman	Harvey, 81	Dec 12	3
5461 Autumn	Harvey, 81	Apr 27	3 0.4b@15.9
5488 Kiyosato	Harvey, 81	Sep 20	3
5504 Lanzerotti	Harvey, 81	Dec 12	3
5513 Yukio	Harvey, 81	Aug 18	3
5528 1992 AJ	Harvey, 81	May 20	3
5540 Smirnova	Harvey, 81	Jul 30	3
5543 Sharaf	Hubbell, 15	Mar 17	2C
5561 Iguchi	Harvey, 81	Sep 20	3
5585 Parks	Harvey, 81	Nov 11	3
5592 Oshima	Harvey, 81	Jul 30	3
5601 1991 VR	Harvey, 81	Dec 12	3
5603 Rausudake	Harvey, 81	May 16	3
5604 1992 FE	Harvey, 81	Mar 19	6

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2017) (V unless otherwise stated)	NO. OBS.
5611 1943 DL	Harvey, 81	Dec 27	3
5636 Jacobson	Harvey, 81	Apr 16	3
5651 Traversa	Harvey, 81	Nov 18-20	3
5711 Eneev	Harvey, 81	Sep 20	3
5728 1988 BJ4	Harvey, 81	Oct 20	3
5735 Loripaul	Harvey, 81	Aug 20	3
5737 Itoh	Harvey, 81	Sep 17	3
5743 Kato	Harvey, 81	Dec 14	3
5772 Johnlambert	Harvey, 81	Aug 16	3
5780 Lafontaine	Harvey, 81	Aug 30	3
5819 Lauretta	Harvey, 81	Sep 23	3
5834 1992 SZ14	Harvey, 81	Oct 28	3
5838 Hamsun	Harvey, 81	May 20	6
5842 Cancelli	Harvey, 81	Aug 20	3
5859 Ostozhenka	Harvey, 81	Apr 1	3
5897 Novotna	Harvey, 81	Sep 21	3
5914 Kathywhaler	Harvey, 81	Nov 23	3
5954 Epikouros	Harvey, 81	Mar 24	3
5970 Ohdohrikouen	Harvey, 81	Apr 21	3
5975 Otakemayumi	Harvey, 81	Dec 10	3
6011 Tozzi	Harvey, 81	Sep 16	3 0.5f@16.1
6015 Paularego	Harvey, 81	May 3	3
6021 1991 TM	Harvey, 81	Jul 20	3
6031 Ryokan	Harvey, 81	Nov 25	3
6032 Nobel	Harvey, 81	Sep 17	3 0.8f@15.8
6041 Juterkilian	Harvey, 81	Sep 15	3
6043 Aurochs	Harvey, 81	Dec 19	3
6045 1991 RG9	Harvey, 81	Jun 26	3
6059 Diefenbach	Harvey, 81	Sep 17	3
6064 Holasovice	Harvey, 81	Aug 20	3
6077 Messner	Harvey, 81	Aug 23	3
6091 Mitsuru	Harvey, 81	Jul 20	3
6104 Takao	Harvey, 81	Nov 25	3
6125 Singto	Harvey, 81	Sep 16	3 0.5f@15.7
6131 Towen	Harvey, 81	Nov 17	3
6133 Royaldutchastro	Harvey, 81	Aug 16	3
6158 Shosanbetsu	Harvey, 81	Dec 11	3
6175 Cori	Harvey, 81	Nov 20	3
6196 Bernardbowen	Harvey, 81	Sep 20	3
6243 Yoder	Harvey, 81	Dec 15	3
6250 Saekohyashi	Harvey, 81	May 3	3
6265 1985 YW3	Harvey, 81	Nov 18	3
6304 Josephus Flavius	Harvey, 81	Nov 17	3
6345 Hideo	Harvey, 81	Apr 2	3
6370 Malpais	Harvey, 81	Apr 17	3
6377 Cagney	Harvey, 81	Jul 30	3
6401 Roentgen	Harvey, 81	Apr 2	3

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2017) (V unless otherwise stated)	NO. OBS.
6409 1992 VC	Harvey, 81	Nov 18	3 0.3b@16.0
6473 Winkler	Harvey, 81	May 3	3
6502 1993 XR1	Harvey, 81	Sep 21	3 0.5f@16.3
6522 Aci	Harvey, 81	Aug 20	3
6549 Skryabin	Harvey, 81	Oct 21	3
6576 Kievtech	Harvey, 81	Nov 11	3
6583 Destinn	Harvey, 81	Nov 11	3
6585 O'Keefe	Harvey, 81	Dec 10	3
6601 Schmeer	Harvey, 81	Nov 11	3
6683 Karachentsov	Harvey, 81	Nov 25	3 0.3b@16.0
6693 1986 CC2	Harvey, 81	Jul 30	3
6708 Bobbievaile	Harvey, 81	Jun 18	3
6749 Ireentje	Harvey, 81	Aug 20	3
6772 1988 BG4	Harvey, 81	Dec 11	6
6825 Irvine	Harvey, 81	Nov 26	3
6831 1991 UM1	Harvey, 81	Sep 19	3
6837 Bressi	Harvey, 81	Oct 16	3
6845 Mansurova	Harvey, 81	Mar 29	3
6852 Nannibignami	Harvey, 81	Dec 14	3
6854 1987 UG	Harvey, 81	Sep 15	3
6862 Virgiliomarcon	Harvey, 81	Dec 19	3
6878 Isamu	Harvey, 81	Aug 23	3
6915 1992 HH	Harvey, 81	Apr 1	3
6929 Misto	Harvey, 81	Nov 20	3
6943 Moretto	Harvey, 81	Nov 20	3
6950 Simonek	Harvey, 81	Apr 1	3
6956 Holbach	Harvey, 81	Nov 27	3
6959 Mikkelkocha	Harvey, 81	Aug 25	3
6963 1990 OQ3	Harvey, 81	Jul 19-20	3
6980 Kyusakamoto	Harvey, 81	Oct 20	3
6988 1994 WE3	Faure, 35	Sep 22-Oct 16	13 (3V, 10C)
7021 Tomiokamachi	Harvey, 81	May 3	3
7041 Nantucket	Harvey, 81	Oct 28	3
7057 Al-Farabi	Harvey, 81	Jul 20	3
7058 Al-Tusi	Harvey, 81	Nov 18	3
7079 Baghdad	Harvey, 81	Jun 27	3
7098 Reaumur	Harvey, 81	May 16	3
7101 Haritina	Harvey, 81	Aug 16	3
7113 Ostapbender	Harvey, 81	Oct 18	3
7159 Bobjoseph	Harvey, 81	Sep 18	3
7198 Montelupo	Harvey, 81	Aug 16-18	3
7237 Vickyhamilton	Harvey, 81	Nov 14	3
7252 Kategawa	Harvey, 81	Oct 25-27	3
7277 Klass	Harvey, 81	Sep 20	3
7328 Casanova	Harvey, 81	Oct 17	3
7362 Rogerbyrd	Harvey, 81	Oct 20	3
7413 Galibina	Harvey, 81	Sep 20	3

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2017) (V unless otherwise stated)	NO. OBS.
7486 Hamabe	Harvey, 81	Nov 25	3
7500 Sassi	Harvey, 81	Nov 17	3
7509 Gamzatov	Harvey, 81	Apr 17	3
7555 Venvolkov	Harvey, 81	Oct 18	3
7616 Sadako	Harvey, 81	Dec 19	3
7637 1984 DN	Harvey, 81	Apr 2	3
7644 Cslewis	Harvey, 81	Oct 27	3
7645 Pons	Harvey, 81	Nov 23	3
7728 Giblin	Harvey, 81	Sep 15	3
7729 Golovanov	Harvey, 81	Apr 2	3
7800 Zhougkeyuan	Harvey, 81	Aug 30	3
7808 Bagould	Harvey, 81	May 15	3
7832 1993 FA27	Harvey, 81	Jul 20	3
7852 Itsukushima	Harvey, 81	Dec 14	3
7857 Lagerros	Faure, 35	Oct 17-18	24 (2V, 22C)
	Harvey, 81	Nov 17	3
7883 1993 GD1	Harvey, 81	May 17	3
7976 Pinigin	Harvey, 81	Oct 20	3
7993 1982 UD2	Harvey, 81	Oct 21	3
7996 Vedernikov	Harvey, 81	Jun 26	3
8003 Kelvin	Harvey, 81	Nov 14	3 0.5f@16.1
8006 Albinadubois	Harvey, 81	Aug 16	3
8054 Brentano	Harvey, 81	Oct 17	3
8213 1995 FE	Harvey, 81	Mar 23	3
8226 1996 TF7	Harvey, 81	Sep 20	3
8228 1996 YB2	Harvey, 81	Dec 11	3
8229 Kozelsky	Harvey, 81	Sep 20	3
8237 Constable	Harvey, 81	Sep 23	3
8269 Calandrelli	Harvey, 81	Nov 18	3
8276 Shigei	Harvey, 81	May 15-16	6
8297 Gerardfaure	Faure, 35	Oct 27	2C
	Rayon, 35	Dec 17	1C
8378 Sweeney	Harvey, 81	Nov 23	3
8393 Tetsumasakamoto	Harvey, 81	Oct 17	3
8400 Tomizo	Harvey, 81	Jul 15	3
8428 Okiko	Hubbell, 15	Mar 20	2C
8434 Colombianus	Harvey, 81	Dec 12	3
8484 1998 VM2	Harvey, 81	Oct 21	3
8512 1991 PC11	Harvey, 81	Aug 16	3
8561 Sikoruk	Harvey, 81	Oct 27	3
8570 1996 TN10	Harvey, 81	Nov 25	3
8577 Choseikomori	Harvey, 81	Sep 16	3 0.7f@15.9
8582 Kazuhisa	Harvey, 81	Sep 23	3
8608 Chelomey	Harvey, 81	Dec 15	3
8643 Quercus	Harvey, 81	Sep 20	3
8670 1991 OM1	Harvey, 81	Aug 16-18	3 0.4f@16.2
8863 1991 UV2	Harvey, 81	Dec 12	3
8922 Kumanodake	Harvey, 81	Dec 14	3
8946 Yoshimitsu	Hubbell, 15	Mar 20	2C
8957 Koujounotsuki	Harvey, 81	Dec 27	3
8992 Magnanimity	Harvey, 81	Oct 21	3
9014 Svyatorichter	Harvey, 81	Dec 19	3
9051 1991 UG3	Harvey, 81	Oct 17	3
9131 1998 JV	Harvey, 81	Aug 18	3
9196 Sukagawa	Harvey, 81	Apr 17	3
9200 1993 FK21	Harvey, 81	Jul 30	3
9208 Takanotoshi	Harvey, 81	Nov 24	3
9299 Vinceteri	Harvey, 81	Mar 29	3
9462 1998 HC37	Harvey, 81	Aug 16	3
9513 1971 UN	Harvey, 81	Sep 20	3
9549 Akplatonov	Harvey, 81	Apr 16	3
9594 Garstang	Harvey, 81	Apr 27	3
9643 1994 RX	Harvey, 81	Nov 17	3
9671 Hemera	Faure, 20	Apr 19-20	2
	Harvey, 81	Apr 27	3
	Rayon, 20	Apr 22-23	3C
9688 Goudsmit	Harvey, 81	Oct 14	3
9690 Houtgast	Harvey, 81	Dec 14	3 0.5f@16.1
9755 1990 RR2	Harvey, 81	Sep 19	3
9780 Bandersnatch	Harvey, 81	Oct 20	6
9865 Akiraohta	Harvey, 81	Jul 19	3
9927 Tyutchev	Harvey, 81	Jul 15	3 0.5f@15.9
9928 1981 WE9	Harvey, 81	Aug 18	3
9960 Sekine	Harvey, 81	Oct 20	3 0.4f@16.2
9967 Awanoyumi	Harvey, 81	Apr 27	3
9972 Minoruoda	Harvey, 81	Mar 30	3
10041 Parkinson	Harvey, 81	Mar 24	6
10065 Fontenelle	Harvey, 81	Jul 31	3
10088 Digne	Harvey, 81	Mar 30	3
10132 Lummelunda	Harvey, 81	Sep 17	3
10238 1998 SO140	Harvey, 81	Oct 27	3
10292 1986 PM	Harvey, 81	Jul 22	3
10337 1991 RO1	Harvey, 81	Aug 23	3
10357 1993 SL3	Harvey, 81	Oct 15	3
10401 1997 VD3	Hubbell, 15	Mar 20	2C
10498 Bobgent	Harvey, 81	Jun 27	3
10503 1987 SG13	Harvey, 81	Nov 11	3
10520 1990 RS2	Harvey, 81	Oct 21	3
10582 Harumi	Harvey, 81	Oct 28	3
10583 Kanetugu	Harvey, 81	Nov 20	3
10594 1996 RE4	Harvey, 81	Oct 21	3
10636 1998 OK56	Harvey, 81	Mar 20	6
10666 Feldberg	Harvey, 81	Nov 20	3
10710 1982 JE1	Harvey, 81	Dec 15	3
10715 Nagler	Harvey, 81	Aug 16	3 0.5f@16.3
10723 1986 TH	Harvey, 81	Oct 20	3

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2017) (V unless otherwise stated)	NO. OBS.
10744 Tsuruta	Harvey, 81	Dec 14	3
10821 Kimuratakeshi	Harvey, 81	Oct 21	3
10838 Lebon	Faure, 35	Sep 22-Oct 26	26 (3V, 23C)
11004 Stenmark	Harvey, 81	Sep 17	3
11014 Svatopluk	Harvey, 81	Nov 17	3
11211 1999 GD24	Harvey, 81	Aug 25	3 0.5f@16.1
11213 1999 HF8	Harvey, 81	Apr 1	3
11239 Marcgraf	Harvey, 81	Nov 25	3
11327 1995 SL2	Harvey, 81	Nov 25	3
11434 Lohnert	Harvey, 81	Jul 30	3
11437 Cardalda	Harvey, 81	Nov 23	3
11546 Myoshimachi	Harvey, 81	Nov 11	3
11649 1997 BR6	Harvey, 81	Dec 15	3
11682 Shiwaku	Harvey, 81	Apr 2	3
11745 1999 NH3	Harvey, 81	Aug 16	3
11751 1999 NK37	Hubbell, 15	Mar 20	2C
11855 Preller	Faure, 35	Sep 21	2
	Harvey, 81	Sep 23	3
11901 1991 PV11	Harvey, 81	Jul 20	3
12262 Nishio	Harvey, 81	Nov 26	3
12315 1992 FA2	Harvey, 81	Nov 24	3
12377 1994 PP	Harvey, 81	Aug 16	3
12387 Tomokofujiwara	Harvey, 81	Dec 11	3
12436 1996 BY1	Harvey, 81	Sep 18	3
12551 1998 QQ39	Harvey, 81	Sep 19	3
12674 Rybalka	Harvey, 81	Aug 1	6
12725 1991 PP16	Harvey, 81	Sep 22	3
12740 1992 EX8	Harvey, 81	Mar 29	3
12800 Oobayashiarata	Harvey, 81	Oct 17	3
12826 1997 AO7	Hubbell, 15	Mar 17	2C
12892 1998 QE52	Harvey, 81	Nov 11	3
12926 Brianmason	Harvey, 81	Sep 24	3
13069 Umbertoeco	Harvey, 81	Dec 15	3
13242 1998 KR44	Harvey, 81	Aug 25	3
13311 1998 RA68	Harvey, 81	Oct 15-27	3
13338 1998 SK119	Harvey, 81	Dec 11	3
13427 1999 VM25	Harvey, 81	Oct 27	3
13632 1995 PW8	Harvey, 81	Sep 21	3
13749 1998 SG49	Harvey, 81	Dec 14	3
14199 1998 XV77	Harvey, 81	Dec 19	6
14245 2000 AS31	Harvey, 81	Oct 20	3
14318 Buzinov	Harvey, 81	Sep 24	3
14328 Granvik	Harvey, 81	Aug 20	3
14339 Knorre	Harvey, 81	May 17	3
14391 1990 RE2	Harvey, 81	Sep 21	3
14446 Kinkowan	Harvey, 81	Aug 20	3
14631 Benryan	Harvey, 81	May 17	3
14659 Gregoriana	Harvey, 81	Mar 29	3
14767 1137 T-1	Harvey, 81	Oct 27	3

