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227.

ROTATION PERIOD FOR 2670 CHUVASHIA

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CCD photometric observations of the outer main-belt asteroid 2670 Chuvashia performed by the author over two nights on 2019 January 28 and 30. The rotation period was found to be 3.846 ± 0.002 h with a lightcurve amplitude of 0.15 ± 0.02 mag.

Asteroid 2670 Chuvashia (previous designations: 1950 XZ, 1977 PW1, 1938 UD, and 1957 AL) is an outer main-belt object discovered at Nauchnyj on 1977 August 14 by N.S. Chernykh.

CCD photometric observations of the asteroid were performed by the author over two nights on 2019 January 28 and 30. A total of 13 hours 10 minutes of observation resulted in 235 data points for analysis. The rotation period was found to be 3.846 ± 0.002 h with a lightcurve amplitude of 0.15 ± 0.02 mag. A search of the asteroid lightcurve database (LCDB, Warner et al., 2009) indicates no previously reported rotation period for this asteroid.

All observations were performed at The Studios Observatory, Grantham, U.K. (Z52) using a Meade 0.36-m LX200 ACF OTA operating at $f/7$ and a Takahashi FS-102 0.10-m $f/8$ refractor as a guide scope. The OTAs are mounted on a Paramount MEII robotic mount.

The 0.36-m OTA is equipped with Moonlite CSL 2.5-inch large format motorized focuser, Astro Physics AP CCDT67 focal reducer, and a QSI 683 cooled CCD camera (KAF-8300, 3326x2504x5.4-microns, binned 2x2). The image scale was 0.86 arcsec/pixel. Exposures were 180 sec using an Astrodon Clear (UV blocking only) filter. Guiding was carried out using a ZWO ASI1600M-Cooled CMOS camera binned 2x2.

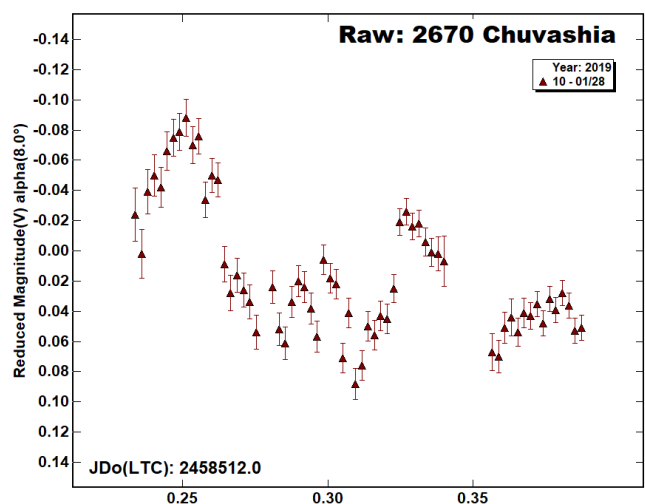
TheSkyX Professional software (Software Bisque, 2019) was used for telescope, focuser, camera control, and guiding. This software was also later used to calibrate all science images using bias, dark, dark-for-flat, and flat field frames. All flat field images were taken at the end of the observing sessions using a wall-mounted whiteboard illuminated by an A4-size electroluminescent (EL) panel. A recent library of bias, dark and dark-for-flat frames was

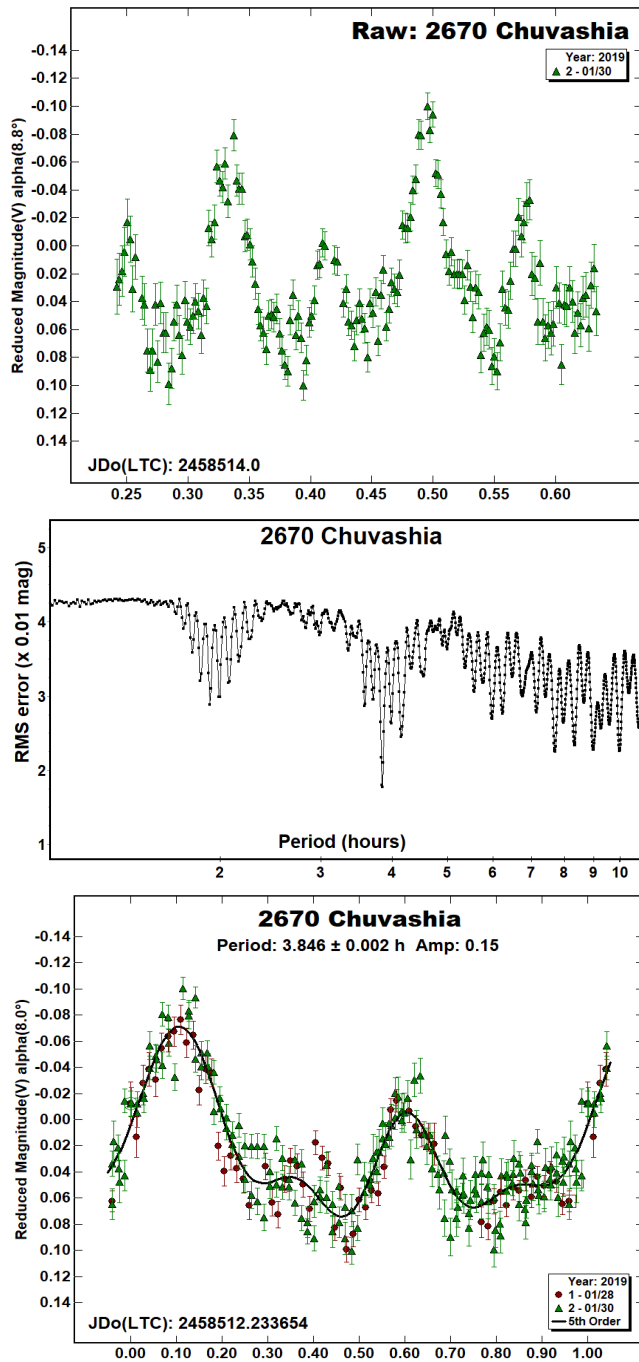
used in the calibration process, no scaling of dark frames was necessary.

All data processing of the calibrated images and subsequent period analysis was performed using *MPO Canopus* (Warner, 2018). Differential photometry measurements were performed using the Comp Star Selector (CSS) and Star-B-Gone procedures of *MPO Canopus*. The asteroid and five solar-like stars were used for all photometric comparisons. The KAF-8300 sensor has a peak spectral response in the green visual band so V band magnitudes and V-R colour indexes were used throughout the data processing. Since the target declination remained below +21 deg, the APASS catalog (Henden et al. 2009) was used for all plate solving (auto-match) and photometric reductions. The asteroid's magnitude ranged from 15.4 V to 15.5 V during the observing period.

Period analysis was performed using the Fourier analysis algorithm (FALC) in *MPO Canopus* that was developed by Harris (Harris et al., 1989). The period search looked for all likely solutions from 1-10 hours. The period spectrum shows that the Fourier analysis indicated the most convincing rotation period of 3.846 h.

All new data were deposited in the ALCDEF database (alcdf.org).





Acknowledgements

This research has made use of data and services provided by the International Astronomical Union’s Minor Planet Center. <https://www.minorplanetcenter.net/iau/mpc.html>

This research was made possible in part based on data from the MPCOSC3-2MASS catalog (a product of the Two Micron All Sky Survey), UCAC4 (the fourth U.S. Naval Observatory CCD Astrograph Catalog), and the AAVSO Photometric All-Sky Survey (APASS), funded by the Robert Martin Ayers Sciences Fund.

The author would like to express his gratitude to Brian D. Warner for his *MPO Canopus* software and support, along with the 2nd edition of his book, *A Practical Guide to Lightcurve Photometry and Analysis*. Both have been invaluable in this research.

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Number	Name	2019 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2670	Chuvashia	01/28-01/30	235	8.0, 8.8	108	1	3.846	0.002	0.15	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 OF 5889 MICKIEWICZ AND 13063 PURIFOY

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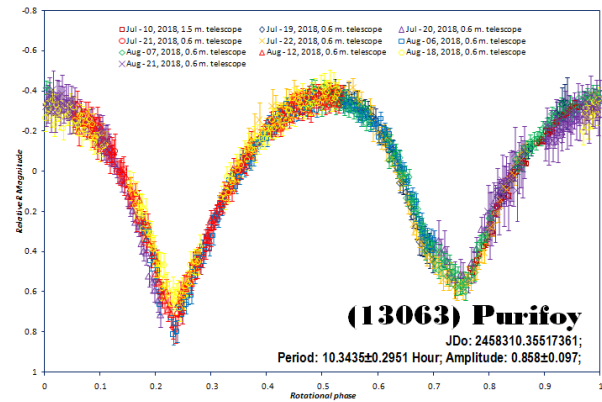
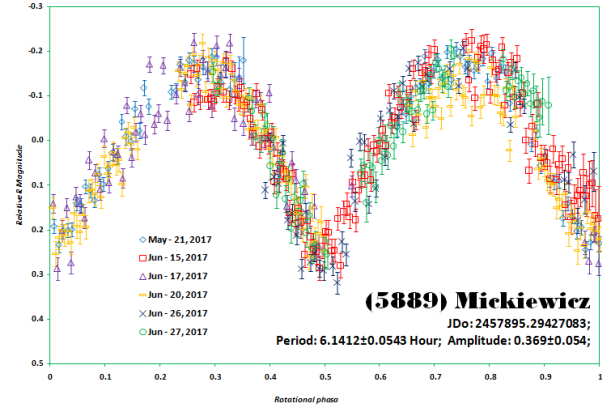
The main-belt asteroids, 5889 Mickiewicz and 13063 Purifoy were observed at Maidanak astronomical observatory, the Ulugh Beg Astronomical Institute, Uzbek Academy of Sciences from May 21 to June 27 in 2017 and July 10 to August 21 in 2018, respectively. Based on the lightcurve analysis of each asteroid, a synodic rotation period for 5889 Mickiewicz was 6.1412 ± 0.0543 hour (0.25524 ± 0.25814 day) and its light curve amplitude was 0.369 ± 0.054 mag, and a synodic rotation period of asteroid 13063 Purifoy was 10.3435 ± 0.2451 hour and its lightcurve amplitude was 0.858 ± 0.097 mag.

All observational data reported here were obtained by the 60-cm Zeiss-600 telescope at the Maidanak observatory (Ehgamberdiyev, 2018), whose observatory code is 188. We used the 1 k x 1 k FLI IMG1001E CCD camera with the resolution of 0.67 arcsec/pixel and the Bessel R filter. The FOV of the camera is $10.7' \times 10.7'$. The temperature of the camera was set at -30°C . Image acquisition was done with MaxIm DL. All images were reduced with master bias, dark, and flat frames. All calibration frames were created using IRAF (Image Reduction and Analysis Facility). And all instrumental star magnitudes were also obtained using IRAF.

5889 Mickiewicz (1979FA3) was discovered on March 31, 1979 by N. S. Chernykh at Nauchnyj. It's named after Adam Mickiewicz (1798-1855), who was a Polish poet. (Minor Planet Circ. 27128). This object is a main-belt asteroid with an orbital period of 5.32 years. Absolute magnitude is 12.2 mag and the diameter is 26.414 km (MPC, JPL). At this time, this asteroid is not included in any group/family (Nesvorný, 2015). LS periodogram was used for period analysis of the photometric data. Analysis of the data provided a synodic rotation period of $P = 6.1412 \pm 0.0543$ h with an amplitude of 0.369 ± 0.054 mag. Its lightcurve is shown in Fig.1.

13063 Purifoy (1991 LB) was discovered on June 5, 1991 by Spacewatch at Kitt Peak (MPC, JPL). It's named after Dana D. Purifoy (b. 1955) who is a pilot in the Flight Crew Branch of NASA's Dryden Flight Research Center, Edwards, California. He has accumulated 4400 hours of flying time over 75 different

aircrafts. Purifoy is a main-belt asteroid with an orbital period of 3.32 years. Absolute magnitude is 14.4 and the diameter is 3.338 km (JPL). Purifoy is a member of the synthetic family (8) Flora / (298) Baptistina and asteroid dynamical family 1249 Rutherfordia (Nesvorný, 2015). LS periodogram was used for period analysis of the photometric data. Analysis of the data provided a synodic rotation period of 10.3435 ± 0.2451 hour with an amplitude of 0.858 ± 0.097 mag. Its lightcurve is shown in Fig. 2



Acknowledgements

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Number	Name	year/ mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
5889	Mickiewicz	2017/05/21-06/27	521	17.3,10.7	279	24	6.1412	0.0543	0.37	0.05	MB
13063	Purifoy	2018/07/10-08/21	971	24.6,7.1	328	7	10.3435	0.2451	0.86	0.09	MB

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

Warner, B.D., Harris, A.W., Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2018 Nov 15 <http://www.minorplanet.info/lightcurvedatabase.html>

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STAFF POSITION OPENING - ASSOCIATE PRODUCER, *MINOR PLANET BULLETIN*

The *Minor Planet Bulletin* announces the opening a new staff position of Associate Producer, with the probability of taking over the *MPB* Producer's position in about two years following a period of mentoring and collaboration. The responsibilities will be to assist the current Producer, Bob Werner, with the layout construction of each quarterly issue of the *Minor Planet Bulletin*, demonstrating proficiency for transitioning to the Producer position. For each *MPB* issue produced, the required tasks and capabilities to be demonstrated include:

- Reformatting approximately 30–40 manuscript documents from the editors.
- Responsive communication with the editorial and distribution staff.
- Able to commit to and adhere to deadlines throughout the calendar year.
- Corresponding with authors via email with article proofs.
- Handling formatting inquiries from new and seasoned authors who contribute manuscripts to the *MPB*.
- Laying out an issue's articles in a single master document, resulting in the ready-to-print and ready-to-release electronic version of each *MPB* issue.
- Constructing a full index of each annual volume.
- Maintaining a long-term electronic archive of all issues.

The skills required for the position of Associate Producer, *Minor Planet Bulletin* include:

- Proficiency with Microsoft Word 2013/2010, Portable Document Format (pdf) computer documents, and email. Production status is tracked using Excel.
- Knowledgeable expertise with asteroid astronomy sufficient for some error checking and recommending editorial corrections.
- Strong skills with written English.

The time commitment required varies from issue to issue, but typically occupies 25 or 30 hours each quarter. *The Minor Planet Bulletin* publishes four issues per year. All *MPB* staff positions, including this announced opening for Associate Producer, are volunteer positions without pay or other compensation. Materials and postage costs, as necessary, are reimbursed.

Persons wishing to be considered for the Associate Producer position should send a statement of interest, a statement on the level of available commitment, and a summary of qualifications to the Editor: rpb@mit.edu Review of applications will begin February 1, 2019. The position will remain open until filled.

PHOTOMETRIC OBSERVATIONS OF MAIN-BELT ASTEROIDS 917 LYKA, 5703 HEVELIUS, (6638) 1989 CA AND 8073 JOHNHARMON

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(Received: 2019 February 5)

Photometric observations of four main-belt asteroids were obtained from October 26 to December 05, 2018 from Malta and the United States in order to update or determine their synodic rotation periods. We provide lightcurves for 917 Lyka, 5703 Hevelius, (6638) 1989 CA and 8073 Johnharmon.

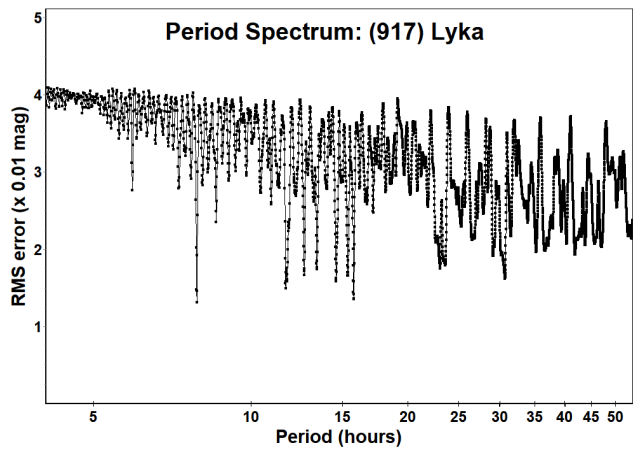
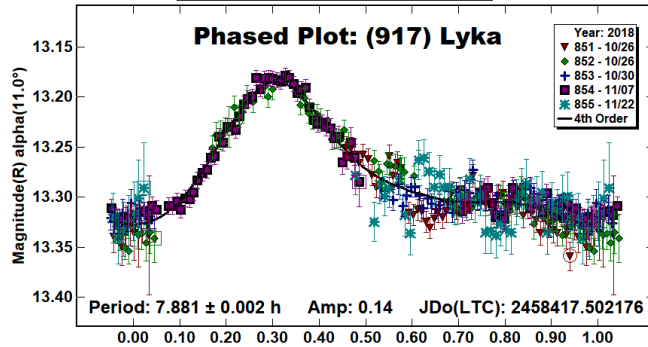
Photometric observations of four main-belt asteroids were carried out from three observatories located in Malta (Europe) and one in the United States. Observations for asteroids 917 Lyka, (6638) 1989 CA and 8073 Johnharmon were obtained from observatories located in Malta that utilized the following configurations. Znith Observatory employed a 0.20-m Schmidt-Cassegrain (SCT) equipped with a Moravian G2-1600 CCD camera at 1x1 binning, whilst Flarestar Observatory utilized the same CCD model coupled with a 0.25-m SCT telescope at 1x1 binning. Antares Observatory used an SBIG STL-11000 CCD camera at 2x2 binning attached to a 0.28-m SCT telescope. The asteroid 5703 Hevelius was observed from Sierra Remote Observatory at Auberry, CA (USA) that utilized a 0.48-m RC telescope coupled with an Apogee U42 CCD camera, at a pixel scale of 0.74 arcseconds/pixel.

All telescopes and cameras were controlled remotely. The observatories in Malta were operated from a nearby location via *Sequence Generator Pro* (Binary Star Software), while the Sierra Remote Observatory was controlled over the internet. Photometric reduction, lightcurve construction and analyses were derived through *MPO Canopus* software (Warner, 2017). Differential aperture photometry was utilized 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 based on the CMC-15 catalogue with magnitudes converted from J-K to BVRI. All images utilized in this research were dark subtracted and flat-fielded

917 Lyka is a large main-belt asteroid that was discovered on 1915 September 05 by Neujmin, G. at Simeis Observatory, Crimea. The asteroid orbits the sun with a semi-major axis of 2.382 AU,

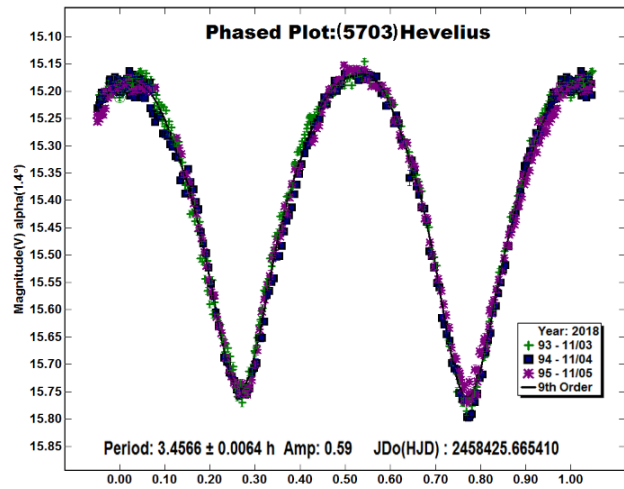
eccentricity 0.200, and orbital period of 3.68 years (JPL, 2019). The JPL Small-Bodies Database Browser lists the diameter of 917 Lyka as 34.878 ± 0.184 km based on an absolute magnitude (H) of 11.6 (JPL, 2019). Behrend, R (2018) has published on the web two synodic periods of (917) Lyka through his website that makes reference to the data obtained by Bernasconi, L (2005) with a period of 7.8672 ± 0.0055 h and by Conjat, M. (2018) with a period of 7.883 ± 0.0003 h.

This asteroid was observed from Znith Observatory on 2018 October 26, 30 and November 07 and 22. We determined the synodic period of 917 Lyka as 7.881 ± 0.002 h with an amplitude of 0.14 mag. Our results are consistent with those obtained by Conjat, M. (2018), and Behrend, R. (2018).



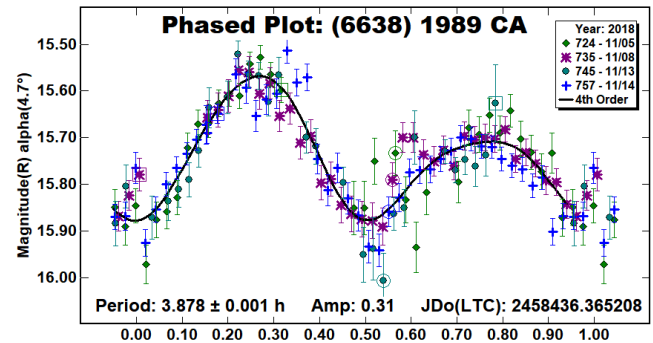
5703 Hevelius is a main-belt asteroid that was discovered on 1931 November 15 by Reinmuth, K. at Heidelberg. It was named after the eminent astronomer Johannes Hevelius (1611-1687), an ardent observer that depicted detailed lunar maps and made astrometric observations of stars and planets. This 5.8 km diameter asteroid has an absolute magnitude (H) of 13.0 and orbits the sun with a semi-major axis of 2.5829 AU. Its orbit has an eccentricity of 0.1762, and a period of 4.15 years (JPL, 2019).

Observations of the asteroid Hevelius were conducted on 3 nights from Sierra Remote Observatory on 2018 November 3, 4 and 5. Results indicate a synodic period of 3.4566 ± 0.0064 h and amplitude of 0.59 ± 0.02 mag. The Light Curve Data Base (LCDB) did not contain any references of the synodic period of this asteroid.



(6638) 1989 CA is a main-belt asteroid that was discovered on 1989 February 02 by Arai, M., Mori, H. at Yorii, Japan. This 5.715 ± 0.234 km diameter asteroid has an absolute magnitude (H) of 13.7 and orbits the sun with a semi-major axis of 2.437 AU. Its orbit has an eccentricity of 0.1619 and a period of 3.80 years (JPL, 2019).—Observations were conducted on 4 nights from Antares Observatory (1 night) and Flarestar Observatory, during the period between 2018 November 05 up to 2018 November 14. Our Results indicate a synodic period of 3.878 ± 0.001 h and amplitude of 0.31 ± 0.06 mag.

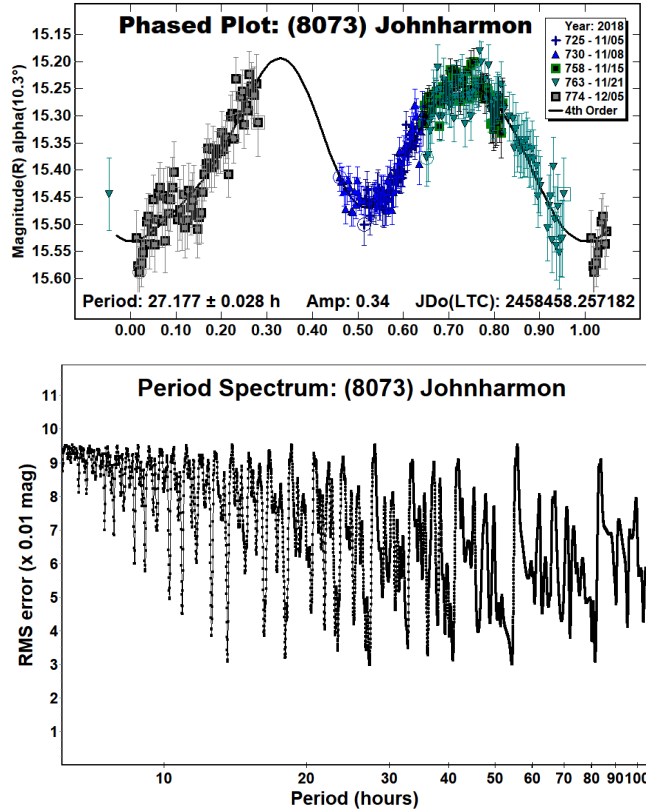
Đurech et. al.,(2018) utilized the lightcurve inversion method to derive the spin axis of asteroid (6638) and obtained a synodic period of 3.877233 ± 0.00002 h. Their lightcurve was listed as having a U quality of U2.



8073 Johnharmon is a main-belt asteroid that was discovered by E. Bowell on 1982 January 24 from the Anderson Mesa Station, Lowell Observatory. This asteroid was named after John K. Harmon (b. 1948), a scientist at the Arecibo Observatory who made outstanding contributions to planetary radar astronomy of Mars, Mercury, the Galilean satellites and comets.

This asteroid orbits the sun with a semi-major axis of 2.592AU, eccentricity 0.169, and period of 4.17 years (JPL, 2019). The JPL Small-Bodies Database Browser (JPL, 2019) lists the diameter of this asteroid as 6.498 ± 0.185 km based on an absolute magnitude (H) of 12.9.

8073 Johnharmon was observed from Flarestar Observatory from 2018 November 11 to 2018 December 05. Our results yielded a synodic period of 27.177 ± 0.028 h and amplitude of 0.34 ± 0.05 mag. Based on the period spectrum and a search of half periods, the period of 27.177 h was found as being the best probable result. This asteroid does not appear to be in the Light Curve Data Base (LCDB).



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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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Number	Name	yyyy/mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Group
917	Lyka	2018 10/26-11/22	315	11.5, 22.3	018	4.9	7.881	0.002	0.14	0.02	ERI
5703	Hevelius	2018 11/03-11/05	162	1.2, 2.3	038	01	3.4566	0.0064	0.59	0.02	EUN
6638	(1989 CA)	2018 11/05-11/14	148	5.3, 0.4	051	-0.6	3.878	0.001	0.31	0.06	NYSA
8073	Johnharmon	2018 11/05-12/05	297	10.3, 9.6, 14.9	050	17	27.177	0.028	0.34	0.05	EUN

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

ASTEROID PHOTOMETRY AT THE CARL SAGAN OBSERVATORY OF UNIVERSIDAD DE SONORA DURING 2017

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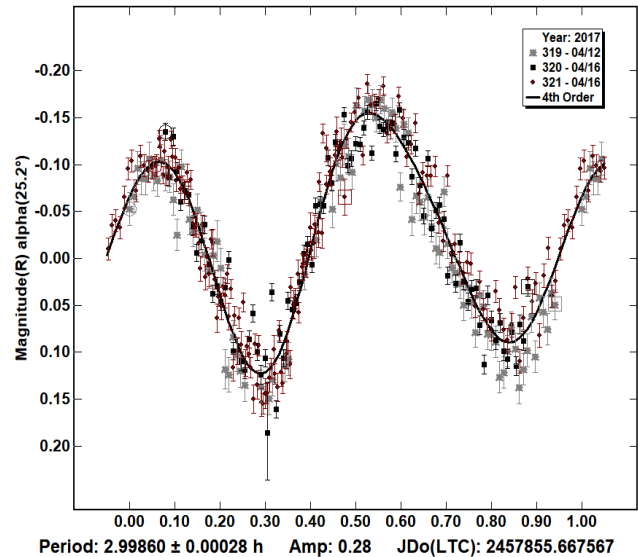
(Received: 2019 Jan 24)

We present photometric lightcurves and rotation period values for three asteroids, namely 4404 Enirac (2.9986 ± 0.0003 h), 5976 Kalatajean (4.5543 ± 0.0001 h) and 9671 Hemera (2.5323 ± 0.0005 h). Observations were carried out at the Carl Sagan Observatory (OCS) of the Universidad de Sonora. In the case of 9671 Hemera we have not found any clear evidence of binarity.

A collective effort between researchers and undergraduate students to observe and analyze optical photometry of asteroids has been initiated at Universidad de Sonora, México. Our team is part of the Mexican Asteroid Photometry Campaign (CMFA in Spanish), a larger Mexican effort aiming to study asteroids via optical photometry. Photometric observations were carried out at our local facility, the Carl Sagan Observatory (OCS in Spanish), where a $3056 \times 3056 \times 12 \mu\text{m}$ Apogee Alta F9000 CCD camera is mounted on a Meade LX-200GPS 0.41-m $f/10$ telescope. Images were trimmed to a subframe of 2000×2000 pixels and binned 2×2 yielding a final plate scale of 1.2 arcsec/pix and an effective 20×20 arcmin² FOV. Data reduction was made following *IRAF* standard procedures to correct for bias, dark current and flat-field effects. In this work, we present photometric analysis of three asteroids as the beginning of our local campaign. Photometric and lightcurve analysis was made using *MPO Canopus (V.9.5.0.14, BDW Publishing, 2017)* software package.

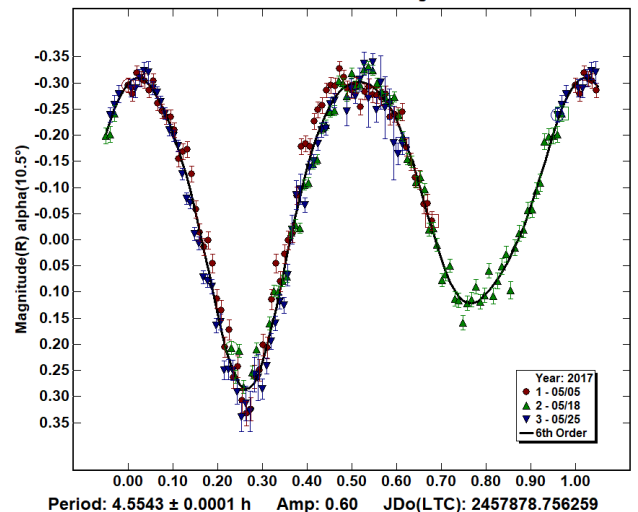
4404 Enirac is an S-type main-belt asteroid (Warner *et al.*, 2009). Mainzer *et al.* (2011, 2016) reported an absolute magnitude of $H=12.9$, an albedo of 0.239 and a diameter of 6.233 km for this object. There are five rotation period reports in the literature. Klinglesmith *et al.* (2014) report a period of 2.998 ± 0.002 h. Later in 2017, Hayes-Gerhke *et al.* have obtained an improved value of 2.9979 ± 0.0003 h with an amplitude of 0.27. In the same year, Behrend (2017) reports a value of 2.998344 ± 0.000192 h. More recently, Mas *et al.* (2018) and Benishek (2018) report a value of 2.997 ± 0.001 with an amplitude of 0.26, and 2.9978 ± 0.0002 with an amplitude of 0.27, respectively. Our observations were carried out during two nights, 2017 April 12 and 16. Based on these data we determined a period value of 2.9986 ± 0.0003 h, with an amplitude of 0.28, which is in good agreement with those previously reported.

Phased Plot: 4404 Enirac



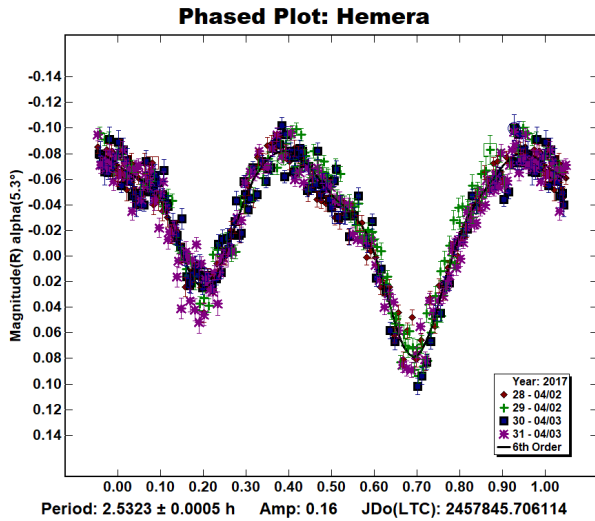
5976 Kalatajean is a main-belt asteroid. It has an absolute magnitude of $H=12.3$ reported by Owings (2018), which is in agreement with previous values reported by Veres *et al.* (2015) and Mainzer *et al.* (2016). It possesses an albedo of 0.226 and a diameter of 11.137 km reported by Mainzer *et al.* (2016). The most recent period value of 4.55362 ± 0.00006 h, is reported by Owings (2018). Our observations, carried out during 2017 May 5, 18 and 25, indicate a period of 4.5543 ± 0.0001 with an amplitude of 0.6. Our value is in good agreement, within uncertainty, with previous values including the most recent one reported by Owings (2018).

Phased Plot: Kalatajean



9671 Hemera is a Mars-crossing Asteroid. This object has a magnitude $H=14.09$ (Veres *et al.*, 2015) with no albedo or size reported. In 2017, three synodic period values were reported. Skiff (2017) reported values of 2.53143 ± 0.00035 h and 2.53144 ± 0.00013 h with an amplitude of 0.17 in both cases. Brincat (2017) and Salvaggio *et al.* (2017) reported a period of 2.532 ± 0.001 h with amplitudes of 0.16, and 2.531 ± 0.001 h, with an amplitude of 0.17, respectively. As noted by these last two reports, this object shows a peculiar bimodal lightcurve which they suggested as indicative of binarity. In 2018, Mas *et al.* and Aznar Macias *et al.* reported a period value of 2.531 ± 0.001 h, with an amplitude of

0.15, and 2.534 ± 0.002 h, with an amplitude of 0.12, respectively. The most recent period report is that of Ditteon and Young (2018) with a value of 2.5318 ± 0.0004 h with and amplitude of 0.14. Our observations were carried out during the nights of 2017 April 2 and 3. Based on these data we have derived a period of 2.5323 ± 0.0005 h, with an amplitude of 0.16. It is worth noticing that our data do not show any clear evidence of 9671 Hemera being a binary object.



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Number	Name	2017 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
4404	Enirac	04/12-04/16	344	25.2,26.3	183.0	33.4	2.9986	0.0003	0.28	0.07	MBM
5976	Kalatajean	05/05-05/25	216	19.2,10.5	205.5	-4.6	4.5544	0.0002	0.60	0.04	EUN
9671	Hemera	04/02-04/03	522	5.3,4.6	197.2	-2.8	2.5323	0.0005	0.16	0.02	MC

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).

DISTRIBUTION OF MINOR PLANET NUMBERS VS CUMULATIVE NUMBER OBSERVED

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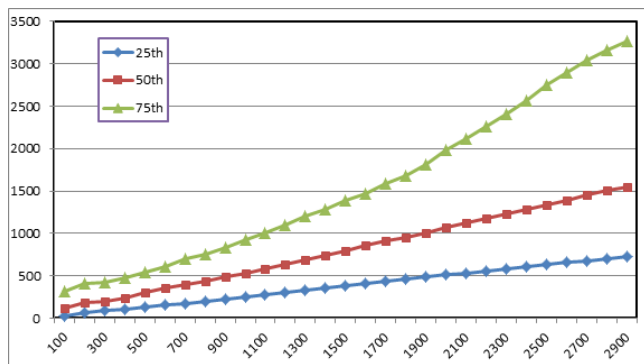
(Received: 2019 February 3)

The author finds that as the cumulative number of minor planets observed increases, the median value of the observed minor planet numbers also increases, in roughly linear fashion. He finds that specific percentage points of the minor planet number distribution increase in proportion to the total number observed.