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2017) (V unless otherwise stated)	NO. OBS.
14892 1991 VE5	Harvey, 81	Aug 23	3
15047 1998 XG49	Harvey, 81	Nov 26	3
15207 1979 KD	Harvey, 81	Aug 20	3
15356 1995 DE	Harvey, 81	Jul 30	3
15419 1998 FZ62	Harvey, 81	Oct 18	3
15424 1998 QE100	Harvey, 81	Dec 11	3
15427 Shabas	Harvey, 81	May 3	3
15549 2000 FN	Harvey, 81	Jul 20	3
15590 2000 GH82	Harvey, 81	May 20	4
15621 Erikhovland	Harvey, 81	Apr 1	3
15751 1991 VN4	Harvey, 81	Nov 14	3
15765 1992 WU1	Harvey, 81	Nov 17	3
15988 Parini	Harvey, 81	May 17	6
16018 1999 CJ67	Harvey, 81	Sep 21	3
16024 1999 CT101	Harvey, 81	Sep 21	3
16041 1999 GM19	Harvey, 81	Nov 11	3
16299 6566 P-L	Harvey, 81	Jul 22	3
16363 1979 MT4	Harvey, 81	Dec 11	3
16444 Godefory	Harvey, 81	Nov 17	3
16518 Akihikoito	Harvey, 81	Nov 11	3
16525 Shumarinaiko	Hubbell, 15	Mar 17	2C
16535 1991 NF3	Harvey, 81	Aug 16	6
16669 Rionuevo	Harvey, 81	Nov 17	3
16773 1996 VO1	Harvey, 81	Dec 19	3
16852 Nuredduna	Harvey, 81	Oct 18	3
16871 1998 BD	Harvey, 81	Oct 27	3
16943 1998 HP42	Harvey, 81	Dec 15	3 0.9f@16.1
17006 1999CH63	Harvey, 81	Aug 18	3 0.5f@16.4
17129 1999 JM78	Harvey, 81	Aug 30	3
17279 jeniferevans	Harvey, 81	Oct 27	3
17284 2000 MJ5	Harvey, 81	Nov 11	3
17297 3560 P-L	Harvey, 81	Oct 25	3
17512 1992 RN	Harvey, 81	Aug 20	3
17567 Hoshinoyakata	Harvey, 81	Mar 30-Apr 1	3
18243 Gunn	Harvey, 81	Nov 27	3
18331 1987 DQ6	Harvey, 81	Sep 20	3
18488 1996 AY3	Harvey, 81	Nov 24	3
18785 Betsywelsh	Harvey, 81	Oct 17	3 0.3f@16.1
18897 2000 HG30	Harvey, 81	May 16	3
19189 Stradivari	Harvey, 81	Nov 20	3
19386 Alexcronstedt	Harvey, 81	Sep 23	3 0.9f@16.3
19480 1998 HC150	Harvey, 81	Nov 20-24	3
19530 1999 GQ23	Harvey, 81	Jul 30	3
19743 2000 AF164	Harvey, 81	Apr 1	3
19830 2000 SC218	Harvey, 81	Sep 24	3
20031 1992 OO	Harvey, 81	Jun 26	3
20041 1992 YH	Harvey, 81	Dec 15	3
20100 1995 SS2	Harvey, 81	Oct 20	3

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2017) (V unless otherwise stated)	NO. OBS.
20115 Niheihajime	Harvey, 81	Dec 14	3
20179 196 XX31	Harvey, 81	Aug 30	3
20435 1999 FU28	Harvey, 81	Oct 17	3
			0.3f@16.0
20445 1999 JN77	Harvey, 81	Aug 23	6
20452 1999 KG4	Harvey, 81	Jun 27	3
20453 1999 KL6	Harvey, 81	May 15	3
			0.5b@15.8
20706 1999 WY3	Harvey, 81	Apr 3	3
20767 2000 PN2	Harvey, 81	Sep 22	3
20885 2000 WD2	Harvey, 81	Jul 20	3
21086 1992 AO1	Harvey, 81	Dec 15	3
			0.6f@16.2
21282 Shimizuyuka	Harvey, 81	Nov 18	3
21893 1999 VL4	Harvey, 81	Jul 19-20	3
22001 1999 XY41	Hubbell, 15	Mar 20	2C
22282 1985 RA	Harvey, 81	Nov 25	3
22360 1993 FT11	Harvey, 81	Sep 23	3
22751 1998 UA27	Harvey, 81	May 17	3
22800 1999 NY22	Harvey, 81	Aug 25	3
			0.5f@16.2
23147 2000 AQ228	Harvey, 81	Nov 17	3
23519 1992 SG13	Harvey, 81	Oct27	3
23621 1996 PA	Harvey, 81	Jul 15	6
23662 1997 ES17	Harvey, 81	Aug 30	3
24384 2000 AR171	Harvey, 81	Sep 21	3
24562 4647 P-L	Hubbell, 15	Mar 20	2C
24626 Astrowizard	Harvey, 81	Oct 27	3
25294 Johnlaberee	Hubbell, 15	Mar 20	2C
25316 Comnick	Harvey, 81	Nov 20	3
25529 1999 XL127	Harvey, 81	Nov 11	3
25535 1999 XF144	Harvey, 81	Apr 2	3
25897 2000 XZ32	Harvey, 81	Sep 24	3
25980 2001 FK53	Harvey, 81	Sep 19	3
26104 1990 VV1	Harvey, 81	Aug 25	3
27095 Girardiwanda	Harvey, 81	Sep 24	3
27621 2001 KF67	Harvey, 81	Sep 22	3
27708 1987 WP	Harvey, 81	Nov 24	3
29076 1972 TR8	Harvey, 81	Jul 31	3
30056 2000 EP47	Harvey, 81	Aug 30	3
30220 2000 GP126	Harvey, 81	May 5	3
30769 1984 ST2	Harvey, 81	Aug 16	3
31105 Oguniyamagata	Harvey, 81	Oct 28	3
31603 1999 GQ3	Harvey, 81	Sep 21	3
31775 1999 JN122	Harvey, 81	Jun 27	3
31867 2000 EG94	Harvey, 81	Jul 15	3
31895 2000 FX44	Harvey, 81	Aug 25	3
32328 2000 QW63	Harvey, 81	Sep 22	3
33982 2000 NQ23	Harvey, 81	Jul 30	3
			0.6f@16.1
35723 1999 FT42	Harvey, 81	Nov 14	3
37569 1989 UG	Harvey, 81	Oct 27	3
39845 1998 BT35	Harvey, 81	Nov 11	3
41794 2000 WK11	Harvey, 81	Oct 27	3
42283 2001 SQ316	Harvey, 81	Sep 20	3
42843 1999 RV11	Harvey, 81	Oct 15	3
44919 1999 VC31	Harvey, 81	Oct 21	3
45287 2000 AB29	Harvey, 81	Aug 23	3
			0.4f@16.3
46977 Krakow	Harvey, 81	Nov 26	3
47592 2000 AO203	Harvey, 81	Sep 18	3
49699 Hidetakasato	Harvey, 81	Nov 24	3
49937 1999 XO180	Harvey, 81	Nov 25	3
53284 1999 FK47	Harvey, 81	Aug 25	3
53595 2000 CK62	Hubbell, 15	Mar 20	2C
54432 2000 LG31	Harvey, 81	Sep 21	3
55546 2001 XQ48	Harvey, 81	Jul 31	3
57038 2001 AX39	Harvey, 81	Sep 22	3
57348 2001 QW281	Harvey, 81	Jul 20	3
			0.4f@16.1
61108 2000 LT31	Harvey, 81	Sep 22	3
64220 2001 TF107	Harvey, 81	Nov 24	3
65679 1989 UQ	Harvey, 81	Oct 15	6
66146 1998 TU3	Pryal, 20	Oct 14-15	5
66280 1999 JF12	Harvey, 81	Sep 18	3
68127 2001 AZ15	Harvey, 81	Aug 30	3
69315 1992 UR2	Harvey, 81	Nov 28	6
			0.5f@15.8
70027 1999 BQ15	Hubbell, 15	Mar 20	2C
73714 1992 SW14	Harvey, 81	Aug 30	3
90075 2002 VU94	Harvey, 81	Apr 5	6
90189 2003 AS40	Harvey, 81	Sep 16	3
91381 1999 JR109	Harvey, 81	Nov 20	3
116640 2004 CK1	Harvey, 81	Dec 11	3
133819 2003 XS	Faure, 35	Sep 20-21	2
	Harvey, 81	Aug 30	3
	Rayon, 20	Sep 21	2C
134886 2000 SR62	Hubbell, 15	Mar 20	2C
138925 2001 AU43	Harvey, 81	Jul 19	6
140158 2001 SX169	Harvey, 81	Nov 27	6
143404 2003 BD44	Harvey, 81	Mar 20	6
	Hubbell, 15	Mar 20	2C
143992 2004 AF	Harvey, 81	Jul 20	6
171576 1999 VP11	Harvey, 81	Oct 25	6
	Pryal, 20	Oct 24	7
190166 2005 UP156	Harvey, 81	May 15	6
190208 2006 AQ	Harvey, 81	Oct 21	6
215588 2003 HF2	Harvey, 81	Apr 3	6
			0.5f@16.5
222541 2001 UQ175	Harvey, 81	Nov 23-24	3
232368 2003 AZ2	Harvey, 81	Jul 30	6
333888 1998 ST4	Harvey, 81	Nov 17	6
415029 2011 UL21	Harvey, 81	Dec 27	6
418849 2008 WM64	Harvey, 81	Dec 19	6
422699 2000 PD3	Harvey, 81	Aug 18	6

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2017) (V unless otherwise stated)	NO. OBS.
441987 2010 NY65	Harvey, 81	Jun 26	6
444584 2006 UK	Harvey, 81	Dec 11	6
496816 1989 UP	Harvey, 81	Oct 27	6
496817 1989 VB	Harvey, 81	Oct 17	6
498548 2008 GH110	Harvey, 81	Oct 20	6
1999 AF4	Harvey, 81	Dec 30	6
2006 XY	Harvey, 81	Dec 12	6
2012 TC4	Harvey, 81	Oct 12	6
2014 JO25	Faure, 20	Apr 19	5
	Harvey. 81	Apr 21	6
	Pryal, 20	Apr 19	8
	Rayon, 20, 35	Apr 19-23	119C
	Werner, 20	Apr 20	9
2014 YC15	Harvey, 81	Sep 16	6
	Rayon, 20	Sep 21	2C
2017 BS5	Harvey, 81	Jul 22	6
2017 CS	Harvey, 81	May 26-27	12
2017 MB1	Harvey, 81	Jul 20	6
2017 MC1	Harvey, 81	Jun 30	6
2017 MC4	Harvey, 81	Jul 10	6
2017 NS5	Harvey, 81	Jul 16	6 0.8f@16.1
2017 OP68	Harvey, 81	Sep 15	6 0.5f@16.1
2017 PR25	Harvey, 81	Sep 22	6
2017 PJ26	Harvey, 81	Sep 15	6
2017 SO17	Harvey, 81	Nov 14	6
2017 TE5	Harvey, 81	Oct 17	6 1.0f@15.7
2017 WX12	Harvey, 81	Dec 17	6

A PHOTOMETRIC STUDY OF 437 RHODIA

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(Received: 2018 Apr 13)

Based on nearly four months of observations, we find for 437 Rhodia a synodic rotation period of 433.2 ± 0.5 hours, amplitude 0.35 ± 0.05 magnitudes, and color index V-R = 0.46. We calculate H = 10.710 ± 0.037 and G = 0.416 ± 0.053 at mid-light in the V photometric system. Tumbling is confirmed, but the second tumbling period could not be found. Applying H and G from this study to parameters from the IRAS study yields albedo p_V = 0.526, diameter D = 13.12 km; and to parameters from the NEOWISE satellite data, p_V = 0.440, D = 14.46 km.

Several previously published rotation periods for minor planet 437 Rhodia are all of low reliability. These include >12 h (Barucci, 1984); 109.25 h (Behrend, 2005); 109.2 h (Behrend, 2016); 56 h (Binzel, 1987).

Pilcher at Organ Mesa Observatory and Polakis at Command Module Observatory conducted independent photometric campaigns and combined their data sets after they completed their observations. Pilcher used a 0.35-m *f*/10 Meade LX200 GPS Schmidt-Cassegrain (SCT) telescope, SBIG STL-1001E CCD, and a clear filter to obtain 70 sessions (Nos. 193 through 353) between 2017 Dec 12 and 2018 Mar 24. Most of the sessions were short, two hours or less, obtained at the end of the night before opposition and the beginning of the night after opposition. This procedure is productive for finding very long periods and tumbling behavior but misses short-period variations. Polakis used a 0.32-m f/6.7 Dall-Kirkham telescope, SBIG STXL-6303 CCD, clear filter to obtain 29 sessions (Nos. 362 through 390) between 2018 Jan 23 and Mar 18. Most of the sessions, except in mid-March, were 6-7 hours and for finding possible short-period variations complement Pilcher's short sessions. No short-period variations were found.

Calibration stars for all sessions are solar colored stars with Sloan r′ magnitudes from the Carlsberg Meridian Circle 15 (CMC15) catalog (Muiñoz et al., 2014), and adjusted to the Johnson R magnitude system by R = r′ – 0.22. This catalog is usually internally consistent within 0.05 magnitudes but occasionally somewhat larger inconsistencies are found. It was noted that magnitudes of the asteroid in Polakis's sessions found by this means were systematically 0.04 magnitudes brighter than those in Pilcher's sessions. Therefore, magnitudes of the calibration stars in Polakis's session were adjusted by 0.04 magnitudes downward,

Number	Name	20yy/mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E	Amp	A.E.
437	Rhodia	17/12/12-18/03/24	6121	14.6,2.2,18.8	118	-6	433.2	0.5	0.35	0.05

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).

and provide a good fit when sessions by both observers are combined in a single lightcurve. The systematic difference is attributed to differences in the transmission paths and detector wavelength sensitivities for the separate observatories.

MPO Canopus software plots multi-session lightcurves by correcting night-to-night magnitude variations caused by changes in Earth and Sun distances and phase angle; the changes that remain are due only to rotational behavior of the target. Corrections for Earth and Sun distances depend upon inverse square brightness laws, and are precise and reliable. The surface properties of the asteroid determine how rapidly the magnitude changes with phase angle and are quantitatively defined by the phase slope parameter, *G*.

For all asteroids, *MPO Canopus* utilizes the value of *G* listed in the MPC orbital database. For 437 Rhodia the listed value is the default *G* = 0.150. A raw lightcurve for 437 Rhodia, using all 99 sessions and assuming *G* = 0.150, is presented in Figure 1. It shows a cyclic variation of two maxima and minima in a period near 18 days with other magnitude changes superposed.

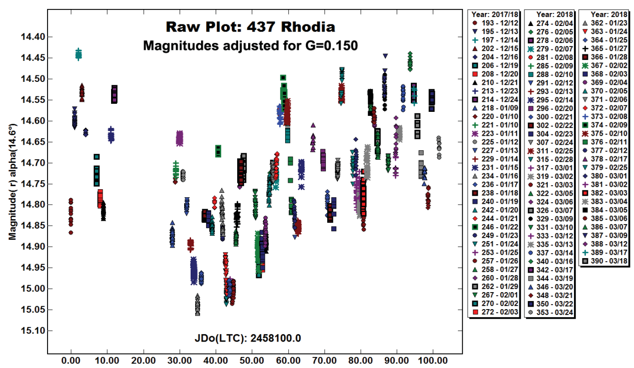

Figure 1. Raw lightcurve of all observations of 437 Rhodia with magnitudes adjusted to *G* = 0.150.

There is a distinct dip in this raw lightcurve that is greater for smaller phase angles. This suggests that the magnitude varies less with phase angle than would be the case if *G* = 0.150.

In order to find improved values of *H* and *G*, 25 data points were obtained alternately in R and V filters on 2018 Feb 20 by Pilcher. The same calibration stars were used for both the R and V filter sessions. Dymock and Miles (2004) provide formulae for converting r′, J, and Ks in the CMC14 catalog (and also for the expanded CMC15 catalog) to Cousins R and Johnson V magnitudes.

$$R = r' - 0.22 \qquad V = 0.6278(J\text{-}Ks) + 0.9947\, r'$$

R magnitudes derived from CMC15 r′ magnitudes were used for the R filter session. V magnitudes derived from CMC15 r′, J, and Ks magnitudes were used for the V filter session. Figure 2 shows all data points from both sessions. The lightcurves are noisy due to the use of color filters for a target near magnitude 15. Adjusting the R magnitudes downward by 0.46 produces a best fit with minimum RMS error. Hence we find V-R = 0.46.

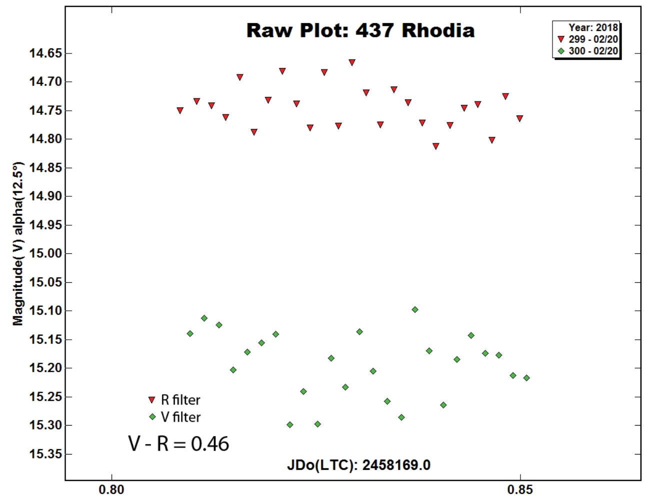

Figure 2. Lightcurve of sessions on 437 Rhodia 2018 02 20 in R and V filters.

Sixteen sessions near mid-light in the 18-day bimodal periodicity were chosen to find *H* and *G* at mid-light with the H-G calculator function of *MPO Canopus.* These sessions are not exactly at mid-light, but the scatter in an H-G diagram is considerably smaller than if all sessions were included. The R magnitudes in the data were converted to the V magnitude system by the aforementioned V-R = 0.46. Applying this procedure to the data in the sixteen sessions near mid-light produces an H-G diagram (Figure 3) with *H* = 10.710 ± 0.037 and *G* = 0.416 ± 0.053, both at mid-light.

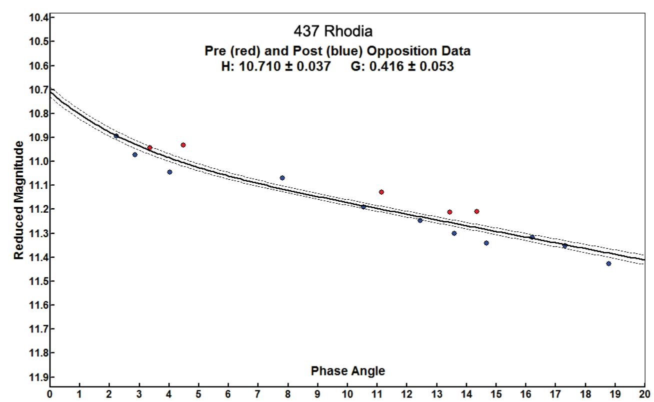

Figure 3. H-G plot for 437 Rhodia.

Two previous studies have published values of *H* and *G* for 437 Rhodia, as well as measurements of the albedo and diameter from far infrared radiometry. One study is by Tedesco et al. (2004) in a final presentation of IRAS satellite data, that gives *H* = 10.41, *G* = 0.150, albedo p_V = 0.7035, and diameter *D* = 13.12 km. The second study involves IR data from the WISE satellite. Preparation of these data at the time of this publication is an ongoing process. The most recent presentation is by Mainzer et al. (2016) and gives *H* = 10.58, *G* = 0.15, p_V = 0.526, *D* = 14.03 km. Harris and Harris (1997) explain a method by which the albedo can be found from the phase constant *G*, and to which the reader is referred for a full explanation. Alan Harris (personal communication) used this method to provide albedos and diameters for 437 Rhodia as revised from the values of *H* = 10.71 and *G* = 0.416 of this study. From the IRAS data (Tedesco et al., 2004), p_V = 0.518, *D* = 13.12 km. From the NEOWISE data (Mainzer et al., 2016), *pv* = 0.440, *D* = 14.46 km. These values of p_V are typical for taxonomic class E asteroids.

MPO Canopus V.10.7 contains a subroutine by which the default *G* can be changed for all sessions. When the raw lightcurve for all 99 sessions (Figure 4) is plotted with $G = 0.416$, that part of the variation caused by the incorrect value of *G* is removed.

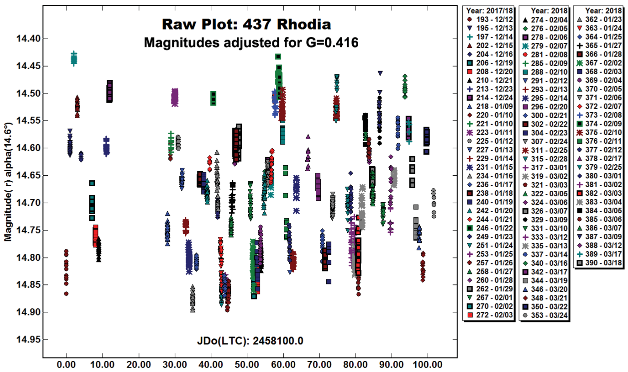

Figure 4. Raw lightcurve of all observations of 437 Rhodia with magnitudes adjusted to $G = 0.416$.

It is now productive to plot with single-period *MPO Canopus* software a phased bimodal lightcurve (Figure 5) that has best fit to a period 433.2 ± 0.05 h and amplitude 0.35 ± 0.05 mag. Scatter due to photometry errors, internal inconsistencies (up to about 0.05 magnitudes, occasionally larger) in the CMC15 catalog, and possible tumbling behavior remain in this lightcurve. Single-period software cannot determine whether the observed scatter is caused by magnitude errors or partially by tumbling.

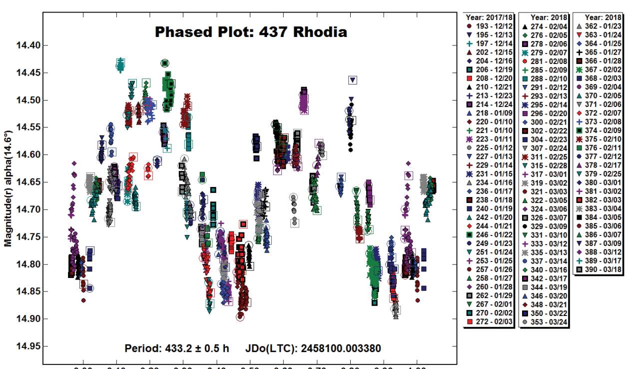

Figure 5. Phased lightcurve of 437 Rhodia.

Petr Pravec (personal communication) used simultaneous dual-period software to search for evidence of tumbling. A principal period of 436 hours, slightly different from 433.2 hours by single-period software, appeared. Tumbling was confirmed, but a second period could not be found. This object must be rated PAR = –2, defined as NPA (non-principal axis) rotation detected based on deviations from the single periodicity, but the second period is not resolved (Pravec et al. 2005). There is some suggestion, very insecure, that the second period may be greater than 1000 hours, which too long to be found in our photometric survey of less than 4 months.

We conclude that the synodic rotation period of 437 Rhodia is 433.2 ± 0.5 h, an amplitude of 0.35 ± 0.05 magnitudes, with confirmed evidence of tumbling. We also find the photometric color index V-R = 0.46 and $H = 10.710 \pm 0.037$ and $G = 0.416 \pm 0.053$ at mid-light.

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LIGHTCURVE AND ROTATION PERIOD DETERMINATION FOR (13124) 1994 PS, (26571) 2000 EN84, AND (29934) 1999 JL46

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(Received: 2018 Apr 15)

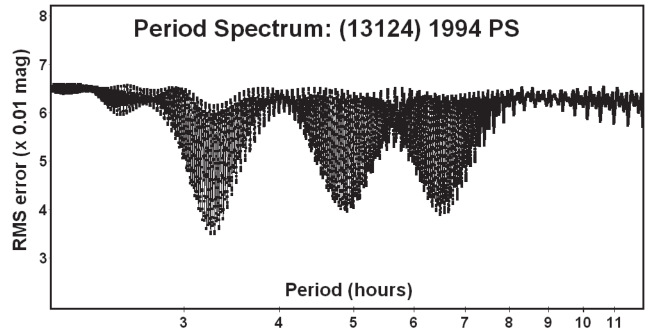
Photometric observations of the main-belt asteroids (13124) 1994 PS, (26571) 2000 EN84, and (29934) 1999 JL46 were made from 2018 Jan 23 to Mar 9. Analysis determined the synodic rotational periods for (13124) 1994 PS, 8.147 ± 0.003 h; (26571) 2000 EN84, 4.105 ± 0.003 h; and (29934) 1999 JL46, 5.841 ± 0.001 h as the most likely solutions.

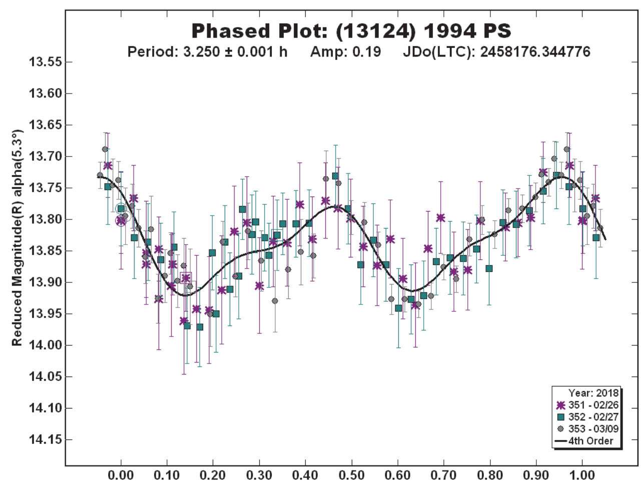
Lightcurve analysis of three main-belt asteroids was performed using images taken at the Astronomical Observatory of the University of Siena (Italy). Data were obtained with 0.30-m *f*/5.6 Maksutov-Cassegrain telescope, SBIG STL-6303E NABG CCD camera, and clear filter; the pixel scale was 2.26 arcsec in binning 2x2. Exposures were 300 seconds.

MPO Canopus (Warner, 2017) was used to measure the images, do Fourier analysis, and produce the lightcurves. Table I lists the asteroids that were observed as well as the period associated with the analysis and the number of data points in the analysis. Orbital data and discovery circumstances were taken from the JPL Small Bodies Node (JPL, 2018).

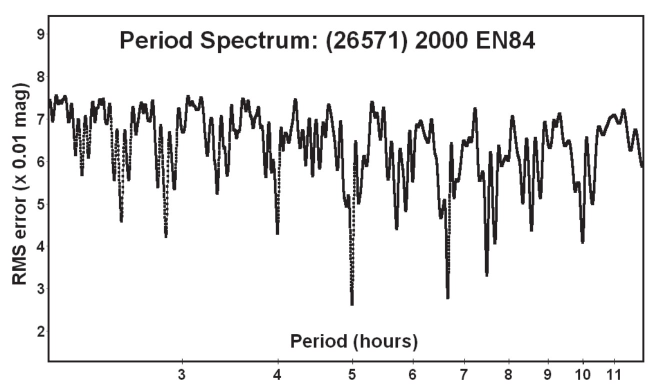
A search through the asteroid lightcurve database (LCDB; Warner et al., 2009) indicates that our results may be the first reported lightcurve observations and results for these objects. The three asteroids were reported as lightcurve photometry opportunities for 2018 January-March in the *Minor Planet Bulletin* (Warner et al., 2018).

<u>(13124) 1994 PS</u> is a main-belt asteroid discovered on 1994 August 14 by Kobayashi at Oizumi. It's a typical main-belt asteroid in an orbit with a semi-major axis of about 2.35 AU, eccentricity 0.108, and orbital period of about 3.60 years. We observed this asteroid from 2018 Feb 26 to Mar 9. The observations resulted in two sessions with a total of 123 data points. The result for the synodic period for (13124) 1994 PS is associated with the established bimodal lightcurve phased to 3.291 ± 0.001 h with an amplitude of 0.19 ± 0.03 mag.



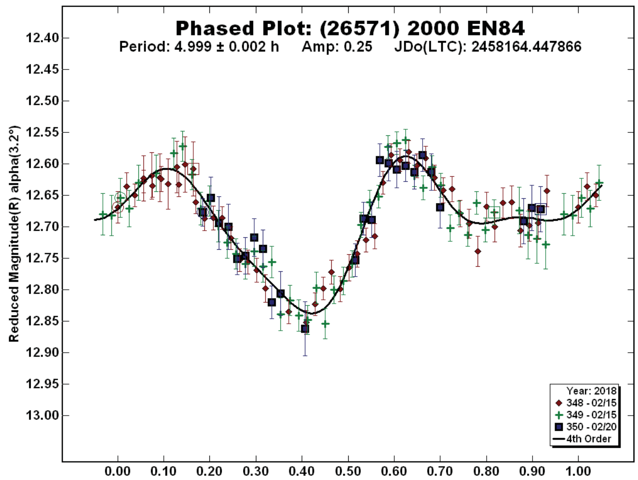


<u>(26571) 2000 EN84 (1990 BW1)</u> is a main-belt asteroid discovered on 2000 March 7 by LINEAR at Socorro. It's a typical main-belt asteroid in an orbit with a semi-major axis of about 2.79 AU, eccentricity 0.097, and orbital period of about 4.65 years. We observed this asteroid from 2018 Feb 14-19. The collaborative observations resulted in 3 sessions with a total of 125 data points. The result for the synodic period for (26571) 2000 EN84 is associated with the established bimodal lightcurve phased to 4.999 ± 0.002 h with an amplitude of 0.25 ± 0.02 mag.

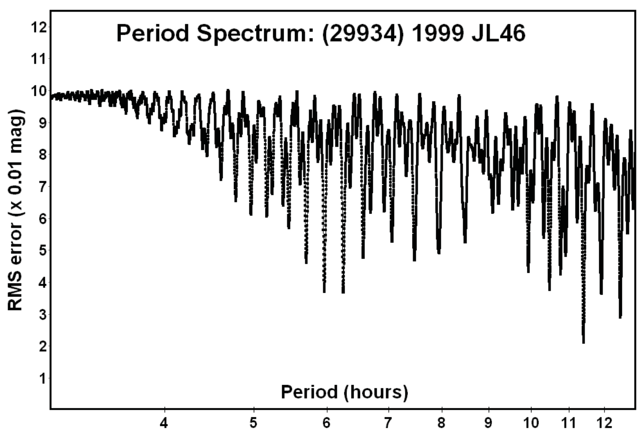


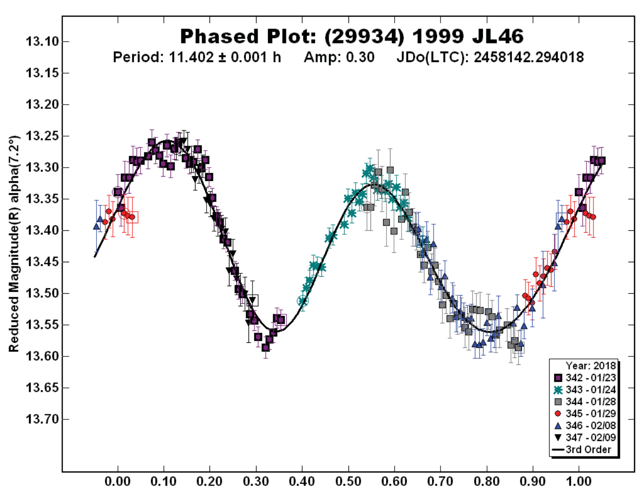
Number	Name	2018/mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
13124	1994 PS	02/26-03/09	123	5.3,2.7	166	3	3.291	0.001	0.19	0.03
26571	2000 EN84	02/14-02/19	125	3.1,4.7	144	6	4.999	0.002	0.25	0.02
29934	1999 JL46	01/23-02/03	170	7.2,7.5	128	-11	11.402	0.001	0.30	0.03

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).



(29934) 1999 JL46 (1934 EF) is a main-belt asteroid discovered on 1999 May 10 by LINEAR at Socorro. It's a typical main-belt asteroid in an orbit with a semi-major axis of about 2.91 AU, eccentricity 0.292, and orbital period of about 4.61 years. We observed this asteroid from 2018 Jan 23 to Feb 2. The collaborative observations resulted in 3 sessions with a total of 170 data points. The result for the synodic period for (29934) 1999 JL46 is associated with the established bimodal lightcurve phased to 11.402 ± 0.001 h with an amplitude of 0.30 ± 0.03 mag.





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LIGHTCURVE ANALYSIS OF 6 ASTEROIDS FROM RMS OBSERVATORY

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(Received: 2018 Apr 15)

CCD images of 6 asteroids were taken from 2017 November 20 to 2018 March 26 for the purpose of determining their synodic rotation periods. The asteroids were: 3233 Krisbarons, 11546 Miyoshimachi, (19472) 1998 HL52, (418849) 2008 WM64, 1999 AF4, and 2017 QL33

CCD photometric observations of 6 asteroids were made from the RMS Observatory (W25) from 2017 November 20 to 2018 March 26. Observations were taken with a 0.35-m SCT operating at f/7.6 using an Atik One 6.0 CCD (unfiltered) binned at 3x3 with an image scale of 1.05 arcseconds per pixel. Exposure times varied from 30s to 300s.

The images were calibrated (bias, dark, and flat) with *AstroImageJ* (Collins and Kielkopf, 2013). Differential photometry measurements were made in *MPO Canopus* (Warner, 2017) using the FALC routine (Harris *et al.*, 1989) to derive the asteroid synodic periods. The StarBGone utility in *MPO Canopus* was applied to measure images when asteroids where located in the vicinity of stars. The *MPO Canopus* Comp Star Selector utility was employed to select comparison stars of near solar-color for differential photometry for all asteroids. R band magnitudes were taken from the CMC-15 catalog (Munos, 2017) and were chosen to best match the unfiltered CCD measurements.

In several cases comparison stars were selected from the Pan-STARRS DR1 (Chambers, K.C. *et al.*, 2016). The method employed (to be submitted to the MPB for publication) involved selecting near solar-color stars from the Pan-STARRS DR1 based on Sloan g and r magnitudes, 0.35 <= g-r <= 0.67, then calculating B, V, and R magnitudes based on transformation equations in Kostov and Bonev, 2017.

$$B = g - 0.017 – 0.508 * (g - r)$$

$$V = g + 0.194 + 0.561 * (g- r)$$

$$R = r - 0.142 - 0.166 * (g - r)$$

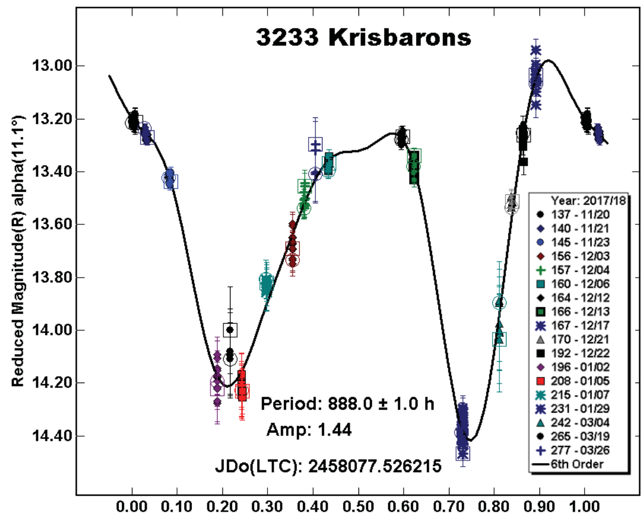
The selected stars were then imported as a user star catalog into *MPO Canopus.* B and V magnitudes were used for the Comp Star Selector, R magnitudes for lightcurve analysis.

Table I lists the observing circumstances and the analysis results.

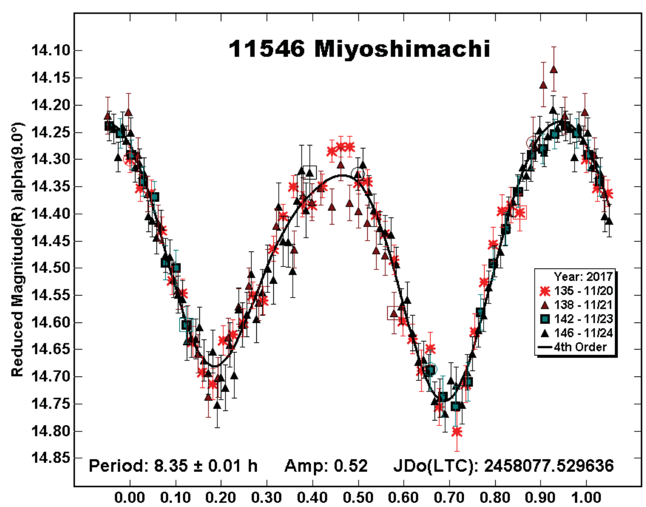
3233 Krisbarons. This member of the Flora group was selected because a search of the LCDB (Warner *et al.*, 2009) gave an uncertainty of 1 and its opposition magnitude would be favorable at 14.9. Previous work indicated a period of 24 h with amplitude of 0.15 (Behrend, 2007web).