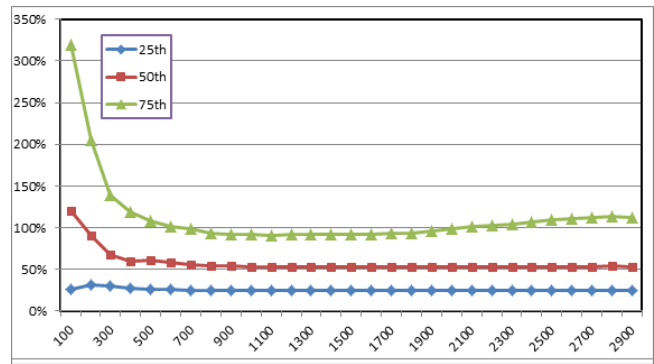
The author visually observed more than 2900 distinct minor planets through the end of 2018 (Salthouse, 2019a). In an earlier paper (Salthouse, 2019b), he reported that the ratio Q/N tended to an asymptote at large N , where N is the number of distinct objects observed and Q is the number of minor planets with assigned number $\leq N$. Following up this analysis, he also found that as the cumulative number of objects N increased, the median value of observed minor planet number increased in nearly linear fashion. The median is a more meaningful metric than mean, as it is far less impacted by outliers or by unnumbered objects in the data. The author also tracked the 25th and 75th percentile points of the distribution of assigned numbers, which are also less impacted by outliers than standard deviations. We adopt the notation p_{25} , p_{50} , and p_{75} to denote the 25th, 50th, and 75th percentile of the distribution of minor planet numbers, respectively. Note that half of the distribution lies between p_{25} and p_{75} . The author found that as N increased:

- The ratio of p_{25} to N tended to an asymptote of about 25%
- The ratio of p_{50} to N tended to an asymptote of about 54%
- The ratio of p_{75} to N tended to an asymptote of about 93% up to $N=1800$, then it increased thereafter to about 113%

These findings are completely consistent with the earlier result (Salthouse, 2019b). The earlier analysis showed that Q/N tended to 79% up to $N=1800$, and then declined to 72% up to $N=2900$ due to the acquisition of a better telescope at the time of $N=1800$. If Q/N tended to 75%, then the ratio p_{75}/N would be 100%; if Q/N tended to more than 75%, then the ratio p_{75}/N would be below 100%, and if Q/N tended to less than 75%, then the ratio p_{75}/N would be above 100%. The observed results are shown in graphs 1 and 2.



Graph 1. Key percentage points of the “n” distribution (y-axis) versus total number observed N (x-axis).



Graph 2. Ratio of p_{25}/N , p_{50}/N , and p_{75}/N (y-axis) versus total number observed N (x-axis)

It appears that the acquisition of a better telescope at $N = 1800$ expanded the upper end of the available minor planet number distribution without having much effect on the lower end. This is consistent with expectations.

Thus, the asymptotes of p_{25}/N , p_{50}/N , and p_{75}/N are likely to depend on telescope aperture. Furthermore, these asymptotes apply to visual observations, and will be very different for CCD observations. In addition to the two hypotheses presented in the earlier paper (Salthouse, 2019b), these results lead the author to propose a third hypothesis:

- The asymptotic ratio of p_x/N is more sensitive to aperture at the upper end of the percentile distribution (higher x) than at the lower end of the distribution (lower x).

The author’s research suggests that the distribution of observed minor planet numbers expands in direct proportion to N , for a fixed aperture. As N increases, the points p_{25} , p_{50} , and p_{75} scale in proportion, implying that the entire distribution scales (with the possible exception of the tails).

The probability of observing a given minor planet depends to a large extent on its visual magnitude. The shape of the percentile distribution of observable minor planet numbers for a given value of N has implications for the probability distribution, and therefore for the magnitude distribution. This is a very interesting subject worthy of further exploration.

The author is unaware of prior published research on this topic. A search of the last twenty years of *Minor Planet Bulletin* issues did not reveal any articles of a similar nature.

Acknowledgements

The author thanks Mr. Brian Warner for providing the Minor Planet Observer suite of products (<http://bdwpublishing.com>) and services (<http://MinorPlanet.info>), without which this work would have been impossible. He also thanks Ms. Mary Ellen Salthouse for the gift of a 45cm reflector in the summer of 2007.

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LIGHTCURVE ANALYSIS OF ASTEROIDS 131 VALA, 1184 GAEA, 7145 LINZEXU, AND 26355 GRUEBER

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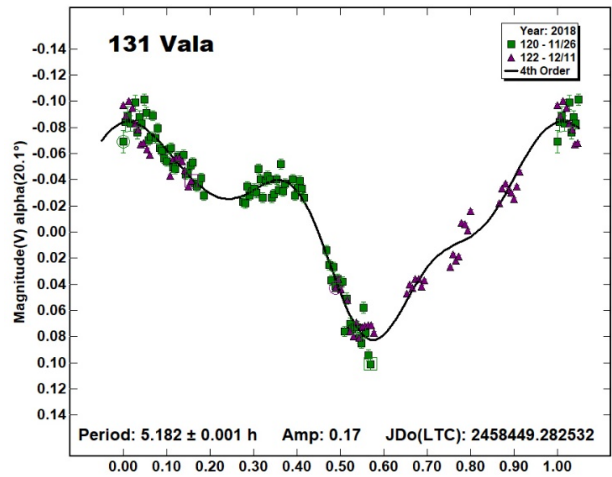
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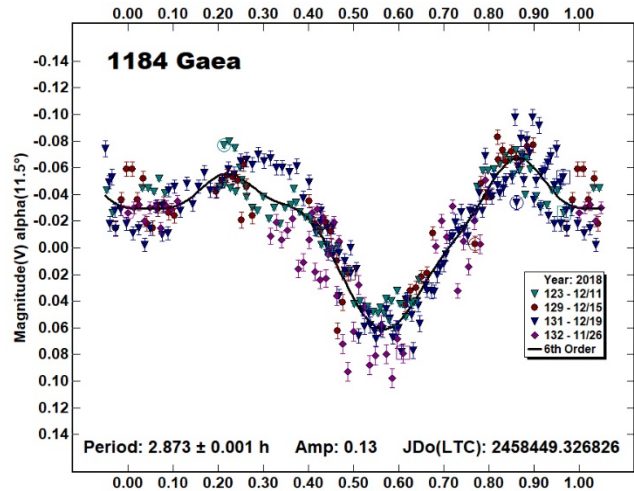
Photometric observations of 4 main-belt asteroids were obtained on four nights between 2018 November 26 and 2018 December 19. We derived the following rotational periods: 131 Vala 5.182 ± 0.001 h; 1184 Gaea 2.873 ± 0.001 h; 7145 Linzexu 2.905 ± 0.001 h and 26355 Grueber 4.539 ± 0.001 h.

We report on the results of photometric observations obtained with two of the Southeastern Association for Research in Astronomy (SARA) consortium telescopes. For the nights of 2018 November 26, 2018 December 11 and 2018 December 15 we utilized the 1m Jacobus Kapteyn Telescope at the Observatorio del Roque de los Muchachos on the Spanish island of La Palma. The telescope is coupled with an Andor iKon-L series CCD. For the night of 2018 December 19 we utilized the 0.9m telescope at Kitt Peak National Observatory. The telescope is coupled with an ARC CCD. The data was calibrated using MaximDL and photometric analysis was performed using MPO Canopus (Warner, 2017). Unfortunately, the bright Moon hindered some of the later observations.

131 Vala. Was selected from the Shape Modelling Target list published in the Minor Planet Bulletin (Warner et al., 2018). We were only able to observe 131 Vala on two nights, as it was too close to the Moon on the third night and equipment failure hampered observations on our last assigned night. There are five previously published rotational periods for 131 Vala. Pilcher (2008) published a rotation period of 10.359h based on a bimodal lightcurve with small amplitude. Behrend (2009) published a period of 5.1803 ± 0.0006 h. Pilcher (2009) re-analyzed his previous data -assuming a near pole-on viewing geometry and a monomodal lightcurve- and added new observations confirming the ~ 5.18 h period suggested by Behrend. Additional observations from 2009 (Galad et al., 2010) and from 2017 (Pilcher, 2017) confirmed the rotational period. We derived a rotational period of 5.182 ± 0.001 h with an amplitude of 0.17 mag in agreement with previous measurements. We will submit our data to the Database of Asteroid Models from Inversion Techniques (DAMIT) (Durech et al., 2010) web site and hopefully contribute to a viable shape model of 131 Vala.



1184 Gaea. Two previously published periods exist for 1184 Gaea. Behrend (2011) reports a period of 2.94 ± 0.06 h. Our group observed the asteroid in 2017 and derived a period of 2.871 ± 0.001 h (Fauerbach and Brown, 2018). We decided to observe 1184 Gaea again in order to provide a shape model of the asteroid in the future. Our observations cover all four available nights and span almost an entire month, thereby providing a larger variation in phase angle than in our previous observation. On three of the nights we observed the asteroid for approximately 6 h, therefore covering two full rotations during each of these nights. We derive a period of 2.873 ± 0.001 h and an amplitude of 0.13 mag in agreement with the previous measurement.

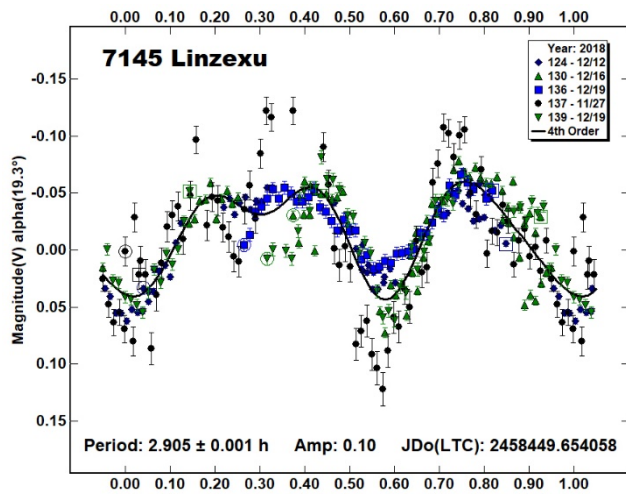


7145 Linzexu. Only one prior measurement of the rotational period exists. Diteon and West (2011) reported a period of 2.905 ± 0.003 h. Our observations cover all four available nights and span almost an entire month. We obtained a rotational period of 2.905 ± 0.001 h with an amplitude of 0.10 mag in excellent agreement with the previous measurement.

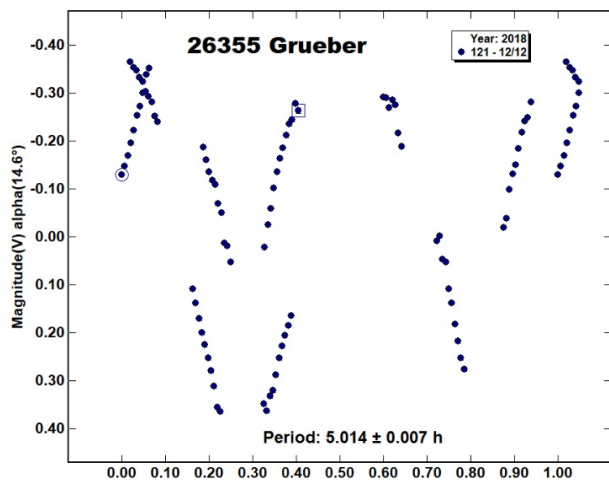
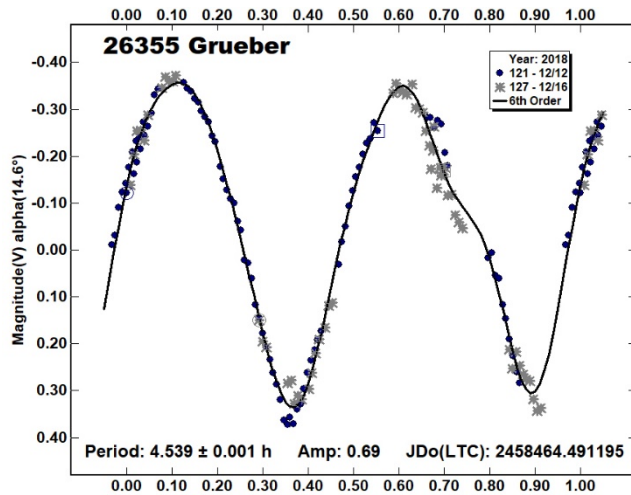
Number	Name	2018 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
131	Vala	11/26,12/11	134	20.1,21.8	10.9	-3.9	5.182	0.001	0.17	0.02	MB-I
1184	Gaea	11/26-12/19	304	6.9,13.8	53.8	12.5	2.873	0.001	0.13	0.02	MB-M
7145	Linzexu	11/27-12/19	306	23.5,16.8	114.6	-11.2	2.905	0.001	0.10	0.02	MB-I
26355	Grueber	12/12,12/16	149	14.1,12.3	108.1	2.0	4.539	0.001	0.69	0.03	MB-I

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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26355 Grueber. The only previously reported rotational period is by Waszczak et al. (2015) based on a fit to sparse data. They reported a period of 5.015 ± 0.0006 h with an amplitude of 0.59 mag. We observed 26355 Grueber on two nights for 7 h and 6 h respectively, thereby covering more than one rotational period each night. Our derived rotational period of 4.539 ± 0.001 h with an amplitude of 0.69 mag does not agree with the previous result. Below we plot our data for a single night -covering 7h of observations- with the Waszczak et al. period to highlight that our data cannot fit the previous result.



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**LOWELL OBSERVATORY NEAR-EARTH ASTEROID
PHOTOMETRIC SURVEY (NEAPS): PAPER 3.**

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(Received: 2019 March 15)

Revised and new photometry is presented for 72 asteroids using telescopes at Lowell Observatory since 2008. The data are reduced as closely as possible to Sloan r' magnitudes.

This paper begins to revisit much of the older data from Skiff et al. (2012; Paper 1 from hereon) and from Koehn et al. (2014; Paper 2 from hereon). The main purpose is to revise completely the hodge-podge magnitudes of the comparison stars used at the time more consistently to Sloan r' using photometric catalogues that have become available since those results were published. Besides zero-point correction, there are also smaller scale-error improvements when previously assumed values were significantly in error. In many cases, previously omitted data-points are restored to the lightcurves thanks to the improved calibration and better evaluation of aberrant observations. All the data have been re-uploaded to the ALCDEF.

Readers should refer to the introductory section of Paper 1 as regards personnel, division of labor, and observing details, as well as the vagaries, especially of the photometry with the LONEOS Schmidt. Those comments cover work up to 2010. Numerous “new” (post-2010) results are added to the present paper from the various telescopes for both ordinary asteroids and NEOs.

Lowell Observatory Telescopes

The LONEOS camera (MPC observatory code 699) is a 0.55-m $f/1.9$ prime-focus Schmidt with a plano-convex field-flattening lens just in front of the CCD. The telescope was closed in 2013 Dec. The image scale was 2.5 arcsec/pixel and always operated unfiltered. From 2010 onwards data from the Schmidt made use of flats aimed at the twilight uniform-illumination ‘Chromey spot’ (Chromey and Hasselbacher 1996), which were superior to the weak night-sky flats obtained earlier in the program. The observing procedure was also changed to produce dense lightcurves within a few nights for one or two targets rather than the original sparse cadence, which too often yielded no rotation periods despite a large observational effort.

The 0.7-m $f/8$ telescope, built in the mid-1960s, is run robotically (this and the remaining telescopes fall under MPC code 688.) It is a long-focus $f/15$ classical Cassegrainian with a 2:1 re-imager/focal-reducer, autoguider, and two filter wheels. The image-scale is 0.91 arcsec/pixel with 2x2 binning of the ‘nasacam’ CCD, which covers a 15'x15' field. The telescope has been variously described in publication as 0.78-m, 0.79-m, 0.8-m, or even 0.9-m aperture. However, the original 31-inch primary mirror has its periphery masked off to reduce the effects of a severe turned-edge. Overall efficiency is roughly that of a sharp 0.5-m telescope.

Details about conversion of this telescope to robotic operation and the associated software are described in Buie (2010). A large catalogue of V and V- R_c photometry of field stars near the ecliptic was produced by Buie et al. (2011) using the telescope in this mode. The appendix of this paper has plots of atmospheric extinction for the Anderson Mesa site, and zero-points and color terms for the CCD system. Not incidentally, both the V and R_c filters used for the asteroid work have large negative color terms, i.e. both are shifted significantly blueward of the standard passbands (*cf.* Figures 7 and 8 in Buie et al.).

The Hall 1.1-m $f/8$ is a Ritchey-Chrétien that went into operation in 1970. With the current ‘nasa42’ CCD system the field is about 22'x22' at image scales 0.74 and 1.11 arcsec/pixel for 2x2 and 3x3 binning. See Hall and Wade (1976) for a brief description and photos of this telescope.

Finally, the venerable Perkins 1.8-m reflector is a long-focus $f/18$ classical Cassegrainian built in 1924 by Warner and Swasey. We used the ‘PRISM’ CCD camera package (designed by Ken Janes, Boston Univ), which includes a 4:1 re-imager/focal-reducer (yielding $f/4.5$) and three filter wheels enabling direct imaging, polarimetry, and very-low-dispersion spectroscopy. The field is about 13'x13', and image scales are 0.78 and 1.17 arcsec/pixel for 2x2 and 3x3 binning. The CCD is cooled with liquid nitrogen, whereas all the other cameras described above have CryoTiger chillers. Some details can be found here:

<https://www.bu.edu/prism/index.html>

Control of telescopes and domes is through ‘MOVE’, written by Lowell astronomer Larry Wasserman. The program allows input of and tracking along ephemerides of comets and asteroids at any desired rate. The LONEOS, 0.7-m, and 1.1-m camera systems and associated software were built in the Lowell instrument shop by Ted Dunham and colleagues. Autoguiders on the 0.7-m, 1.1-m, and 1.8-m telescopes were also Lowell-built, and operate under the control of ‘MOVE’. A wide ‘VR’ filter was used for some observations at the 1.1-m and 1.8-m telescopes. This is a custom interference filter intended to maximize throughput. The rectangular passband has half-maximum wavelengths near 5200Å and 7000Å, midway between V and R_c , and thus is similar to the Sloan r' passband (half-maximum range 5600Å to 6950Å) but somewhat wider. Asteroid data adjust to Sloan r' without difficulty as long as colors of the comparison stars are restricted.

Data Reduction and Period Analysis

Only occasionally have original images been remeasured of the older source data from Papers 1 or 2. Instead a general reanalysis has been done based simply on more experience (and skepticism) at the task from work on both variable stars and asteroids. Because of the tardy publication, in many cases other authors have published data from the same or later apparitions. Sometimes our

data are better, other times not. We cite previous results mostly just of the earliest (correct) period-determination, but also mention results from the same apparition as our observations, and sometimes incorrect results. The present legacy lightcurves can also contribute data from which shape modelling and YORP-related effects can be derived downstream.

Measurement of the images and period analysis were done throughout using *MPO Canopus*. The asteroids and three to five comparison stars were measured, preserving comp stars among adjacent nights if possible in hopes of reducing nightly zero-point shifts. We attempted to keep the comparison stars within the range of ‘asteroidal’ colors, roughly $0.5 < B-V < 0.95$, or Sloan $0.3 < g-r < 0.85$, though this was not always possible. In order to reduce the internal scatter in the data, we chose the brightest stars of appropriate color that had peak ADU counts below the range where the CCD response becomes nonlinear in each camera. Typical signal-to-noise levels for the comp stars was 150 to 300.

Although we used the *MPO Canopus* internal star catalogue to select comp stars by approximate color-index, we ignored the magnitudes. To set the zero-points in each ‘session’, we instead adopted photometry from a combination of CMC15 (Muiñoz et al. 2014), APASS DR9 (Munari et al. 2015), GAIA1 G magnitudes (Sloan $r' = G + 0.066$ for stars of asteroidal color *in GAIA1 only*), as well as SDSS DR7 and DR12 (Abazajian et al. 2009, Alam et al. 2015), Pan-STARRS (Magnier et al. 2016), and SkyMapper (Wolf et al. 2018) catalogues. This process took into consideration the number of nights of measurement and the internal errors for each star as reported in the catalogues. We usually adopted only the higher-accuracy Pan-STARRS or system-defining SDSS DR7 and DR12 data for stars fainter than their saturation limits, which are roughly $r' = 13.7$ and 15.0 , respectively. Where they overlap, these various sources were compared star-by-star for consistency. CMC15 and APASS DR9 and DR10 have substantial systematic offsets up to ~ 0.3 mag in many zones; they were not used unless the values could be confirmed using GAIA photometry. In general the Sloan r' data sources for brighter stars agreed within about 0.1 mag total range, so we took weighted mean values rounded to 0.01 mag precision. We also checked for obvious variables using the TASS MkIV survey (Droege et al., 2006) and VSX (Watson et al., 2006). Nearly all these data were collected from the CDS VizieR catalogue-query service (Ochsenbein et al., 2000), the Pan-STARRS search page at the Space Telescope MAST archive (though now also at VizieR), and finally, the SkyMapper query page.

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 through a series. (Some of these offsets result from incorrect G phase-function values for the asteroids, not errors in the photometry). This is about as good as one can do anyway by measuring the asteroid field stars against primary standard-star fields on strictly photometric nights, but avoids that complication entirely. We believe the overall external zero-points are within about ± 0.05 mag of ‘truth’. We said nearly the same thing in Paper 1(!), but we now realize the systematic errors in the older catalogues are much larger than we knew at the time. A description of systematic zonal errors especially in APASS DR9 and SkyMapper is given by Tonry et al. (2018).

The reductions of the LONEOS data were described *in extenso* in Paper 1. The measuring apertures used on the 0.7-m data varied depending on seeing, but were typically 13 or 15 pixels (12 or 14 arcsec) diameter. When necessary we made use of the *MPO*

Canopus ‘Star-B-Gone’ feature to subtract the effects of contaminating field stars, sometimes successfully. Images from the two larger telescopes were measured in an analogous, consistent manner.

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

The Asteroid Lightcurve Database (LCDB; Warner et al., 2009) was consulted in early 2019 February to locate previously published results. Access to the excellent archive of printed journals and observatory serials in the Lowell Observatory library meant that publications unavailable on-line (not scanned, behind a paywall, etc.) and quite obscure references could be examined. Finally, we note that all our new and revised data are deposited in the ALCDEF database.

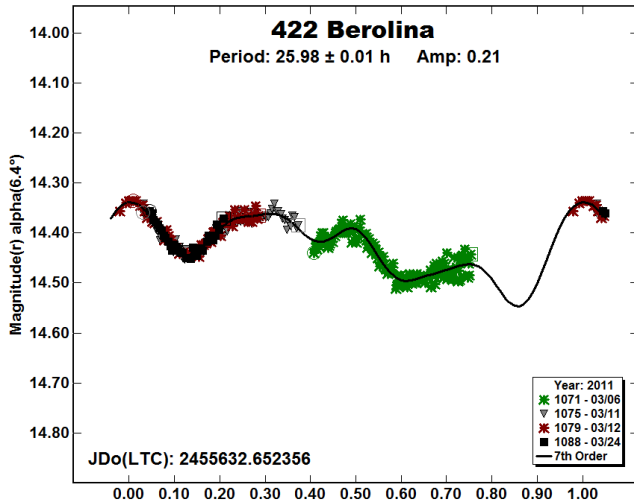
The phased plots below always show the primary maximum at zero phase. Having the maxima at zero phase makes it easy to compare the lightcurve morphology with results from the same or different apparitions and with other observers. We also show “observed” apparent magnitudes, not “reduced” magnitudes, if only so that it is easy to see why lightcurves for faint objects are noisy. Despite efforts on our part described above, we believe the tie-in with the photometric zero-point of the standard system is not so secure that “reduced” magnitudes have much value in terms of asteroid size and albedo. The magnitudes are scaled by *MPO Canopus* to the first night of each series in a plot. For most of the asteroids described here we note the root-mean-square (RMS) scatter on the phased lightcurves. This value gives a convenient figure-of-merit of the internal data quality that encompasses errors from the calibration of the frames, measurement of the comp stars and the asteroid itself, and the appropriateness of the actual fitted curve.

Acknowledgements

Funding for the Near-Earth Asteroid Photometric Survey (NEAPS) from 2008 to 2010 was provided by NASA grant NNX08AR28G awarded to Ted Bowell. Since then, Skiff has been supported in this activity by the Lowell Observatory research fund. We also gratefully acknowledge Sasha Brownsberger (now at Harvard Univ.), who transformed the old image-preparation code to IDL based on Marc Buie’s algorithms. Student observers included Emily K. Bevins, Jared Nelson, and Graham Vickowski. The Lowell technical staff was *sine qua non* for maintenance of telescopes, domes, camera electronics, computer systems and software – especially Larry Wasserman, Ralph Nye, Ted Dunham, Peter Collins, and Len Bright. The first author is also grateful to the Lowell library and to archivist Lauren Amundson for providing access to printed journals so that references could be browsed in-person. Larissa Nofi and Tom Polakis assisted with MSWord details. As with many MPB papers, the fingerprints of Brian D. Warner are all over this; his help with *Canopus* and with lightcurve interpretation is appreciated.

This research has made extensive use of the VizieR catalogue access tool provided by the CDS, Strasbourg, France.

422 Berolina. The earliest lightcurve for this Flora asteroid is by Harris and Young (1989), who obtained data over a seven-night interval in 1979 Aug-Sep. They preferred a 12.8-hour single-mode period solution that gave only a hint of a secondary minimum. More recently Pilcher (2017) has shown a complex lightcurve with twice this period. We obtained four nights of data in 2011 Mar using the 0.7-m telescope. Though combinations of pairs of nights show a convincing 12.8-hour period, all the nights together give only the longer solution, albeit with incomplete rotational phase coverage. The morphology appears to be significantly different from Pilcher's, so some shape information is developing. The observed range in the lightcurve is 0.15 mag (the fitted curve has an unconstrained extremum), and the RMS scatter on the fit is 0.010 mag.

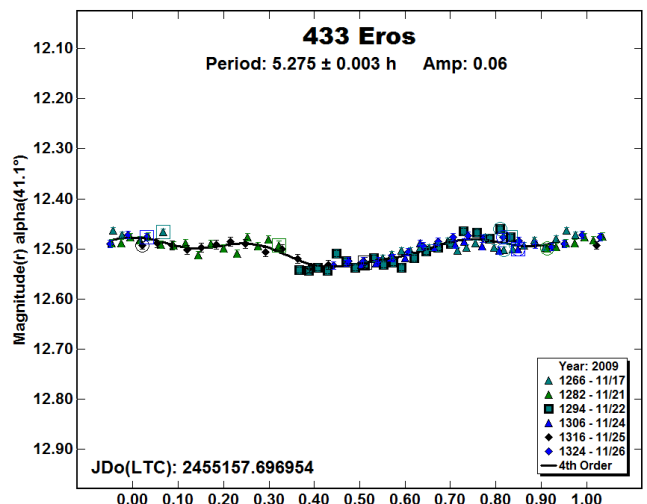
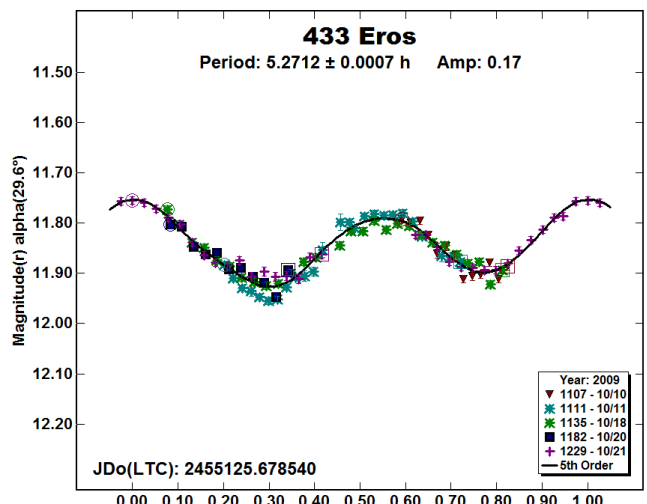
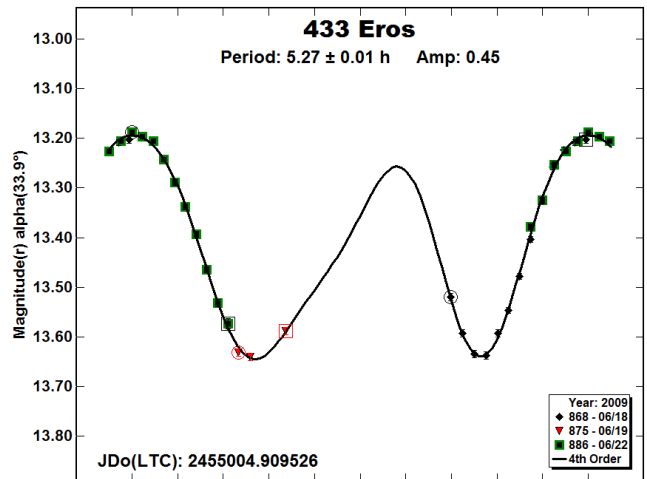


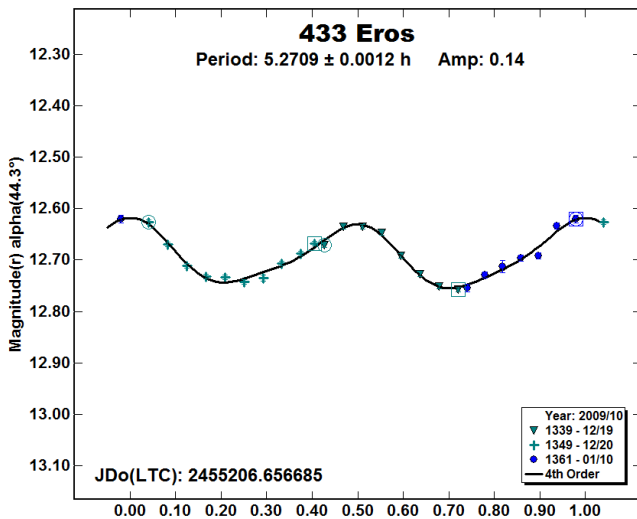
433 Eros. Eros was one of the first asteroids observed to vary. Perihelic apparitions, where the asteroid becomes quite bright, recur at roughly 40-year intervals. A comprehensive study was done by Solon Bailey (1913), who provides a complete early bibliography as well as new data obtained during the perihelic apparition of the late 1890s from Harvard photographic plates and visual photometers. The rotation period was well-determined at this time, and the lightcurves in that paper are illustrative. The first photoelectric data were obtained by Roach and Stoddard (1938) on a single night at Steward Observatory at the time of the subsequent bright apparition. Maria Campa (1938) obtained many nights of data during the same interval using a visual photometer on the 22-cm Merz refractor at Brera Observatory. These and other early works allowed the shape and pole-orientation to be estimated.

Comprehensive modern study did not come until the next bright apparition in 1974-75, when the first radar observations were obtained, accompanied by a large campaign comprising multicolor photometry, spectroscopy, and near-infrared data. A special issue of *Icarus*, volume 28, number 1 (1976), was devoted to results from this effort.

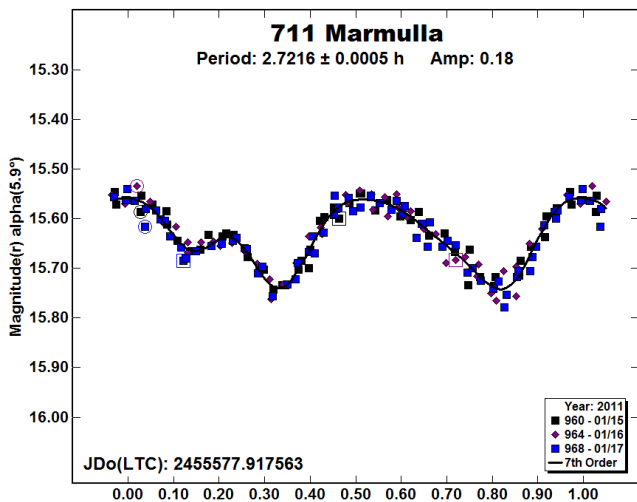
In Paper 2 we showed a lightcurve from only 3 nights of 17 obtained with the LONEOS Schmidt through the 2009 apparition. Adjustment of the comparison stars to Sloan *r'* now allows all the data to be analyzed. Four lightcurves from 2009 Jun until 2010 Jan are shown. When it was bright, exposures as short as 2 and 3 seconds were used with the *f*/1.9 Schmidt. Behrend (2009web) shows a lightcurve obtained by Audejean and Naves from 2009 Jul-Aug, midway between our first and second runs. The lightcurve amplitude varied considerably as the viewing geometry

changed, becoming nearly constant in 2009 Nov. The RMS scatter in our phased lightcurves for this bright target range from 0.007 to 0.014 mag.

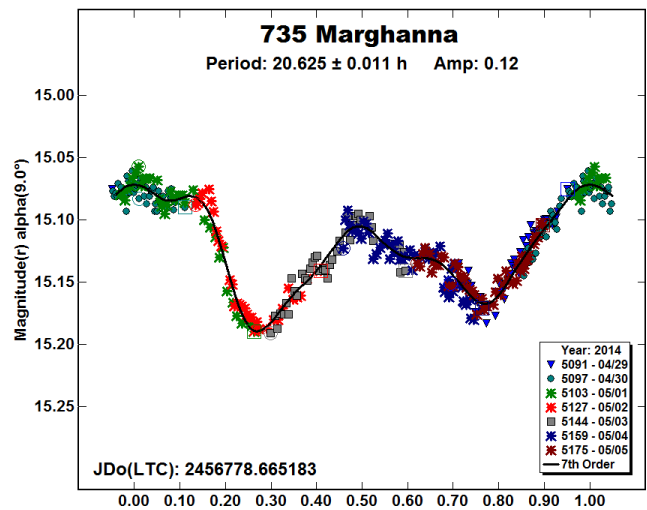




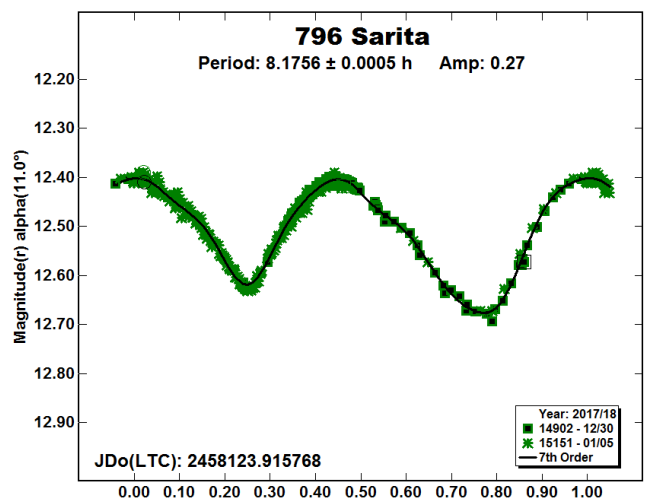
711 Marmulla. This Flora object has one previous period determination by Kryszczyńska et al. (2012) from the 2009 apparition. We obtained three long consecutive nights of data in 2011 Jan using the 0.7-m telescope. The total dwell-time was 27 hours, covering either three or four complete cycles each night. This yielded a precise period of 2.7216 h. This period is somewhat different than Kryszczyńska et al., but it seems likely that the minimal variation in 2009 (0.03 mag) prevented them from getting better accuracy, despite their data having quite good internal precision. The RMS scatter on our phased lightcurve is 0.017 mag.



735 Marghanna. We obtained seven consecutive nights of data on this fairly large main-belt asteroid in 2014 Apr-May with the 0.7-m telescope. A previous period estimate by Mohamed et al. (1995) appears to be incorrect due to their having lightcurve segments on only two nights in 1993 Nov. The small-amplitude lightcurve has weakly double-humped maxima. The RMS scatter on the fit is 0.008 mag.