After four months of observation this object was found to be a slow rotator with a large amplitude, P = 888 h +/- 1 h, amplitude 1.44. Although coverage is missing during the rapid drops near the 0.1 and 0.65 phases, the remainder of the curve seems complete enough to feel confident of the period and amplitude.

Since this target covered a large part of the sky over several months and its magnitude dropped to V ~ 17.6 in 2018 March all comparison stars were chosen from the Pan-STARRS DR1 to minimize zero point corrections and to provide enough comparison stars as the target dimmed. For this target, no zero point corrections were used.



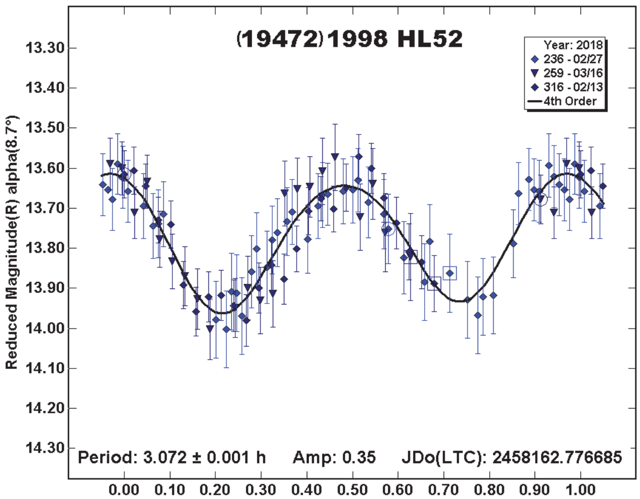
11546 Miyoshimachi. This member of the Flora group was selected because a search of the LCDB (Warner *et al.*, 2009) did not find any previous period and its predicted opposition magnitude (V = 15.5) and declination (+23) were favorable. Analysis showed a well-defined bimodal lightcurve with a period of 8.35 h.



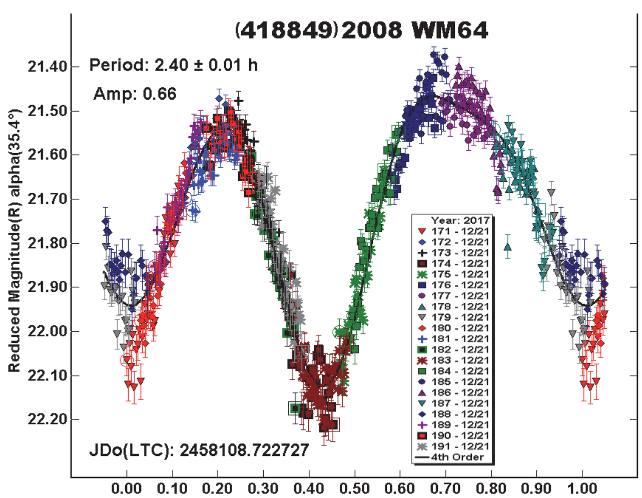
Number	Name	20xx mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
3233	Krisbarons	17/11/20-18/3/26	281	11.0,25.5	41,79	5,3	888.0	1.0	1.44	0.04	FLOR
11546	Miyoshimachi	17/11/20-17/11/24	178	8.8,11.0	46	5	8.35	0.01	0.52	0.03	FLOR
19472	1998 HL52	18/2/13-18/3/16	97	9.6,12.2	155	19	3.072	0.001	0.35	0.05	MB
418849	2008 WM64	17/12/21	617	37.8	107	-10	2.40	0.01	0.66	0.05	NEA
	1999 AF4	18/1/29	100	15.3	130	-11	3.2	0.1	0.15	0.04	NEA
	2017 QL33	18/1/3-18/1/7	474	48.6,34.4	99,110	26,19	14.56	0.08	0.14	0.06	NEA

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. The definitions and values are those used in the LCDB (Warner *et al.* 2009).

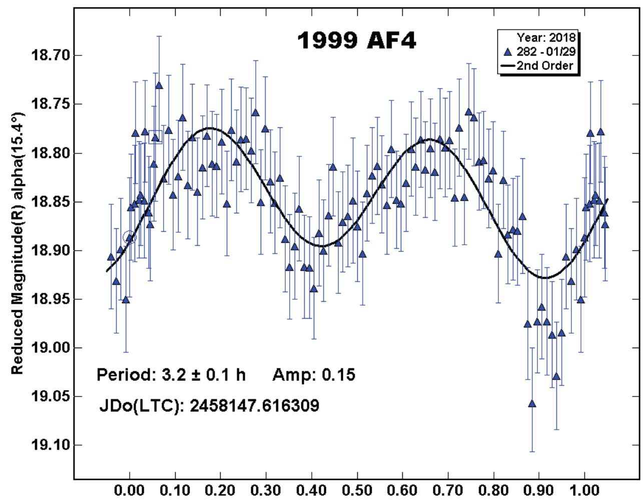
(19472) 1998 HL52. Previous work on this main-belt asteroid gave a period of 3.072 h (Waszczak, *et al.*, 2015). The result found this year is in good agreement with those findings.



(418849) 2008 WM64. This near-Earth asteroid was listed as a lightcurve photometry opportunity (Warner, *et al.* 2017). At the time this target was selected for observation, a search of the LCDB (Warner et al., 2009 - updated 2017, Nov 9) did not find any previously reported period. Upon completion of this analysis, a re-check of the most current LCDB (Warner et al., 2009 - updated 2018, March 7) found results reported by Warner, B.D. His result of P = 2.4055 h and amplitude = 0.62 are in good agreement with those reported here.



1999 AF4. This Near Earth Asteroid was listed as a lightcurve photometry opportunity (Warner, *et al.,* 2018). At the time this target was selected for observation, a search of the LCDB (Warner et al., 2009 - updated 2017 Nov 9) did not find any previously reported period. Upon completion of this analysis, a re-check of the most current LCDB (Warner et al., 2009 - updated 2018 March 7) found results reported by Warner, B.D. His result of P = 3.123 h and amplitude = 0.11 are in fair agreement with those reported here. Since these observations only cover one night and Warner's cover two (with less scatter), Warner's results are certainly higher quality.



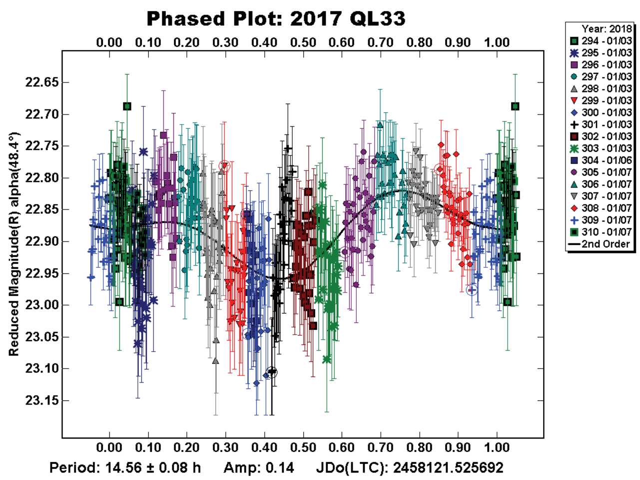
2017 QL33. This near-Earth asteroid was discovered on 2017 August 1 by Pan-STARRS1. Its orbit indicated a close approach to the Earth of 0.034 AU on 2017 December 30 and it would reach a maximum brightness of V ~ 16 around 2018 January 2 (JPL 2018). Also its declination of ~ +70 would make the target circumpolar for several nights. Unfortunately full moon was also on January 2. Local weather conditions indicated a single favorable night on January 3, and the target was scheduled however, this also meant the targets rapid motion of ~ 15 arcsec/min would mean trailing during the exposure. For this target a 90s exposure was used. At an image scale of 1.05 arcseconds per pixel, this corresponds to a trail of about 21 pixels. More data was obtained on January 6, 7 when the target was slightly fainter (V ~ 16.2) and the motion was slower ~ 9 to 10 arcsec/min.

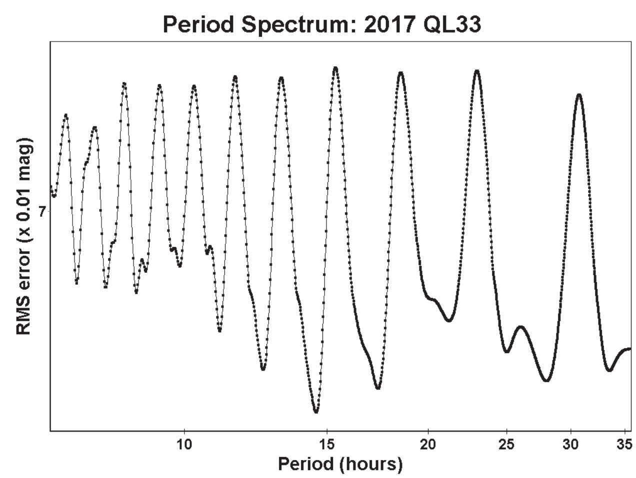
Multiple sessions were needed for each night. All comparison stars were selected from the Pan-STARRS DR1 due to the target's northern declination and to minimize zero point corrections (none were used).

Since this was a newly discovered asteroid no prior lightcurve analysis existed, however a check of the most recent LCDB (2018, March 7) showed this target was also worked by Brian Warner from 2018 January 11 to 24, finding a period of 31.73 h and amplitude of 0.21.

An attempt was made to force this data to the 31.73 h period, but it was not possible. The period reported here is 14.56 h +/- 0.08 h, amplitude 0.14. Possible reasons for the discrepancy include my errors in measuring the target's magnitude in the trailed images, insufficient number of data points compared to Warner, and changing viewing geometry. These observations were done at a higher phase angle than Warner (49 to 34 vs. 26 to 12). It is also possible 14.56 is a half period alias for the 31.73 h period.

It should be noted these data are very noisy due to the low SNR caused by the trailed target image. This required using a rectangular aperture in *MPO Canopus* to produce the highest SNR.





Acknowledgements

The Pan-STARRS1 Surveys (PS1) and the PS1 public science archive have been made possible through contributions by the Institute for Astronomy, the University of Hawaii, the Pan-STARRS Project Office, the Max-Planck Society and its participating institutes, the Max Planck Institute for Astronomy, Heidelberg and the Max Planck Institute for Extraterrestrial Physics, Garching, The Johns Hopkins University, Durham University, the University of Edinburgh, the Queen's University Belfast, the Harvard-Smithsonian Center for Astrophysics, the Las Cumbres Observatory Global Telescope Network Incorporated, the National Central University of Taiwan, the Space Telescope Science Institute, the National Aeronautics and Space Administration under Grant No. NNX08AR22G issued through the Planetary Science Division of the NASA Science Mission Directorate, the National Science Foundation Grant No. AST-1238877, the University of Maryland, Eotvos Lorand University (ELTE), the Los Alamos National Laboratory, and the Gordon and Betty Moore Foundation.

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10132 LUMMELUNDA: A NEW BINARY ASTEROID SYSTEM

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(Received: 2018 April 15)

CCD photometric observations carried out at several observatories over a wide range of longitudes in 2017 August-September revealed that the main-belt asteroid 10132 Lummelunda is a binary asteroid system with a primary rotational period of 2.5099 ± 0.0001 h and a secondary orbital period of 22.44 ± 0.01 h.

The inner main-belt asteroid 10132 Lummelunda was discovered on 1993 March 20 at La Silla. According to the Asteroid Lightcurve Database (LCDB; Warner et al., 2009) prior to commencing our measurements no synodic rotation period determination was reported for this asteroid. Here we describe our extensive data set involving observers spanning a wide range of longitudes, conclusively revealing Lummelunda to be a binary system with both a primary and secondary period. The discovery report on the 10132 Lummelunda binary system appeared in CBET 4440 (Benishek et al., 2017) on 2017 October 9. Observations made in a similar time period were submitted in January 2018 and published by Salvaggio et al. (2018), where their abstract reports a period value of 2.51 ± 0.03 h, consistent with the primary rotation period we report here.

Photometric observations were initiated at Sopot Astronomical Observatory in Serbia by Benishek on 2017 August 26 with the simple aim of the rotational lightcurve and period determination. The first night's data revealed a short rotational period and the existence of an overall ascending trend independent of rotational variations. This trend was not observed on the second night (2017 August 27-28 UT). Suspecting that the observed trend could arise due to a potential satellite attenuation event, Benishek sent his early data to Pravec for a preliminary analysis. Pravec confirmed that the deviation was likely part of an attenuation event caused by a binary companion. To increase the data collecting efficiency Benishek extended an invitation to Pilcher of Organ Mesa Observatory in New Mexico, USA to join the observations which was kindly accepted. Pravec also made a call for observations through the Photometric Survey for Asynchronous Binary Asteroids (Pravec, 2017) observing group website. As a result, Pray of Sugarloaf Mountain Observatory in Massachusetts, USA, Aznar of Astronomia Para Tolos Observatory Group (APTOG) in Spain, Durkee (Shed of Science Observatory, Minnesota, USA) and Aceituno (Observatorio de Sierra Nevada, Spain) began to observe this object. Kušnirák and Kučáková also carried out observations from Ondřejov Observatory in Czech Republic. Pilcher's data obtained on 2017 August 29.3 detected another attenuation, and Pravec confirmed that it represented a deep satellite event, while the attenuation observed on 2017 August 27.0 it was found to be a shallow event. There was no longer any doubt that a new binary asteroid system had been detected photometrically.

Table I summarizes the equipment used by various observers.

Observer	Telescope	CCD Camera
Pilcher	0.35-m f/10 SCT	SBIG STL-1001E
Benishek	0.35-m f/6.3 SCT	SBIG ST-8XME
Kušnirák, Kučáková	0.65-m f/3.6 CT	Moravian G2-3200
Pray	0.50-m f/4 NA	QSI 632s
Durkee	0.50-m f/5.3 CDK	SBIG ST-10XME
Aznar	0.35-m f/10 SCT	SBIG STL-1001E
Aceituno	0.91-m f/8 RC	Princeton Instr. VersArray 2048B

Abbreviations: SCT=Schmidt-Cassegrain, CT=Cassegrain, NA=Newtonian Astrograph, CDK=Corrected Dall-Kirkham, RC= Ritchey–Chrétien

As of 2017 September 28 a total of 22 data sets have been obtained as a result of the joint effort.

Differential photometry using up to five comparison stars of near solar color (0.5 ≤ B-V ≤ 0.9) employed within the "Comparison Star Selector" (CSS) feature of *MPO Canopus* software (Warner, 2016), was performed by all authors. Since the authors made internal photometric calibrations of field comparison stars relying on different catalogs and photometric bands, subsequent adjustments of magnitude zero-points for individual data sets were required to achieve the minimum RMS residual for the Fourier model.

Period analysis of the overall data and lightcurve construction were performed by Pravec using his custom period analysis software capable of solving for multiple periods simultaneously.

Number	Name	2017/mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
10132	Lummelunda	08/26-09/28	1477	10.5,2.4,10.1	349	3	2.5099	0.0001	0.11	0.01	MB-I
	P_{ORB}						22.44	0.01	0.08-0.16		

Table II. Observing circumstances and results. Pts is the number of data points. Phase is the solar phase angle given at the start and end of the date range, the middle value is the minimum solar phase angle. L_{PAB} and B_{PAB} are the average phase angle bisector longitude and latitude (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009): MB-I = main-belt inner

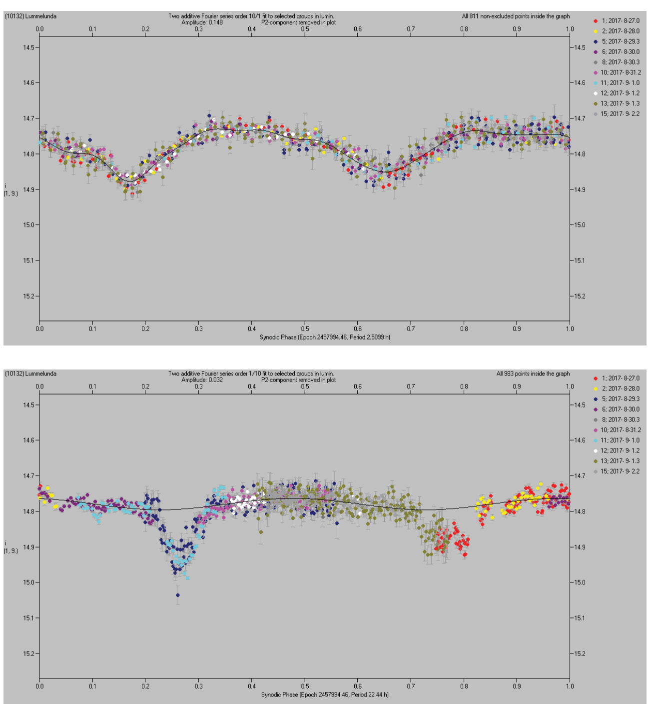
Although the amplitude and shape evolution of the primary rotational lightcurve was minimal over the total solar phase angle range (Table II), it was nevertheless decided to split the data into three subsets that were independently analyzed. The first subset included data obtained between 2017 August 26 and 2017 September 2, the second refers to data obtained from 2017 September 10-13 and the third contains data from 2017 September 18 through 2017 September 28. The period analysis shows very consistent results for derived periods for all three subsets. The primary rotation period was found to be: 2.5099 ± 0.0001 h with amplitude of 0.11 mag. at low solar phase angles of 2-3 degrees, while a secondary rotational component was not detected. A value of 22.44 ± 0.01 h was determined for the orbital period of this binary system, while the intensity depth for the satellite attenuation events ranging from 0.08 to 0.16 mag. An estimation of the lower limit on the satellite mean diameter (*Ds*) to primary body mean diameter (*Dp*) ratio is made according to the formula:

$$\frac{Ds}{Dp} \geq \sqrt{10^{0.4d} - 1} \ ,$$

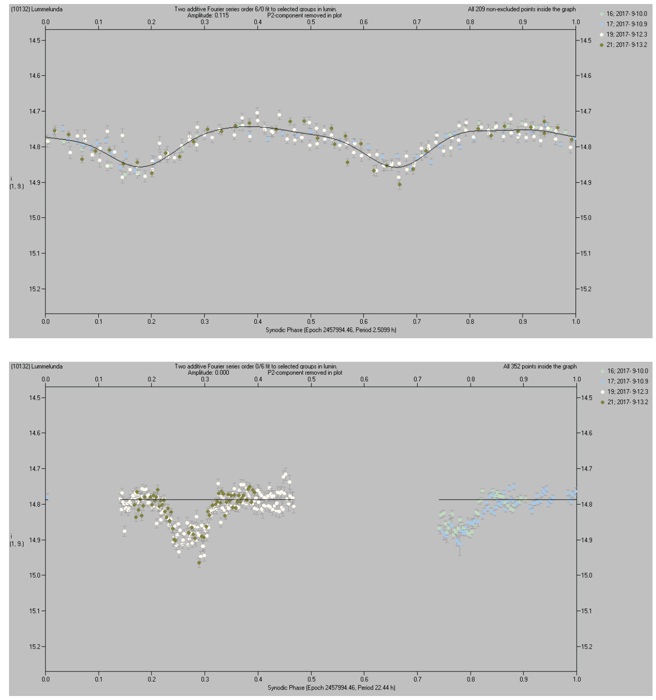
where d represents the attenuation of the shallower event in magnitudes.

In the case of 10132 Lummelunda (d = 0.08 mag.) this ratio is: $Ds/Dp \geq 0.28$.

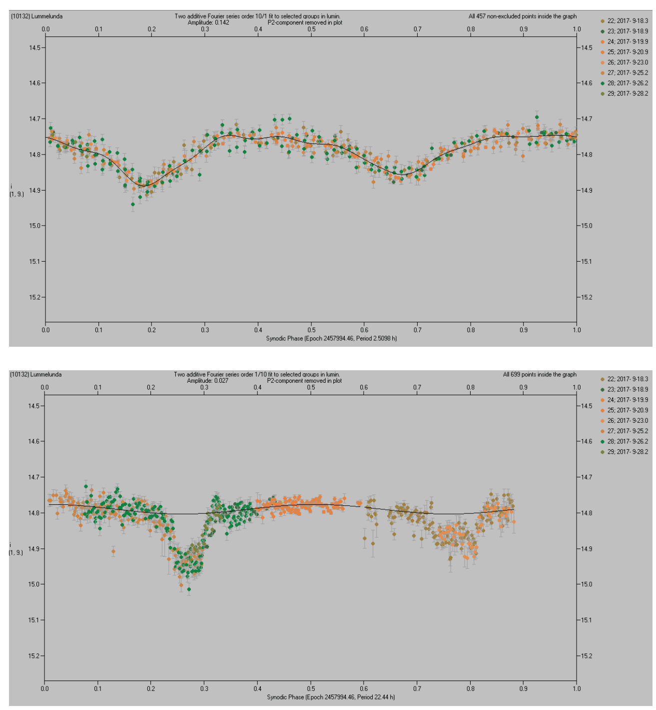
The observations performed at Ondřejov observatory were absolutely calibrated to the Cousins R magnitude system, which enabled the determination of the mean absolute R magnitude for the whole binary system (H_R) outside attenuation events. The mean absolute R magnitude is found to be: H_R = 13.76 ± 0.06, derived assuming the phase relation slope parameter G = 0.24 ± 0.11 (Pravec, private communication).



Figs. 1-2. Top: the primary rotational lightcurve for the data obtained from 2017 August 26 through 2017 September 2. Bottom: the corresponding secondary orbital lightcurve.



Figs. 3-4. Top: the primary rotational lightcurve for the data obtained from 2017 September 10 - 13. Bottom: the corresponding secondary orbital lightcurve.



Figs. 5-6. Top: the primary rotational lightcurve for the data obtained from 2017 September 18 through 2017 September 28. Bottom: the corresponding secondary orbital lightcurve.

Acknowledgements

Research at Sugarloaf Mountain Observatory and Shed of Science Observatory is supported by a Gene Shoemaker NEO Grant from the Planetary Society.

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4435 HOLT: A NEWLY DISCOVERED SINGLY-ASYNCHRONOUS BINARY

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We report that asteroid 4435 Holt is a singly-asynchronous binary asteroid. The primary lightcurve has a primary period of 2.8670 ± 0.0002 h and an amplitude 0.15 to 0.30 mag. with a secondary orbital period of 42.65 ± 0.05 h.

The Mars-crosser 4435 Holt was initially observed by Benishek on 2017 Aug 30 as part of the Photometric Survey for Asynchronous Binary Asteroids (Pravec, 2017). Observations through 2017 Sep 24 did not show any attenuation events. Stephens started independent observations of Holt on 2017 Oct 10, almost immediately detecting a significant attenuation event. Table I gives the telescopes and CCD cameras used for observations. Exposures were unfiltered and ranged from 25 to 300 seconds. The group made more than 4,600 observations over 110 nights. There were no previously reported rotational periods in the asteroid lightcurve database (LCDB; Warner *et al.* 2009).

Observer	Telescope	Camera
Stephens	0.40m SCT	FLI Proline 1001E
Pray	0.50m New.	SBIG 10XME / QSI632s
Benishek	0.35m SCT	SBIG ST-8X ME

Table I. Observers and equipment. SCT: Schmidt-Cassegrain.

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. Stars were chosen from the APASS (Henden et al.,2009) or CMC-15 catalog (*http://svo2.cab.inta-csic.es/vocats/cmc15/*), or the MPOSC3 catalog which is based on the 2MASS catalog (*http://www.ipac.caltech.edu/2mass*). Generally, needed zero points adjustments are within ±0.05 mag

Number	Name	yyyy/mm/dd	Phase	L_{PAB}	B_{PAB}	Period	P.E.	Amp	A.E.
4435	Holt	08/30/2017-01/19/18	25,19,40	20-56	26-31	2.8670	0.0002	0.30	0.02
						42.65	0.05	0.15	0.02

Table II. Observing circumstances and results. Pts is the number of data points. The first line is the primary (P1) period and the second line is the secondary (P2) period.

of one another, but larger adjustments can be required to minimize the RMS value from the Fourier analysis.

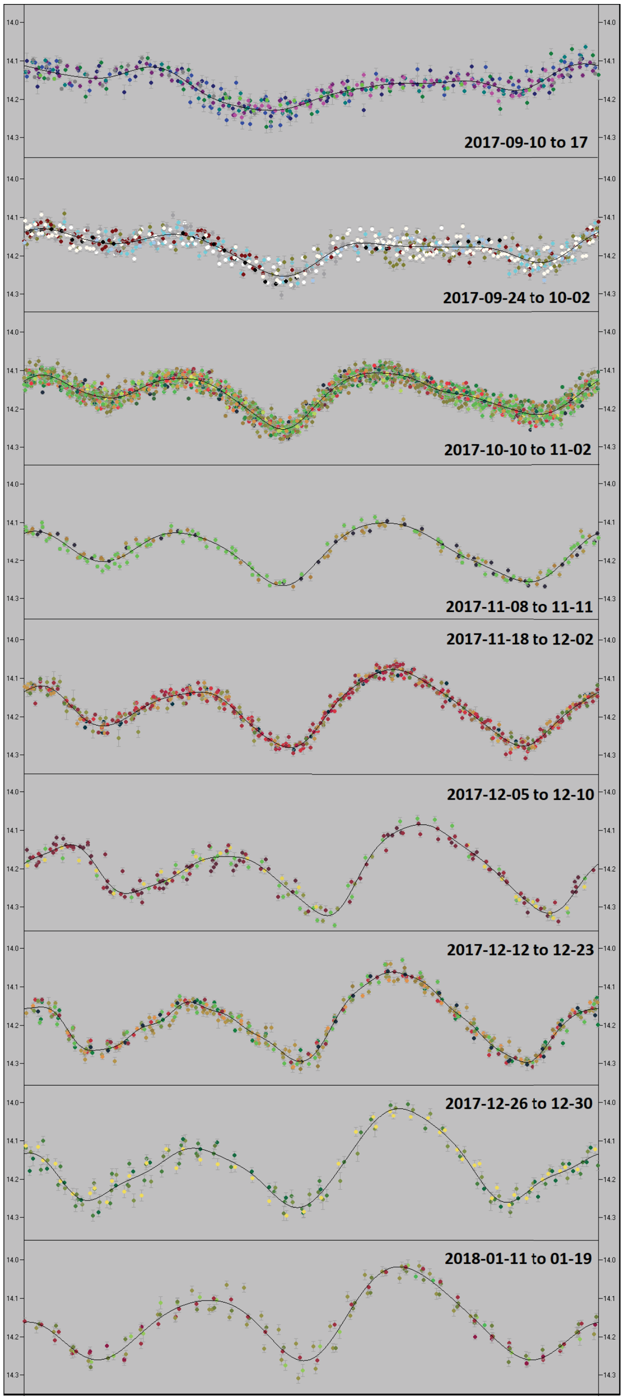

Figure 1. The evolution of the primary lightcurve over the observing run between 2017 Sep to 2018 Jan. During this period, Holt passed from phase angle 25° to 19° and then back to 40°.

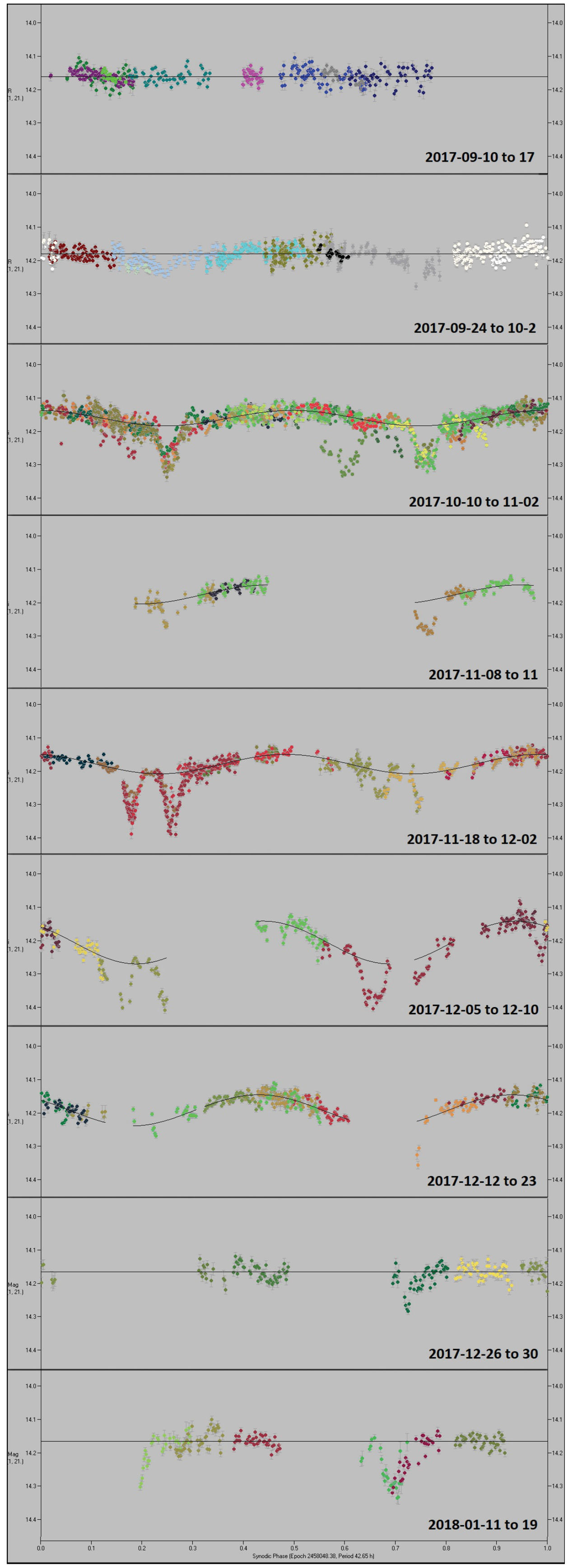

Figure 2. The evolution of the secondary lightcurve over the observing run. The first attenuation events were recognized in early 2017 October and then found in the late September dataset.

Period Analysis

All data were sent to Petr Pravec, whose software solves for the primary and secondary period simultaneously. The dual period analysis found a primary lightcurve of P_1 = 2.8670 ± 0.0002 h (Figure 1). The amplitude changed from 0.15 to 0.30 mag over the course of the observing run. The orbital period is P_2 = 42.65 ± 0.05 h (Figure 2). Mutual eclipse/occultation events that are up to 0.15 mag deep indicate a lower limit on the secondary-to-primary mean-diameter ratio of 0.34.

The assembled plots show the evolution of the primary lightcurve of 4435 Holt over the four months it was observed. The shape of the lightcurve changed as the geometry of the view from Earth changed. The phase angle decreased from 25° to 19° and then increased up to 40°. The secondary appears synchronous, i.e., its orbital and rotation periods are the same, and it has an amplitude in the combined primary plus secondary lightcurve of 0.05 mag. A few additional attenuations of 0.07 to 0.17 mag occurred between 2017 Oct 12 and Dec 5. These were not aligned with the 42.65 h orbital period, thus suggesting the presence of a third body in the system.

The mean absolute magnitude of the whole system in the Cousins R photometric system is H_R = 13.25 ± 0.13, assuming a slope parameter G = 0.24 ± 0.11.

Acknowledgements

Work on the asteroid lightcurve database (LCDB) was funded by National Science Foundation grant AST-1507535.The purchase of Stephens' FLI-1001E CCD camera was made possible by a 2013 Gene Shoemaker NEO Grant from the Planetary Society. Pray's 0.5-meter telescope was made possible by a 2013 Gene Shoemaker NEO Grant from the Planetary Society.

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ASTEROIDS OBSERVED FROM CS3: 2018 JANUARY - MARCH

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CCD photometric observations of 6 main-belt asteroids were obtained from the Center for Solar System Studies from 2018 January to March.

The Center for Solar System Studies "Trojan Station" (CS3, MPC U81) has two telescopes which are normally used in program asteroid family studies such as Jovian Trojans and Hildas. During the first quarter of 2018 alternate Main Belt targets were selected when the Moon was too close to the program targets. These targets were selected to provide data for future shape model studies. Selection criteria included shorter rotational periods to permit completion during the week around the Full Moon.

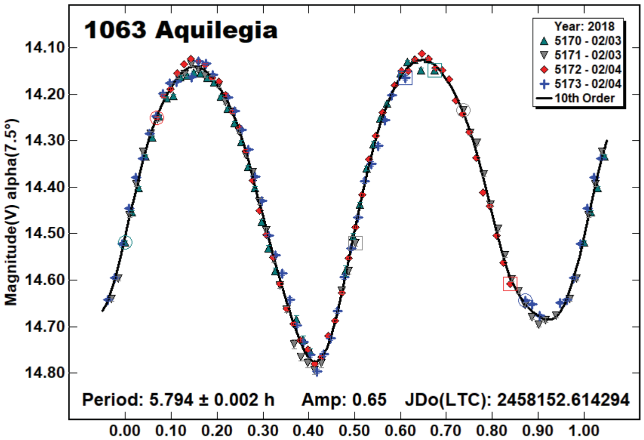
All images were made with a 0.4-m or a 0.35-m SCT using an FLI ML-Proline 1001E or FLI ML-Microline 1001E CCD camera. Images were unbinned with no filter and had master flats and darks applied. Image processing, measurement, and period analysis were done using MPO Canopus (Bdw Publishing), which incorporates 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. The Comp Star Selector feature in *MPO Canopus* was used to limit the comparison stars to near solar color.

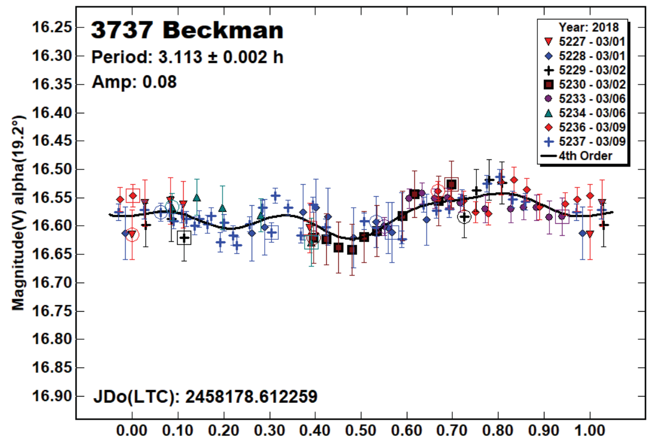
In the lightcurve plots, the "Reduced Magnitude" is Johnson V corrected to a unity distance by applying -5*log (rΔ) to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and the Earth-asteroid distances in AU. The magnitudes were normalized to the phase angle given in parentheses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

1063 Aquilegia. Binzel (1987) and Behrend (2018) each reported results of 5.79 h. This result is in good agreement with those prior findings.