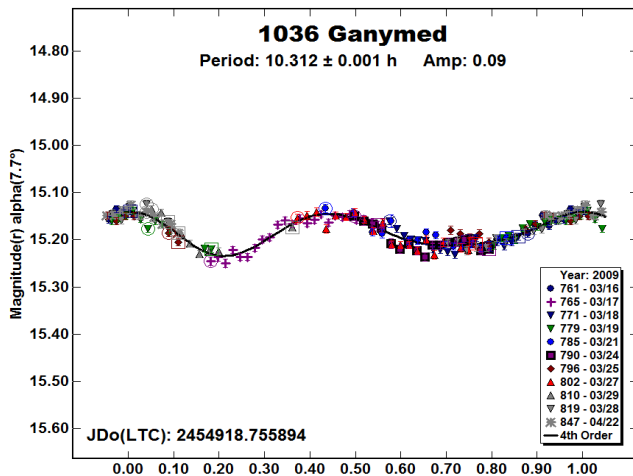
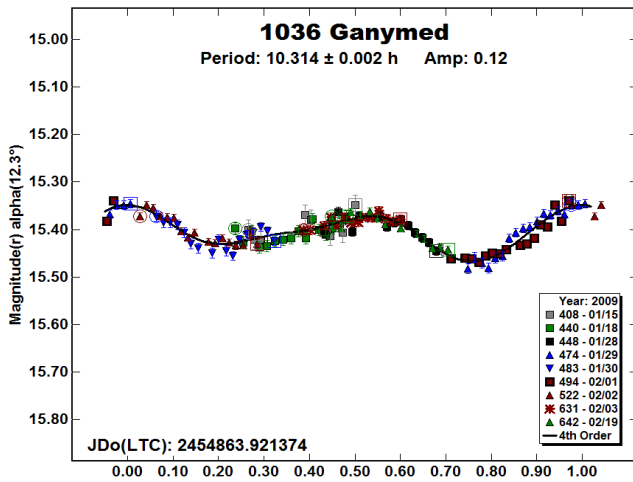
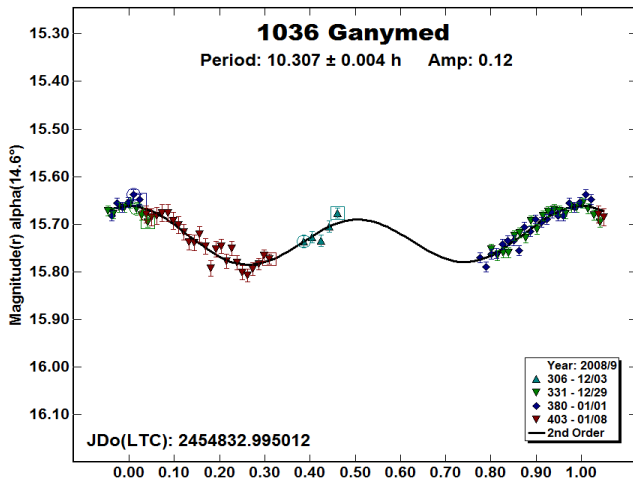


796 Sarita. The orbit of this main-belt asteroid has moderately high inclination and eccentricity. The LCDB shows two previous period determinations. The one by Hans Schober (1981) was obtained on a single night, 1978 Oct 1, and does not quite cover a complete rotation; consequently the derived period is somewhat in error. He did provide reliable photoelectric UBV colors, however. Behrend (2004web) presents a nearly complete lightcurve from 2004 Dec-2005 Jan data by Manzini, Bosch, and Roy. His derived period matches very closely our new data taken over New Year's 2017/18 using the 0.7-m telescope. The RMS scatter on the present lightcurve is 0.008 mag. The lightcurve morphology from all three series is very similar.

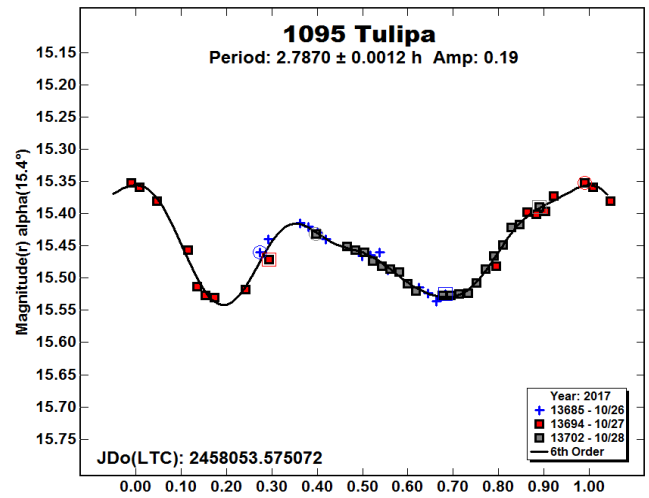


1036 Ganymed. This is the largest NEA, which has an extensive observational history. The first complete lightcurve, however, was not obtained until 1985, when the 10-hour rotation period was found by Lupishko et al. (1988). These results were combined with additional data by others and given extensive analysis in Hahn et al. (1989). The LCDB suggests ours are the only photometric data from the aphelic apparition 2008 Dec to 2009 Apr, when the asteroid was more than 3 AU from Earth, below mag 15, and fairly far south (about -20° Dec). In Paper 1 we gave two sample lightcurves from 24 nights of LONEOS Schmidt data (mostly 60- to 90-second exposures) in two lunations that were relatively well observed. We now show phased plots involving all the nights, mainly to indicate that there was no great change in the lightcurve morphology during this apparition (the viewing

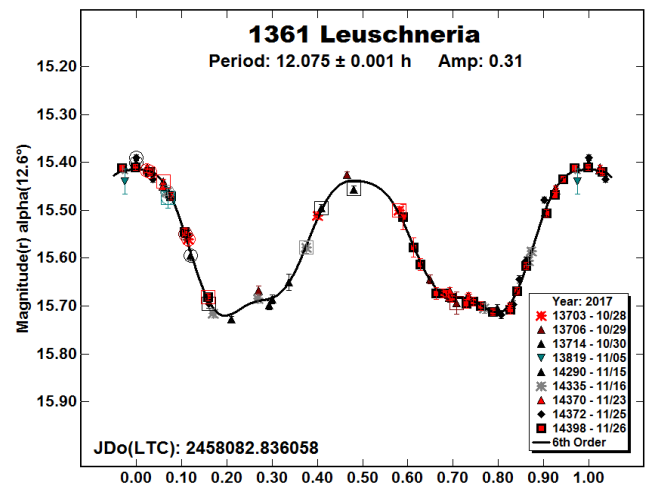
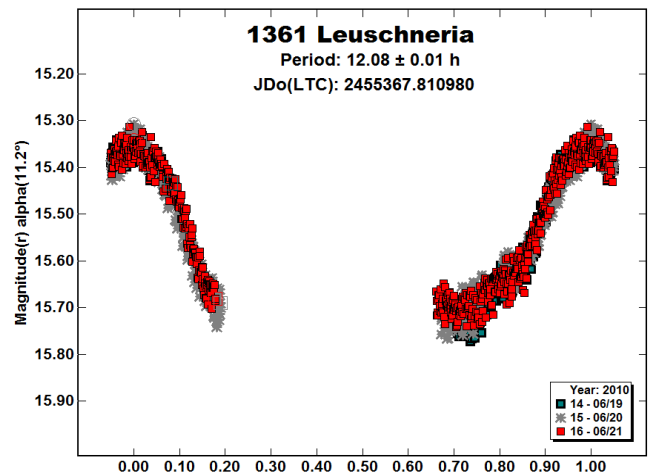
geometry changed very little). The RMS scatter on the fits in the three lightcurves is 0.014, 0.013, and 0.012 mag, respectively.



1095 Tulipa. These data were taken for another purpose near evening quadrature in 2017 Oct using the 0.7-m telescope, but are sufficient to derive an accurate period. The asteroid is well-studied and the rotation period also well-determined on several occasions. Three similar, fairly sparse lightcurves were obtained earlier in the 2017 apparition by Klinglesmith (2017), a single night by Stephens (2018), and again by Klinglesmith and Hendrickx (2018). The RMS scatter on the current data is 0.008 mag.

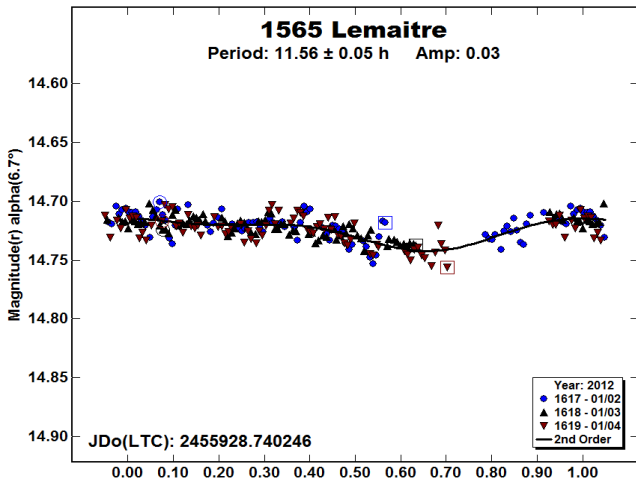


1361 Leuschneria. This main-belt asteroid is named in honor of the famed orbit computer Armin Leuschner. It was observed using the LONEOS Schmidt on three nights in 2010 Jun. Some 1400 unfiltered 15-second exposures were obtained. As found later by Clark (2016), the period was seen to be closely commensurate with a sidereal day, probably 12 hours, and so observing was abandoned because of the short solstice nights. The shorter period found by Casalnuovo (2016) from rather noisy data (RMS scatter ~0.07 mag) during the 2015 apparition is probably an alias.

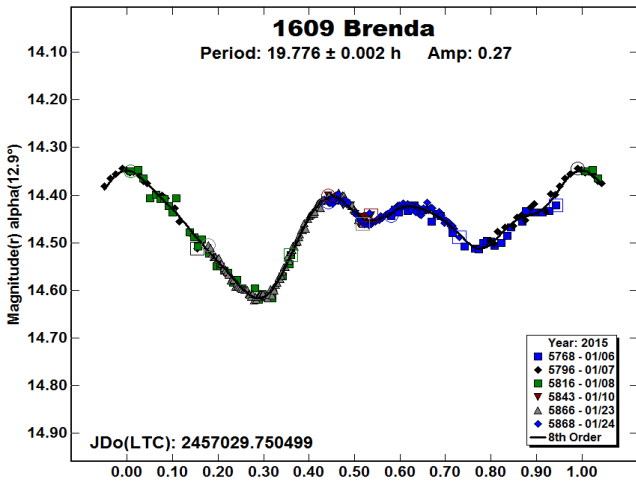


In preparation for this paper, we obtained intermittent data over four weeks in 2017 Oct-Nov when the asteroid was again near opposition. Most of the data were taken using the 0.7-m telescope and R_c filter; one night (Nov 23) was obtained with the 1.1-m telescope and Sloan r' filter. This new series showed unambiguously that the earlier period just over 12 hours is correct. The phased lightcurves from the 2010 and 2017 runs are presented. The independent period determinations match surprisingly well, even though the rotational phase coverage in 2010 is incomplete (but very dense!). Clark (2016) is also correct but incomplete. The RMS scatter on the new lightcurve is 0.010 mag.

1565 Lemaître. We obtained three 8-hour runs on this Mars-crossing Phocaea on consecutive nights in 2012 Jan using the 0.7-m telescope. As Warner and Vander Haagen (2008) found in 2007 Aug-Sep, the amplitude is minimal, precluding a precise period determination. The phase-angle bisectors at the two apparitions are significantly different. We have binned the 90-second exposures into three-image 5-minute averages, and find a period of 11.56 hours with a simple order-2 fit. The RMS scatter on the lightcurve is 0.008 mag.



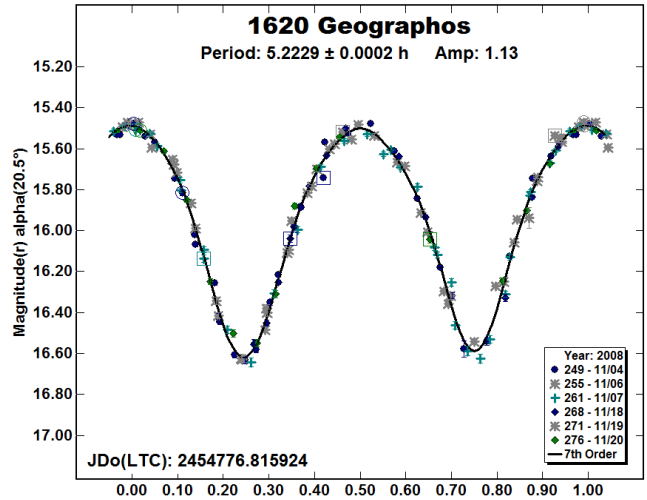
1609 Brenda. Richard Binzel (1987) obtained sparse photoelectric photometry for this main-belt asteroid on four nights in 1984. His period (19.46 h) is somewhat shorter than ours.



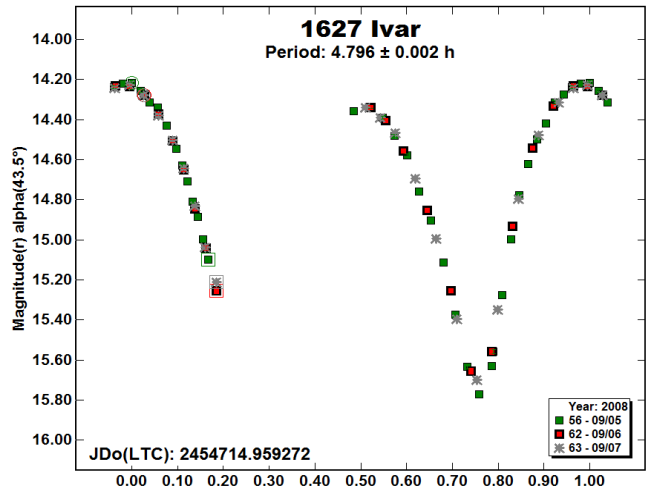
We observed it with the 0.7-m telescope on six nights in 2015 Jan. Three 7-hour runs and two 6.5-hour runs are included, plus one

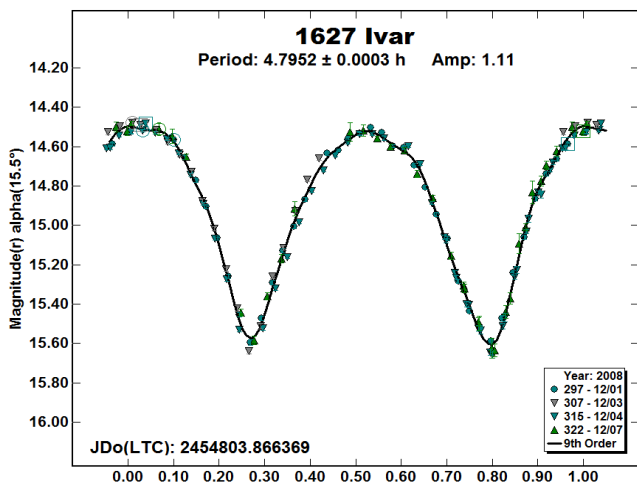
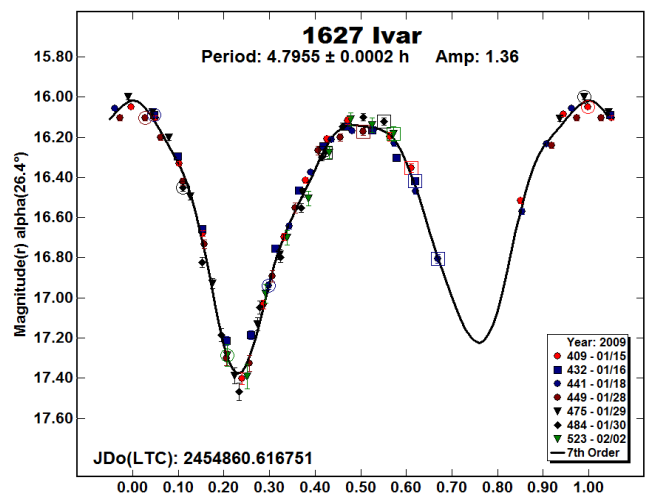
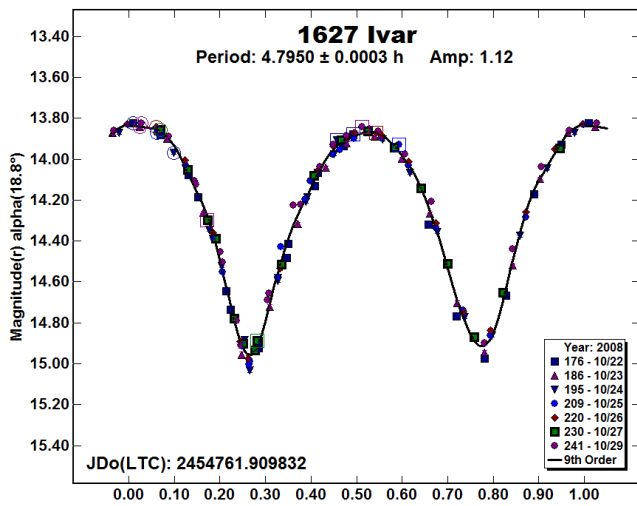
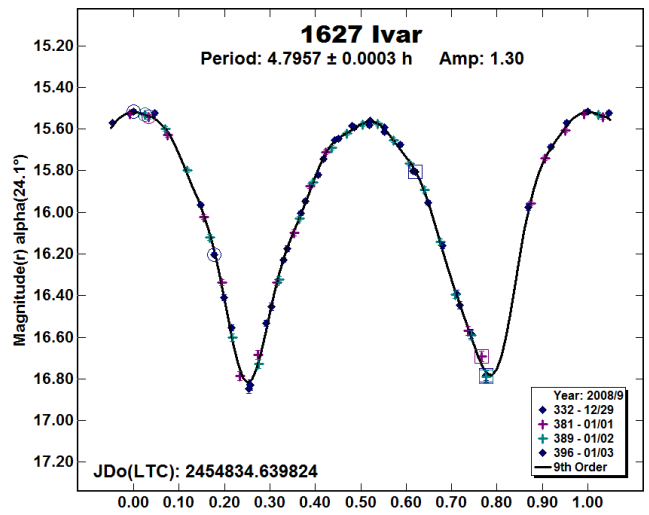
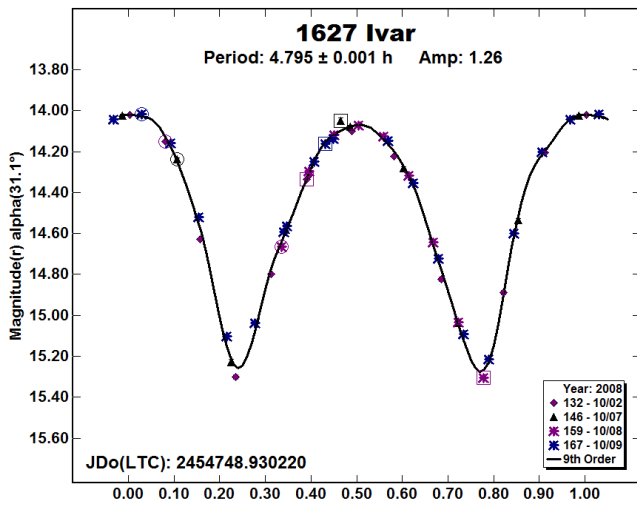
short night. Despite this, there is multiple rotational phase coverage over only portions of lightcurve. The period nevertheless seems secure. The RMS scatter on the fitted curve is 0.008 mag.

1620 Geographos. As early as 1969 Dunlap (1974) collected comprehensive multicolor photometry of this well-known Apollo that first established the rotation period, color-indices, and other physical properties. Thus we give no significant new information here. In Paper 1 we showed a lightcurve from LONEOS Schmidt observations in 2008 Nov. This is repeated here with adjustment of the zero-point to Sloan r', and an extra decimal precision justified in the period determination. The RMS scatter on the fit is 0.039 mag.

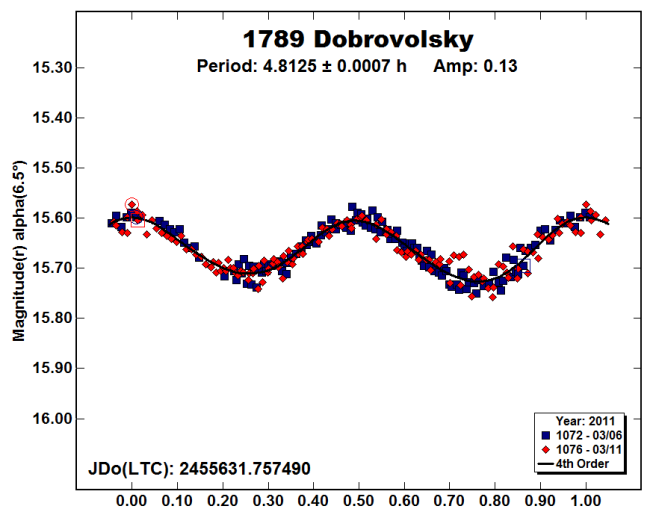


1627 Ivar. The first lightcurves for this well-studied Amor, obtained in 1985 by Jim Young and others, were summarized by Hahn et al. (1989). Our data, using the LONEOS Schmidt, appear to be the only ones from late 2008, when the asteroid was fairly faint and receding from Earth. In Paper 1 we showed a lightcurve from 2008 Oct, and a combined fit to all the data covering a five-month span. Since the amplitudes at each lunation differ significantly, these are parsed out here following adjustment of the comparison stars to Sloan r'. Exposures ranged from 20 seconds to 3 minutes. The RMS scatter on the fitted curves is about 0.03 mag for all but the final one (0.045 mag), when the asteroid was only mag 16 at maximum. This scatter is masked to a great extent by the large amplitudes.



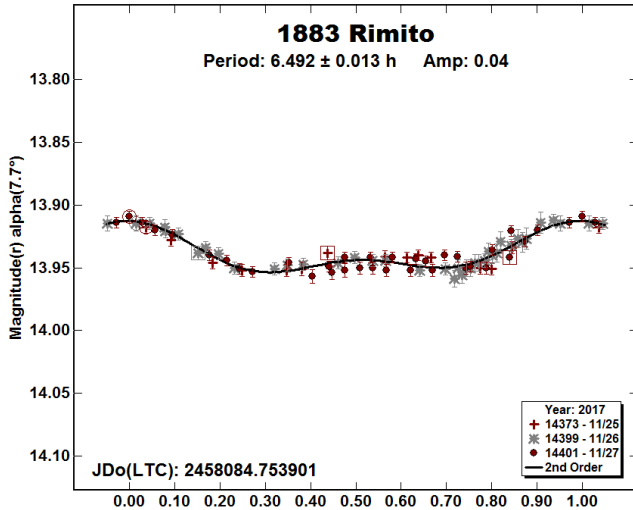


1789 Dobrovolsky. Two full-night runs separated by five days in 2011 Mar were sufficient to get quite good precision on the period for this Flora asteroid. We used the 0.7-m telescope with 90-second exposures; each night covered about 1½ rotation cycles.

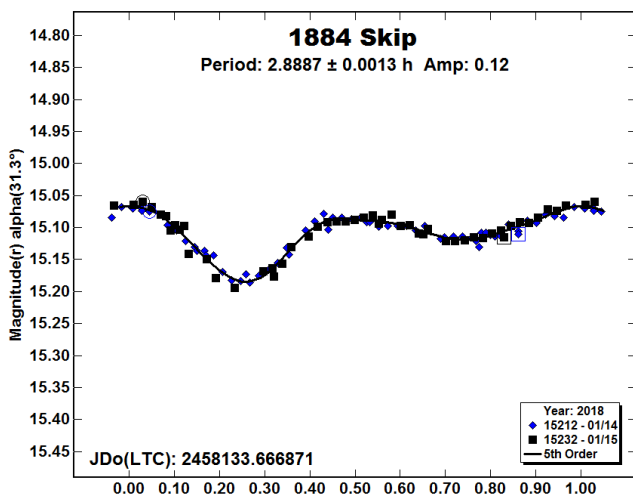


Lagerkvist (1978) obtained a photographic lightcurve on a single night in 1973, finding a period of 5.8 hours, but with much scatter in a large-amplitude lightcurve. Since then sparse data from the Palomar Transient Factory have provided accurate periods similar to the present determination (Chang et al., 2015; Waszczak et al., 2015). The RMS scatter on our lightcurve is 0.015 mag.

1883 Rimito. This Phocaea-family asteroid was observed at the request of Tom Polakis (2018) to check on the existence of a low-amplitude lightcurve. Images on three consecutive nights using the 0.7-m telescope (200-second exposures) showed a clean lightcurve of only 0.04 mag amplitude. On the second and third nights the series extended for more than 9 hours, so the period is secure. The RMS scatter on the fitted curve is just 0.005 mag.

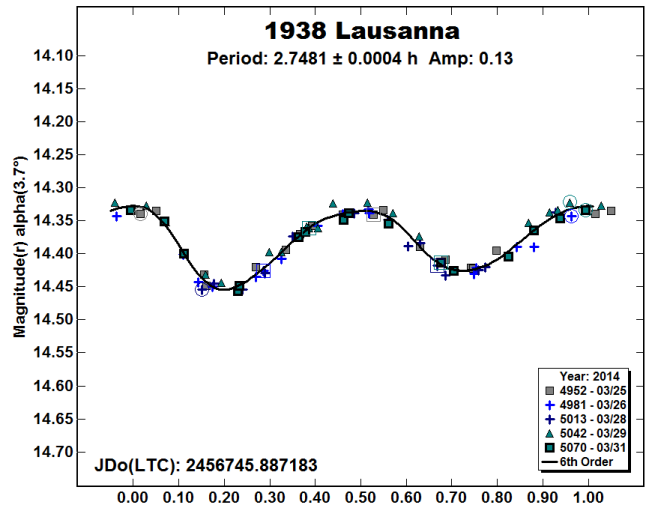


1884 Skip is another Phocaea caught in 2018 Jan near evening quadrature. Two nights of 200-second exposures with the 0.7-m telescope were sufficient to derive an accurate period of moderately small amplitude. Previously, di Martino et al. (1994) determined a somewhat longer period from single-channel photoelectric data on four nights. The RMS scatter on the fit here is 0.007 mag.



1938 Lausanna. Relatively sparse observations were obtained on five nights over a six-day interval in 2014 Mar using the 0.7-m telescope and 3-minute exposures. Similar data were obtained

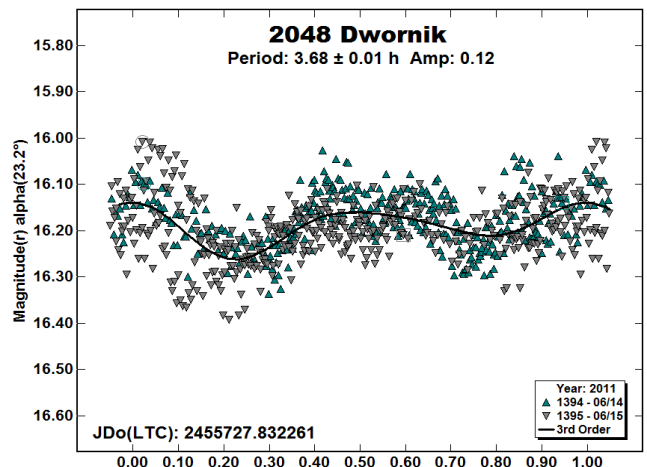
during the same apparition by Warell and Pappini (2015) with similar results. The RMS scatter on the lightcurve fit is 0.009 mag.

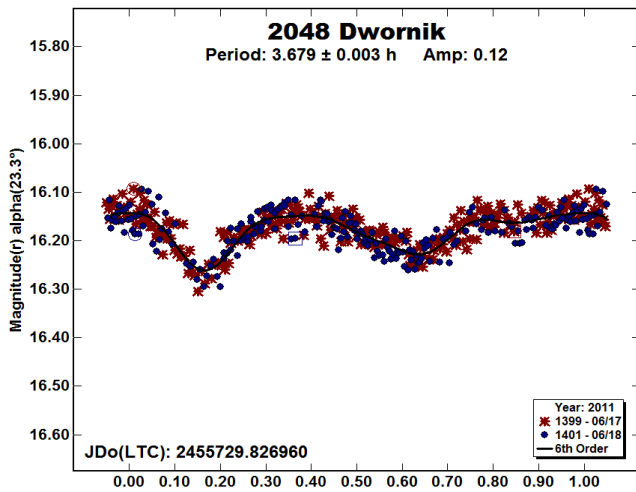


1980 Tezcatlipoca. As described in Paper 1, we obtained few observations of this object in 2008 Sep using the LONEOS Schmidt. The corrected nightly mean Sloan r' magnitudes are substantially brighter than we gave there, however.

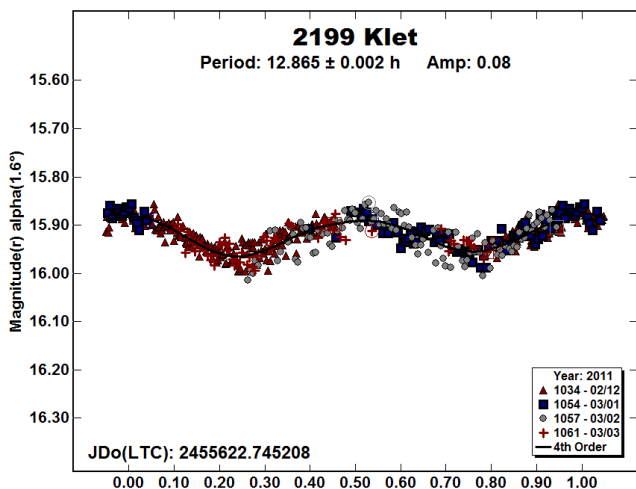
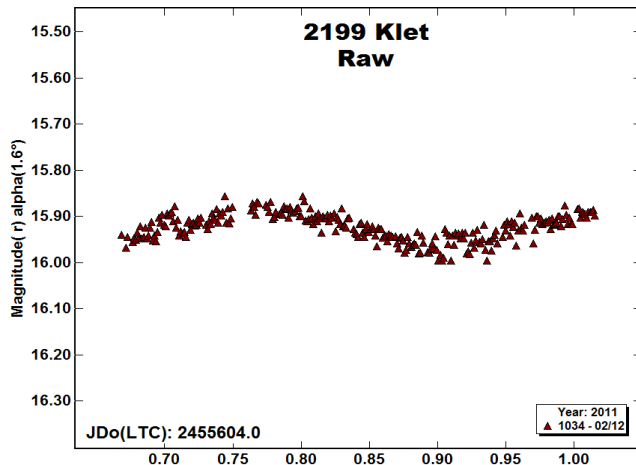
UT date	obs	r'	unc
2008-09-07	2	16.35	0.03
2008-09-20	4	16.47	0.10
2008-09-22	4	16.25	0.02

2048 Dwornik. Shevchenko et al. (2003) obtained the first CCD lightcurve starting in 2000 Apr. We obtained photometry for this Hungaria asteroid on two telescopes in 2011 Jun. Two consecutive nights using the LONEOS Schmidt yielded a likely period near 3.7 hours, but the data were rather noisy. Two more nights directly following were done on the 0.7-m telescope, which gave a clean result with better internal errors. In both cases each nightly run covers approximately two rotation cycles. Phased plots from both telescopes are shown at the same vertical scale. Note that the independent photometric zero-points from the two series are within a couple percent of each other. The LONEOS data are force-fitted to the period determined from the 0.7-m data, and assigned an arbitrary period-uncertainty of 0.01 h. The RMS scatter values are 0.055 mag (LONEOS) and 0.023 mag (0.7-m). The lightcurve morphology is similar to that of Shevchenko et al.

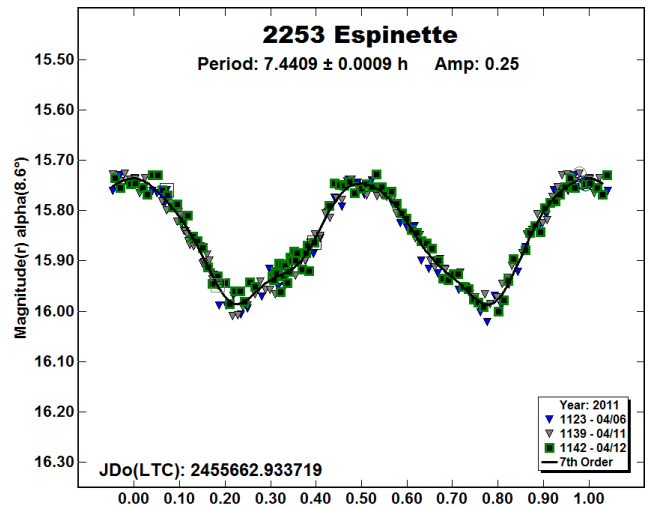




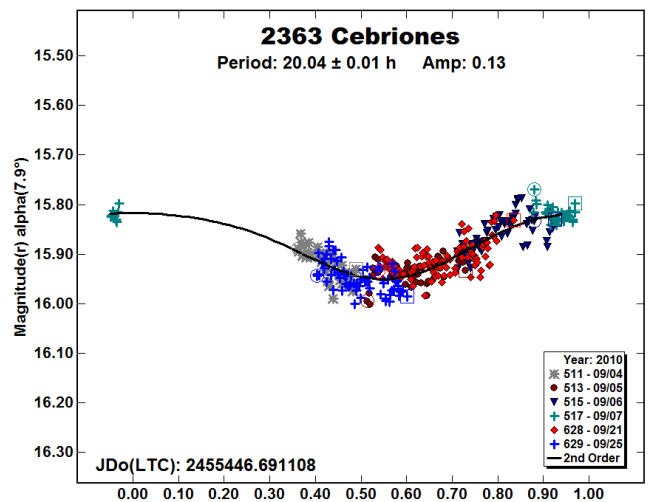
2199 Klet. Four 8-hour runs on this main-belt asteroid with the 0.7-m telescope in 2011 Feb-Mar show a clean small-amplitude lightcurve. The data each night show symmetric sine waves of about 6.5-hours period, thus excluding the 4.02-hour period found by Warner (2006). A plot of the raw data from our first night is shown as an example. The double-mode morphology is *assumed* at this low phase-angle. The RMS scatter on the data is 0.018 mag; the two minima in the fitted curve differ by only about 0.01 mag.



period of 7.3 hours from two nights of observation. We obtained three 7-hour runs using the 0.7-m telescope in 2011 April, totaling two hundred fifty 90-second exposures. These allow the period to be refined to 7.44 hours with small uncertainty. The RMS scatter on the fitted lightcurve is 0.016 mag.

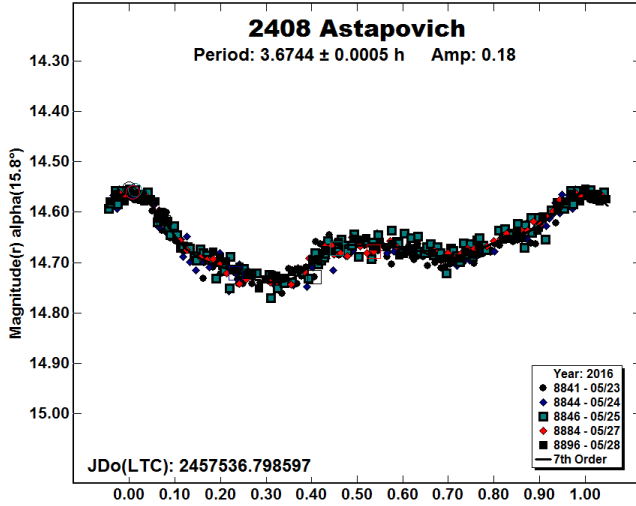


2363 Cebrenes. We observed this Jupiter Trojan using the LONEOS Schmidt on two nights in 2008 Jun, and with the 0.7-m telescope over six nights in 2010 Sep. The 2008 data are insufficient for further analysis. In Paper 1 we presented a phased lightcurve from the 2010 data, but found an uncertain period somewhat longer than those previously determined near 20.05 hours (the data were mistakenly described as having been taken with the 1.1-m telescope). Revision of the comparison stars to Sloan r' on all the nights showed that this solution was incorrect. Instead we now find a period not far from the previous ones, starting with Mottola et al. (2011) from 1994 observations, but still uncertain due to incomplete rotational phase coverage. We show a 2nd-order single-mode fit, which may, in fact, be appropriate given the small amplitude. The RMS scatter on this fit is 0.025 mag.

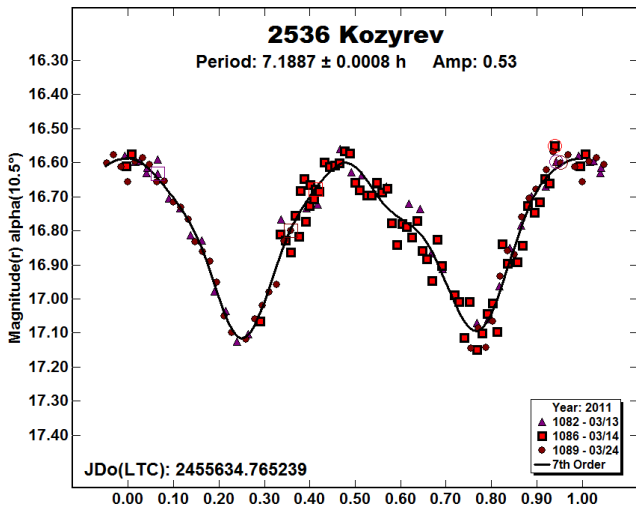


2253 Espinette. This Mars-crosser was first measured by Wisniewski et al. (1997) in 1987 June, who found an approximate

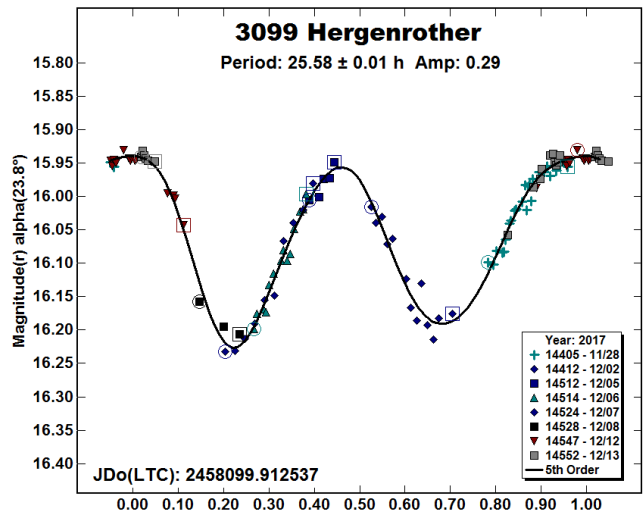
2408 Astapovich. The LCDB records several observers who got lightcurves for this main-belt asteroid during the 2016 Apr-Jun apparition, all with similar results. The present lightcurve derives from observations on five of six consecutive nights in 2016 May using the 0.7-m telescope and either 2- or 3-minute exposures. On two nights the rotation cycle was covered twice, and more than once on the remaining three. The RMS scatter on the fitted lightcurve is 0.014 mag.



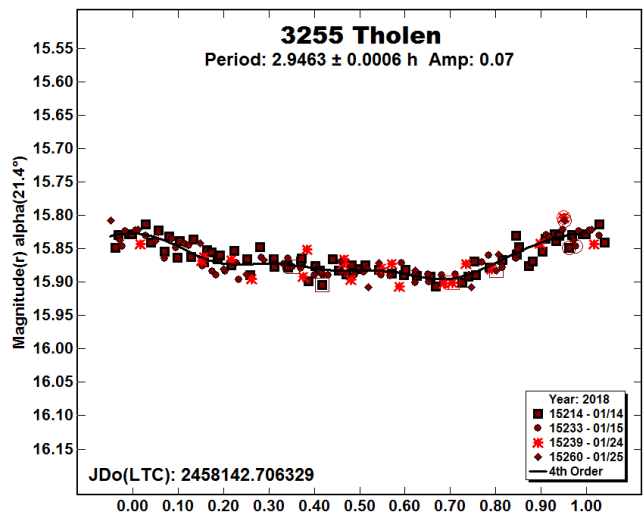
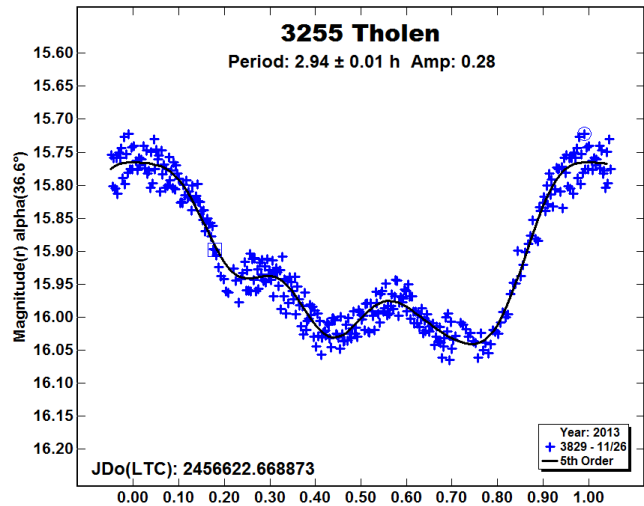
2536 Kozyrev. This Flora asteroid was observed by Brines et al. (2017) during the 2016 apparition; they found a period similar to that determined here. Our data were taken with the 0.7-m telescope in 2011 Mar on three nights. All these had rather poor conditions, especially 2011 Mar 14, which contributes most of the large RMS scatter (0.041 mag) around the fitted lightcurve.



3099 Hergenrother. Behrend (2008web) reported a provisional period of just over 24 hours from two isolated nights of observation in 2008 Jan by Pierre Antonini. A two-week series in 2017 Dec with the 0.7-m telescope showed that the period is somewhat longer – lucky in terms of gradually shifting the rotational phase coverage. While the period is now secure, the phase coverage is nevertheless not quite complete. The RMS scatter on the fitted curve is 0.013 mag.

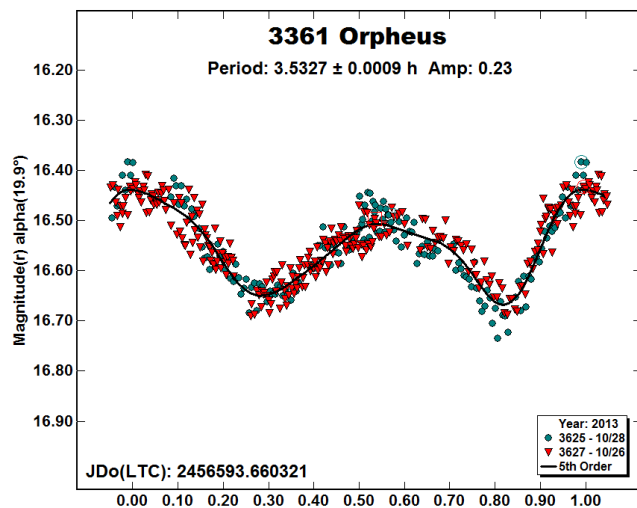
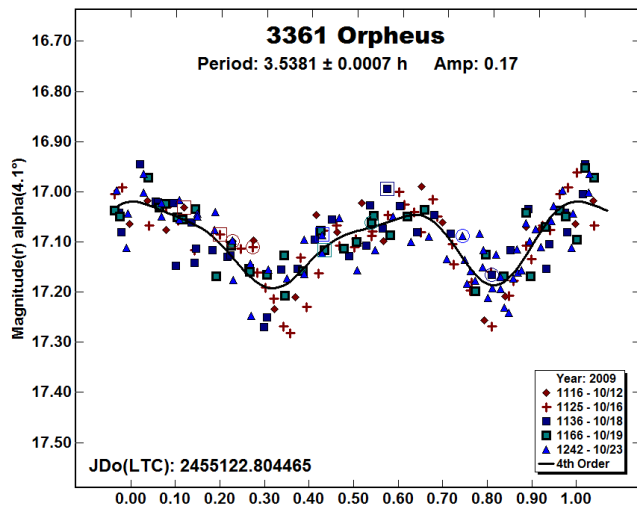


3255 Tholen. We got four nights of data on this Mars-crosser in 2013 Nov using the LONEOS Schmidt. Photometry by Ferrero (2014) from earlier in the same apparition (2013 Sep) indicates a period of 2.947 h with amplitude 0.11 mag. Although our data show the same short-period variation, the lightcurve morphology changed enough each night that no two nights can be linked.

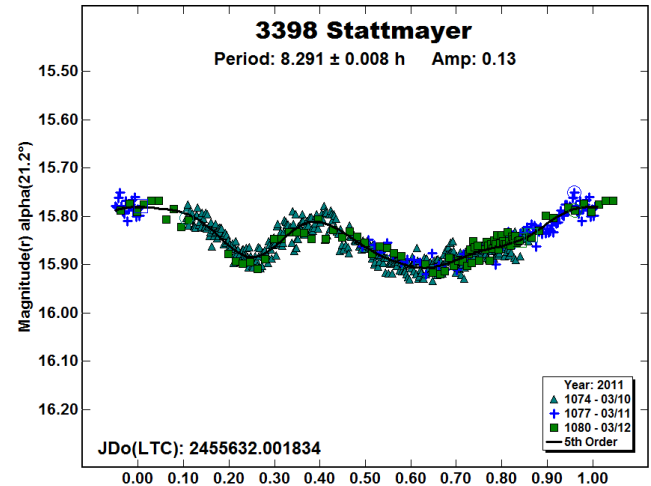


We show a phased lightcurve from a 5-hour run on the best of those nights (RMS scatter 0.020 mag on the fit). In hopes of finding additional evidence of tumbling, we got another series using the 0.7-m telescope in 2018 Jan. The phase-angle bisectors were distinctly different. As shown in the second plot (same vertical scale), the lightcurve is completely different – small amplitude and stable over the 11-day interval (RMS scatter 0.012 mag). Clearly this will have to be investigated further.

3361 Orpheus. Carlos Torres found this 300-m Apollo PHA asteroid using the 0.7-m Maksutov telescope at Cerro El Roble near Santiago de Chile. Wisniewski (1991) gave a rotation period of 3.58 hours from a single 5-hour run on 1986 May 6. Polishook (2012) found a similar but less certain period from rather noisy data taken at Wise Observatory in 2005 Nov. We acquired photometry at two apparitions using the LONEOS Schmidt. The 2009 Oct data were obtained using 90-second exposures on five nights spanning 11 days, but they are relatively sparse. A dense lightcurve was obtained on two consecutive nights using 45-second exposures in 2013 Oct. Both series yield periods similar to previously published ones. The RMS scatter on the order-4 fit to the 2009 data is 0.042 mag; the 2013 data are somewhat better, with RMS scatter of 0.028 mag.

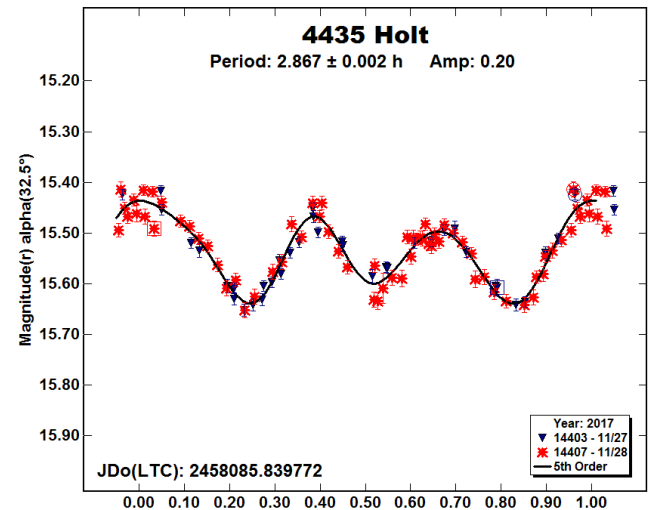


3398 Stattmayer. We obtained data for this Phocaea on three consecutive nights in 2011 Mar. On the first night, we used the LONEOS Schmidt (unfiltered 30-second exposures) followed by two more nights with the 0.7-m telescope (R_c filter, 90-second exposures). There are no other lightcurve data shown by the LCDB. Data from the two telescopes are merged in the lightcurve, which has modest amplitude; the RMS scatter is 0.016 mag.



4257 Ubasti. Our few data-points on a single night (2008 Sep 24) from Paper 1 apparently remain the only published photometry for this Apollo. On that night the mean Sloan r' = 17.5 with total range 0.34 mag. It has become brighter than mag 18 only briefly a few times since then. To the extent one can infer anything from five observations, the variation is consistent with a period of roughly 4.4 h, but this could easily be wrong.

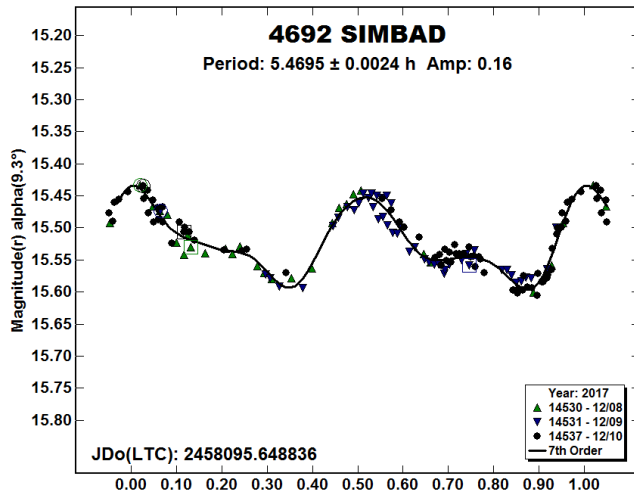
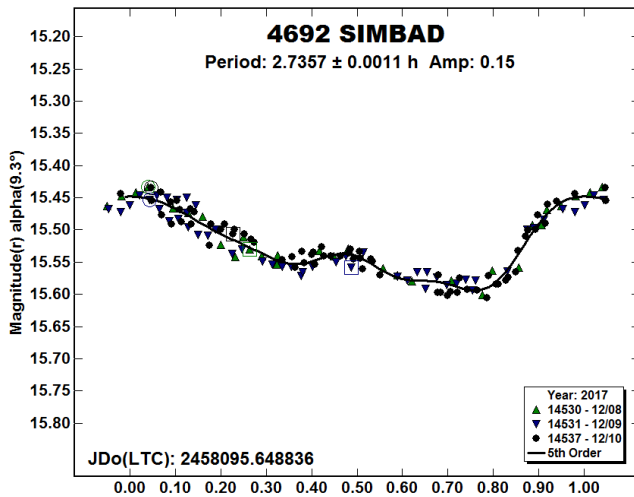
4435 Holt is a Mars-crosser named for lunar geologist Hank Holt, later known for his work helping Gene and Carolyn Shoemaker in their survey for NEOs and comets using the 0.46-m “little Schmidt” at Palomar Mountain. The first complete lightcurve was obtained by Aznar Macías et al. (2018) in 2017 Sep, who presented an ordinary double-mode lightcurve of 2.710 hours period from three nights of data.



We obtained two nights in 2017 Nov using the 0.7-m telescope, each covering over 7 hours, or about 2½ rotation cycles. The solution clearly indicated a trimodal morphology with a somewhat longer period of 2.867 h. The RMS scatter on the fitted lightcurve

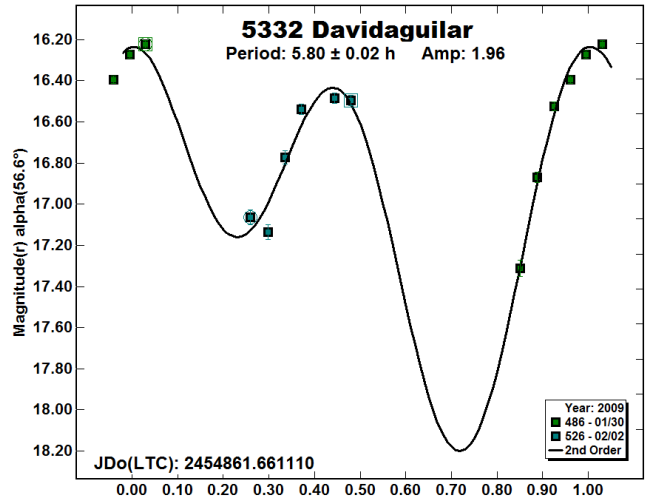
is 0.020 mag, which is not much better than that of Aznar Macias et al. The period difference is most likely explained by the binary nature announced by Stephens et al. (2018). They find the primary component has a period of 2.8670 ± 0.0002 hours, exactly confirming our two-night result outside mutual events.

4692 SIMBAD. This is one of many discoveries on photographic plates taken with the Lowell 33-cm ‘Pluto Camera’ astrograph in the 1980s. It is an ordinary Flora asteroid named for the indispensable stellar bibliographic database maintained by the Centre de Données Astronomiques de Strasbourg. There is as yet no similar database for solar-system bodies, though the LCDB approaches this. Zeigler et al. (2018) obtained a period of 5.44 hours assuming a near-identical double-mode morphology from two nights of data in 2017 Nov. Three runs of 6 to 8 hours on consecutive nights in 2017 Dec with the 0.7-m telescope were sufficient to get complete multiple rotational phase coverage along the moderately low-amplitude lightcurve. We show both single- and double-mode solutions. The RMS scatter on the fitted curves is 0.013 mag. A split-halves plot suggests the double-mode fit, if valid, is only subtly different.

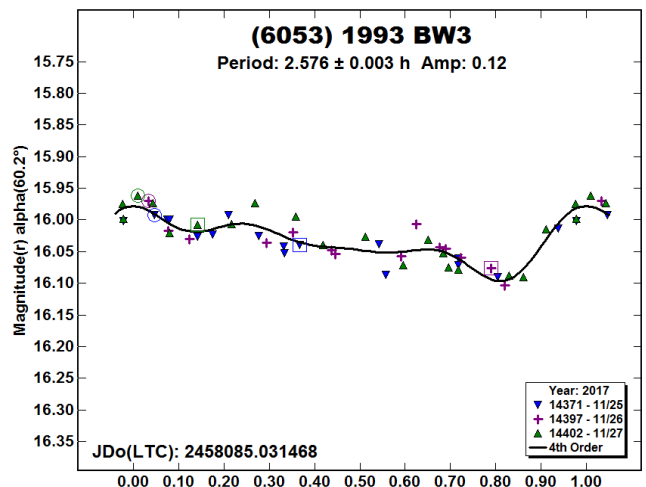
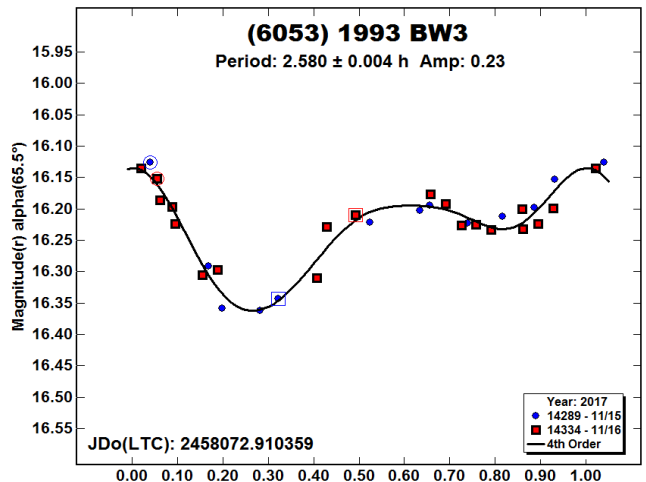


5332 Davidaguilar. As described in Paper 1, we obtained sparse Schmidt data for this Amor on three nights in 2008 Sep and 2009 Jan-Feb. The two nights in early 2009 can be phased without forcing to the 5.8-h period established first by Binzel (1990) and by Wisniewski et al. (1997). The unconstrained deep minimum in the fit is surely exaggerated, however. From eight images on the

earlier night, 2008 Sep 5, at much smaller phase-angle, we find a mean magnitude of Sloan $r' = 16.75 \pm 0.03$.



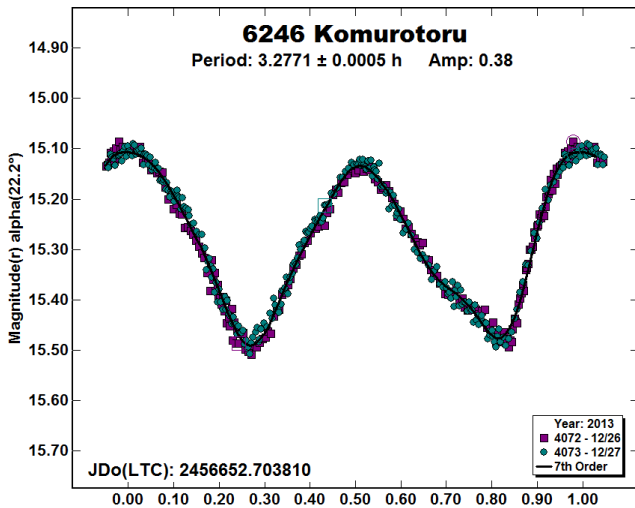
(6053) 1993 BW3. Several series of photometry of this Apollo have been published, starting with Pravec et al. (1997), who obtained extensive data through 1995 and 1996, also enabling them to assess the shape and pole-orientation.



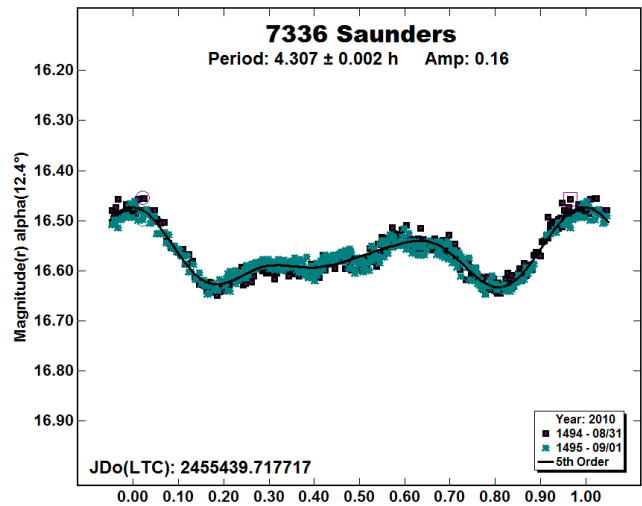
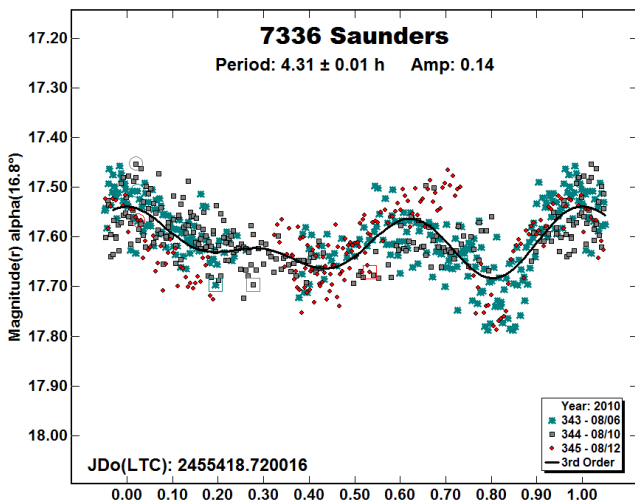
We obtained relatively sparse data in the post-midnight hours of 2017 Nov using the 0.7-m telescope, which exhibited a significant

change in the lightcurve morphology over just a ten-day interval. The two series are shown separately. The first has a clear double-mode character, while the second is more ambiguous and only half the amplitude. The RMS scatter on the fitted curves is 0.021 and 0.018 mag, respectively.

6246 Komurotoru. Two consecutive photometric nights near the 2013 Dec winter solstice with the LONEOS Schmidt were sufficient to get good coverage on this Phocaea-type asteroid. The first night covered a bit under 1½ cycles, while the second covered more than two rotational cycles. The resulting lightcurve is very clean, and the RMS scatter on the fitted curve is 0.013 mag. Sparse data from the Palomar Transient Factory in 2009 (Waszczak et al., 2015) gave a similar period, but at different phase-angle bisectors, possibly useful downstream for shape modeling.

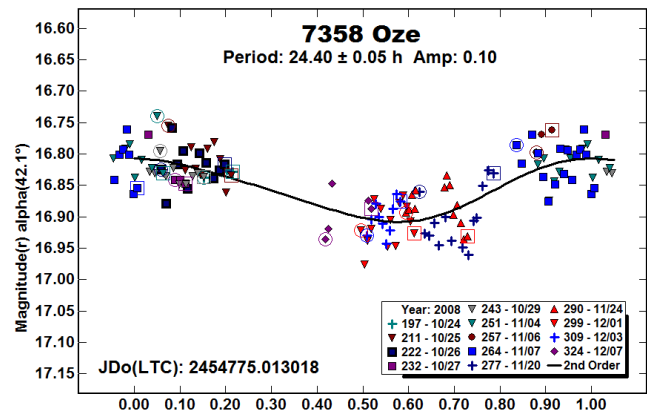
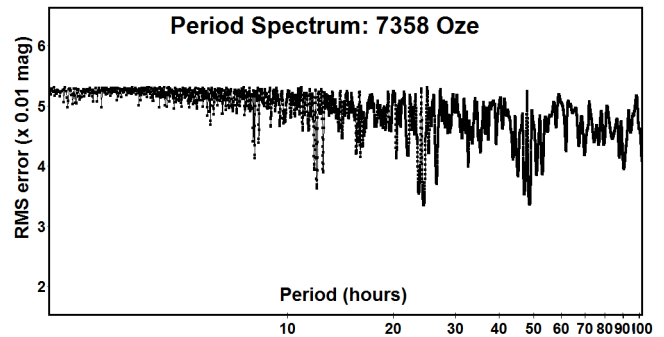


7336 Saunders. We observed this Amor in early 2010 Aug with the LONEOS Schmidt, and again at the very end of the month using the 0.7-m telescope, when the asteroid was a full magnitude brighter. Previously Hoffmann et al. (1993), Pravec (2003web), and Warner (2018a) gave periods near 6, 6.4, and 3.4 hours, respectively – but all appear to be incorrect. Warner (2018b) has since made a revision based the following.



The LONEOS data were near the limit of the instrument, and produce a rather poor result. By contrast, the 0.7-m data are of good quality and densely cover more than 1½ rotational cycles each night. This makes the period unambiguous even from the raw plots. Phased lightcurves from the two telescopes are shown separately. The RMS scatter on the fitted curves is 0.049 mag for the LONEOS data and 0.013 mag for the 0.7-m data. Despite the large internal errors of the LONEOS data, the lightcurve morphology is broadly homologous to the much better 0.7-m data.

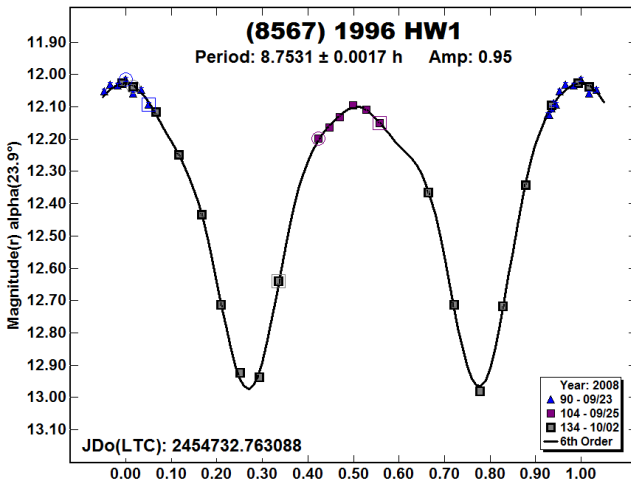
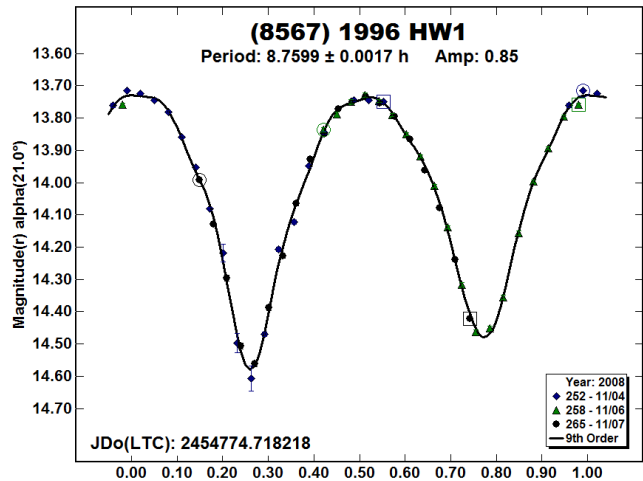
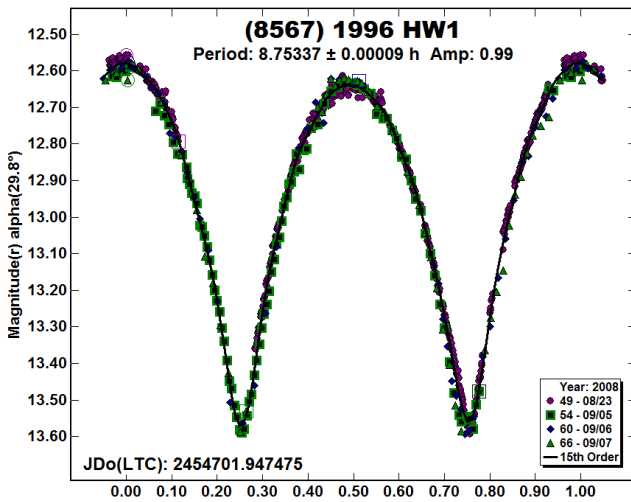
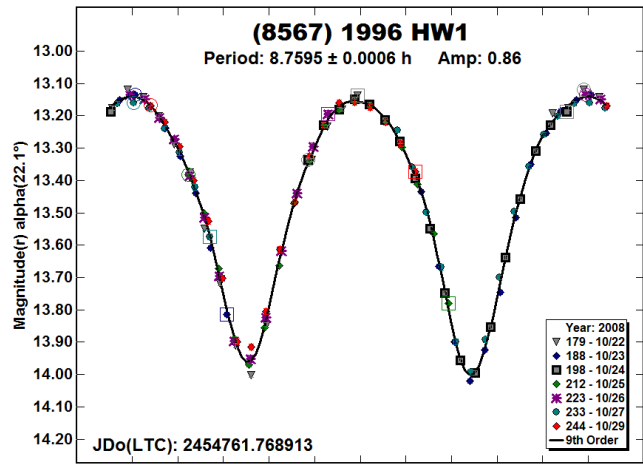
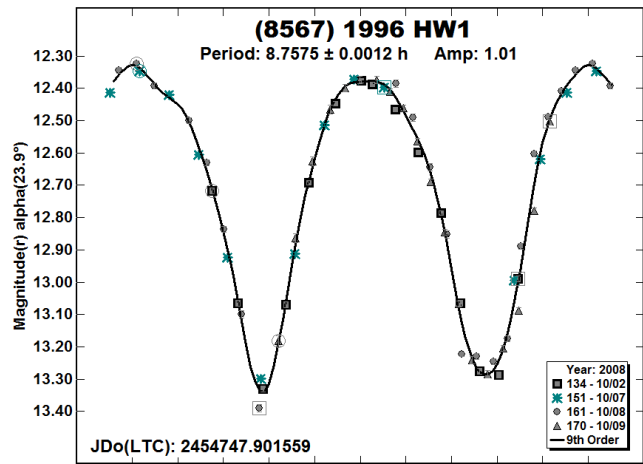
7358 Oze. In Paper 1 we showed a 5.4-hour lightcurve from 2008 Oct-Dec fitted to a period near the one given by Pravec (1998web). After adjusting the comparison stars on each night to Sloan r', this period is no longer tenable, but neither could any confident solution could be found. Groups of nights over shorter intervals yield nothing significant.

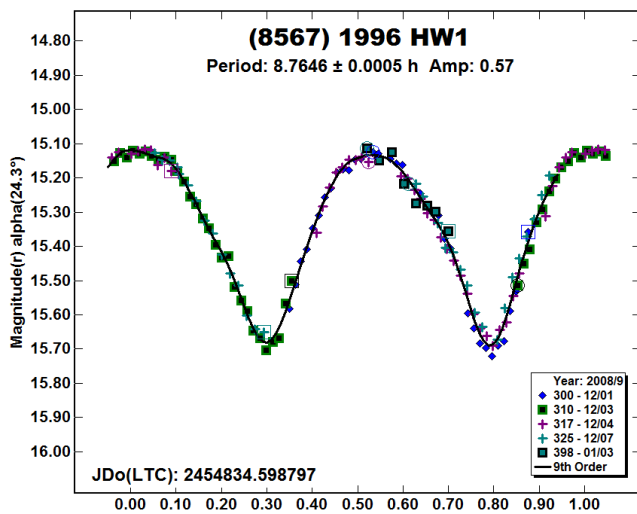
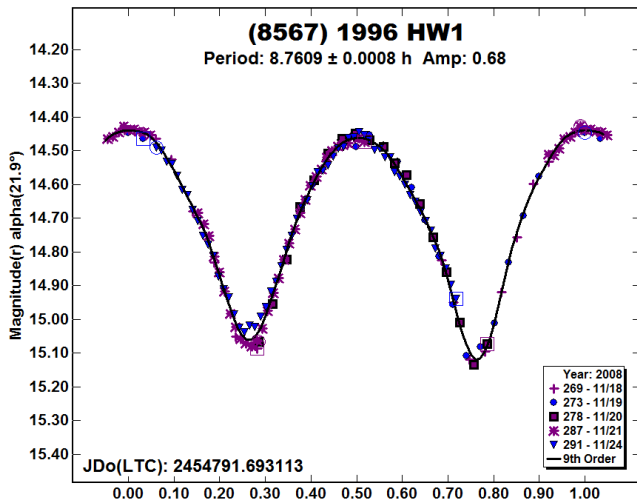


The phased lightcurve and period spectrum are shown for a new, tentative 24.4-hour period; the double-period near 49 hours is not excluded. This conclusion could be seriously compromised by the large gaps in data-taking, the relatively noisy data (RMS 0.033 mag as phased), and possibly phase-angle effects.

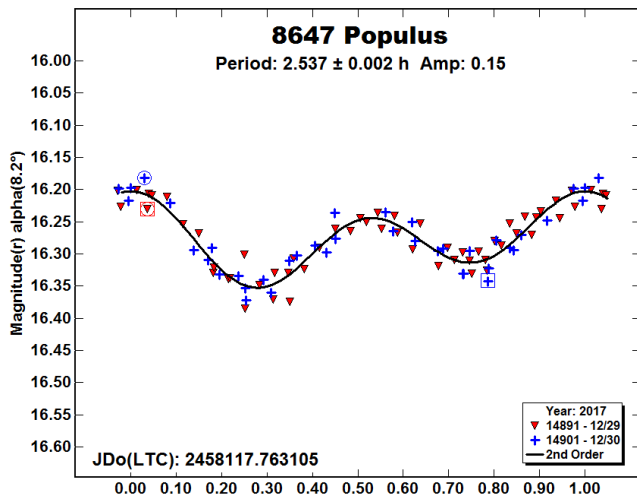
(8567) 1996 HW1. The first lightcurve for this 3-km Amor, derived from data in 2005, was by Higgins et al. (2006a). The object was extensively observed during its close 2008 apparition. Comprehensive radar and photometry results are summarized by Magri (2011), showing a strongly bifurcated contact binary; these must be regarded as definitive. Our photometry from Paper 1, also from 2008, added very little to this.

Only 7 of 30 nights of LONEOS Schmidt data were shown in Paper 1. The complete dataset, spanning four months, is adjusted here more closely to Sloan r' and parsed out into seven groups of nights where reasonably complete rotational phase coverage was obtained. Exposure times ranged from 5 seconds up to 3 minutes on the very last night. The plots are all at the same vertical scale. The RMS scatter on the fitted curves, hidden by the large amplitudes, is mostly 0.015 to 0.020 mag. The fitted curves are of high Fourier order because of the asteroid morphology. Interestingly, the fitted synodic rotation periods increase monotonically on either side of opposition (mid-September 2008), indicative of prograde rotation.



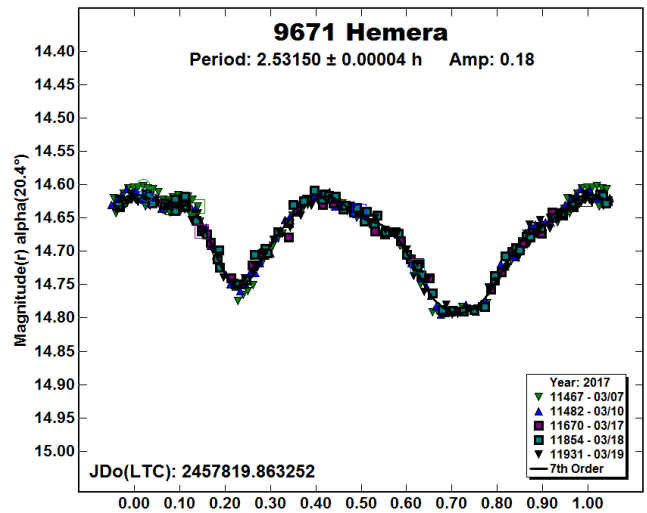


8647 Populus. Two long winter nights in 2017 Dec with the 0.7-m telescope revealed a short rotation period for this inner main-belt asteroid; roughly four cycles were witnessed each night. The RMS scatter on the fitted curve is 0.018 mag.