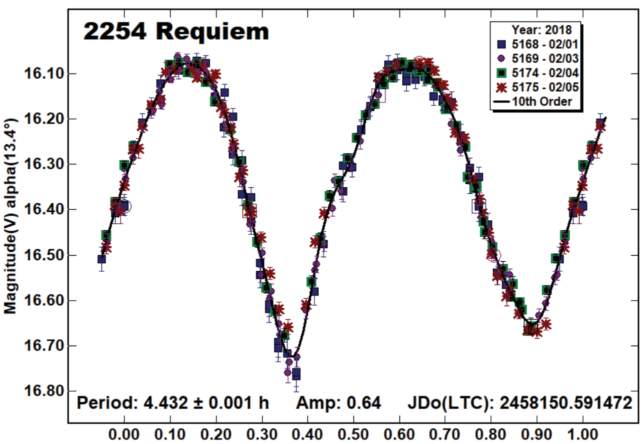
Number	Name	2018 mm\dd	Pts	Phase	LPAB	BPAB	Period	P.E.	Amp	A.E.	Grp
1063	Aquilegia	02/03-02/04	184	7.5,8.0	121	4	5.794	0.002	0.65	0.01	FLOR
2254	Requiem	02/01-02/05	247	13.4,3.9,13.3	201	3	4.432	0.001	0.64	0.02	FLOR
3343	Nedzel	03/27-03/30	150	18.8,17.6	213	12	5.467	0.002	0.71	0.02	MC
3737	Beckman	12/31-12/31	97	18.8,0.0,17.6	0	0	3.113	0.002	0.08	0.01	MC
5168	Jenner	03/29-04/03	81	29.5,30.4	133	6	3.255	0.001	0.35	0.02	PHO
8256	Shenzhou	03/01-03/09	88	28.3,29.5	114	9	3.397	0.001	0.45	0.03	MC

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).

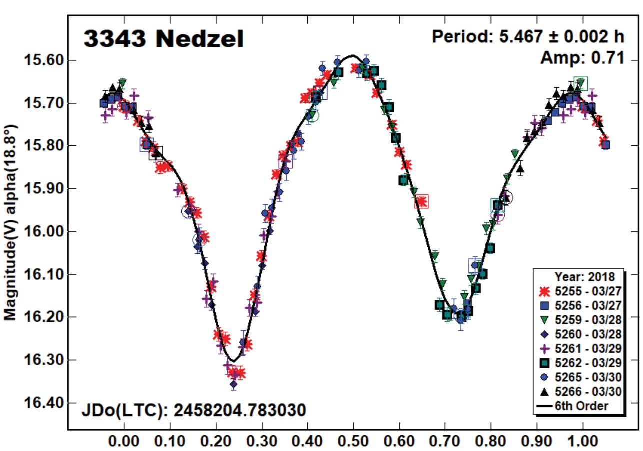




2254 Requiem. This member of the Flora family was previously studied by Warner (2014) and Waszczak et al., (2015) each reporting a rotational period of 4.43 h. The result found this year is in good agreement with those findings.

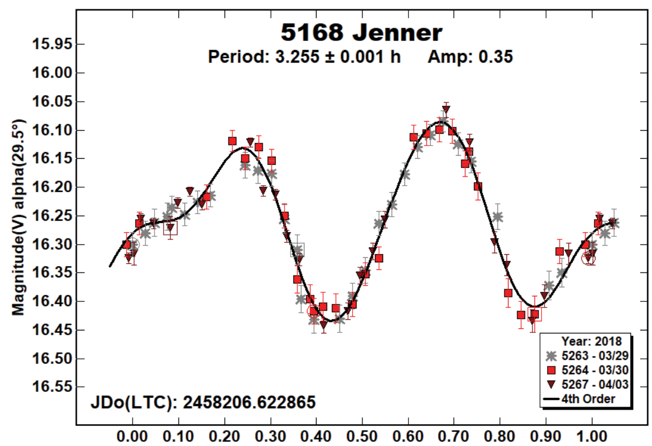


3343 Nedzel. This Mars crosser has been previously observed by Folberth et al., (2012) finding a rotational period of 5.462 h. This year's result is in good agreement with that finding.

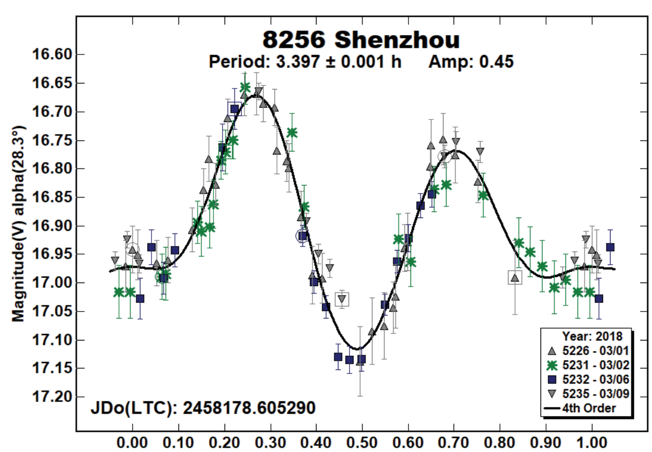


3737 Beckman. Klinglesmith et al. (2014) and Wisniewski (1989) each found rotational periods near 3.1 h and reporting amplitudes of 0.27 and 0.16 mag. The lightcurve obtained this year had an amplitude of only 0.08 mag. and a period consistent with the prior results.

5168 Jenner. This member of the Phocaea family has been observed several times in the past. Aymami (2011), Stephens (2011), and Waszczak et al., (2015) each reported rotational periods near 3.26 h. This result is in good agreement with those findings.



8256 Shenzhou. Pravec (2018) reported a rotational period of 3.396 h from the Photometric Survey for Asynchronous Binary Asteroids. Crawford (2008) found the same period. This result agrees with those determinations.



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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LIGHTCURVE ANALYSIS OF L5 TROJAN ASTERIODS AT THE CENTER FOR SOLAR SYSTEM STUDIES: 2018 JANUARY TO MARCH

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Lightcurves for six Jovian Trojan asteroids were obtained at the Center for Solar System Studies (CS3) from 2018 January to March.

CCD Photometric observations of six Trojan asteroids from the L_5 (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.

Telescope	Camera
0.40-m f/10 Schmidt-Cass	FLI Proline 1001E
0.35-m f/11 Schmidt-Cass	FLI Microline 1001E

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

Table I 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.

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 or APASS (Henden *et al*., 2009) catalogs. 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 $-5*\log(r\Delta)$ 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.

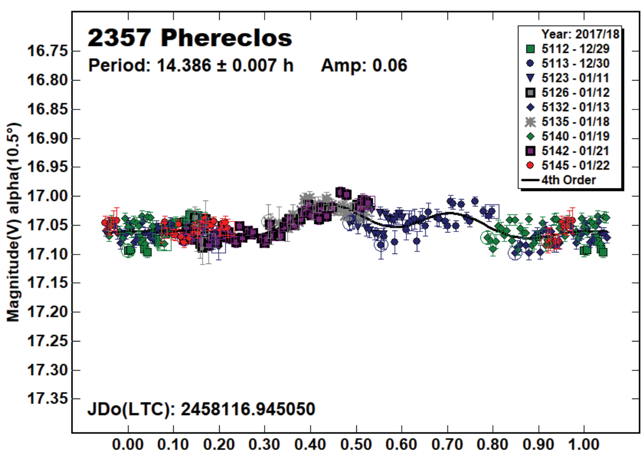
The amplitude indicated in the plots (e.g. Amp: 0.23) is the amplitude of the Fourier model curve and not necessarily the adopted amplitude of the lightcurve.

Targets were selected for this L_5 observing campaign based upon the availability of dense lightcurves acquired in previous years. We obtained two to four 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).

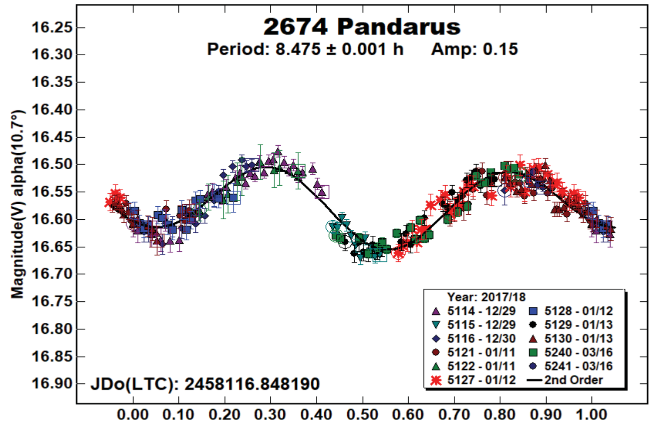
To evaluate the quality of the data obtained to determine how much more data might be needed, preliminary pole and shape models were created for all of these targets. These will be published at a later date. Sparse data observations were obtained from the Catalina Sky Survey and USNO-Flagstaff survey using the AstDyS-3 site (*http://hamilton.dm.unipi.it/asdys2/*). These sparse data were combined with our dense data as well as any other dense data found in the ALCDEF asteroid photometry database (*http://www.alcdef.org/*) using *MPO LCInvert*, (Bdw Publishing). This Windows-based program 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.

2357 Phereclos. The synodic period found this year produced a low amplitude, single extrema lightcurve consistent with rotational periods found in previous years (Mottola et al., 2011; Stephens et al., 2016b, 2017). These data were combined with our data from the last two years and available sparse data to create a preliminary shape model with a sidereal period of 14.35153 ± 0.00001 h.

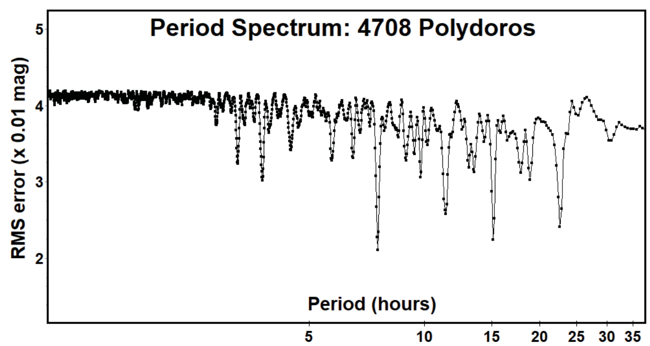


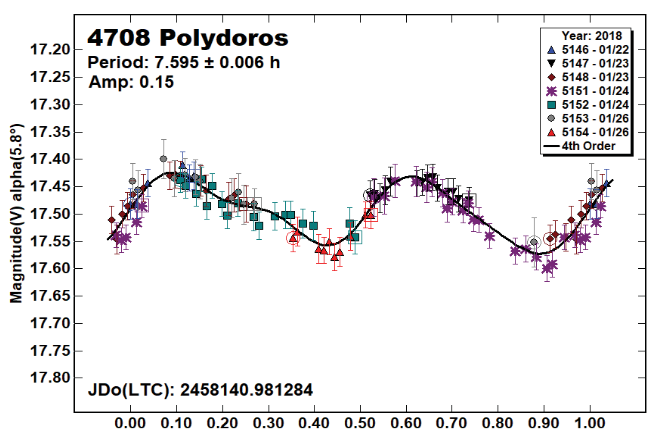
2674 Pandarus. We previously found the synodic period to be about 8.48 h (French 1987, Stephens et al., 2016b, 2017), in good agreement with the latest result.

The data collected this year, when combined with our previous data and available sparse data, were used to create a preliminary shape model with a sidereal rotational period of 8.47194 ± 0.00001 h.



4708 Polydoros. We found ambiguous rotational periods for this Trojan in the past. We observed it in 2011 (French et al., 2012) and 2014 (Stephens et al., 2015), finding periods of 20.03 h and 20.24 h, respectively. We obtained a much denser dataset in 2016 (Stephens et al., 2016b) that favored a 7.517 hour period with aliases at 15.037 h and around 23 h. We adopted the 7.517 h solution because it produced a bimodal lightcurve. The data from 2014 could be fit to 7.520 h with an asymmetrical bimodal lightcurve with 0.09 mag amplitude. The 2011 data could also be fit to a monomodal lightcurve with P = 7.52 h. The 2018 data match these previous efforts with a bimodal lightcurve and an amplitude of 0.15 mag. Our four dense lightcurves and available sparse data were used to find a preliminary shape model and a sidereal rotational period of 7.52077 ± 0.00001 h.



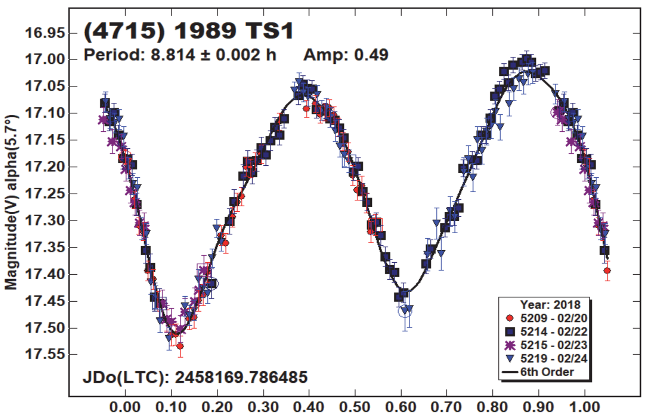


(4715) 1989 TS1. This Trojan previously had its rotational period measured five times (Mottola et al., 2011; Stephens et al., 2015, 2016b, and 2017; and Waszczak et al., 2015) all with synodic periods near 8.8 h. This year's synodic rotational period is a little longer, but in good agreement with those prior findings. When

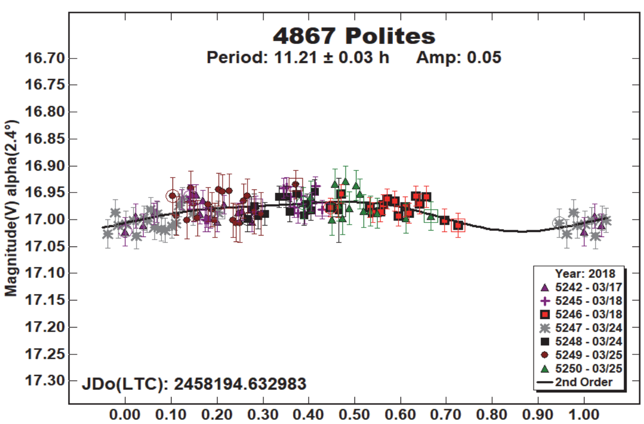
Number	Name	2018 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
2357	Phereclos	12/29-01/22	273	10.5,8.3	167	-1	14.386	0.007	0.06	0.02
2674	Pandarus	12/29-01/13	228	10.7,9.3	163	-1	8.475	0.001	0.17	0.02
4708	Polydoros	01/23-01/27	169	5.6,5.0	152	-6	7.558	0.006	0.14	0.02
4715	1989 TS1	02/20-02/24	188	3.5,2.7	168	6	8.814	0.002	0.49	0.02
4867	Polites	03/17-03/26	157	2.4,4.0	168	-8	11.21	0.02	0.07	0.02
5144	Achates	01/18-01/21	148	2.6,2.1	134	2	5.960	0.003	0.22	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).

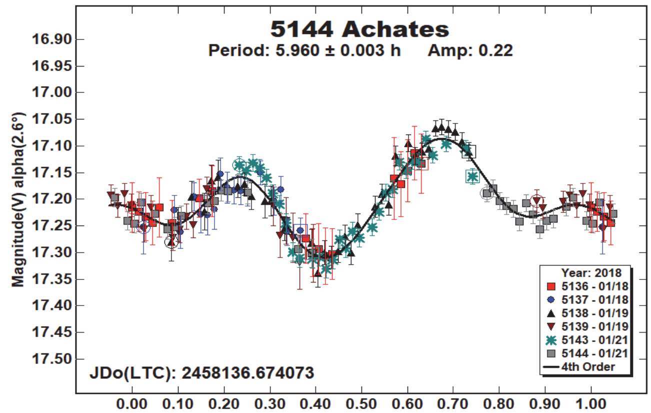
those data were combined with this year's data and sparse data, we were able to create a preliminary shape model with a sidereal period of 8.81413 ± 0.00001 h.



4867 Polites. We observed Polites five times in the past (French et al., 2011; Stephens et al., 2014, 2015, 2016b, and 2017) finding synodic periods near 11.24 h. This year's observations resulted in a low amplitude, momodal lightcurve with a similar rotational period. The new and previous data were combined with available sparse data to find a preliminary shape model with a sidereal rotational period of 11.23973 ± 0.00001 h.



5144 Achates. The synodic period found this year is similar to those found in previous years (Mottola et al., 2011; Stephens et al., 2015). Despite only having two dense lightcurves and some sparse data, we created a reasonable preliminary shape model with a sidereal rotational period of 5.95392 ± 0.00001 h.



Acknowledgements

Work on the asteroid lightcurve database (LCDB) was funded in part by National Science Foundation grant 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 two FLI-1001E CCD cameras was made possible by 2013 and 2015 Gene Shoemaker NEO Grants from the Planetary Society.

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ERRATUM

Brincat and Galdies, "Photometric Observations of Main-belt Asteroids 1637 Swings, 10498 Bobgent, and (25980) 2001 FK 53" MPB ***45****, 115–116.*

The text reporting results for 1637 Swings should read: "Our results yielded a synodic period of 10.624 ± 0.004h and amplitude of 0.28 ± 0.02 mag."

LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2018 JULY-SEPTEMBER

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We present lists of asteroid photometry opportunities for objects reaching a favorable apparition and have no or poorly-defined lightcurve parameters. Additional data on these objects will help with shape and spin axis modeling via lightcurve inversion. We also include lists of objects that will or might be radar targets. 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 2018 July-September.

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

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

The ephemeris generator on the CALL web site allows you to create custom lists for objects reaching V ≤ 18.0 during any month in the current year, e.g., limiting the results by magnitude and declination.

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

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 database. This can be accessed for uploading and downloading data at

http://www.alcdef.org

Containing almost 3.2 million observations for more than 13380 objects, we believe this to be the largest publicly available database of raw asteroid time-series lightcurve data.

Now that many backyard astronomers and small colleges have access to larger telescopes, we have expanded the photometry opportunities and spin axis lists to include asteroids reaching V = 15.5 and brighter (sometimes 15.0 when the list has more than 100 objects.