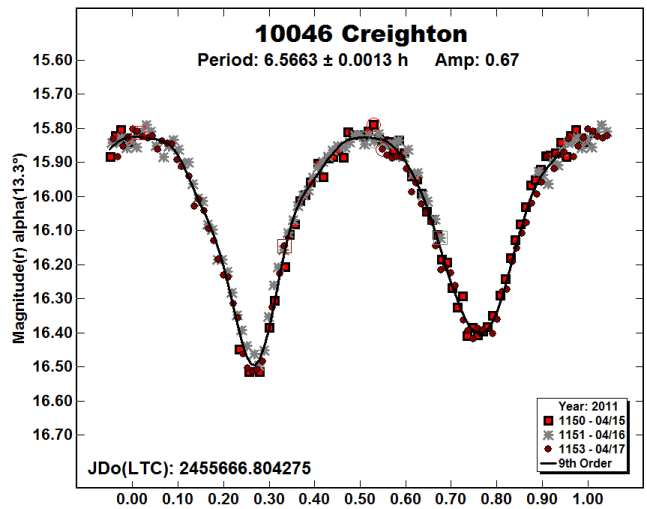


9671 Hemera. This Mars-crosser was observed photometrically for the first time by five independent groups during 2017 Mar-Apr. First into print was Stephen Brincat (2017), who found the

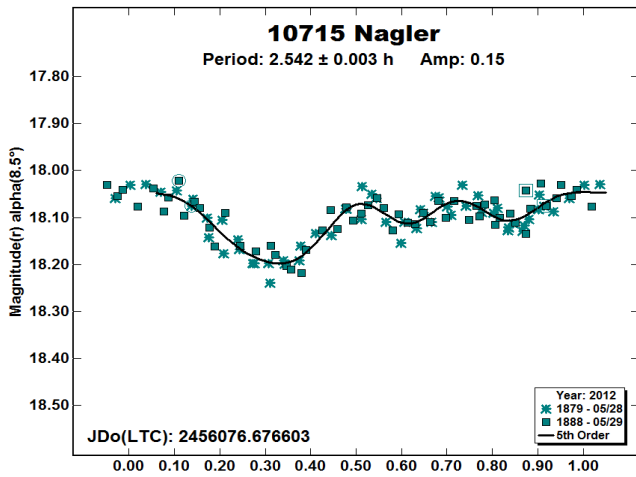
correct short period near 2.5 hours. Our data include two nights in early March using the 1.1-m telescope and 90-second exposures, and three more nights the following week with the 0.7-m telescope and 200-second exposures. The multiple nightly cycles and 12-day baseline yielded a quite precise period; the RMS scatter on the fitted curve is 0.008 mag.



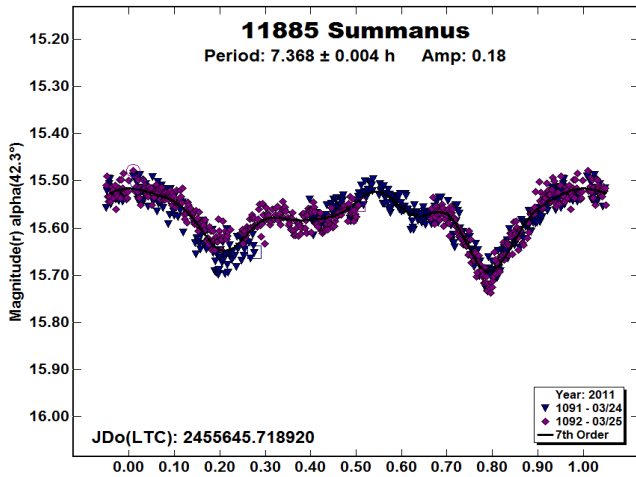
10046 Creighton. Three five-hour runs on consecutive nights in 2011 Apr using the 0.7-m telescope allowed the lightcurve of this inner main-belt object to be well-determined. Clark (2012) published the first lightcurve from observations taken later in the same apparition. His period is very similar despite somewhat higher noise. The RMS scatter on our fitted curve is 0.024 mag.



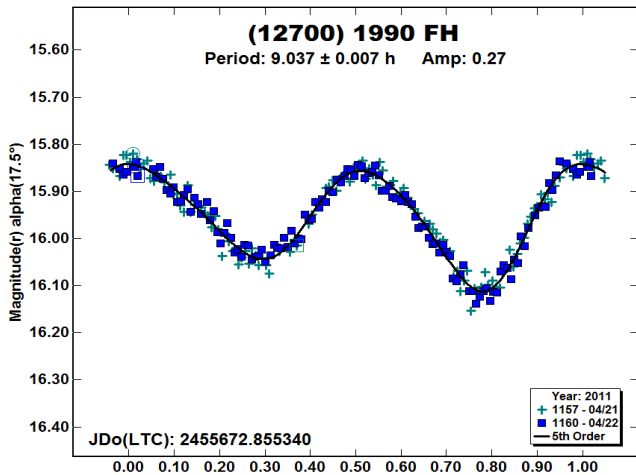
10715 Nagler. This main-belt asteroid is a Lowell ‘Pluto Camera’ discovery named in honor of optical designer Al Nagler. From two cloud-free nights of data in 2012 May using the 1.1-m telescope and R_c filter, we find a short-period, small-amplitude lightcurve. More than two rotational cycles were covered each night. The RMS scatter on the fit is 0.023 mag.



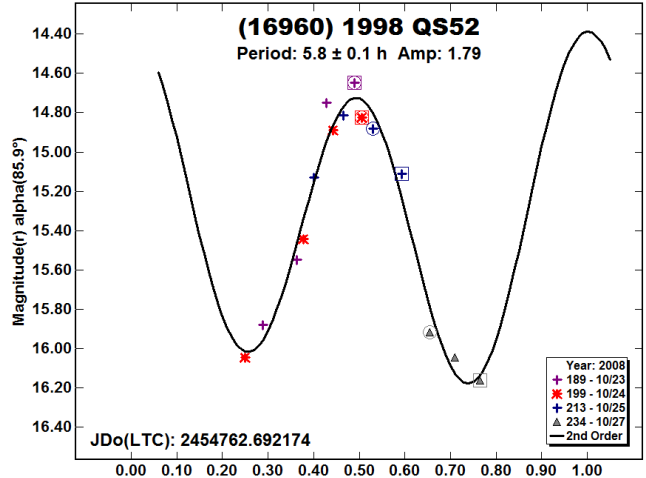
11885 Summanus. This was the first near-Earth asteroid identified automatically via software by the Spacewatch program in 1990. We obtained two nights of photometry using 20-second exposures on the LONEOS Schmidt in 2011 Mar. These yielded a moderately complex lightcurve of intermediate period and amplitude. The RMS scatter on the fitted curve is 0.020 mag.



(12700) 1990 FH. Two full nights covering about 8½ hours each using the 0.7-m telescope showed a clean lightcurve for this Phocaea asteroid. The RMS scatter is 0.016 mag.

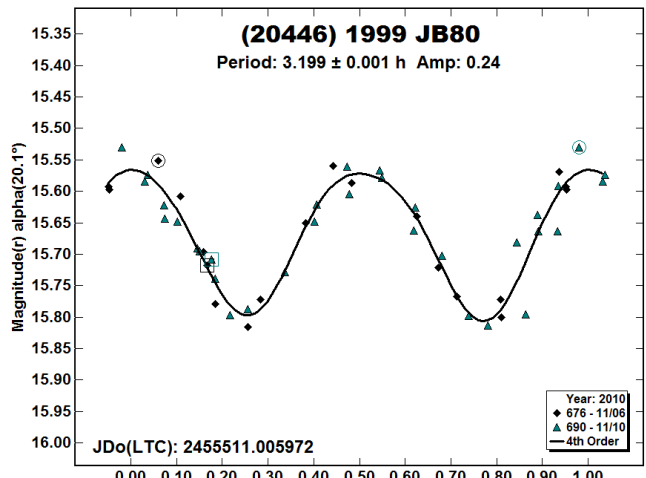


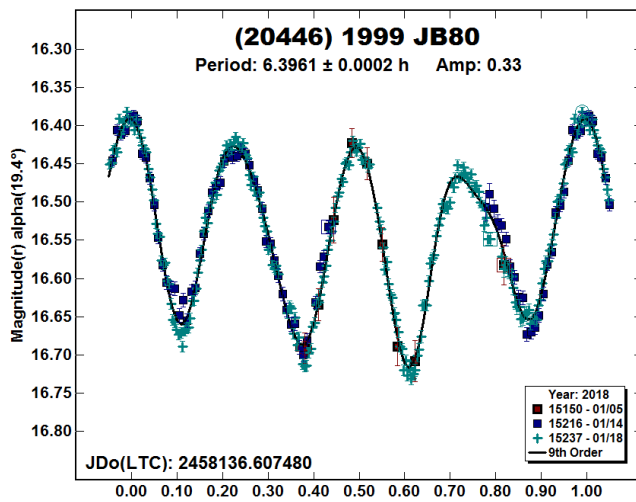
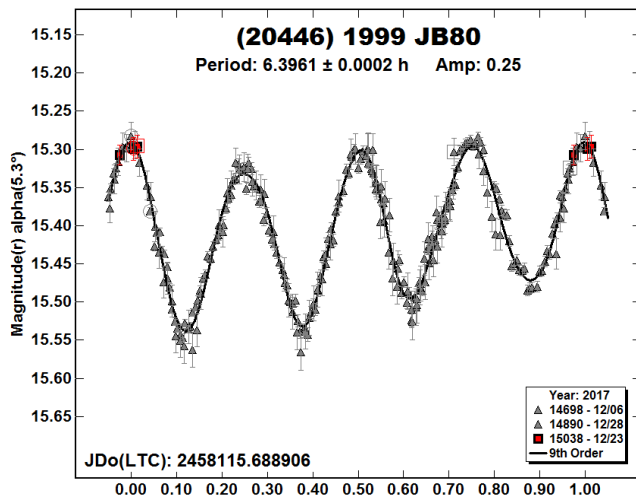
(16960) 1998 QS52. This Apollo was observed on four nights in 2008 Oct using the LONEOS Schmidt, but only fifteen useful observations were obtained. In Paper 1 we showed a single-mode fit, which is untenable. The very high phase-angle and large amplitude mean the lightcurve must have at least a double-mode character. We show here a notional fit, which although obviously uncertain, is consistent with the period by Warner (2009) as later revised to the double-period in the LCDB.



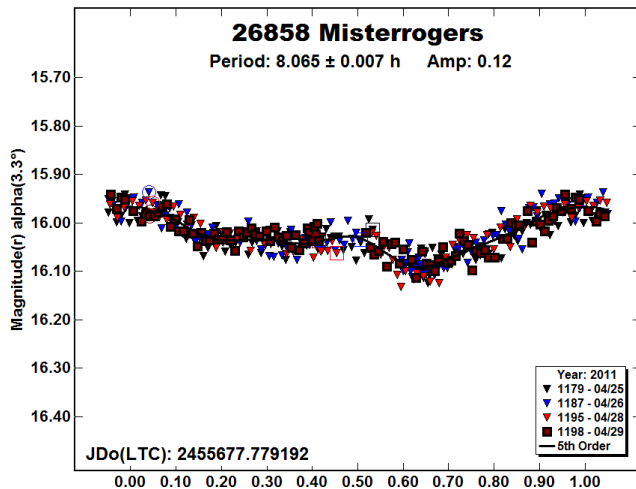
(20446) 1999 JB80. We observed this Mars-crossing Phocaea on two nights in 2010 Nov using the 0.7-m telescope. Sparse sampling covered more than 7 hours each night. The data support an unremarkable double-mode lightcurve of about 3.2-hours period; the RMS scatter is 0.028 mag. In hopes of improving this, we obtained several nights of data in 2017 Dec and 2018 Jan using the 0.7-m, 1.1-m, and 1.8-m telescopes with R_c or Sloan r' filters.

The two resulting lightcurves show clear quadramodal morphology at the double-period, which veers toward larger amplitude in the 2018 Jan series at higher phase-angle. The RMS scatter for these fits are 0.015 and 0.012 mag for the 2017 Dec and 2018 Jan runs, respectively. All three lightcurves are shown. The changing morphology is indicative of a binary for which the fits represent the short-period component, but for which the present data are insufficient to deal with resolving the system properly.



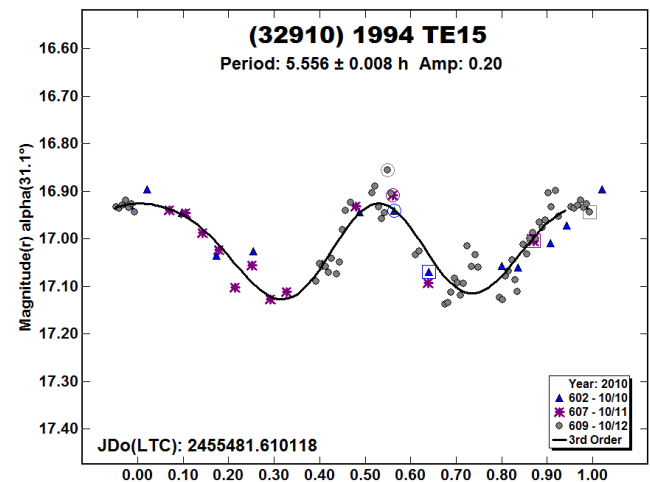
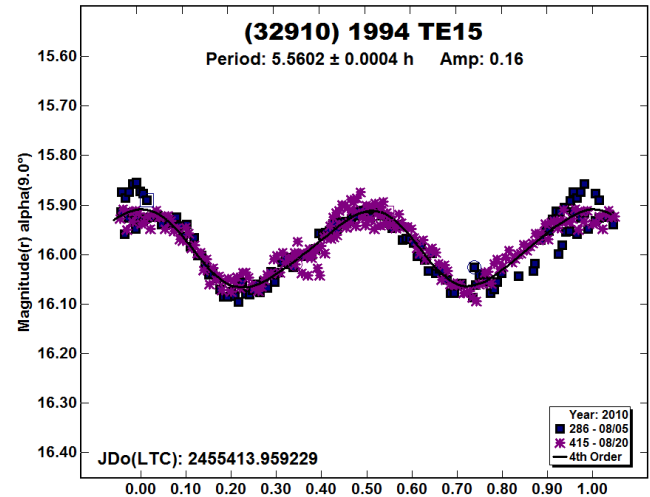


26858 Misterogers. Four 7-hour runs over a five-night interval with the 0.7-m telescope in 2011 Apr yielded a smooth lightcurve of moderately-low amplitude for this Mars-crosser. The 90-second exposures gave RMS scatter of 0.020 mag around the fitted curve. These are the only lightcurve data published hitherto.



(32910) 1994 TE15. This Mars-grazer was discovered by Otomo at Kiyosato; it is about 2.5-km in diameter and at perihelion comes just inside Mars' orbit. Previously, Pravec (2010web) obtained a

period of 5.5596 ± 0.0006 hours during the 2010 apparition. Avdellidou et al. (2012) obtained a similar result from data in 2010 Aug. We also obtained two series of observations in 2010. The LONEOS Schmidt was used on three widely separated nights in July and August. The first of these is omitted from analysis since the data are poor. On the other two nights, a total of 899 frames was acquired with 20- and 30-second exposures. We show the phased lightcurve from these data binned into three-image 3-minute averages (304 points). The derived period and amplitude are close to that of Pravec, and within our mutual uncertainties. The RMS scatter on the fit is 0.020 mag.



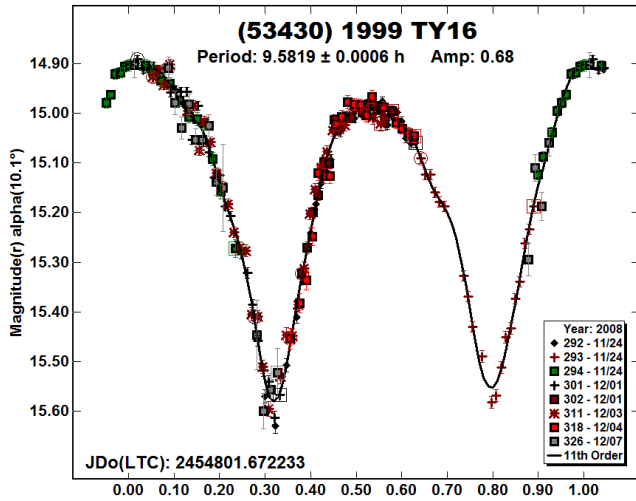
Two months later a three-night series was obtained with the 0.7-m telescope. Although conditions were generally good, the asteroid was too faint for the 1-minute exposures used. For this reason the lightcurve shows the data binned in pairs. The period-determination from this run is less certain due to the larger errors; the RMS scatter is 0.035 mag from an order-3 fit.

(39572) 1993 DQ1. Revision of the comparison star magnitudes has not permitted improved analysis from what we presented in Paper 1, which is the only published photometry. Though there is some variation each night, no coherent period could be found in the sparse data. Mean Sloan r' magnitudes are shown below for each night. With the exception of 2008 Oct 8, these are essentially constant, whereas the predicted brightness given by JPL Horizons ephemeris declines by approximately 0.8 mag between the first and last night listed.

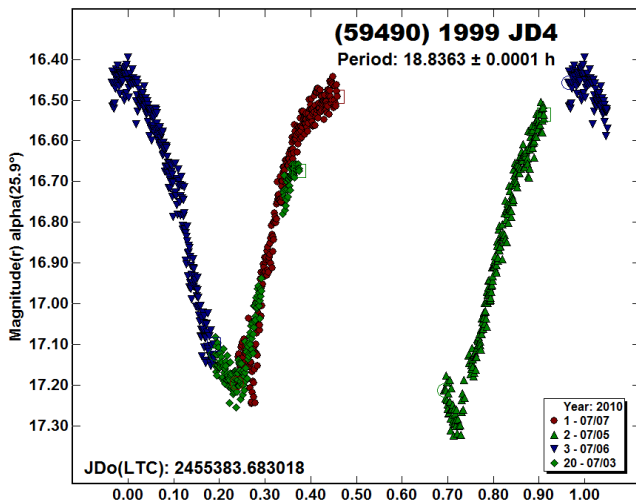
UT date	obs	mean r'
2008-10-07	4	17.06
2008-10-08	7	17.33
2008-10-22	10	17.04
2008-10-24	8	17.06
2008-10-25	7	17.08

(52750) 1998 KK17. We obtained only 18 frames of this 1.5-km Apollo on 2010 May 11 with the LONEOS Schmidt. Warner (2017a) has suggested that this is a wide binary with two disparate rotation periods. The data from our short run are basically flat with mean Sloan $r' = 16.79 \pm 0.02$ mag based on Pan-STARRS values for the comparison stars.

(53430) 1999 TY16. We presented a lightcurve of this object in Paper 1, which is revised here mainly to correct the photometric zero-point closer to Sloan r' and to improve the precision of the period determination. The period matches that of Ye et al. (2009), who observed during the same lunation in 2008, and also more recently Warner (2015b). The RMS scatter on the fit to the LONEOS Schmidt data is 0.024 mag.

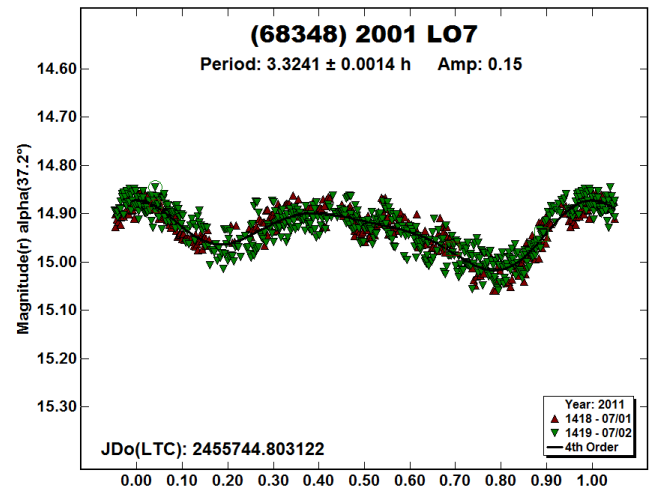


(59490) 1999 JD4. This 3.5-km Mars-crosser found by the LINEAR survey was observed on four nights in 2010 July using the LONEOS Schmidt. Exposures were 15 seconds (first night) and 30 seconds (remaining nights).

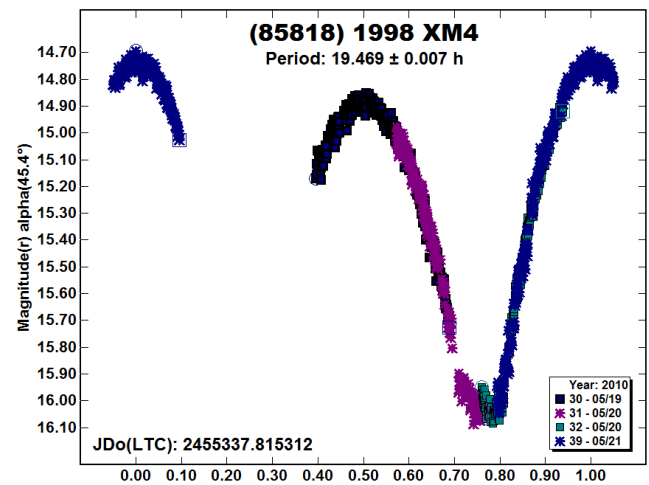


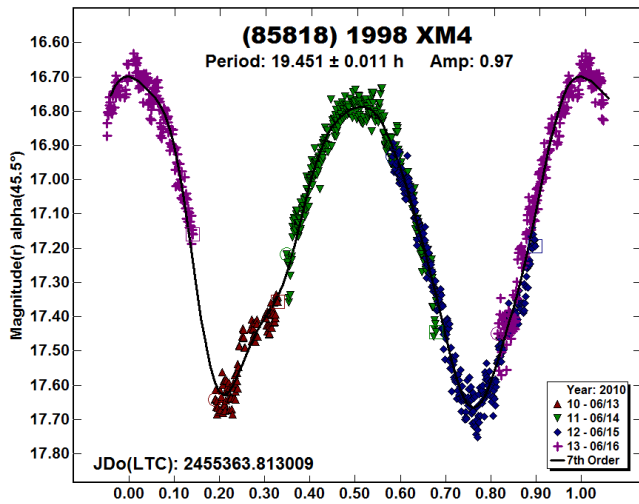
The relatively long period meant that rotational phase coverage was incomplete over the short nights near summer solstice. Nevertheless, the period from these data is clearly near 18.8 hours. The plot shows the data phased with the period determined by Pravec (2014web) from data obtained during the 2014 Oct apparition, which also has incomplete coverage at a smaller phase-angle. Adopting this force-fit period, the RMS scatter in the present data is 0.035 mag.

(68348) 2001 LO7. We obtained two 6-hour runs on this Apollo using 15- and 10-second exposures on consecutive nights with the LONEOS Schmidt in 2011 Jul. The period from these data (RMS scatter 0.023 mag.) seems well-determined, and is very close to that reported by Vaduvescu et al. (2017) from data taken by Adrián Galád at Modra just one week after ours. Their internal precision is very good, with RMS scatter about 0.015 mag. They also report a 9-hour secondary period. These periods differ significantly, however, from possible binary periods found later by Warner (2015a) from a longer temporal baseline. Warner (2017c) also presents a 3.8-hour quadrumodal lightcurve, for which he indicates no binary tendency (his RMS scatter, however, is about 0.06 mag). Additional data and analysis is required to reconcile the disparate results from the four series.



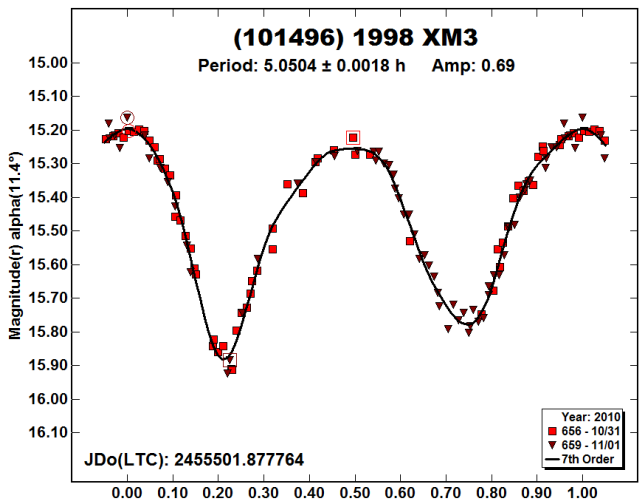
(85818) 1998 XM4. There is no entry in the LCDB for this 2-km Apollo found by the LINEAR survey.





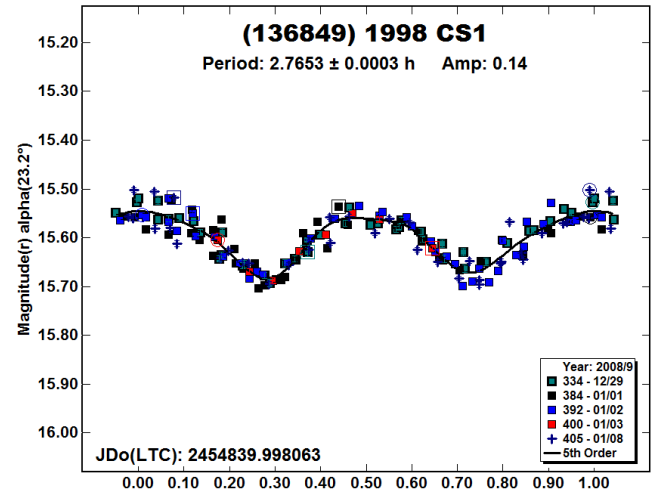
Two observing runs four weeks apart in 2010 May and June were obtained using the LONEOS Schmidt. The unfiltered exposures were 12 and 20 seconds in 2010 May, and 45 seconds in June, totaling some 2260 frames. The asteroid was at similar phase-angle, but two magnitudes fainter during the second series. The period is moderately long, so rotational phase coverage was again incomplete over the short nights near summer solstice. Even so, the large amplitude makes the period unambiguous, though the likely uncertainty is larger than shown, perhaps some hundredths of an hour. The RMS scatter on the phased lightcurves is 0.032 mag in May and 0.042 mag for the fainter June series.

(101496) 1998 XM3. We obtained two 8½-hour runs for this Mars-crosser on consecutive nights using the 0.7-m telescope, thus covering about 1½ rotational cycles each night. There are no other data shown in the LCDB. The lightcurve is uncomplicated, and the RMS scatter on the fit is 0.027 mag.

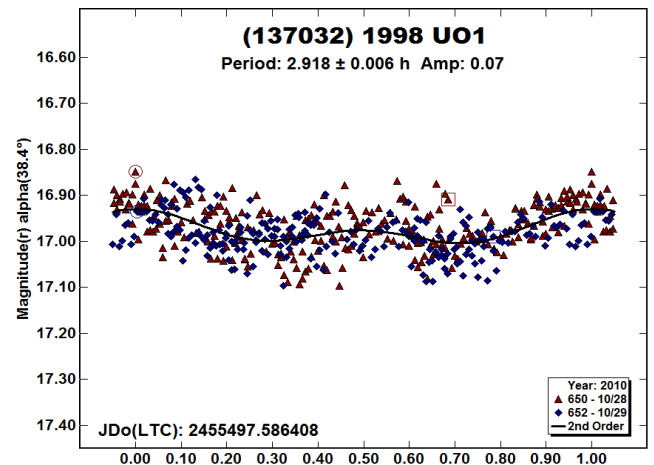
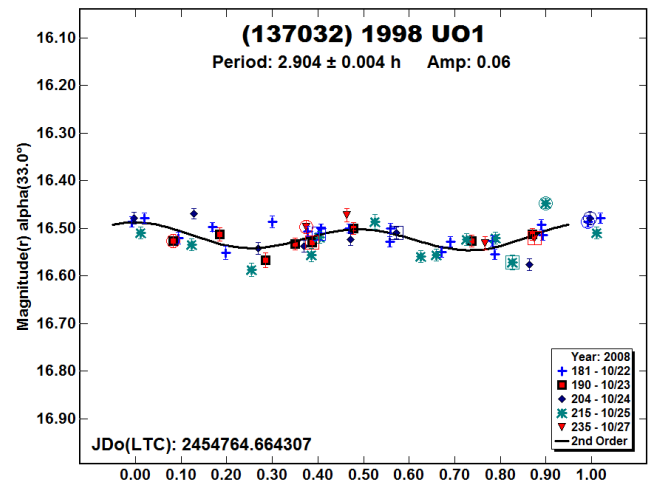


(136849) 1998 CS1. Quanzhi Ye (2010) published the first correct rotation period for this PHA Apollo, which was both discovered and followed-up with the Beijing Schmidt. We observed it on five nights during the same lunation as Ye over New Year's 2008/09 using the LONEOS Schmidt. Exposures ranged from 20 to 100 seconds. On four of the nights the coverage spanned seven hours, roughly 2½ rotational cycles; the period is thus unambiguous. The original lightcurve was part of Paper 1. Along with a more accurate adjustment to the Sloan r' zero-point, we now give an

extra decimal in the period determination. The RMS scatter on the fit is 0.021 mag.

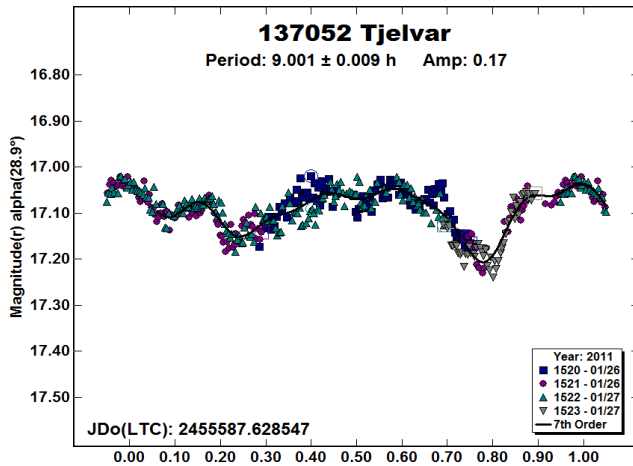


(137032) 1998 UO1. In Paper 1 we showed a period of 4.42 hours from LONEOS Schmidt data taken in 2010 Oct, which appears to be a 3:2 alias of the correct period. Reanalysis, including adjustment of the comparison stars to Sloan r' using the Pan-STARRS catalogue, indicates the correct period is near 2.9 hours, as found previously by Pravec (2004web) and by Warner (2015b, 2017b).

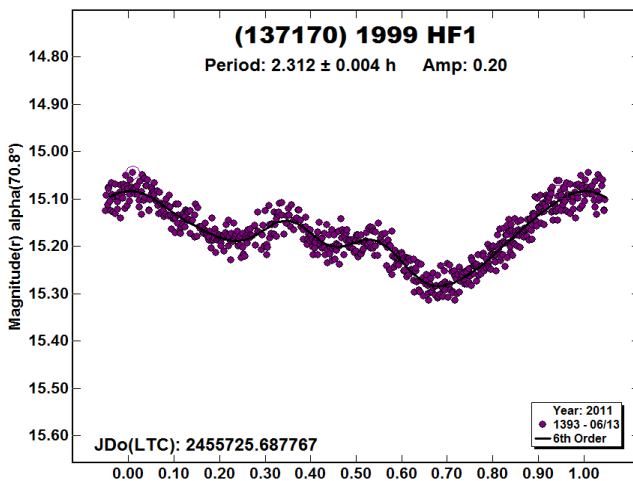


We can now show phased lightcurves (at the same vertical scale) from a previously abandoned 2008 Oct run and from 2010 Oct. The sparse 2008 data were also taken with the Schmidt using 3-minute exposures, whereas the denser 2010 lightcurve was done using 45-second exposures. The amplitudes are quite small relative to the noise in the data, which have RMS scatter of 0.025 mag in 2008 and 0.042 mag in 2010, i.e. only about 2-sigma significance.

137052 Tjelvar. We obtained two nights of data on this Apollo using the 1.1-m telescope in 2011 Jan and a single rather poor night a week later with the LONEOS Schmidt. The latter are not considered further. The 1.1-m data show a complex lightcurve that is not well-reproduced each night. Thus some doubt remains about whether the solution is correct, and possibly some tumbling or binary component is involved. The RMS scatter is 0.021 mag.

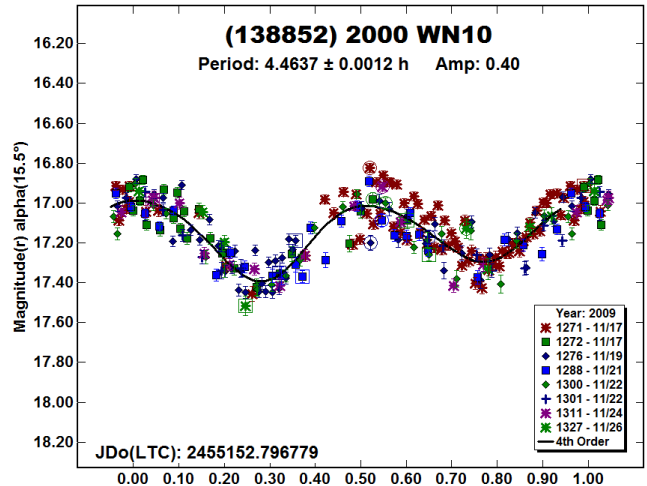


(137170) 1999 HF1. This Aten is a LONEOS discovery that was first observed photometrically starting only three days afterward by Pravec et al. (2002a, 2002b).

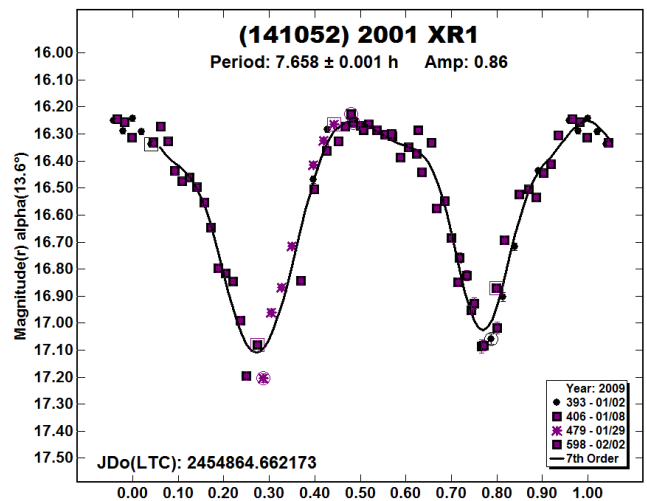


These authors identified it as a binary showing two periods in the lightcurve of 2.319 and 14.02 hours. Our single night run with the LONEOS Schmidt in 2011 Jun covers three rotational cycles of the short-period component that are very similar in morphology to the Pravec et al. nightly lightcurve fragments. The RMS scatter on the fit is 0.021 mag, and looks very good – but is only part of the story!

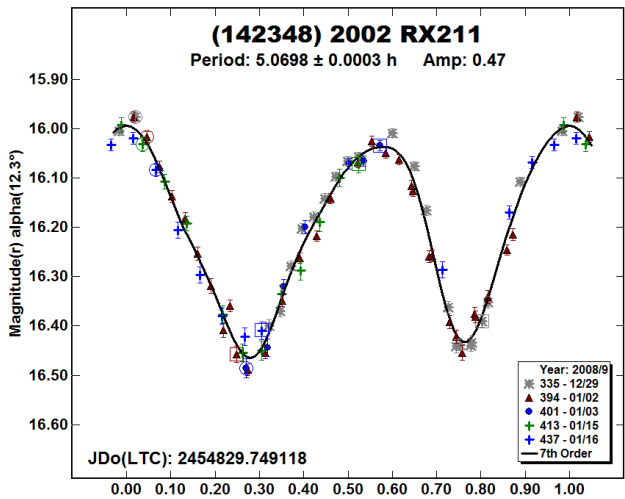
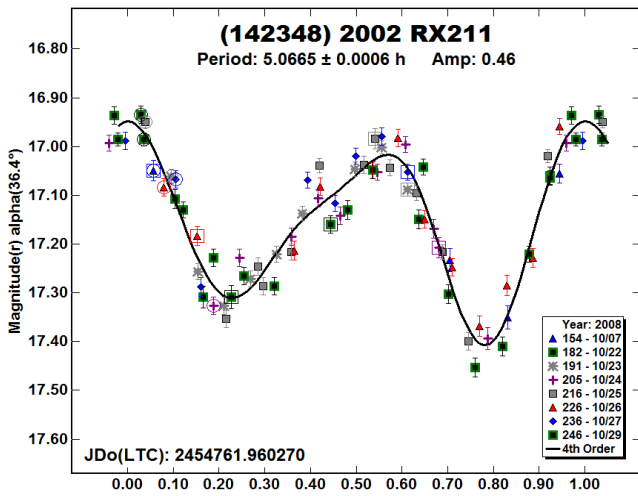
(138852) 2000 WN10. The revised LONEOS Schmidt data for this Apollo are similar to what we showed in Paper 1. The derived period is consistent with Pravec (2011web) data taken during the same lunation in 2009, and with Warner (2016a) from 2015 Nov. The RMS scatter unfortunately is quite large, 0.08 mag. On an isolated night a year earlier (2008 Nov 20), we get only a mean magnitude of Sloan $r' = 16.95 \pm 0.03$ from fourteen frames.



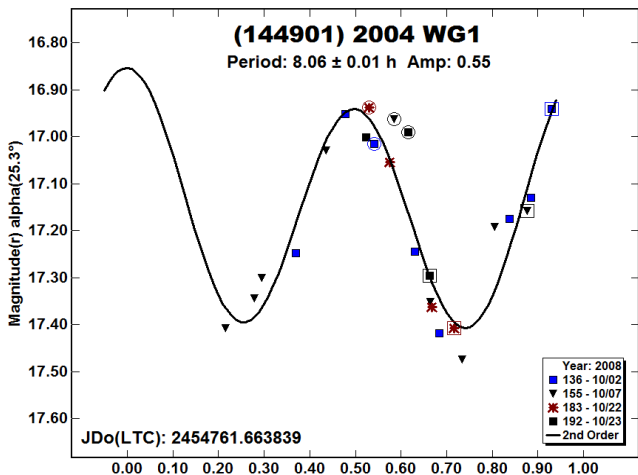
(141052) 2001 XR1. There are no other lightcurve data published for this Apollo beyond what appears in Paper 2. The data were taken with the LONEOS Schmidt on pairs of nights four weeks apart at much different phase-angles (about 14° and 60°); the lightcurve amplitude did not change much between the pairs of nights. Revision of the zero-point for the comparison stars allows a modest improvement in the period fit. The RMS scatter is nevertheless quite poor (0.07 mag).



(142348) 2002 RX211. The lightcurve for this Amor presented in Paper 1 combined nights spanning a three-month interval. The data are parsed out here into the two widely separated lunations. The LONEOS Schmidt was used, mainly with 3-minute exposures. The period determinations are close to the one obtained by Higgins et al. (2006b) from 2005 Oct-Nov, when the asteroid was similar in brightness. The RMS scatter is 0.041 mag (2008 Oct) and 0.024 mag (2009 Jan). The lightcurve morphology is modestly different at the two epochs.

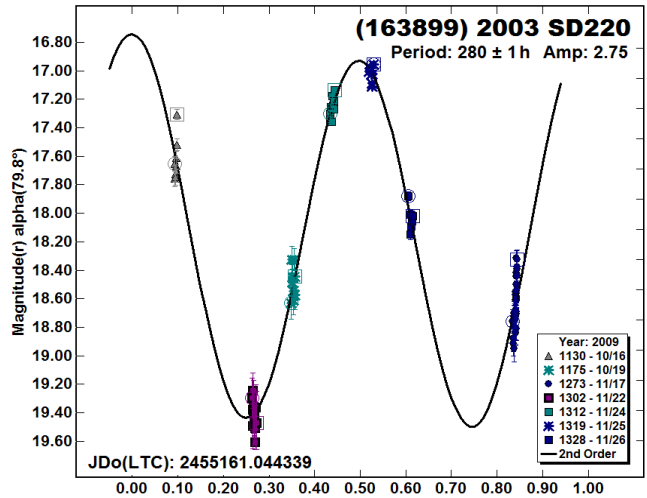


(144901) 2004 WG1. Revision of the comparison stars for this Apollo (Paper 1) did not improve the sparse Schmidt data.

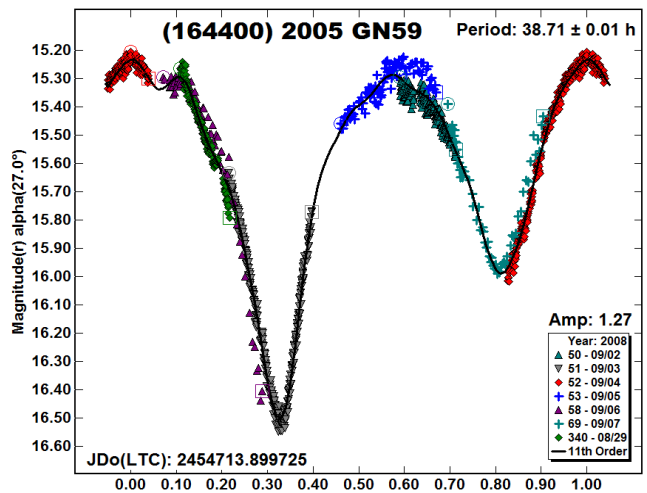


No other results are given in the LCDB. We show a notional period-fit similar to the original one. The RMS scatter is 0.07 mag, rather poor, and the resulting lightcurve is probably not meaningful. The rotation period and quality must be considered provisional only.

(163899) 2003 SD220. This PHA Aten asteroid is a LONEOS discovery. We obtained short runs of only one or two hours prior to morning twilight on seven nights in 2009 Oct-Nov using the Schmidt. Taken alone these were inadequate to define the lightcurve in any way. After adjustment of the comparison star data, we show a fit to a minimum in the period spectrum near the 285-hour period found by Warner (2016a). The match may be coincidental. Even ignoring the unconstrained maximum, the amplitude is still about 2.4 mag due to the very high phase-angle.

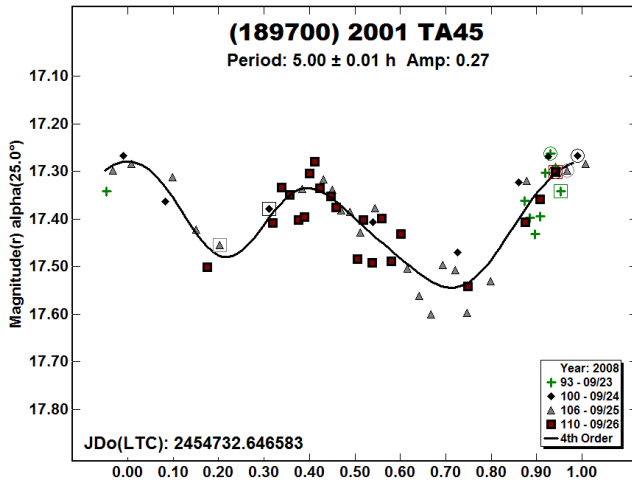


(164400) 2005 GN59. Some 1300 usable observations were obtained on this Apollo with the LONEOS Schmidt, mostly 45-second exposures. In Paper 1 we suggested that the moderately-long-period, large-amplitude lightcurve also had a tumbling component due to modest variation in the morphology over a nine-day interval.

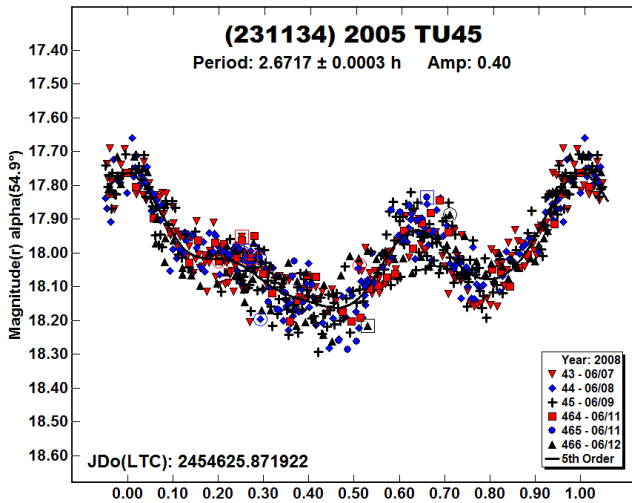


After adjusting the comparison stars, there is no essential change in this conclusion, and indeed the results match those of Vander Haagen (2011), who observed the asteroid during the same apparition. The phased lightcurve is shown with no nightly zero-point offsets. Although the dominant period cannot be far from 38.7 hours, the formal uncertainty is surely optimistic, and is probably several hundredths of an hour. The RMS scatter is 0.033 mag, but this results partly from the poor formal fit; the nightly internal errors are somewhat better.

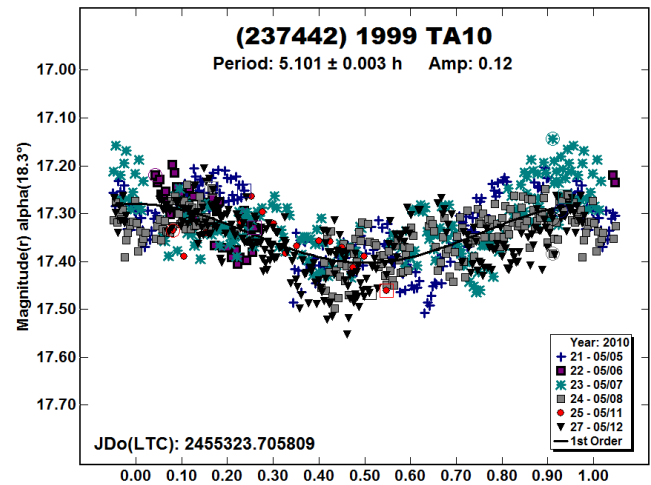
(189700) 2001 TA45. The four nights of sparse LONEOS Schmidt data in Paper 1 are the only ones available for this Amor. Revision of the photometric zero-point improved the data marginally, and a new lightcurve is given here. We have rounded off the period-determination to 0.01 hours. The asteroid was rather faint for the Schmidt, so the RMS scatter on the fit is 0.044 mag.



(231134) 2005 TU45. The results we published in Paper 1 for this 1-km Apollo were not quite correctly described. Three nights of data were obtained in 2008 June with the LONEOS Schmidt (569 unfiltered 45-second exposures) followed by two more nights using the 0.7-m telescope (138 unfiltered 3-minute exposures). The asteroid was rather faint for the latter telescope. After adjusting the comparison stars to Sloan r' based on Pan-STARRS data, the period determination is the same but the uncertainty is significantly reduced, as shown in Table I. The RMS scatter of the fit to the complete dataset is 0.06 mag. This remains the only lightcurve for the asteroid available hitherto.

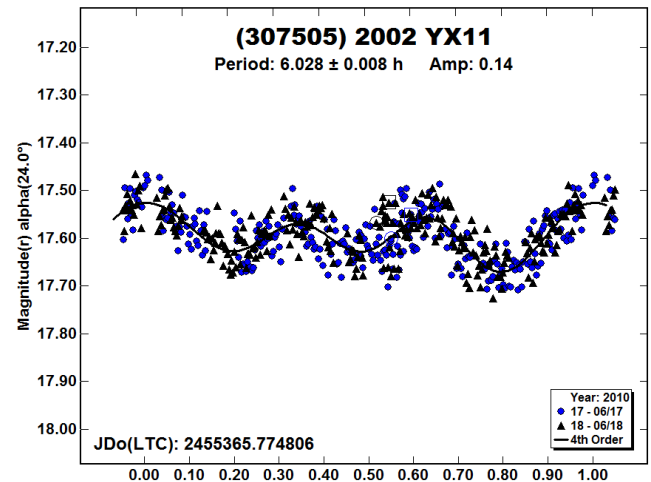


(237442) 1999 TA10. We obtained images on six nights for this small Amor in 2010 May using the LONEOS Schmidt, totaling 872 data-points. Some variation is certainly present, but the period determination is inconclusive. We show a simple single-mode fit, which could be spurious. A fit to the double period, however, is much poorer. The RMS scatter on the fit is 0.05 mag. If the amplitude is as small as suggested, much better precision will be required for a proper period determination.

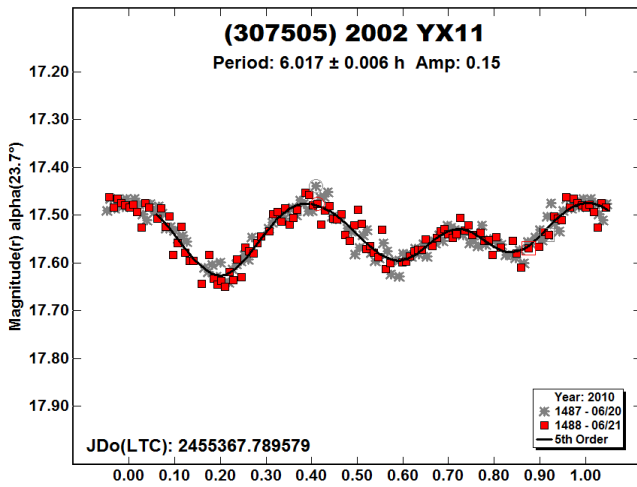


(257744) 2000 AD205. As we described in Paper 1, this half-kilometer Apollo was essentially constant over three nights in 2008 Jun using 45-second exposures with the LONEOS Schmidt. The asteroid was discovered in 2000 Jan using the same telescope. In preparing the present paper, revision of the comparison star magnitudes using Pan-STARRS photometry showed that the mean magnitude on these dates was Sloan $r' = 17.23, 17.15, \text{ and } 17.08 \pm 0.01$. This slight increase in brightness is consistent with the JPL Horizons ephemeris prediction from geometry only. The RMS scatter on straight-line fits each night are 0.045, 0.035, and 0.035 mag, respectively, similar to the internal errors on constant stars in the same magnitude range with this telescope. Thus the range of variation we witnessed cannot be more than a few percent, and not so much as the 0.28 mag indicated in Paper 1, which resulted from poor comparison star photometry. A notional period of 27 hours, also hinted at in Paper 1, is spurious.

(307505) 2002 YX11. We observed this LINEAR discovery, a 1.5-km Mars-crosser, on two consecutive nights using the LONEOS Schmidt, followed-up a few nights later with the 1.1-m telescope.



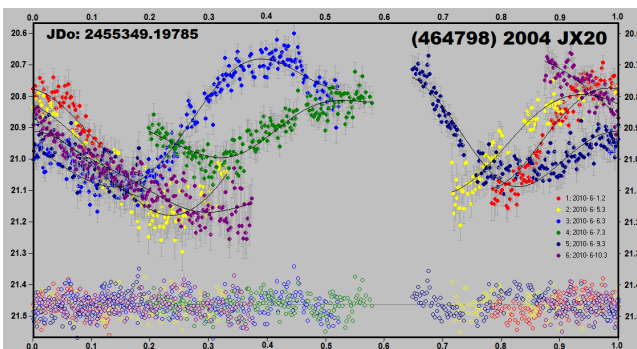
At LONEOS a total of 540 data points was obtained with exposures of 15 seconds (first night) and 45 seconds (second night). The 1.1-m data were obtained with a wide 'VR' filter using 90- and 180-second exposures, totaling 206 frames. All were reduced using Sloan r' mags for the comparison stars.



In a CALL post (Skiff 2010web), we gave a period of 4.02 hours from the LONEOS data only, assuming a low-amplitude double-mode lightcurve morphology, but commented that a triple-mode period near 6 hours was not excluded. The 1.1-m data have much smaller internal errors, and so the 6-hour solution becomes unambiguous. Lightcurves at the same vertical scale from the two telescopes are shown here for comparison. The scatter is 0.036 mag for the LONEOS data, and 0.018 mag for the 1.1-m data.

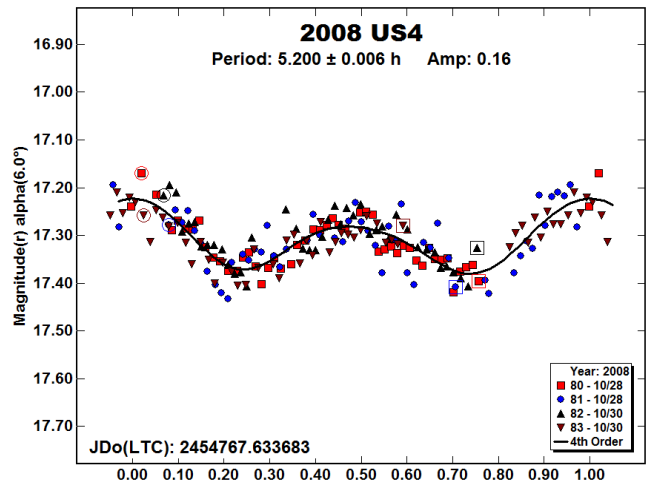
(414586) 2009 UV18. Our short, single-night run on 2010 May 15 shows some variation but no lightcurve. The mean Sloan r' = 17.21 ± 0.03 with about 0.2 mag total range.

(464798) 2004 JX20. Warner (2016b) gave uncertain results for data taken in 2016 May on this 1-km Aten found by the Catalina survey. We observed it with the LONEOS Schmidt on six nights over nine days in early June 2010, acquiring some 1400 exposures of 45 seconds each. The nightly curves were non-repeating, indicating a tumbling object. The data were analyzed by Petr Pravec, who found two non-commensurate periods around 10 hours (formally 10.76 h and 9.24 h). The RMS scatter of the photometry in this solution is 0.034 mag. The observational coverage, however, is not quite sufficient to provide a unique solution for the two relatively long periods. The tumbling nature is nevertheless reasonably well resolved with the available data, which Pravec rates as PAR = -2 on the scale defined in Pravec et al. (2005). The plot shows the two-dimensional Fourier solution that disentangles the nightly lightcurves. The bottom portion shows the residuals from the fit.

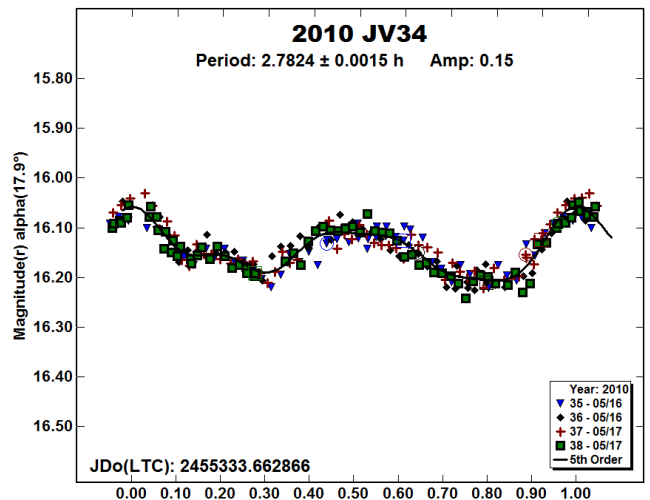


2008 US4. In Paper 1 we showed a noisy lightcurve for this 200-meter Apollo, resulting from two nights of 1-minute exposures with the LONEOS Schmidt (about 9 and 8 hours on target, respectively). This is the only published photometry for the

asteroid. After adjustment of the comparison stars to Sloan r' , we find the original period to be correct. The phased lightcurve here has the 576 usable data points averaged into 195 three-image 5-minute bins. The RMS scatter on the unbinned data is 0.055 mag versus 0.033 mag in the averaged plot, about as expected from root-n considerations.



2010 JV34. This 250-meter diameter PHA Apollo is a Catalina discovery, observed so far only during its 2010 discovery apparition. It has not been even as bright as mag 22 since then. Hasegawa et al. (2018) observed the asteroid on two nights in 2010 May using the 1-m Kiso Schmidt, obtaining BVRI colors as well. From about 10 hours of data, they obtained a period of 2.783 h with RMS scatter of roughly 0.07 mag. We observed the asteroid on the same two consecutive nights using the LONEOS Schmidt, which yielded a clean double-mode lightcurve of period 2.782 h. The phased lightcurve is shown with the 701 measurements from unfiltered 30- and 45-second exposures averaged into 236 three-image 3-minute bins. The same comparison stars were used for the two sessions each night. The RMS scatter on the fitted curve is 0.019 mag.



Number	Name	yyyy	mm/dd	Phase	L _{PAB}	B _{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
422	Berolina	2011	03/06-03/24	6.2,13.2	151	3	25.98	0.01	0.15	0.05	FLOR
433	Eros	2009	06/18-06/22	33.9,33.3	328	2	5.27	0.01	0.45	0.01	NEA
433	Eros	2009	10/10-10/21	29.5,34.1	343	14	5.2712	0.0007	0.17	0.01	NEA
433	Eros	2009	11/17-11/26	41.0,42.3	356	14	5.275	0.003	0.06	0.01	NEA
433	Eros	2009/10	12/19-01/10	44.2,45.0	17	12	5.2709	0.0012	0.14	0.01	NEA
711	Marmulla	2011	01/15-11/17	6.0,5.2	126	6	2.7216	0.0005	0.18	0.01	FLOR
735	Marghanna	2011	04/29-05/05	8.9,10.4	192	9	20.625	0.011	0.12	0.01	MB-O
1036	Ganymed	2008/09	12/03-01/08	14.4,14.6,13.1	163	-25	10.307	0.004	0.12	0.01	NEA
1036	Ganymed	2009	01/15-02/19	10.7,7.5	163	-26	10.314	0.002	0.12	0.01	NEA
1036	Ganymed	2009	03/16-04/22	7.7,12.6	160	-24	10.312	0.001	0.09	0.01	NEA
1095	Tulipa	2017	10/26-10/28	15.3,15.7	345	1	2.7870	0.0012	0.19	0.01	EOS
1361	Leuschneria	2010	06/19-06/21	11.2,11.4	255	27	12.08	0.01	0.40	0.05	MB-O
1361	Leuschneria	2017	10/28-11/26	12.6,9.8	59	-25	12.075	0.001	0.31	0.01	MB-O
1609	Brenda	2015	01/06-01/24	12.8,17.5	77	-8	19.776	0.002	0.27	0.01	MB-I
1620	Geographos	2008	11/04-11/20	35.3,30.3	36	22	5.2229	0.0002	1.13	0.02	NEA
1627	Ivar	2008	09/05-09/07	43.6,43.2	38	-11	4.796	0.002	1.55	0.05	NEA
1627	Ivar	2008	10/02-10/09	31.3,27.2	47	-13	4.795	0.001	1.26	0.02	NEA
1627	Ivar	2008	10/22-10/29	19.0,14.8	49	-14	4.7950	0.0003	1.12	0.02	NEA
1627	Ivar	2008	12/01-12/07	15.3,17.7	50	-12	4.7952	0.0003	1.11	0.02	NEA
1627	Ivar	2008/09	12/29-01/03	24.0,24.9	54	-10	4.7957	0.0003	1.30	0.02	NEA
1627	Ivar	2009	01/15-02/02	26.4,26.9	59	-9	4.7955	0.0002	1.36	0.03	NEA
1789	Dobrovolsky	2011	03/09	6.3,8.5	151	2	4.8125	0.0007	0.13	0.01	FLOR
1883	Rimito	2017	11/25-11/27	7.7,7.6	61	-10	6.492	0.013	0.04	0.01	PHO
1884	Skip	2018	01/14-11/15	31.3,31.4	54	26	2.8887	0.0013	0.12	0.01	PHO
1938	Lausanna	2014	03/25-03/31	3.5,7.2	179	1	2.7481	0.004	0.13	0.01	FLOR
1980	Tezcatlipoca	2008	09/07-09/22	44.3,45.1	263	2					NEA
2048	Dwornik	2011	06/14-06/15	23.2,23.2	259	35	3.68	0.01	0.12	0.03	H
2048	Dwornik	2011	06/17-06/18	23.3,23.3	259	35	3.679	0.003	0.12	0.01	H
2199	Klet	2011	02/12-03/03	1.8,0.1,7.5	146	0	12.865	0.002	0.08	0.01	MB-I
2253	Espinette	2011	04/06-04/12	8.7,6.0	212	5	7.4409	0.0009	0.25	0.01	MC
2363	Cebriones	2010	09/04-09/25	7.8,9.4	320	33	20.04	0.01	0.13	0.02	TR-J
2408	Astapovich	2016	05/23-05/28	15.7,16.6	235	25	3.6744	0.0005	0.18	0.01	FLOR
2536	Kozyrev	2011	03/13-03/24	10.4,14.1	148	-5	7.1887	0.0008	0.53	0.03	FLOR
3099	Hergenrother	2017	11/28-12/13	23.7,23.5	145	17	25.58	0.01	0.29	0.01	MB-O
3255	Tholen	2013	11/26-11/26	36.6	23	29	2.940	0.010	0.28	0.01	MC
3255	Tholen	2018	01/14-01/25	21.5,15.6	148	10	2.9463	0.0006	0.07	0.01	MC
3361	Orpheus	2009	10/12-10/23	3.7,20.4	16	-2	3.5381	0.0007	0.17	0.03	NEA
3361	Orpheus	2013	10/26-10/28	16.0,19.5	23	-4	3.5327	0.0009	0.23	0.02	NEA
3398	Stattmayer	2011	03/10-03/12	21.2,21.1	168	34	8.291	0.008	0.13	0.01	PHO
4257	Ubasti	2008	09/24	31.6	326	12	4.4 ?	?	0.34	?	NEA
4435	Holt	2017	11/27-11/28	32.4,32.4	30	32	2.867	0.002	0.20	0.01	MC
4692	SIMBAD	2017	12/08-12/10	2.4,3.6	62	0	2.7357	0.0011	0.15	0.01	FLOR
4692	SIMBAD	2017	12/08-12/10	9.1,10.2	62	0	5.4695	0.0024	0.16	0.01	FLOR
5332	Davidaguilar	2009	01/30-02/02	56.5	72	-28	5.80	0.02	1.1	0.1	NEA
6053	1993 BW3	2017	11/15-11/16	65.6,65.1	101	40	2.580	0.004	0.23	0.01	NEA
6053	1993 BW3	2017	11/25-11/27	60.3,59.2	110	36	2.576	0.003	0.12	0.01	NEA
6246	Komurotoru	2013	12/26-12/27	22.0,22.5	67	16	3.2271	0.0005	0.38	0.01	PHO
7336	Saunders	2010	08/06-08/12	16.8,15.4	320	12	4.31	0.01	0.14	0.03	NEA
7336	Saunders	2010	08/31-09/01	12.4,12.3	333	8	4.307	0.002	0.16	0.01	NEA
7358	Oze	2008	10/24-12/07	42.2,22.2	103	0	24.40	0.05	0.10	0.02	NEA
8567	1996 HW1	2008	08/23-09/07	29.8,25.7	352	11	8.75337	0.00009	0.99	0.01	NEA
8567	1996 HW1	2008	09/23-10/02	23.9,23.9	19	-7	8.7431	0.0017	0.95	0.01	NEA
8567	1996 HW1	2008	10/02-10/09	23.9,23.5	25	-11	8.7575	0.0012	1.01	0.02	NEA
8567	1996 HW1	2008	10/22-10/29	22.0,21.3	36	-16	8.7595	0.0006	0.86	0.01	NEA
8567	1996 HW1	2008	11/04-11/07	21.0,21.0	41	-16	8.7599	0.0017	0.85	0.01	NEA
8567	1996 HW1	2008	11/18-11/24	21.8,23.8	48	-16	8.7609	0.0008	0.68	0.01	NEA
8567	1996 HW1	2008/09	12/01-01/03	24.2,30.3	59	-15	8.7646	0.0005	0.57	0.01	NEA
8647	Populus	2017	12/29-12/30	8.3,7.7	110	3	2.537	0.002	0.15	0.01	FLOR
9671	Hemera	2017	03/07-03/19	20.5,14.1	191	-4	2.53150	0.00004	0.18	0.01	MC
10046	Creighton	2011	04/15-04/17	13.4,12.6	222	11	6.5663	0.0013	0.67	0.01	MB-I
10715	Nagler	2012	05/28-05/29	8.4,8.6	241	21	2.542	0.003	0.15	0.02	MB-M
11885	Summanus	2011	03/24-03/25	42.7,41.1	157	3	7.368	0.004	0.18	0.01	NEA
12700	1990 FH	2011	04/21-04/22	17.4,17.5	197	19	9.037	0.007	0.27	0.01	PHO
16960	1998 QS52	2008	10/23-10/27	85.3,100.9	5	58	5.8	0.1	1.5	0.2	NEA

Table I. Observing circumstances and results. The phase angle (α) is given at the start and end of each date range (0 h UT), 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): FLOR:Flora; H: Hungaria; MB-I/M/O: Main-belt inner/middle/outer; MC:Mars-crosser; NEA: Near-Earth asteroid; PHO: Phocaea; TR-J: Jupiter trojan

Number	Name	yyyy	mm/dd	Phase	LPAB	BPAB	Period (h)	P.E.	Amp	A.E.	Grp
20446	1999 JB80	2010	11/06-11/10	20.3, 17.8	66	-14	3.199	0.001	0.24	0.01	MC
20446	1999 JB80	2017	12/06-12/28	5.2, 13.4	70	-4	6.3961	0.0002	0.25	0.01	MC
20446	1999 JB80		2018 01/12	19.3, 23.4	74	2	6.3961	0.0002	0.33	0.01	MC
26858	Misterrogers	2011	04/25-04/29	3.1, 5.0	209	4	8.065	0.007	0.12	0.01	MC
32910	1994 TE15	2010	08/05-08/20	9.1, 8.3	320	8	5.5602	0.0004	0.16	0.01	MC
32910	1994 TE15	2010	10/10-10/12	31.0, 31.3	335	6	5.556	0.008	0.20	0.02	MC
39572	1993 DQ1	2008	10/07-10/25	42.4, 38.4	348	16					NEA
52750	1998 KK17	2010	05/11-05/11	27.5, 27.5	243	23					NEA
53430	1999 TY16	2008	11/24-12/07	10.3, 30.1	54	-6	9.5819	0.0006	0.68	0.02	NEA
59490	1999 JD4	2010	07/03-07/07	23.9, 25.8	250	15	18.84	0.01	0.9	0.1	MC
68348	2001 LO7	2011	07/01-07/02	36.9, 37.7	289	37	3.3241	0.0014	0.15	0.02	NEA
85818	1998 XM4	2010	05/19-05/21	45.3, 45.3	251	35	19.469	0.007	1.30	0.05	NEA
85818	1998 XM4	2010	06/13-06/16	45.3, 45.1	240	50	19.451	0.011	0.97	0.03	NEA
101496	1998 XM3	2010	10/31-11/01	11.1-11.8	25	-1	5.0504	0.0018	0.69	0.02	MC
136849	1998 CS1	2008/09	12/29-01/08	23.3, 21.6	118	-2	2.7653	0.0003	0.14	0.01	NEA
137032	1998 UO1	2008	10/22-10/27	33.0, 32.7	8	21	2.904	0.004	0.06	0.01	NEA
137032	1998 UO1	2010	10/28-10/29	38.3, 38.1	2	19	2.918	0.006	0.07	0.02	NEA
137052	Tjelvar	2011	01/26-01/26	28.7	125	28	9.001	0.009	0.17	0.01	NEA
137170	1999 HF1		2011 06/13	70.6	260	60	2.312	0.004	0.20	0.01	NEA
138852	2000 WN10	2009	11/17-11/26	16.5, 9.9	58	-2	4.4637	0.0012	0.40	0.05	NEA
141052	2001 XR1	2009	01/02-02/02	13.9, 0.3, 58.9	110	-3	7.658	0.001	0.86	0.04	NEA
142348	2002 RX211	2008	10/07-10/29	36.4, 40.2	46	-17	5.0665	0.0006	0.46	0.02	NEA
142348	2002 RX211	2008/09	12/29-01/16	12.5, 6.7	110	3	5.0698	0.0003	0.47	0.01	NEA
144901	2004 WG1	2008	10/02-10/23	25.8, 6.8	27	-9	8.06	0.01	0.55	0.05	NEA
163899	2003 SD220	2009	10/16-11/26	79.8, 78.4, 81.5	*101	12	280	1	2.4	0.2	NEA
164400	2005 GN59	2008	08/29-09/07	25.5-29.5	345	19	38.71	0.01	1.27	0.03	NEA
189700	2001 TA45	2008	09/23-09/26	25.0, 24.1	353	15	5.00	0.01	0.27	0.03	NEA
231134	2005 TU45	2008	06/07-06/12	55.1, 50.4	270	44	2.6717	0.0003	0.40	0.04	NEA
237442	1999 TA10	2010	05/05-05/12	18.2, 21.8	234	15	5.101	0.003	0.12	0.03	NEA
257744	2000 AD205		2008 06/03	37.9	249	26					NEA
307505	2002 YX11	2010	06/17-06/18	24.0, 23.9	253	22	6.028	0.008	0.14	0.02	MC
307505	2002 YX11	2010	06/20-06/21	23.7, 23.6	253	21	6.017	0.006	0.15	0.01	MC
414586	2009 UV18		2010 05/15	5.8	234	7					NEA
464798	2004 JX20		2010 06/06	49.5	234	24	[†] 10.758	0.001	0.50	0.05	NEA
							9.24	0.01	0.50	0.05	NEA
	2008 US4	2008	10/28-10/30	5.4, 9.5	33	4	5.200	0.006	0.16	0.02	NEA
	2010 JV34	2010	05/16-05/17	17.0, 20.3	228	7	2.7824	0.0015	0.15	0.01	NEA

Table I (*continued*). Observing circumstances and results. *Longitude range $\pm 20^\circ$ of value. [†]The primary period of a tumbling asteroid (the second line is a possible secondary period). The phase angle (α) is given at the start of each date range (0 h UT), 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). MB-I/M/O: Main-belt inner/middle/outer; MC: Mars-crosser; NEA: Near-Earth asteroid.

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ROTATION PERIOD FOR 2053 NUKI

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CCD photometric observations of the outer main-belt asteroid 2053 Nuki were made by the author over seven nights between 2019 February 4-21. The rotation period was found to be 11.604 ± 0.001 h with a lightcurve amplitude of 0.40 ± 0.05 mag.

The outer main-belt asteroid 2053 Nuki (previous designations: 1976 UO, 1928 RW, and 1961 TW) was discovered at La Silla on 1976 October 24 by R.M. West. It is named in honor of Nodari West, the son of the discoverer. [Ref: *Minor Planet Circ.* 4786].

CCD photometric observations were made by the author over seven nights between 2019 February 4-21. A total of 39 hours 42 minutes of observations resulted in 610 data points for analysis. The rotation period was found to be 11.604 ± 0.001 h with a lightcurve amplitude of 0.40 ± 0.05 mag. A search of the asteroid lightcurve database (LCDB, Warner *et al.*, 2018) indicates no previously reported rotation period for this asteroid.

All observations were performed at The Studios Observatory, Grantham, U.K. (Z52) using a Meade 0.36-m LX200 ACF OTA operating at *f*/7 and a Takahashi FS-102 0.10-m *f*/8 refractor as a guide scope. The OTAs are mounted on a Paramount MEII robotic mount.

The 0.36-m OTA is equipped with Moonlite CSL 2.5-inch large format motorized focuser, Astro Physics AP CCDT67 focal reducer, and a QSI 683 cooled CCD camera (KAF-8300, 3326x2504x5.4-microns, binned 2x2). The image scale was 0.86 arcsec/pixel. Exposures were 180 sec using an Astrodon Clear (UV blocking only) filter. Guiding was carried out using a ZWO ASI1600M-Cooled CMOS camera binned 2x2.