Lightcurve/Photometry Opportunities

Objects with U = 3– or 3 are excluded from this list since they will likely appear in the list 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
7055	1989 KB	07 02.2	14.6	-42			
9805	1997 NZ	07 03.3	14.5	-24	16.86	0.23	2
6526	Matogawa	07 05.0	14.7	-17			
702	Alauda	07 06.7	11.5	-26	8.3531	0.09-0.12	2
3616	Glazunov	07 10.6	15.0	-18			
2399	Terradas	07 10.8	14.7	-15			
4262	DeVorkin	07 11.5	14.0	-16			
3163	Randi	07 12.0	14.4	-14	59.5	0.54-1.2	2
14720	2000 CQ85	07 13.4	15.0	-39		0.35	
3229	Solnhofen	07 15.2	14.6	-27	11.52	0.38-0.71	2
4770	Lane	07 15.9	14.7	-6	34.75	0.23	2
1455	Mitchella	07 18.8	14.8	-18	118.7	0.60	2+
4246	Telemann	07 19.5	14.8	-27	8.96	0.11	2
7653	1991 UV	07 21.7	14.8	-17			
12470	Pinotti	07 23.0	14.7	-17			
3928	Randa	07 23.7	14.4	-17	29.9	0.06-0.12	2
13019	1988 NW	07 26.3	15.0	-20	5.906	0.38	2
12505	1998 FN77	07 29.4	15.0	-17			
3330	Gantrisch	07 31.1	14.7	-33			
445	Edna	08 02.7	13.2	-7	19.97	0.21	2
3072	Vilnius	08 07.0	14.9	-13			
4226	Damiaan	08 08.3	14.2	-7	24.	0.05	1
24779	Presque Isle	08 08.5	14.6	-14			
7305	Ossakajusto	08 09.5	14.3	-15			
676	Melitta	08 09.7	12.9	-11	16.74	0.04-0.20	2+
3677	Magnusson	08 11.1	14.8	-7			
2037	Tripaxeptalis	08 14.2	15.0	-21	2.33	0.10	2
7723	Lugger	08 14.5	14.9	-21		1.1	
13553	***Masaakikoyama***	***08 16.5***	***14.5***	***+15***	***38.***	***1.1***	***2***
3807	Pagels	08 21.9	14.5	-10	3.3	0.13	2
1946	Walraven	08 24.0	13.3	-25	10.21	0.6-0.90	2+
20280	1998 FQ49	08 26.0	15.0	-11			
9853	1991 AN2	08 26.2	14.9	-14			
3736	Rokoske	08 27.6	14.7	-13			
1746	Brouwer	08 28.0	14.4	-7	19.8	0.21-0.35	2
6618	1936 SO	08 28.0	14.5	-10			
4269	Bogado	08 29.8	14.6	-10			
2481	Burgi	08 29.9	14.9	-12	30.086	0.20	2
3919	Maryanning	08 31.2	14.9	-9			
28281	1999 CT29	09 01.5	14.8	-3		0.32	
22176	2000 XG36	09 01.8	15.0	+3	4.794	0.48	2
2373	Immo	09 07.5	15.0	-11			
1229	Tilia	09 08.3	14.7	-5			
2406	Orelskaya	09 11.8	14.2	-6	6.11	0.14	2
2046	Leningrad	09 13.1	14.7	-8	5.296	0.11	2+
26377	1999 FH4	09 13.9	14.7	-5			
11650	1997 CN	09 15.3	14.6	+8		0.79	
2816	Pien	09 15.5	14.7	-16	80.315	0.50	2
6425	1994 WZ3	09 16.0	14.4	+13	103.9	0.92	2
2393	Suzuki	09 16.6	14.2	+9	9.31	0.40	2+
1550	Tito	09 17.3	13.3	-21	54.2	0.16-0.40	2
2915	Moskvina	09 17.3	15.0	-2	2.177	0.47	2
1010	Marlene	09 17.4	14.1	-8	31.06	0.17-0.32	2+
831	Stateira	09 20.2	14.4	-1	>4.	0.05	1
1557	Roehla	09 21.6	14.8	+0	5.679		2
3062	Wren	09 21.8	14.5	-16	7.097	0.17-0.25	2+
1991	Darwin	09 22.3	14.8	+6	4.7	0.08	2
1409	Isko	09 23.3	14.1	+0	11.6426	0.20	2
4384	Henrybuhl	09 23.9	14.9	+17			
1006	Lagrangea	09 25.5	13.6	+18	32.79	0.17	1
1400	Tirela	09 27.6	14.7	+12	13.356	0.25-0.55	2
1392	Pierre	09 29.2	13.9	+5	18.	0.09	2
10128	Bro	09 29.5	15.1	-5			
961	Gunnie	09 30.0	14.6	-3			

Low Phase Angle Opportunities

The Low Phase Angle list includes asteroids that reach very low phase angles. The "α" column is the minimum solar phase angle for the asteroid. Getting accurate, calibrated measurements (usually V band) at or very near the day of opposition can provide important information for those studying the "opposition effect." Use the on-line query form for the LCDB to get more details about a specific asteroid.

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

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-G_{12}, introduced by Muinonen *et al.* (2010; *Icarus* **209**, 542-555). It will be some years before H-G_{12} becomes the standard. Furthermore, it still needs refinement. That can be done mostly by having data for more asteroids, but only if at very low and moderate phase angles. We strongly encourage obtaining data every degree between 0° to 7°, the non-linear part of the curve that is due to the opposition effect. At angles $\alpha > 7°$, well-calibrated data every 2° or so out to about 25-30°, if possible, should be sufficient. Coverage beyond about 50° is not generally helpful since the H-G system is best defined with data from 0-30°.

Num	Name	Date	α	V	Dec	Period	Amp	U
1015	Christa	07 11.5	0.83	13.6	-19	11.230	0.12-0.20	3-
522	Helga	07 20.0	0.02	13.7	-21	8.129	0.13-0.31	3
52	Europa	07 20.4	0.62	11.0	-19	5.630	0.09-0.12	3
140	Siwa	07 24.5	0.71	10.4	-21	34.445	0.05-0.15	3
1349	Bechuana	07 27.0	0.37	13.8	-20	15.692	0.29-0.30	3-
408	Fama	07 28.7	0.61	13.7	-17	202.1	0.58	3
171	Ophelia	07 30.0	0.46	13.1	-20	6.665	0.14-0.46	3
1069	Planckia	08 12.5	0.31	14.0	-14	8.665	0.14-0.42	3
76	Freia	08 19.3	0.67	13.0	-10	9.973	0.05-0.15	3
269	Justitia	08 22.1	0.65	11.9	-11	33.128	0.14-0.25	3
633	Zelima	08 24.8	0.46	13.3	-12	11.730	0.14-0.53	3
263	Dresda	09 11.0	0.59	13.6	-03	16.809	0.37-0.55	3
69	Hesperia	09 18.2	0.71	11.3	+00	5.655	0.12-0.20	3
329	Svea	09 20.1	0.31	12.7	-01	22.778	0.09-0.13	2+
734	Benda	09 26.3	0.13	13.8	+01	7.110	0.28-0.32	3
4509	Gorbatskij	09 26.8	0.24	13.5	+02	6.006	0.81-0.81	3
93	Minerva	09 30.2	0.27	11.4	+03	5.982	0.04-0.20	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
592	Bathseba	07 02.5	14.3	-10	7.7465	0.22-0.32	3
659	Nestor	07 02.5	15.4	-28	15.98	0.22-0.31	3
305	Gordonia	07 04.3	13.9	-17	12.893	0.10-0.23	3
855	Newcombia	07 04.4	13.9	-44	3.003	0.33-0.41	3
459	Signe	07 04.5	14.5	-38	5.5362	0.25-0.54	3
811	Nauheima	07 04.5	14.2	-20	4.0011	0.11-0.20	3
1799	Koussevitzky	07 05.0	15.4	-8	6.318	0.25-0.40	3
275	Sapientia	07 06.4	12.6	-19	14.931	0.05-0.12	3-
1029	La Plata	07 06.8	14.8	-26	15.31	0.26-0.58	3
198	Ampella	07 07.7	10.6	-18	10.379	0.11-0.22	3
533	Sara	07 09.4	13.7	-13	11.654	0.19-0.30	3
294	**Felicia**	**07 10.6**	**13.2**	**-17**	**10.4227**	**0.19-0.24**	**3**
1143	Odysseus	07 11.3	15.2	-19	10.114	0.15-0.22	3
611	Valeria	07 12.0	14.1	-3	6.977	0.08-0.16	3
2292	Seili	07 12.3	14.1	+3	5.121	0.25-0.42	3
1425	Tuorla	07 14.0	15.2	-2	7.75	0.17-0.40	3
3115	Baily	07 15.7	14.9	-13	16.012	0.08- 0.2	3-
1052	Belgica	07 16.0	14.4	-23	2.7097	0.08-0.10	3
483	Seppina	07 16.2	13.3	+2	12.727	0.14-0.29	3
1257	Mora	07 18.6	15.1	-14	5.2948	0.23-0.43	3
522	**Helga**	**07 20.0**	**13.6**	**-21**	**8.129**	**0.13-0.31**	**3**
2478	Tokai	07 21.9	15.0	-14	25.885	0.41-0.90	3
309	Fraternitas	07 22.1	13.4	-26	22.398	0.10-0.35	3
563	Suleika	07 24.2	12.6	-29	5.69	0.13-0.28	3
911	Agamemnon	07 24.2	15.1	-36	6.592	0.04-0.29	3
773	**Irmintraud**	**07 28.8**	**12.6**	**-27**	**6.7514**	**0.09-0.15**	**3**
156	Xanthippe	07 29.2	12.1	-4	22.37	0.10-0.12	3
332	Siri	07 29.3	12.8	-23	8.0074	0.10-0.35	3
1129	Neujmina	07 29.4	14.5	-11	5.0844	0.06-0.20	3
1602	Indiana	07 30.2	15.5	-24	2.601	0.12-0.19	3
118	Peitho	07 30.5	12.8	-31	7.8055	0.11-0.33	3
785	Zwetana	07 30.9	13.1	-34	8.8882	0.13-0.20	3
204	Kallisto	08 02.6	11.8	-4	19.489	0.09-0.26	3
1689	Floris-Jan	08 03.5	14.2	-19	145.	0.02- 0.4	3
10597	**1996 TR10**	**08 04.2**	**14.2**	**-6**	**6.5967**	**0.28-0.32**	**3**
1967	Menzel	08 05.5	14.5	-24	2.835	0.24-0.39	3
2105	Gudy	08 09.1	15.0	+17	15.795	0.18-0.52	3-
70	Panopaea	08 09.7	10.8	-36	15.8052	0.07-0.18	3
1069	Planckia	08 12.5	13.9	-14	8.665	0.14-0.42	3
475	**Ocllo**	**08 14.4**	**13.6**	**-60**	**7.3151**	**0.19-0.81**	**3**
929	Algunde	08 15.5	13.8	-7	3.3102	0.13-0.17	3
81	Terpsichore	08 19.0	12.1	-20	10.943	0.06-0.10	3
598	Octavia	08 21.1	12.4	-30	10.8903	0.05-0.28	3
1016	Anitra	08 22.8	14.3	-19	5.9295	0.26-0.50	3
633	**Zelima**	**08 24.8**	**13.3**	**-12**	**11.73**	**0.14-0.49**	**3**
715	Transvaalia	09 05.4	13.6	-26	11.83	0.19-0.32	3
6602	**Gilclark**	**09 06.3**	**15.2**	**-4**	**4.5686**	**0.21-0.54**	**3**
2014	Vasilevskis	09 09.2	14.3	+20	32.16	0.26-0.31	3-
18109	***2000 NG11***	***09 12.4***	***14.6***	***-9***	***4.25***	***0.77-1.13***	***3***
782	Montefiore	09 12.5	14.0	-13	4.0728	0.31-0.54	3
1292	Luce	09 13.2	14.7	-1	6.9541	0.17-0.26	3
481	Emita	09 15.2	12.2	-18	14.412	0.16-0.30	3
2577	Litva	09 15.3	15.1	+5	2.8126	0.14-0.36	3
2429	Schurer	09 15.6	15.2	-14	6.66	0.12-0.77	3-
3754	Kathleen	09 15.9	15.3	-12	11.18	0.13-0.20	3-
9873	**1992 GH**	**09 16.0**	**14.2**	**-2**	**2.9257**	**0.20-0.34**	**3**
374	Burgundia	09 17.1	12.6	+7	6.972	0.05-0.18	3
721	Tabora	09 23.1	13.7	-7	7.982	0.19-0.30	3
503	Evelyn	09 25.9	13.1	-6	38.78	0.30- 0.5	3-
734	**Benda**	**09 26.3**	**13.7**	**+1**	**7.11**	**0.28-0.32**	**3**
1670	Minnaert	09 27.2	15.3	-11	3.528	0.23-0.25	3
815	Coppelia	09 27.6	14.7	-15	4.421	0.17-0.24	3
583	Klotilde	09 29.3	14.1	+12	9.2135	0.17-0.30	3
131	Vala	09 29.7	13.3	-4	5.1812	0.08-0.32	3

Radar-Optical Opportunities

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

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 or their Facebook or Twitter accounts) 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. This is why observing asteroids that already have well-known periods is still a valuable use of telescope time. It is even more so when considering the BYORP (binary-YORP) effect among binary asteroids that 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.

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, NPAR for a tumbler, and/or "Bin" to indicate the asteroid is a binary (or multiple) system. If "Bin" is followed by "?" it means that the asteroid is a suspected 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/index.php

Asteroid	Period	Amp	App	Last	R SNR
(441987) 2010 NY65 NEA PHA	4.973	0.24	2	2017	**1560 A** **890 G**
(420591) 2012 HF31 NEA					380 A 22 G
398188 Agni NEA PHA NPAR(-2)	21.99	1.12	1	2014	**1600 A** **90 G**
(99799) 2002 LJ3 NEA					62 A
1627 Ivar NEA	4.795	0.25 1.40	5	2018	**124 A**
(436771)2012 JG11 NEA					33 A
(163373) 2002 PZ39 NEA					
(438429) 2006 WN1 NEA	3.686	0.22	1	2015	14 A
(358744) 2008 CR118 NEA					4 A
2015 FP118 NEA PHA					**1100 A** **655 G**
(481394) 2006 SF6 NEA					**<1 A**
(481394) 2006 SF6 *NEA PHA (2019 Nov)*					***8600 A*** ***493 G***
(18109) 2000 NG11 NEA	4.25	0.77	3	2014	30 A
(144332) 2004 DV42 NEA					**7000 A** **400 G**
(455594) 2004 SV55 NEA					37 A

Table I. Summary of radar-optical opportunities in 2018 July-October. Data from the asteroid lightcurve database (Warner *et al.,* 2009; *Icarus* **202**, 134-146). (481394) 2006 SF6 is included twice: the first line is for 2018 so that photometry and/or astrometry can be obtained in anticipation the very favorable apparition in 2019 November (second line).

The "A" is for Arecibo and "G" is for Goldstone. Note that this calculator assumes full power at Arecibo.

The estimated SNR 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 current quarter.

If the SNR value is in bold text, the object was found on the radar planning pages listed above. Otherwise, the planning 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 is usually placed on the list only if the estimated Arecibo SNR > 10. This would produce a marginal signal, not enough for imaging, but might allow improving orbital parameters.