TheSkyX Professional software (Software Bisque, 2019) was used for telescope, focuser, camera control, and guiding. This software was also later used to calibrate all science images using bias, dark, dark-for-flat, and flat field frames. All flat field images were taken at the end of the observing sessions using a wall-mounted whiteboard illuminated by an A4-size electroluminescent (EL) panel. A recent library of bias, dark and dark-for-flat frames was used in the calibration process, no scaling of dark frames was necessary.

All data processing of the calibrated images and subsequent period analysis was performed using *MPO Canopus* (Warner, 2018). Differential photometry measurements were performed using the Comp Star Selector (CSS) and Star-B-Gone procedures of *MPO Canopus*. The asteroid and five solar-like stars were used for all photometric comparisons. The KAF-8300 sensor has a peak spectral response in the green visual band so V band magnitudes

Number	Name	2019 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2053	Nuki	02/04-02/21	610	15.14,19.56	104.8	-10.3	11.604	0.001	0.40	0.05	MB-O

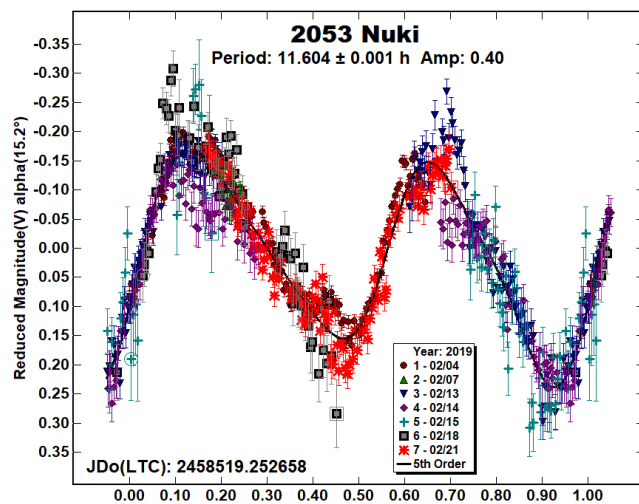
Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984). Grp is the asteroid family/group (Warner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

and V-R colour indexes were used throughout the data processing. Since the target declination remained below +21 deg, the APASS catalog (Henden et al., 2009) was used for all plate solving (auto-match) and photometric reductions. The asteroid's magnitude ranged from 15.7 V to 16.0 V during the observing period.

Number	Date 2019	Duration	Pts	Phase
2053	02/04	7 h 29	131	15.1
2053	02/07	0 h 22	8	16.0
2053	02/13	7 h 16	117	17.7
2053	02/14	6 h 59	118	18.0
2053	02/15	5 h 06	64	18.2
2053	02/18	5 h 50	67	18.9
2053	02/21	6 h 40	105	19.6

Table I. Observing Schedule. Date is in month/day format. Pts is the number of data points. The

Period analysis was performed using the Fourier analysis algorithm (FALC) in *MPO Canopus* that was developed by Harris (Harris et al., 1989). The period search was made from 1 to 14 hours. The resulting period spectrum shows a single, clearly dominant solution as 11.604 h. Table II provides an overview of the observed results. All new data are deposited in the ALCDEF database (*alcdef.org*).



Acknowledgements

This research has made use of data and services provided by the International Astronomical Union's Minor Planet Center.

<https://www.minorplanetcenter.net/iau/mpc.html>

This research was made possible in part based on data from the MPCOSC3-2MASS catalog (a product of the Two Micron All Sky Survey), UCAC4 (the fourth U.S. Naval Observatory CCD Astrograph Catalog), and the AAVSO Photometric All-Sky Survey (APASS), funded by the Robert Martin Ayers Sciences Fund.

The author would like to express his gratitude to Brian D. Warner for his *MPO Canopus* software and support, along with the 2nd edition of his book *A Practical Guide to Lightcurve Photometry and Analysis*. Both have been invaluable in this research.

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ROTATION PERIOD DETERMINATION FOR 449 HAMBURGA

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Twenty-three sessions on 449 Hamburga 2018 Dec. 3 – 2019 Feb. 12 provide a good fit to a synodic rotation period of 36.516 ± 0.001 hours with amplitude 0.06 ± 0.01 magnitudes and three unequal maxima and minima per rotational cycle.

Author Pilcher at the Organ Mesa Observatory used a 0.35-meter Meade LX200 GPS Schmidt-Cassegrain (SCT), SBIG STL-1001E CCD, and clear filter. Author Marchini at the Astronomical Observatory of the University of Siena used a 0.30 meter MCT telescope, SBIG STL-6303e CCD, binned 2x2, and R filter. Both observers measured their images and constructed lightcurves with *MPO Canopus* software and calibration star magnitudes from the Carlsberg Meridian Circle 15 (CMC 15) catalog. To reduce the large number of data points on the lightcurve and make them easier to read, they have been binned in sets of 3 with a maximum time difference of 5 minutes.

Two previously published periods found for 449 Hamburga are by Brinsfield (2010), 18.263 hours; and by Behrend (2011), 18.145 hours, both with bimodal lightcurves containing some gaps. A more comprehensive observation campaign was initiated by first author Pilcher and later joined by Marchini. They were able to fit their data to a lightcurve with period 36.516 ± 0.001 hours, amplitude 0.06 ± 0.01 magnitudes, with three unequal maxima and minima per rotational cycle. This period is twice as great as the periods found by Brinsfield (2009) and by Behrend (2011). A period spectrum between 16 hours and 56 hours is also provided and shows that a period near 18.2 hours can be definitively rejected.

After first author Pilcher had made the first 14 sessions, he sent the data to Petr Pravec for independent analysis. Pravec found a suggestion of very low amplitude tumbling behavior and recommended that additional observations be made from Europe. Lorenzo Franco requested Alessandro Marchini to obtain additional sessions and thereafter led the collaboration. Marchini kindly provided data for sessions 709, 710, 715, 719, and 723 as

plotted on the lightcurve. All other sessions are by Pilcher.

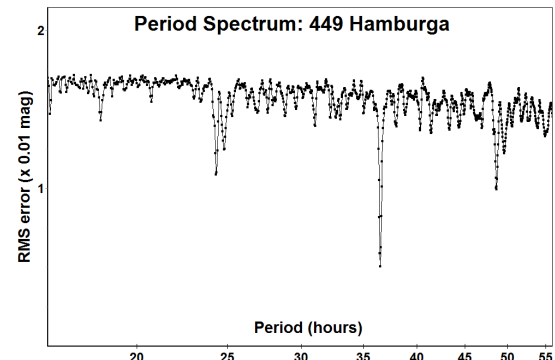
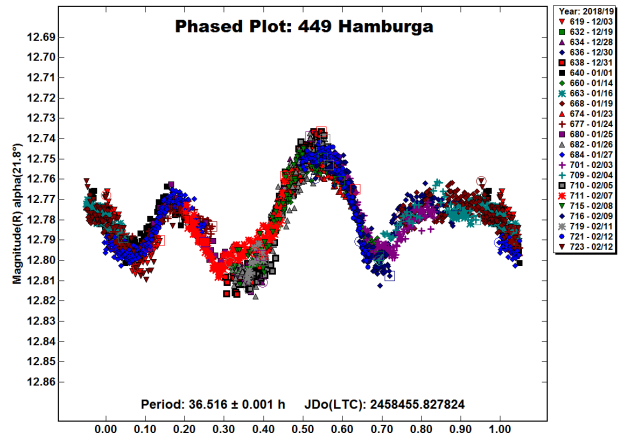
After all 23 sessions had been completed, Pravec again examined the data and found no strong evidence for tumbling exceeding 0.02 magnitudes. The authors believe that tumbling is very unlikely. For an object as large as 449 Hamburga, whose diameter is about 80 kilometers, and rotation period as short as 36.5 hours, the time for expected for tumbling to decay to principal axis rotation is short compared with the age of the solar system.

Acknowledgment

The authors thank Petr Pravec for independent analyses of the data.

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Number	Name	yyyy/mm/dd	Pts	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.
449	Hamburga	2018/12/03-2019/02/12	6728	21.8, 1.6, 13.2	119	2	36.516	0.001	0.06	0.01

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

**ROTATION PERIOD FOR
(33143) 1998 DJ7, (57735) 2001 UQ159,
AND (73308) 2002 JJ74**

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(Received: 2019 February 21)

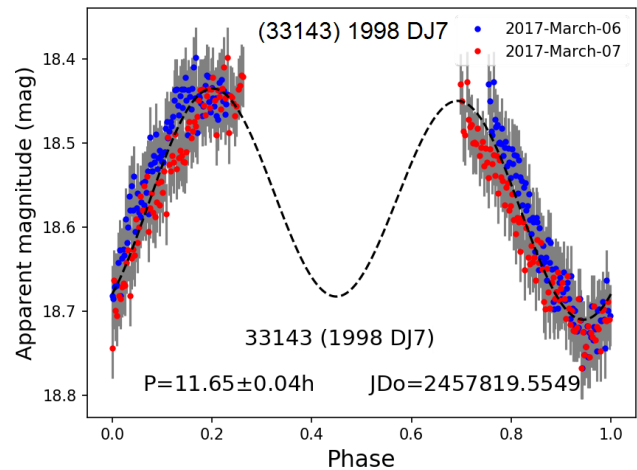
The asteroids (33143) 1998 DJ7, (57735) 2001 UQ159, and (73308) 2002 JJ74 were observed in 2017 March, 2018 April, and 2018 March, respectively. The possible synodic periods were found to be 11.65 h, 16.26 h, and 1.57 h, respectively.

The asteroids (33143) 1998 DJ7 and (57735) 2001 UQ159 belong to the Karin family, located in the outer main-belt (Carruba et al., 2016). The asteroid (73308) 2002 JJ74 is located in the inner main-belt and is not related to any identified family.

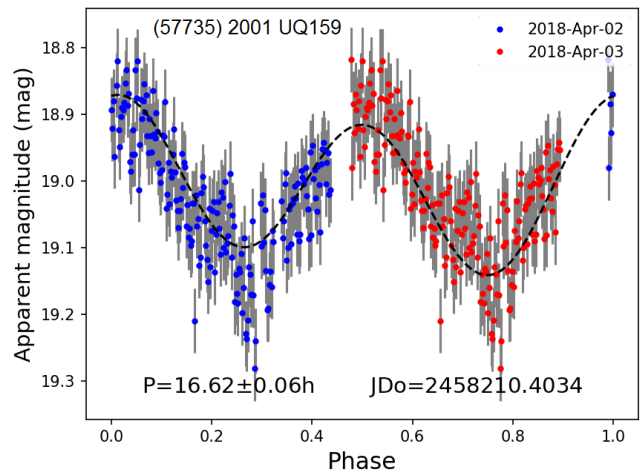
The asteroids were observed with the 2.12-m *f*/7.5 Ritchey-Chretien telescope of the National Astronomical Observatory in San Pedro Mártir-Mexico (OAN-SPM). The CCD camera was a Spectral with an array of 2048x2048x13.5 micron pixels that was binned 2x2. This configuration gave a field-of-view of approximately 6x6 arcmin and an image scale of 0.17 arcsec/pix.

The calibration images were reduced using *IRAF* (Image Reduction and Analysis Facility) and for photometry we used an automated pipeline (Mommert, 2017). The phased lightcurves show the apparent magnitude versus the phase, corrected by light-time travel UT. We wrote a program in Python in which the period was found by fitting a Fourier series to the data following the methodology of Harris et al., (1989). In a search of the asteroid lightcurve database (Warner et al., 2009), we did not find a previously reported result for the three asteroids. The observational circumstances and results are summarized in Table I.

(33143) 1998DJ7. This was observed on 2017 March 6 and 7 for about 12 hours in R filter, with an exposure time of 90 s. In the analysis of the lightcurves, we found a rotation period of 11.65 ± 0.04 h ($f = 2.06/\text{day}$) with a second-order Fourier curve. Our data cover a half of the full phased lightcurve.



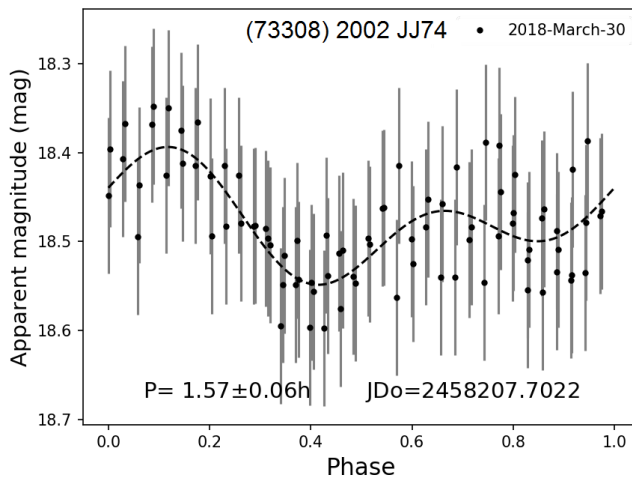
(57735) 2001 UQ159. This asteroid was observed on 2018 April 2 and 3 for about 14 hours in R filter, with an exposure time of 90s. The best solution was obtained with second-order fit with a period of 16.62 ± 0.06 h ($f = 1.44/\text{day}$). Our data cover the major part of the phased lightcurve.



(73308) 2002 JJ74. This was observed on 2018 March 30 for about 4 hours. The best period found was 1.57 ± 0.06 h ($f = 15.27/\text{day}$) with second-order of Fourier fit. It is a fast rotator with a frequency that falls beyond the rotation rate barrier of 11 rev/d for rubble piles. On average, its structure could be like a monolith (Pravec and Harris, 2000).

Number	Name	yyyy	mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
33143	1998 DJ7	2017	03/06-03/07	376	12.2,12.6	135	1	11.65	0.04	0.27	0.01	KAR
57735	UQ159	2018	04/02-04/03	383	4.0,4.4	183	4	16.62	0.06	0.77	0.01	KAR
73308	2002 JJ74	2018	03/30-03/30	83	20.0,20.0	228	3	1.57	0.06	0.14	0.01	-

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



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SPIN AXIS AND SHAPE MODEL FOR 1117 REGINITA

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We present shape and spin axis model for main-belt asteroid 1117 Reginita. The model was achieved with the lightcurve inversion process using combined dense photometric data acquired from nine apparitions between 2003-2018 and sparse data from USNO Flagstaff. Analysis of the resulting data found a sidereal period $P = 2.946472 \pm 0.000002$ hours and two mirrored pole solutions at $(\lambda = 0^\circ, \beta = 43^\circ)$ and $(\lambda = 174^\circ, \beta = 47^\circ)$ with an uncertainty of ± 5 degrees.

The spin-axis determination of an asteroid is an important source of statistical data for physical studies of asteroids (e.g. collisional families evolution). The lightcurve inversion method is one of the main sources of the spin-axis measurement (Durech et al. 2010). We aimed to contribute to this goal.

The minor planet 1117 Reginita was observed in the past by the authors in order to acquire data for lightcurve inversion work (Franco et al., 2018; Galdies et al., 2019). A search in the asteroid lightcurve database (LCDB; Warner et al., 2009) shows many entries covering a wide range of phase angle bisectors. This presented an ideal starting point for lightcurve inversion. Dense photometric data were downloaded from ALCDEF (ALCDEF, 2019) and from CDS service (CDS, 2018). Sparse data were taken from the Asteroids Dynamic Site (AstDyS-2, 2018).

The observational details of the dense data used are reported in Table I with the mid date of the observing campaign, longitude and latitude of phase angle bisector (L_{PAB} , B_{PAB}).

Lightcurve inversion was performed using *MPO LCInvert* v.11.7.5.1 (BDW Publishing, 2016). For a description of the modeling process see the *LCInvert Operating Instructions Manual* and Warner et al. (2017). Our data set of observations had sparse data from (689) USNO Flagstaff station in addition to the dense data. Figure 1 shows the wide PAB longitude/latitude distribution for dense/sparse data used in the lightcurve inversion process. Figure 2 (top panel) shows the sparse photometric data distribution (intensities vs JD) and (bottom panel) the corresponding phase curve (reduced magnitudes vs phase angle).

Reference	Mid date	PABL°	PABB°
Kryszczyńska et al. (2012)	2003-03-26	82	-3
Kryszczyńska et al. (2012)	2004-03-09	163	2
Kryszczyńska et al. (2012)	2005-09-15	11	-4
Kryszczyńska et al. (2012)	2007-01-22	127	-2
Kryszczyńska et al. (2012)	2008-06-28	274	6
Kryszczyńska et al. (2012)	2010-01-16	93	-4
Kryszczyńska et al. (2012)	2011-04-07	196	5
Waszczak et al. (2015)	2014-02-21	152	0
Franco et al. (2018); Galdies et al. (2019)	2018-05-26	244	7

Table I. Observational details for the data used in the lightcurve inversion process for 1117 Reginita.

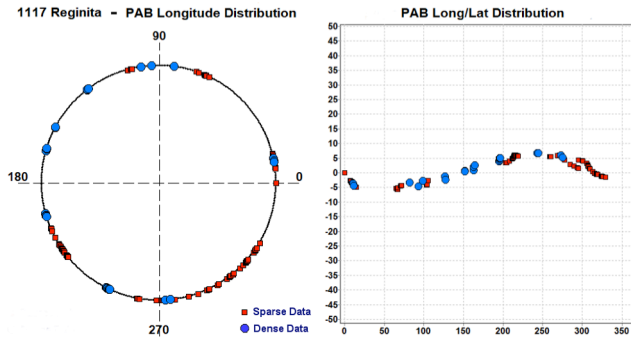


Figure 1. PAB longitude and latitude distribution of the data used for the lightcurve inversion model.

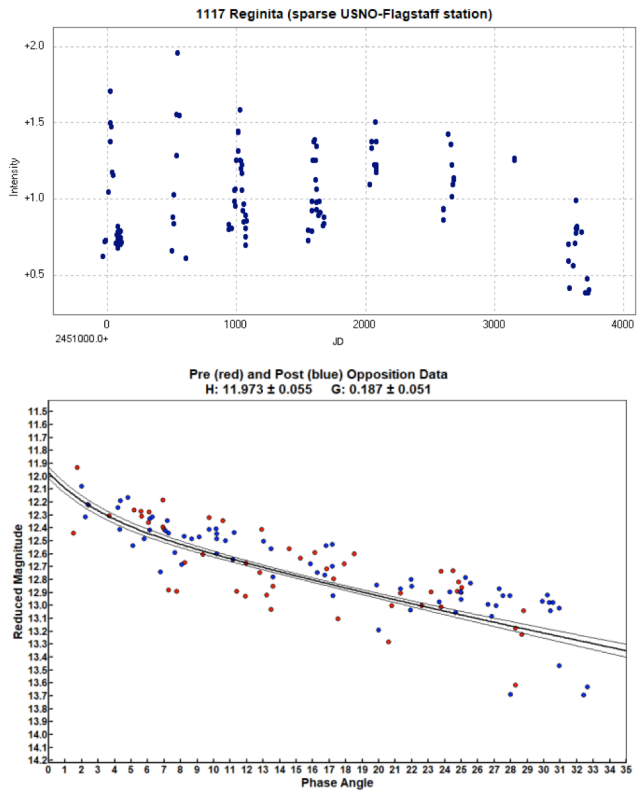


Figure 2. Top: sparse photometric data point distribution from USNO Flagstaff station. Bottom: phase curve obtained from the sparse data.

The sidereal period search was started around the average of the synodic periods found in the asteroid lightcurve database (LCDB; Warner et al., 2009). We found no other sidereal periods with a Chi-Sq within 10% of the lowest Chi-Sq (Figure 3), thus giving good confidence in the period solution.

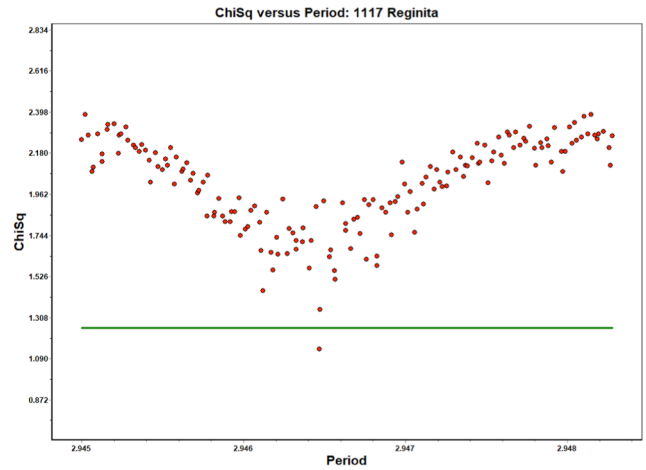


Figure 3. The period search for 1117 Reginita shows no other Chi-Sq values within 10% of the lowest value.

The pole search was started using the “medium” option with the previously found sidereal period set to “float”. The “dark facet” weighting factor was set to 0.5 and the number of iterations was set to 50. From this step we found two roughly mirrored lower Chi-Sq solutions (Figure 4) separated by 180° in ecliptic longitude, (0°, 45°) and (180°, 45°).

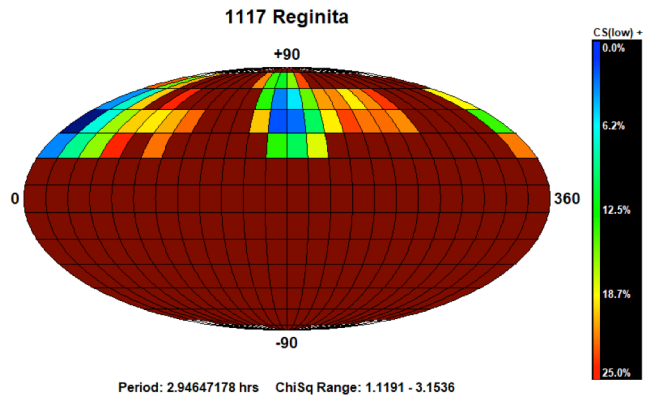


Figure 4. Pole search distribution. The dark blue indicates the better solutions (lower Chi-Sq), while maroon the worst ones.

The subsequent “fine” search that was centered on these rough positions allowed us to refine the position of the pole (Figure 5). The analysis shows two clustered solutions of ecliptic longitude-latitude pairs within 5° that had Chi-Sq values within 5% of the lowest value.

The two best solutions (lower two Chi-Sq) are reported in Table II. The sidereal period was obtained by averaging the two solutions found in the pole search process. Typical errors in the pole solution are ± 5° and the uncertainty in sidereal period has been evaluated as a rotational error of 10° over the total time span of the dense data set. Figure 6 shows the shape model (first

solution) while Figure 7 shows the fit between the model (black line) and some observed lightcurves (red points).

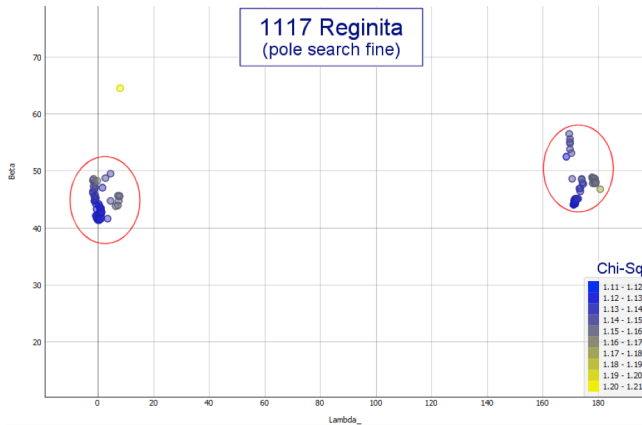


Figure 5. The “fine” pole search shows two clustered solutions centered at the ecliptic longitude/latitude (1°, 44°) and (173°, 47°) with radius approximately of 5 degrees and Chi-Sq values within 5% of the lowest value.

λ °	β °	Sidereal Period (hours)	RMS
0	43	2.946472 ± 0.000002	0.0331
174	47		0.0334

Table II. The two spin axis solutions for 1117 Reginita (ecliptic coordinates). The sidereal period was the average of the two solutions found in the pole search process.

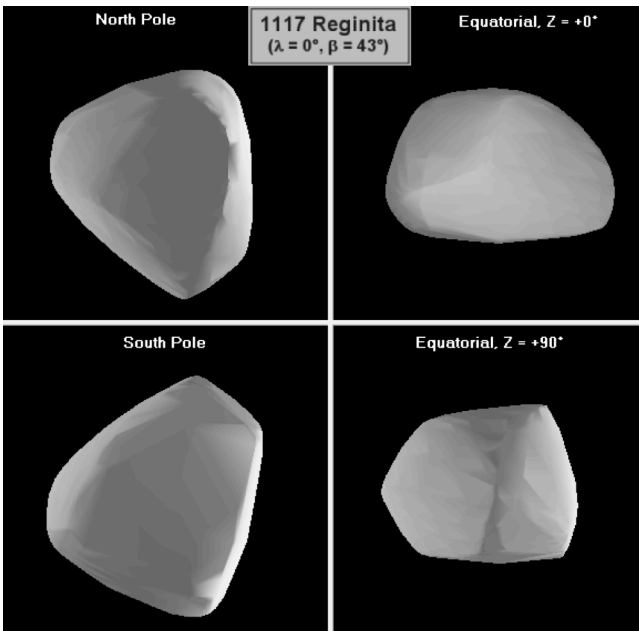


Figure 6. The shape model for 1117 Reginita ($\lambda = 0^\circ, \beta = 43^\circ$).

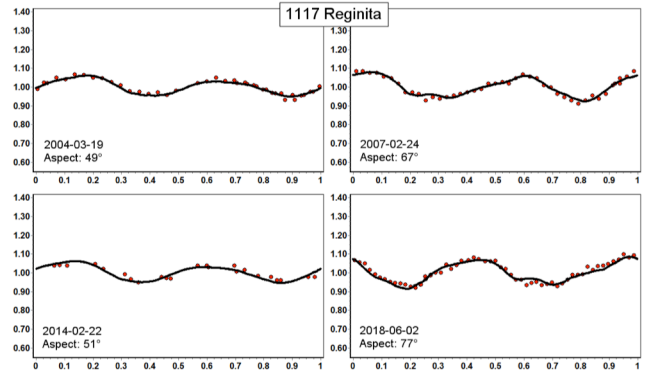


Figure 7. Model fit (black line) versus observed lightcurves (red points) for ($\lambda = 0^\circ, \beta = 43^\circ$) solution.

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LIGHTCURVE ANALYSIS OF TEN ASTEROIDS

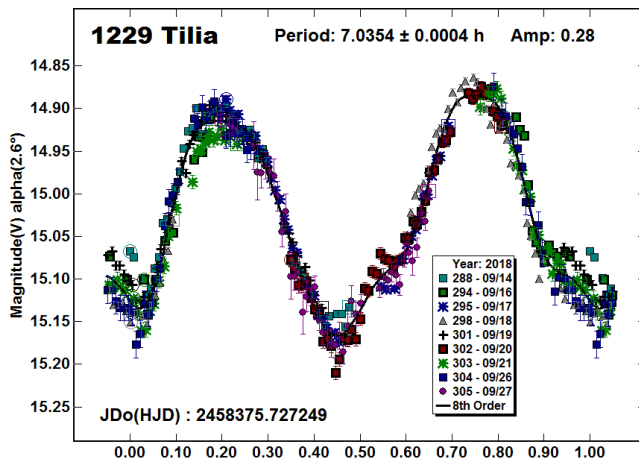
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(Received: 2019 February 27)

Lightcurves for ten main-belt asteroids were obtained at the Barnes Ridge Observatory from 2018 May 30 through 2018 November 18. Synodic rotation periods and amplitudes are found for nine main-belt asteroids. The nine are 1229 Tilia: 7.0354 h, 0.28 mag; 2206 Gabrova: 5.076 h, 0.25 mag; 2399 Terradas: 15.234 h, 0.058 mag; 3072 Vilnius: 7.1940 h, 0.56 mag; 3677 Magnusson: 9.4660 h, 0.72 mag; 3788 Steyaert: 18.467 h, 0.57 mag; 7230 Lutz: 5.6960 h, 0.25 mag; 10358 Kirchoff: 7.4084 h, 0.36 mag; (11650) 1997 CN: 7.7246 h, 0.33 mag; (26377) 1999 FH4: 6.7755 h, 0.41 mag.

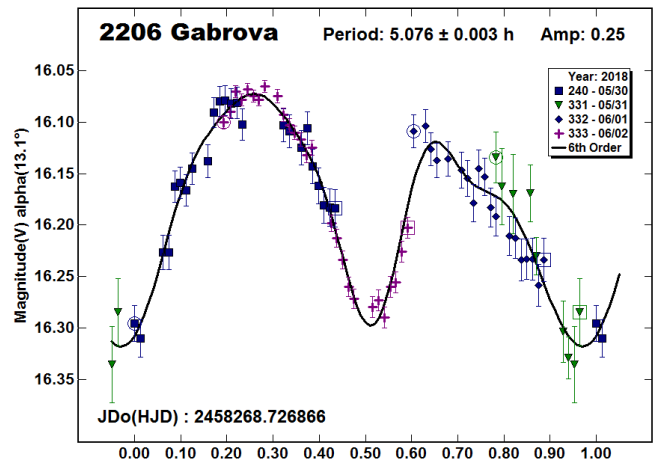
Photometric data for nine asteroids were obtained at Barnes Ridge Observatory located in northern California, USA, using a 0.43-m PlaneWave f/6.8 corrected Dall-Kirkham astrograph and Apogee U9 camera. The camera was binned 2x2 with a resulting image scale of 1.26 arcsec per pixel. All image exposures 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 except 2206 Gabrova with a minimum of 30.

1229 Tilia. Data were collected from 2018 September 14 through 27 resulting in 9 nights totaling 407 data points. 1229 Tilia was tracked through 44.652 revolutions from phase angles of 2.54 through 7.97 deg. A period of 7.0354 ± 0.0004 h was calculated with a peak-to-peak amplitude of 0.28 ± 0.05 mag. Observations at small phase angles allowed calculation of H-G values of 11.587 ± 0.044 and 0.746 ± 0.131 respectively. Data were previously reported by KlingleSmith III (2018) with a period of 7.035 ± 0.001 h and amplitude of 0.30 ± 0.05 mag.

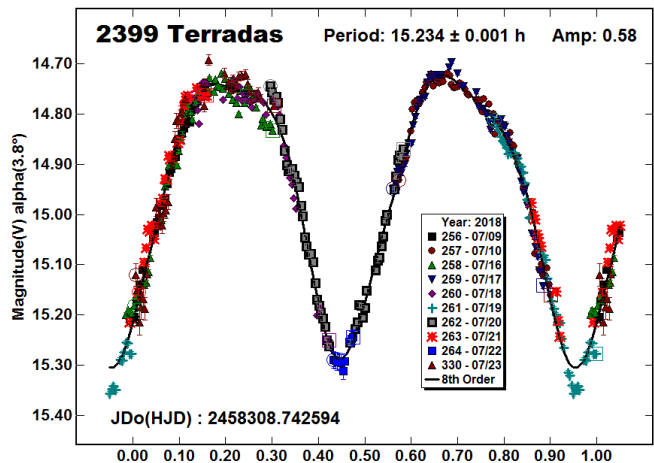


2206 Gabrova. Data were collected from 2018 May 30 through June 02 resulting in 4 nights totaling 81 data points. Most data points were greater SNR than 100 with a few as low as 30. 2206 Gabrova was tracked through 14.592 revolutions from phase angles of 13.09 through 13.94 deg. A period of 5.076 ± 0.003 h

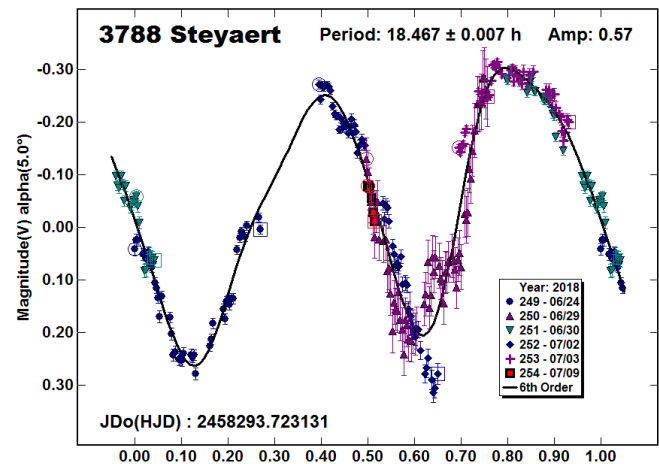
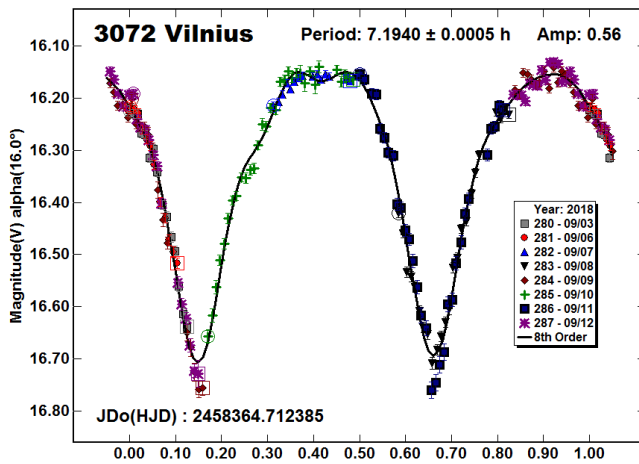
was calculated with a peak-to-peak amplitude of 0.025 ± 0.05 mag. With phase angles being in the range of 13 deg. H-G values were not calculated. A search of the Asteroid Lightcurve Database (and other resources) did not find any previously reported results for asteroid 2206.



2399 Terradas. Data were collected from 2018 July 09 through 23 resulting in 10 nights totaling 455 data points. 2399 Terradas was tracked through 22.306 revolutions from phase angles of -3.85 through 8.89 deg. A period of 15.234 ± 0.001 h was calculated with a peak-to-peak amplitude of 0.58 ± 0.05 mag. Observations at small phase angles allowed calculation of H-G values of 13.488 ± 0.042 and 0.038 ± 0.062 respectively. A search of the Asteroid Lightcurve Database (and other resources) did not find any previously reported results for asteroid 2399.

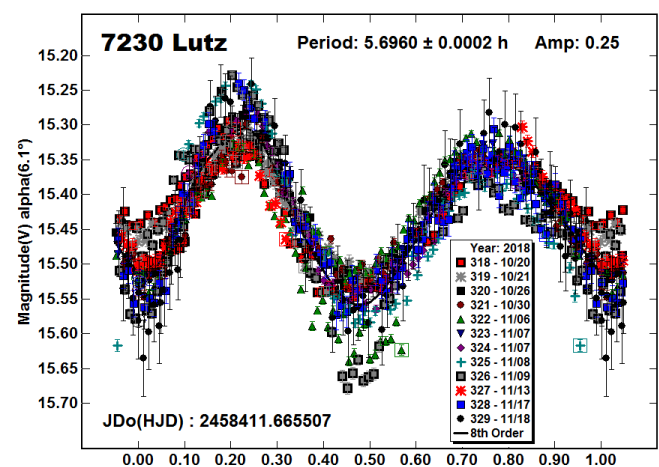
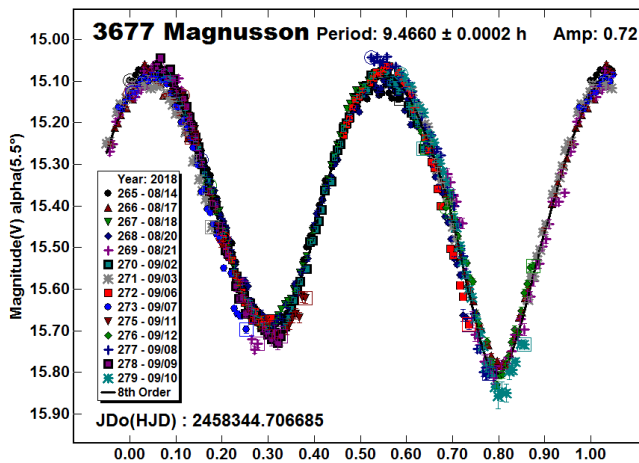


3072 Vilnius. Data were collected from 2018 September 03 through 12 resulting in 8 nights totaling 195 data points. 3072 Vilnius was tracked through 30.151 revolutions from phase angles of 15.16 through 20.00 deg. A period of 7.1940 ± 0.0005 h was calculated with a peak-to-peak amplitude of 0.56 ± 0.03 mag. Due to data being taken only at large phase angles reliable H-G values were not calculated. A search of the Asteroid Lightcurve Database (and other resources) did not find any previously reported results for asteroid 3072.