(441987) 2010 NY65 (Jul, *H* = 21.5, PHA)

Warner (2016; 2017) found an average period of about 4.975 h for this 150-meter NEA. Closest approach is on June 24 at only 0.019 AU, or about 7-8 lunar distances. It remains a target for larger scopes for the first week or so of July.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/01	16 50.6	+23 18	0.05	1.05	17.1	51.1	127	71	-0.93	+36
07/02	16 55.2	+20 53	0.06	1.05	17.3	48.7	129	78	-0.88	+34
07/03	16 58.8	+18 57	0.07	1.06	17.5	46.9	130	86	-0.81	+33
07/04	17 01.6	+17 22	0.07	1.07	17.7	45.4	132	95	-0.72	+32
07/05	17 04.0	+16 03	0.08	1.07	17.8	44.3	133	104	-0.63	+31
07/06	17 05.9	+14 56	0.09	1.08	18.0	43.4	133	114	-0.53	+30
07/07	17 07.7	+13 58	0.09	1.08	18.2	42.7	134	124	-0.43	+29
07/08	17 09.2	+13 07	0.10	1.09	18.3	42.1	134	133	-0.33	+29

(420591) 2012 HF31 (Jul, *H* = 19.4)

There are no results in the LCDB (Warner et al., 2009) for this NEA. The estimated diameter is 390 meters. The asteroid stays close to the galactic plane throughout July, so it may prove to be a difficult target. Fortunately, at closest approach in early August, the declination will be within the range of both Arecibo and Goldstone. It will be V ~ 19 at that time.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
07/01	16 45.8	-67 34	0.20	1.16	17.7	40.5	132	62	-0.93	-14
07/04	16 21.4	-68 57	0.18	1.14	17.6	44.1	129	86	-0.72	-13
07/07	15 50.2	-70 11	0.17	1.12	17.4	48.2	125	110	-0.43	-12
07/10	15 10.3	-71 03	0.15	1.10	17.3	53.0	120	125	-0.14	-11
07/13	14 20.7	-71 19	0.14	1.08	17.2	58.6	115	114	+0.00	-10
07/16	13 23.0	-70 33	0.12	1.06	17.1	65.0	109	88	+0.12	-8
07/19	12 22.1	-68 13	0.11	1.04	17.1	72.7	102	67	+0.42	-6
07/22	11 24.8	-63 49	0.10	1.03	17.1	81.9	93	65	+0.72	-3
07/25	10 35.9	-56 52	0.08	1.01	17.3	93.2	82	84	+0.93	+1
07/28	09 56.5	-47 06	0.08	0.99	17.7	106.7	69	112	-1.00	+6

(99799) 2002 LJ3 (Jul-Sep, *H* = 18.3)

The estimated diameter of this NEA is 650 meters. There are no lightcurve results in the LCDB. *This is the only apparition between 1995 and 2050 that the asteroid reaches V < 16 mag.* During the quarter, it goes through a large range of phase angles, including α < 5°; this makes it a prime target for finding H-G values.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
07/01	20 42.0	-10 05	0.35	1.32	17.7	24.2	148	8	-0.93	-29
07/11	20 48.8	-12 12	0.28	1.28	17.1	18.4	157	128	-0.07	-32
07/21	20 54.1	-16 01	0.23	1.24	16.3	11.0	166	89	+0.62	-34
07/31	20 58.7	-22 02	0.19	1.21	15.5	4.8	174	31	-0.91	-37
08/10	21 04.5	-30 27	0.16	1.17	15.4	13.0	165	161	-0.03	-41
08/20	21 15.1	-40 42	0.14	1.14	15.5	25.9	151	58	+0.67	-44
08/30	21 36.9	-51 13	0.13	1.11	15.7	38.8	136	69	-0.88	-46
09/09	22 18.2	-60 00	0.13	1.09	15.9	49.6	125	132	-0.01	-48
09/19	23 25.2	-65 15	0.14	1.07	16.2	57.2	116	60	+0.69	-50
09/29	00 45.5	-66 00	0.14	1.06	16.4	61.3	112	85	-0.84	-51

(144332) 2004 DV42 (Jul-Sep, *H* = 16.5, PHA)
2004 DV42 stays at high phase angles throughout the quarter. This often has a significant impact on lightcurve shape and amplitude because of deep shadowing effects. The estimated diameter is 1.5 km. Arecibo is planning high-res imaging. Since the period is unknown, observations before the radar runs in mid-September will be greatly appreciated and important.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
07/01	20 12.3	+81 36	1.03	1.24	19.0	52.1	75	100	-0.93	+24
07/11	20 03.1	+82 46	0.95	1.20	18.8	54.9	75	76	-0.07	+25
07/21	19 44.1	+83 27	0.86	1.16	18.6	58.3	76	99	+0.62	+25
07/31	19 18.5	+83 34	0.74	1.12	18.3	62.2	78	96	-0.91	+26
08/10	18 51.9	+82 58	0.61	1.09	17.9	66.7	80	77	-0.03	+27
08/20	18 30.3	+81 21	0.46	1.06	17.4	71.6	83	101	+0.67	+28
08/30	18 15.5	+77 35	0.30	1.04	16.7	76.7	86	91	-0.88	+28
09/09	18 05.1	+64 34	0.14	1.02	15.1	81.1	91	89	-0.01	+29
09/19	17 57.5	-40 24	0.07	1.01	13.7	82.4	94	26	+0.69	-8
09/29	17 50.6	-77 57	0.22	1.01	16.1	81.1	86	113	-0.84	-23

1627 Ivar (Jul-Sep, *H* = 13.2)
This well-studied NEA is back for a return engagement. However, even with its diameter of about 6.8 km, closest approach is far enough out that the SNR at Arecibo will be only 120 or so. Still, the radar team is planning imaging runs, so any and all photometry from throughout the quarter will help refine modeling.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
07/01	14 40.6	+08 46	0.33	1.19	12.4	51.6	114	95	-0.93	+58
07/11	14 51.3	+04 23	0.31	1.16	12.3	55.9	109	138	-0.07	+53
07/21	15 09.0	-01 09	0.30	1.14	12.3	58.8	107	11	+0.62	+46
07/31	15 34.3	-07 42	0.29	1.13	12.2	60.3	105	109	-0.91	+37
08/10	16 08.0	-14 58	0.28	1.12	12.2	60.2	106	125	-0.03	+26
08/20	16 51.0	-22 15	0.29	1.13	12.1	58.6	107	4	+0.67	+14
08/30	17 42.7	-28 29	0.30	1.15	12.2	56.0	110	110	-0.88	+1
09/09	18 39.8	-32 39	0.33	1.17	12.4	52.9	112	123	-0.01	-12
09/19	19 37.0	-34 23	0.37	1.20	12.6	49.8	114	14	+0.69	-24
09/29	20 29.1	-33 59	0.42	1.24	12.9	47.2	115	109	-0.84	-34

398188 Agni (Jul-Sep, *H* = 19.5, PHA)
Warner (2015) found a dominant period of 21.99 h for the 370 meter NEA. There were definite signs that the asteroid is “tumbling” (NAPR; see Pravec et al., 2005). However the second period, that of rotation or precession, could not be reliably determined. This and the 2014 apparitions are the only ones from 1995-2050 with $V < 16$, although there are a couple with $V \sim 17$.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
07/10	20 58.8	+31 01	0.14	1.10	17.4	52.4	121	97	-0.14	-10
07/15	20 41.7	+29 25	0.12	1.09	16.9	48.3	127	133	+0.05	-8
07/20	20 17.6	+26 19	0.10	1.09	16.4	43.4	133	97	+0.52	-5
07/25	19 44.5	+20 41	0.08	1.08	15.8	38.3	139	48	+0.93	-2
07/30	19 00.5	+11 06	0.07	1.07	15.3	35.6	142	54	-0.96	+3
08/04	18 05.7	-03 03	0.06	1.06	15.2	41.6	136	120	-0.58	+9
08/09	17 04.6	-18 49	0.06	1.05	15.6	56.4	121	155	-0.09	+13
08/14	16 05.2	-31 19	0.07	1.03	16.3	72.0	104	70	+0.10	+15
08/19	15 13.7	-39 12	0.08	1.02	17.1	84.3	91	26	+0.57	+16
08/24	14 31.4	-43 45	0.10	1.00	17.8	93.6	81	75	+0.95	+15

(18109) 2000 NG11 (Aug-Oct, *H* = 17.0)
Numerous observers have determined a rotation period of 4.25 h for 2000 NG11. It will be a marginal radar target for Arecibo.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
08/01	22 47.2	-10 35	0.41	1.38	16.8	22.1	149	15	-0.85	-56
08/11	22 55.9	-10 10	0.35	1.34	16.3	17.5	157	151	+0.00	-58
08/21	23 02.8	-09 55	0.30	1.30	15.7	12.1	164	75	+0.75	-59
08/31	23 08.4	-09 44	0.26	1.27	15.1	6.4	172	45	-0.81	-60
09/10	23 13.6	-09 26	0.23	1.24	14.6	3.5	176	175	+0.00	-61
09/20	23 19.8	-08 49	0.22	1.22	14.7	8.5	170	47	+0.78	-62
09/30	23 28.5	-07 38	0.21	1.20	14.8	14.3	163	76	-0.75	-62
10/10	23 40.8	-05 47	0.21	1.19	14.9	19.4	157	146	+0.01	-63
10/20	23 56.9	-03 20	0.22	1.19	15.1	23.5	152	26	+0.79	-63
10/30	00 16.3	-00 26	0.23	1.20	15.4	26.7	147	101	-0.69	-62

(163373) 2002 PZ39 (Aug, *H* = 18.9/18.1)
This will not be an easy photometric target given the high phase angles and low solar elongations. Unfortunately, 2002 PZ39 is not a good radar target this year. It’s been included in anticipation of the 2020 February apparition the minimum distance will be 0.06 AU and the Arecibo SNR will be greater than 1000. A rotation period found this year will be a big help to the radar team in 2020. Two values for *H* are given. The fainter one is the current value in the MPCORB file. However, Pravec et al. (2012) found H_R = 18.59. Assuming an average V-R = 0.45 (Warner et al., 2009) gives *H* = 18.14, which makes a significant difference in the diameter (about 0.21 km; or 40%).

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
08/10	12 49.8	-08 47	0.18	0.93	19.3	112.9	58	78	-0.03	+54
08/11	13 02.6	-10 05	0.17	0.94	19.1	110.6	60	66	+0.00	+53
08/12	13 16.4	-11 25	0.17	0.95	18.9	108.1	63	55	+0.01	+51
08/13	13 31.1	-12 48	0.16	0.96	18.7	105.3	66	44	+0.04	+49
08/14	13 46.8	-14 13	0.16	0.97	18.5	102.3	69	34	+0.10	+47
08/15	14 03.5	-15 36	0.15	0.98	18.4	99.1	72	24	+0.18	+44
08/16	14 21.0	-16 58	0.15	0.99	18.2	95.7	76	16	+0.27	+41
08/17	14 39.2	-18 16	0.15	1.00	18.0	92.2	79	9	+0.37	+38
08/18	14 57.9	-19 29	0.15	1.00	17.9	88.6	83	8	+0.47	+34
08/19	15 17.0	-20 34	0.15	1.01	17.8	85.0	87	13	+0.57	+31

(358744) 2008 CR118 (Aug-Sep, *H* = 18.8)
This 500 meter NEA is included despite its very low SNR when in the declination range covered by Arecibo. Southern Hemisphere observers should be able to get good photometry, especially in September. Almost exactly every five years, the asteroid has a modest Arecibo SNR when near the celestial equator and then dips deep below the celestial equator at the time of closest approach.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
08/20	14 13.5	-24 27	0.12	0.98	17.8	100.3	73	39	+0.67	+35
08/24	15 08.1	-33 14	0.10	1.00	17.1	90.5	84	70	+0.95	+21
08/28	16 28.6	-41 24	0.10	1.03	16.5	77.3	97	98	-0.98	+5
09/01	18 08.4	-45 17	0.10	1.05	16.2	63.2	112	125	-0.72	-12
09/05	19 37.8	-43 54	0.12	1.08	16.2	51.3	124	153	-0.29	-26
09/09	20 40.4	-40 01	0.14	1.10	16.3	42.7	132	142	-0.01	-37
09/13	21 21.3	-35 52	0.16	1.13	16.6	36.9	138	99	+0.14	-45
09/17	21 48.8	-32 12	0.19	1.16	16.9	33.2	141	57	+0.51	-50
09/21	22 08.3	-29 08	0.22	1.19	17.2	30.9	143	20	+0.85	-54
09/25	22 22.8	-26 33	0.25	1.22	17.5	29.6	143	34	-1.00	-57

(436771) 2012 JG11 (Aug, *H* = 19.0)
There is a short window (~ Sep 1-10) for Arecibo to catch this 470 meter with a SNR > 10. Larger scopes will be required since the asteroid never gets brighter than V = 18, which makes this the brightest apparition through 2050. Similar apparitions occur every 17 years, so if not this time, try again in 2035.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
08/10	20 29.7	+64 37	0.22	1.07	18.3	69.2	99	95	-0.03	+15
08/11	20 20.7	+65 40	0.21	1.06	18.2	70.6	98	96	+0.00	+16
08/12	20 10.1	+66 46	0.20	1.06	18.2	72.1	97	97	+0.01	+18
08/13	19 57.6	+67 52	0.20	1.05	18.1	73.7	96	96	+0.04	+19
08/14	19 42.7	+68 59	0.19	1.04	18.1	75.4	94	95	+0.10	+21
08/15	19 24.9	+70 06	0.18	1.04	18.1	77.4	93	93	+0.18	+23
08/16	19 03.5	+71 09	0.17	1.03	18.0	79.5	91	92	+0.27	+25
08/17	18 37.8	+72 06	0.17	1.02	18.0	81.7	89	91	+0.37	+27
08/18	18 07.0	+72 52	0.16	1.02	18.0	84.2	87	90	+0.47	+29
08/19	17 30.9	+73 21	0.15	1.01	18.0	87.0	84	91	+0.57	+32

(438429) 2006 WN1 (Sep, *H* = 18.9)
Warner (2016) found a period of 3.686 h for 2006 WN1, a 490 meter NEA. It’s a marginal target even for Arecibo. However, this is the only apparition when the Earth distance is < 0.2 AU, so maybe it will be put on their observing list.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
09/01	20 25.7	+08 43	0.18	1.15	16.8	32.2	142	93	-0.72	-16
09/04	20 36.4	+09 04	0.18	1.16	16.8	31.9	143	126	-0.40	-18
09/07	20 47.6	+09 19	0.18	1.16	16.8	31.4	143	152	-0.11	-21
09/10	20 59.1	+09 28	0.18	1.16	16.9	30.8	144	139	+0.00	-23
09/13	21 10.8	+09 32	0.19	1.16	16.9	30.2	144	106	+0.14	-25
09/16	21 22.6	+09 30	0.19	1.17	16.9	29.5	145	74	+0.41	-28
09/19	21 34.3	+09 25	0.20	1.17	17.0	28.8	146	45	+0.69	-30
09/22	21 45.9	+09 15	0.21	1.18	17.1	28.1	146	24	+0.91	-32
09/25	21 57.3	+09 02	0.21	1.19	17.1	27.5	147	35	-1.00	-34
09/28	22 08.4	+08 48	0.22	1.20	17.2	26.9	147	65	-0.91	-37

(481394) 2006 SF6 (Sep, *H* = 19.9, PHA)

Under normal circumstances, this 300 meter NEA would not be included. Looking to 2019 November, it will reach a minimum Earth distance of about 0.029 AU (~ 11 lunar distances), the closest approach it makes between 1995-2050. So, while for larger scopes only this time around, any and all astrometry and photometry from this apparition will eventually prove important for the 2019 apparition.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
09/01	23 06.0	+26 17	0.23	1.21	18.4	29.0	145	54	-0.72	-31
09/03	22 58.8	+25 25	0.23	1.21	18.3	27.3	147	77	-0.51	-31
09/05	22 51.6	+24 28	0.23	1.21	18.3	25.8	149	102	-0.29	-31
09/07	22 44.5	+23 25	0.23	1.21	18.2	24.6	150	127	-0.11	-31
09/09	22 37.5	+22 18	0.23	1.21	18.2	23.6	151	146	-0.01	-31
09/11	22 30.7	+21 05	0.23	1.21	18.2	23.0	152	144	+0.02	-31
09/13	22 24.1	+19 49	0.23	1.21	18.2	22.8	152	124	+0.14	-31
09/15	22 17.9	+18 31	0.23	1.21	18.2	22.9	152	100	+0.31	-31
09/17	22 12.1	+17 10	0.23	1.22	18.3	23.4	151	77	+0.51	-31
09/19	22 06.7	+15 48	0.24	1.22	18.3	24.3	150	55	+0.69	-31

(455594) 2004 SV55 (Sep-Oct, *H* = 17.8)

This will be the third closest Earth approach from 1995-2050 for 2004 SV55, an 820 meter NEA. No rotation period was found in the LCDB.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
09/20	15 50.2	-01 27	0.17	0.93	18.0	110.4	61	66	+0.78	+38
09/22	16 32.2	+04 45	0.18	0.96	17.6	100.8	69	80	+0.91	+33
09/24	17 09.8	+10 06	0.19	0.98	17.4	92.0	77	94	+0.99	+27
09/26	17 42.1	+14 23	0.21	1.00	17.4	84.4	84	108	-0.99	+22
09/28	18 09.2	+17 39	0.23	1.02	17.4	78.1	89	120	-0.91	+17
09/30	18 31.8	+20 07	0.26	1.05	17.5	72.9	93	131	-0.75	+13
10/02	18 50.7	+21 58	0.29	1.07	17.7	68.7	96	136	-0.55	+10
10/04	19 06.7	+23 23	0.32	1.09	17.8	65.1	98	134	-0.32	+7
10/06	19 20.3	+24 28	0.35	1.11	18.0	62.1	100	123	-0.13	+5
10/08	19 32.1	+25 19	0.38	1.14	18.1	59.6	101	108	-0.02	+3

2015 FP118 (Sep-Oct, *H* = 19.3, PHA)

In photometric terms, this NEA will "burn a hole in the chip" for the radar observers. Even Goldstone will get an SNR ~ 650. The estimated diameter is 400 meters. Sky motion peaks at 25 arcsec/min on Sep 6 (MPC web site). The rotation period is unknown, so pre-close approach photometry will be highly useful.

DATE	RA	Dec	ED	SD	V	Ph	SE	ME	MP	GB
08/20	13 41.2	+17 25	0.09	0.96	18.9	121.3	55	61	+0.67	+75
08/25	13 50.2	+26 54	0.06	0.98	18.4	124.0	53	116	+0.98	+77
08/30	14 12.2	+47 41	0.04	0.99	17.0	117.9	60	128	-0.88	+64
09/04	20 47.8	+80 57	0.03	1.01	14.9	87.7	91	76	-0.40	+22
09/09	00 56.1	+47 08	0.04	1.03	14.6	55.6	122	113	-0.01	-16
09/14	01 12.4	+29 51	0.07	1.06	15.1	39.5	138	149	+0.22	-33
09/19	01 16.9	+21 25	0.09	1.09	15.6	29.7	148	97	+0.69	-41
09/24	01 18.1	+16 32	0.12	1.12	16.0	22.1	155	38	+0.99	-46
09/29	01 17.8	+13 20	0.15	1.15	16.4	15.7	162	31	-0.84	-49
10/04	01 16.8	+11 05	0.18	1.18	16.6	9.9	168	100	-0.32	-51

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.

THE MINOR PLANET BULLETIN (ISSN 1052-8091) is the quarterly journal of the Minor Planets Section of the Association of Lunar and Planetary Observers (ALPO). Current and most recent issues of the *MPB* are available on line, free of charge from:

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Effective with Volume 38, the *Minor Planet Bulletin* is a limited print journal, where print subscriptions are available only to libraries and major institutions for long-term archival purposes. In addition to the free electronic download of the *MPB* noted above, electronic retrieval of all *Minor Planet Bulletin* articles (back to Volume 1, Issue Number 1) is available through the Astrophysical Data System

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The deadline for the next issue (45-4) is July 15, 2018. The deadline for issue 46-1 is October 15, 2018.