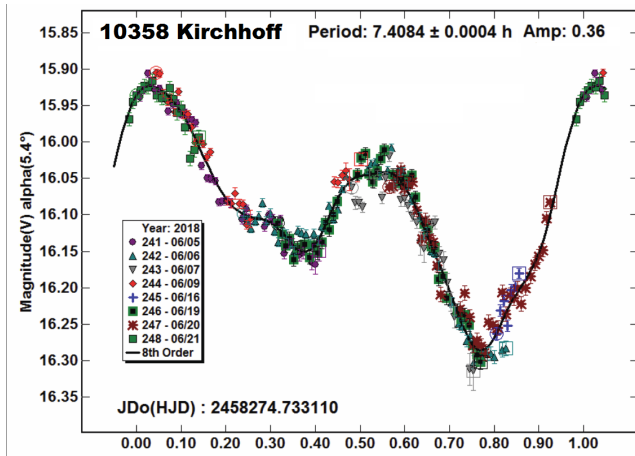
3677 Magnusson. Data were collected from 2018 August 14 through September 12 resulting in 14 nights totaling 743 data points. 3677 Magnusson was tracked through 73.879 revolutions from phase angles of 4.99 through 19.54 deg. A period of 9.4660 ± 0.0002 h was calculated with a peak-to-peak amplitude of 0.72 ± 0.08 mag. Observations at small phase angles allowed calculation of H-G values of 14.061 ± 0.056 and 0.118 ± 0.060 respectively. Data were previously reported by Klingensmith III (2018) with a period of 9.47 ± 0.01 h and amplitude of 0.68 ± 0.10 mag.

7230 Lutz. Data were collected from 2018 October 20 through November 18 resulting in 12 nights totaling 936 data points. 7230 Lutz was tracked through 123.096 revolutions from phase angles of 6.17 through 21.65 deg. A period of 5.6960 ± 0.0002 h was calculated with a peak-to-peak amplitude of 0.25 ± 0.12 mag. Calculated H-G values were 13.937 ± 0.077 and -0.041 ± 0.060 respectively. Data were previously reported by Marchini et al, (2018) with a period of 5.682 ± 0.007 h and amplitude of 0.18 ± 0.02 mag.

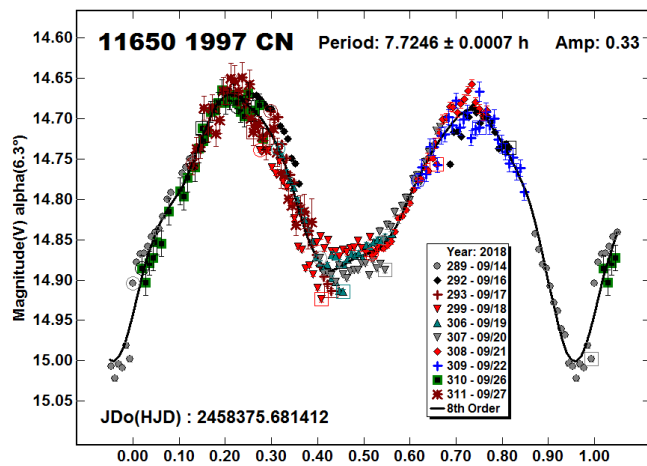


3788 Steyaert. Data were collected from 2018 June 24 through July 09 resulting in 6 nights totaling 259 data points. On the nights data were collected for 3788 Steyaert it was located in the Milky Way along with a dense field of background stars. Even using Canopus' Star Subtraction feature it was difficult to determine if some background stars may have contaminated the data. Even though a period of 18.467 ± 0.007 h was calculated with a peak-to-peak amplitude of 0.57 ± 0.16 mag. more data would help secure a better solution. 3788 Steyaert was tracked through 19.517 revolutions. With phase angles of 5.01 through 9.50 deg. H-G calculated values were 12.294 ± 0.140 and 0.150 ± 0.200 respectively using fixed G. A search of the Asteroid Lightcurve Database (and other resources) did not find any previously reported results for asteroid 3788.

10358 Kirchhoff. Data were collected from 2018 June 05 through 21 resulting in 8 nights totaling 261 data points. A period of 7.4084 ± 0.0004 h was calculated with a peak-to-peak amplitude of 0.36 ± 0.03 mag. 10358 Kirchhoff was tracked through 52.141 revolutions from phase angles of 5.42 through 13.97 deg. Calculated H-G values were 14.330 ± 0.125 and 0.251 ± 0.179 respectively. A search of the Asteroid Lightcurve Database (and other resources) did not find any previously reported results for asteroid 10358.

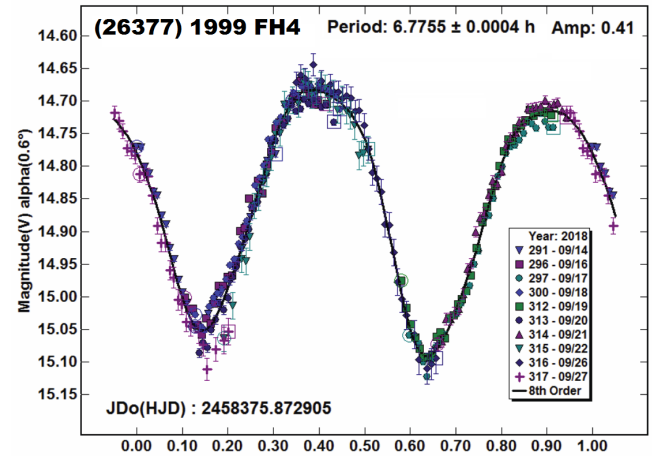


(11650) 1997 CN. Data were collected from 2018 September 14 through 27 resulting in 10 nights totaling 312 data points. A period of 7.7246 ± 0.0007 h was calculated with a peak-to-peak amplitude of 0.33 ± 0.05 mag. (11650) 1997 CN was tracked from phase angles of 1.45 through 9.38 deg. Calculated H-G values were 13.773 ± 0.073 and 0.974 ± 0.255 respectively. Data were previously reported by Mollica et al, (2018) with a period of 7.7175 ± 0.0007 h and amplitude of 0.27 ± 0.01 mag.



(26377) 1999 FH4. Data were collected from 2018 September 14 through 27 resulting in 10 nights totaling 324 data points. A period of 6.7755 ± 0.0004 h was calculated with a peak-to-peak amplitude of 0.41 ± 0.04 mag. (26377) 1999 FH4 was tracked from phase angles of -0.65 through 7.61 deg. Since the maximum phase angle measured was 7.61, G was fixed at 0.150 resulting in

H-G values of 12.940 ± 0.056 and 0.150 ± 0.200 . A search of the Asteroid Lightcurve Database (or other resources) did not find any previously reported results for asteroid (26377).



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LCDB: <http://www.minorplanet.info/lightcurvedatabase.html>

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Number	Name	20yy mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp
1229	Tilia	18/09/14-18/09/27	407	2.54, 7.97	345.7	0.6	7.0354	0.0004	0.28
2206	Gabrova	18/05/30-18/06/02	81	13.09, 13.94	215.8	4.8	5.076	0.003	0.25
2399	Terradas	18/07/09-18/07/23	455	-3.85, 8.89	288.2	4.8	15.234	0.001	0.58
3072	Vilnius	18/09/03-18/09/12	195	15.16, 20.00	318.2	0.7	7.1940	0.0005	0.56
3677	Magnusson	18/08/14-18/09/12	743	4.99, 19.54	320.2	5.8	9.4660	0.0002	0.72
3788	Steyaert	18/06/24-18/07/09	259	5.01, 9.50	277.87	8.8	18.467	0.007	0.57
7230	Lutz	18/10/20-18/11/18	936	6.17, 21.65	21.2	0.5	5.6960	0.0002	0.25
10358	Kirchoff	18/06/05-18/06/21	261	5.42, 13.97	248.4	3.8	7.4084	0.0004	0.36
11650	1997 CN	18/09/14-18/09/27	312	1.45, 9.38	353.6	8.4	7.7246	0.0007	0.33
26377	1999 FH4	18/09/14-18/09/27	324	-0.65, 7.61	351.4	-2.0	6.7755	0.0004	0.41

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). family/group (Warner et al., 2009).

LIGHTCURVE ANALYSIS OF MINOR PLANETS OBSERVED AT THE OAKLEY SOUTHERN SKY OBSERVATORY: 2018 MAY–JUNE

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During 2018 May and June, we observed twelve minor planets from the Oakley Southern Sky Observatory. The targets were 1032 Pafuri, 2071 Nadezhda, 2206 Gabrova, 2685 Masursky, 3214 Makarenko, 3403 Tammy, 4990 Trombka, 5547 Acadiau, (7834) 1993 JL, 10358 Kirchhoff, (11200) 1999 CV121, and (33903) 2000 KH68.

In 2018, we made CCD photometric observations on every clear night from May 7-23 for 1032 Pafuri, 2206 Gabrova, 2685 Masursky, 3214 Makarenko, (7834) 1993 JL, and (11200) 1999 CV121. Observations of 2071 Nadezhda, 3403 Tammy, 4990 Trombka, 5547 Acadiau, 10358 Kirchhoff, and (33903) 2000 KH68 were made from June 2-13.

The telescope in the Oakley Southern Sky Observatory is a 0.5-m corrected Dall-Kirkham from Planewave. A new camera, a ProLine PL4240 from Finger Lakes Instrumentation, was installed in 2018 April. The camera has 13.5 μm pixels. When binned 2x2, this gave an image scale of 1.63 arcseconds per pixel. Standard image processing was done using *MaxImDL*. The photometric measurements were made with *MPO Canopus*.

Table I lists the targets, the range of dates when they were observed, the number of data points used, the phase angle range, and the phase angle bisector longitude and latitude. If a period was determined, it is included in the table with an estimated uncertainty on the period. For all of the minor planets, an amplitude was determined with an estimated uncertainty.

We were unable to determine periods for 2071 Nadezhda, 2685 Masursky, 3214 Makarenko, 3404 Tammy and 4990 Trombka because our data for these minor planets was too noisy.

1032 Pafuri. In 2007 (Hawkins and Ditteon, 2008) and again in 2008 (Carbo *et al.* 2009), we collected data on this minor planet but were unable to determine a period. We are very pleased to finally report a rotation period of 33.39 ± 0.03 h.

Number	Name	2018 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
1032	Pafuri	05/07-05/23	179	4.4, 9.9	219	7	33.39	0.03	0.14	0.02
2071	Nadezhda	06/02-06/13	142	4.3, 10.0	247	-4			0.20	0.05
2206	Gabrova	05/09-05/23	147	6.0, 10.8	215	6	5.07	0.01	0.15	0.05
2685	Masursky	05/04-05/23	148	1.8, 10.5	220	2			0.04	0.02
3214	Makarenko	05/07-05/23	159	6.3, 9.8	220	12			0.04	0.02
3403	Tammy	06/02-06/12	121	4.7, 9.9	246	5			0.12	0.03
4990	Trombka	06/02-06/13	129	5.0, 10.1	249	-6			0.4	0.1
5547	Acadiau	06/02-06/13	110	3.2, 8.6	246	2	3.642	0.004	0.15	0.03
7834	1993 JL	05/07-05/23	193	7.9, 12.9	220	12	15.77	0.05	0.12	0.04
10358	Kirchhoff	06/02-06/13	111	3.8, 9.5	248	4	7.40	0.02	0.40	0.03
11200	1999 CV121	05/09-05/23	171	5.8, 12.4	219	3	6.793	0.001	0.30	0.03
33903	2000 KH68	06/02-06/13	142	2.0, 8.5	248	1	14.40	0.03	0.16	0.02

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

(7834) 1993 JL. Our period of 15.77 ± 0.05 h just barely overlaps with the period of 15.707 ± 0.016 h found by Waszczak *et al.* (2015).

(11200) 1999 CV121. Galdies *et al.* (2019) has recently reported a period of 6.792 ± 0.001 h, which agrees with our finding of 6.793 ± 0.001 h.

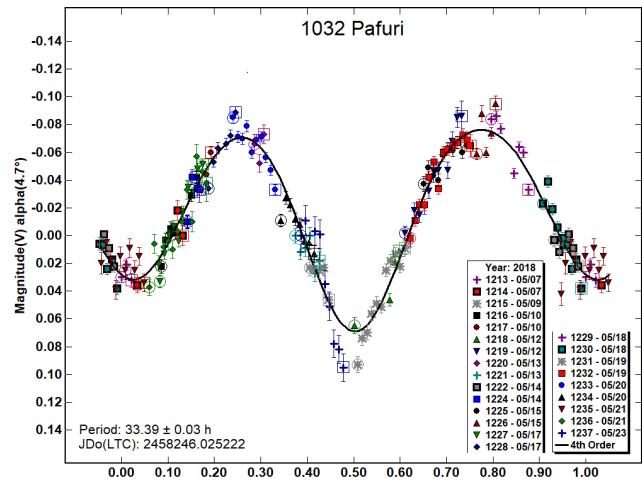
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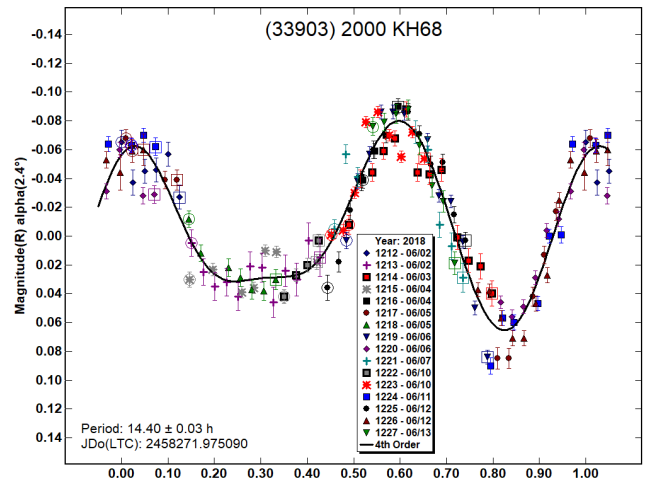
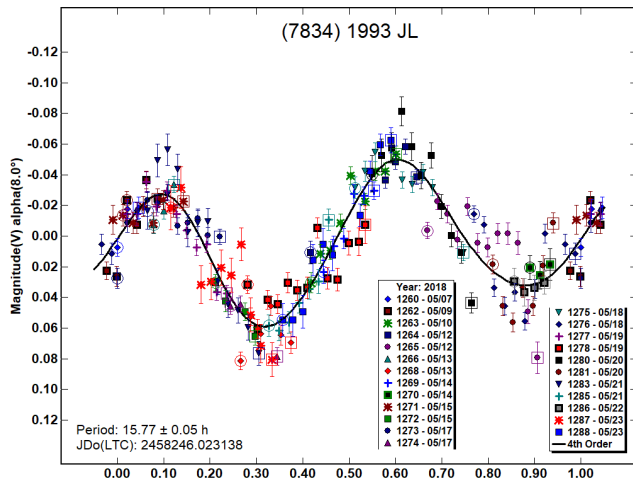
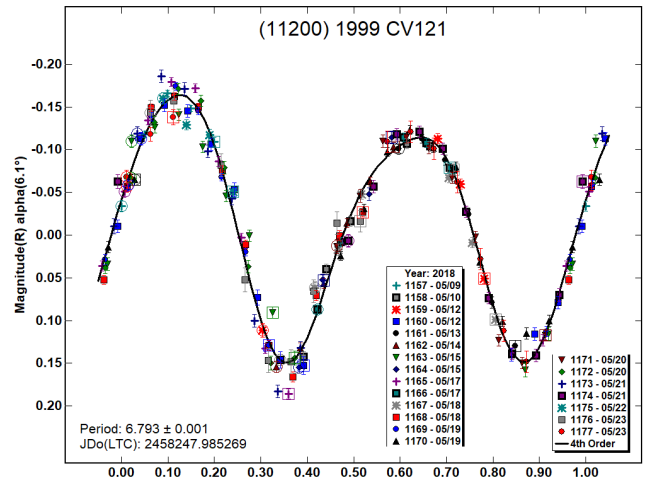
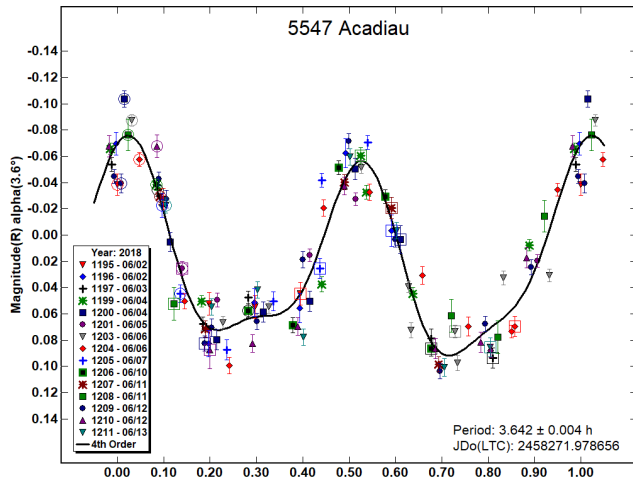
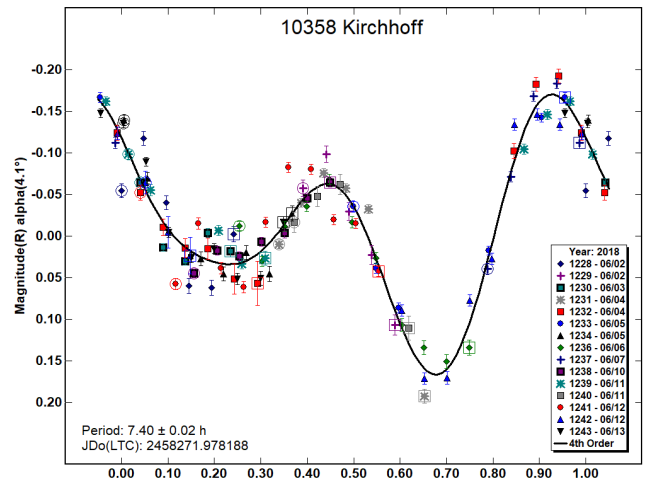
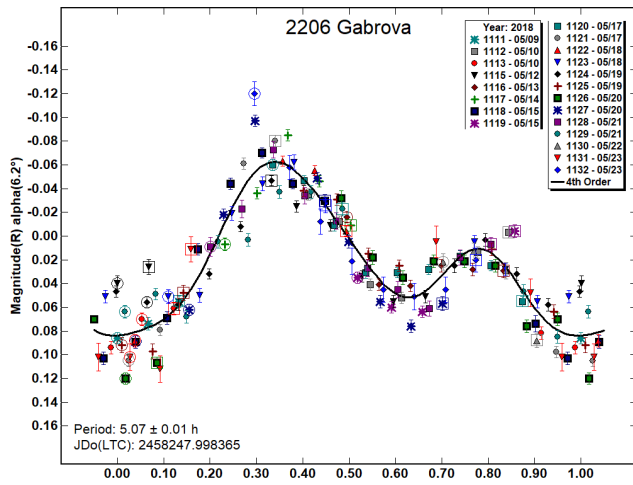
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**ROTATIONAL PERIOD DETERMINATION FOR
ASTEROIDS 1802 ZHANG HENG
AND (110767) 2001UB25**

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(Received: 2019 March 17)

CCD photometric observations of two main-belt asteroids were obtained in order to measure their rotation period. These measures were performed during two different nights on 6/1/2019 and 8/3/2019, using the instrumentation available at the Osservatorio Astronomico Margherita Hack located on the hills near Florence (Italy).

CCD photometric observations of two main-belt asteroids were carried out in 2019 January and March at the Osservatorio Astronomico Margherita Hack (A57). We used a 0.35-m f/8,25 Smith-Cassegrain telescope, a SBIG ST10 XME CCD camera, and clear filter. The pixel scale was 1 arcsec when binned at 2x2 pixels. Exposures were 120 sec. on 1802 Zhang Heng and 240 sec. on (110767) 2001UB25. Data processing and analysis were done with MPO Canopus (Warner, 2017). All the images were calibrated with dark and flat field frames using Astroart 6.0. Table I shows the observing circumstances and results.

1802 Zhang Heng was discovered on 1964 Sep 10 at Nanking by Purple Mountain Observatory. It was named in memory of Zhang Heng (78-139), a prominent scientist of the Eastern Han Dynasty. It was chosen from the list of lightcurve photometry opportunities on the Minor Planet Bulletin (Warner et al., 2019 Jan-Mar). It is a main-belt asteroid with a semi-major axis of 2.842 AU, eccentricity 0.0369, inclination 2.690 deg, and an orbital period of 4.79 years. Its absolute magnitude is $H = 11.7$ (JPL, 2019; MPC, 2019). Our observations were conducted in the night across 8/3/2019 and 9/3/2019 and provided 93 data points distributed in about 6 hours. The period analysis shows a bimodal solution for the rotational period with $P = 3.1554 \pm 0.0068$ hr and an amplitude $A = 0.34$, (amplitude error) $AE = 0.01$ mag (Figure 1). The split-halves plot (Figure 2) let us solve the potential ambiguity between monomodal e bimodal solution by showing that the two halves of the 3.15 hr solution are not superimposable. This makes the bimodal solution much more probable.

Moreover, we consulted the asteroid lightcurve database (LCDB; Warner et al., 2009) and we found two previous calculated periods: $P = 3.162 \pm 0.001$ h (Simpson, 2013) e $P = 3.160 \pm 0.0004$ h (Waszczak, 2015). The period we found seems to be in good agreement with the previous mentioned periods.

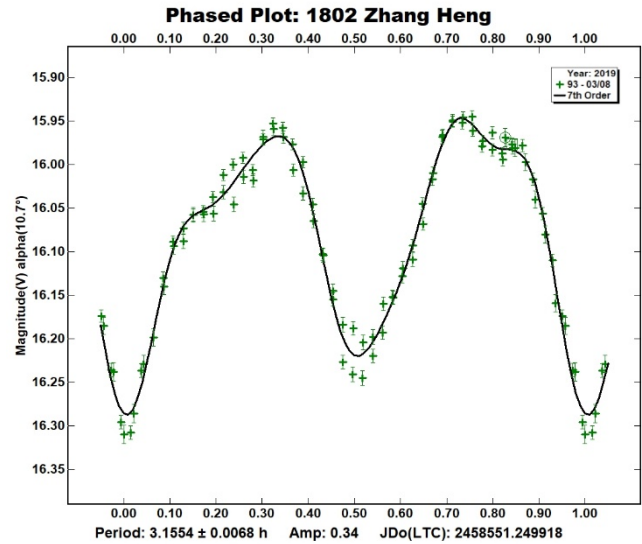


Figure 1. Phased lightcurve of 1802 Zhang Heng.

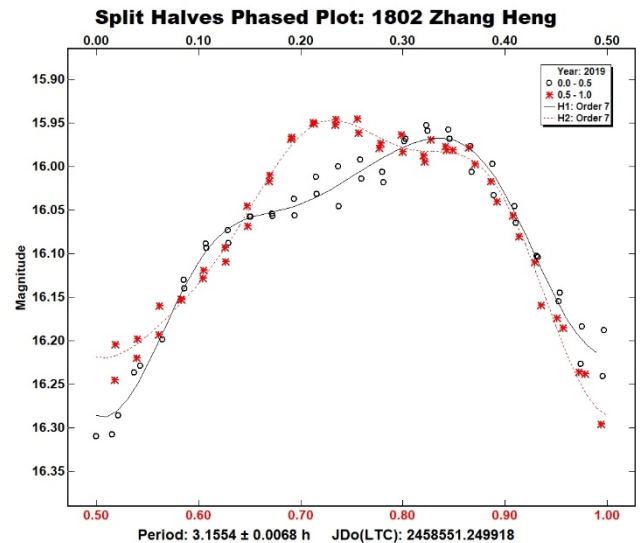


Figure 2. Split halves lightcurve of 1802 Zhang Heng.

(110767) 2001UB25 A search through the asteroid lightcurve database (LCDB; Warner et al., 2009) indicates that our results may be the first lightcurve observation and result for this object. It was discovered at Socorro on 2001 Oct 18 by LINEAR. It is a main-belt asteroid with the semi-major axis of 2.574 AU, eccentricity 0.132, inclination 12.19 deg, and an orbital period of 4.13 years. Its absolute magnitude is $H = 15.1$ (JPL, 2019; MPC, 2019).

Number	Name	2019 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1802	Zhang Heng	03/08	93	10.7	141.7	0.2	3.1554	± 0.0068	0.34	0.01	MB
110767	2001 UB25	01/06	79	4.9	103.8	-8.4	3.1324	± 0.0354	0.32	0.06	MB

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

Observations of this asteroid were conducted in the night across 6/1/2019 and 7/1/2019, and provided 79 data points distributed in about 8 hours. The period analysis shows a bimodal solution for the rotational period $P = 3.1324 \pm 0.0354$ hr with an amplitude $A = 0.32$, $AE = 0.06$ mag (Figure 3).

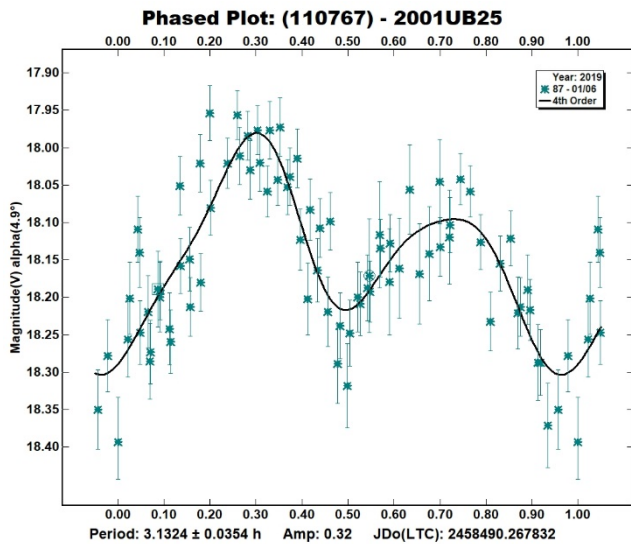


Figure 3. Phased lightcurve of (110767) – 2001 UB25

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TRAPPIST LIGHTCURVES OF MAIN-BELT ASTEROIDS 31 EUPHROSYNE, 41 DAPHNE, AND 89 JULIA

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(Received: 2019 March 29)

Densely sampled lightcurves of three large main-belt asteroids were obtained with the TRAPPIST-South (TS) and TRAPPIST-North (TN) telescopes from 2017 September to 2018 July. We found their synodic rotation periods and amplitudes to be: 31 Euphrosyne, 5.5312 ± 0.0007 h and 0.07 mag; 41 Daphne, 5.9912 ± 0.0028 h and 0.18 mag; and 89 Julia, 11.3844 ± 0.0002 h and 0.19 mag. All data have been submitted to the ALCDEF database.

Observations of the three large and bright main-belt asteroids (MBAs), 31 Euphrosyne, 41 Daphne, and 89 Julia, were obtained with the robotic telescopes TRAPPIST-North (TN, Z53) and TRAPPIST-South (TS, I40) of the Liège University (Jehin et al., 2011). They are located, respectively, at the Oukaïmeden Observatory in Morocco and the ESO La Silla Observatory in Chile. Both are a 0.6-m Ritchey-Chrétien telescope operating at $f/8$ on German Equatorial mounts. At TN the camera is an Andor IKONL BEX2 DD (0.60 arcsec/pixel) and at TS it is a FLI ProLine 3041-BB (0.64 arcsec/pixel).

The photometric measurements were made with *IRAF* scripts after proper calibration with corresponding flat fields, bias, and dark frames. The differential photometry and lightcurve construction were made with Python scripts. For the differential photometry, all the stars with a sufficient SNR were used and checked to discard any variable stars. Various apertures were tested to maximize the SNR. In the lightcurves below, the normalized relative flux is plotted against the rotational phase. The rotation periods were determined with the software *Peranso* (Vanmunster, 2018), which implements the FALC algorithm (Harris et al., 1989). The reported amplitudes are from the Fourier model curves.

Rotation periods for the three targets have already been reported multiple times. A compilation of these results can be found in the asteroid lightcurve database (LCDB; Warner et al., 2009).

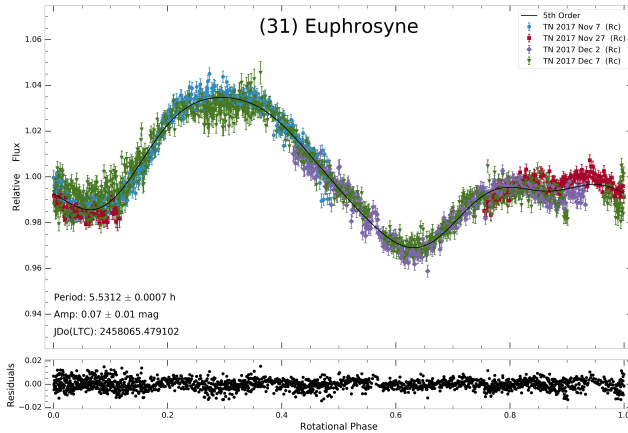
These three asteroids were observed in the framework of the ESO Large Programme ID 199.C-0074 (Vernazza et al., 2018) using

Number	Name	yyyy	mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
31	Euphrosyne	2017	11/07-12/07	1836	19.8, 14.8	90	27	5.5312	0.0007	0.07	0.01	MB-O
41	Daphne	2018	07/08-07/09	1158	19.3, 19.1	338	9	5.9912	0.0028	0.18	0.01	MB-O
89	Julia	2017	09/20-12/23	4411	11.4, 27.5	88	24	11.3844	0.0002	0.19	0.01	MB-I

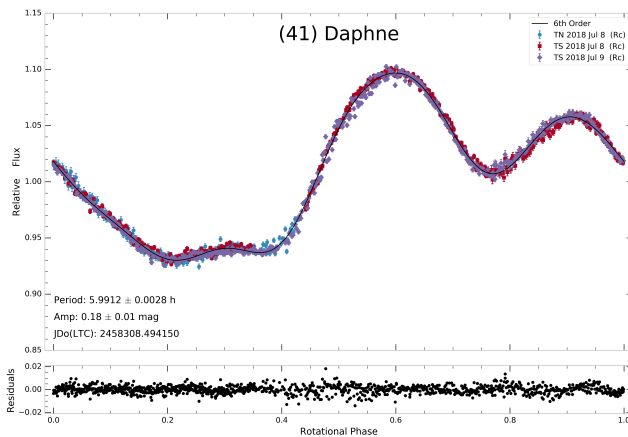
Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid orbital group (see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

the new SPHERE AO facility of the ESO VLT to model the precise volume of a substantial fraction of the largest MBAs.

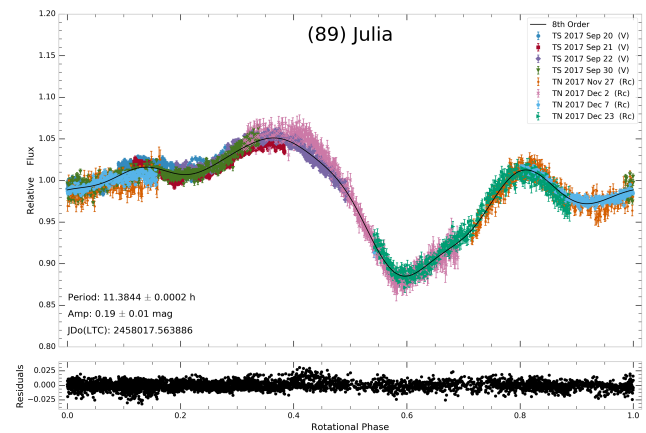
31 Euphrosyne was observed with TN on four nights between 2017 Nov 7 and Dec 7. We used a Rc filter, no binning, and exposure time of 10 s. The period best fitting our data is 5.5312 h, which in agreement with values in the LCDB.



41 Daphne was observed on 2018 July 8 by TN and TS and then by TS only on July 9. It had a V mag of 12. We used an exposure of 30 s with the Rc filter. About 100 comparison stars were used. We derived a period of 5.9912 h, in agreement with values in the LCDB. Those measurements were used by Carry et al. (2019) in the multi-data sources modeling aimed at the characterization of 41 Daphne and its satellite.



89 Julia. This large inner main-belt asteroid was observed for a total of eight nights, first by TS between 2017 Sep 20-30 and then by TN between Nov 27 - Dec 23. The TS observations were made with the V filter while the Rc filter was used at TN. We used exposure of 10 s and about 50 comparison stars. A very dense phased lightcurve was constructed using 4411 individual measurements. The derived rotation period of 11.3844 h is in agreement with values in the LCDB, including Warner (2018). This lightcurve has been used in the shape modelling of 89 Julia in Vernazza et al. (2018).



Acknowledgements

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LIGHTCURVE ANALYSIS OF MINOR PLANETS OBSERVED AT THE OAKLEY SOUTHERN SKY OBSERVATORY: 2018 AUGUST–SEPTEMBER

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During 2018 August and September, we targeted seventeen minor planets for CCD photometric observations using the Oakley Southern Sky Observatory: 1359 Prieska, 1504 Lappeenranta, 2373 Immo, 3197 Weissman, 3248 Farinella, 3330 Gantrisch, 3819 Robinson, 3901 Nanjingdaxue, 4286 Rubtsov, 6086 Vrchlicky, 7291 Hyakutake, 7497 Guangcaishiye, (10565) 1994 AT1, (14874) 1990 US4, (16880) 1998 BW11, (17989) 1999 JE64, and (52402) 1993 TL.

In 2018 we made CCD photometric observations every clear night from Aug 1-11 for the minor planets 1504 Lappeenranta, 3197 Weissman, 3330 Gantrisch, 3901 Nanjingdaxue, (14874) 1990 US4, and (17989) 1999 JE64. From Aug 28 through Sep 9 we observed 1359 Prieska, 3248 Farinella, 6086 Vrchlicky, 7291 Hyakutake, (10565) 1994 AT1, (16880) 1998 BW11 at every opportunity. Minor Planets 2373 Immo, 3819 Robinson, 4286 Rubtsov, 7497 Guangcaishiye, and (52404) 1993 TL were observed when possible from Sep10-20.

The telescope in the Oakley Southern Sky Observatory is a 0.5-m corrected Dall-Kirkham reflector. The camera is a ProLine PL4240 made by Finger Lakes Instrumentation with 13.5 μm pixels. The camera was binned 2x2 which results an image scale of 1.63 arcseconds per pixel. Standard image processing was done using *MaxImDL*. The photometric measurements were made with *MPO Canopus*.

Table I lists the targets, the range of dates when they were observed, the number of data points used, the phase angle range, the phase angle bisector longitude and latitude. If a period was determined, that is also listed with an estimated uncertainty on the period. For all of the minor planets, the peak-to-peak amplitude was determined with an estimated uncertainty.

As it turned out, 3197 Weissman was only about a degree away from Mars during our observations. The glare from Mars prevented us from even measuring this minor planet, so it does not appear in Table I.

We were unable to determine a period for 1359 Prieska, 3819 Robinson, 6086 Vrchlicky, or 7291 Hyakutake because our data for these minor planets was too noisy.

1359 Prieska. In 2011 (Ditteon et al., 2012) and again in 2013 (Vinson et al. 2014), we collected data on this minor planet but were unable to determine a period. Unfortunately, we are still unable to determine a period. Our data collected in 2018 show a very long period (greater than 48 hours) and very low amplitude.

1504 Lappeenranta. Our period of 15.18 ± 0.05 h agrees with the period of 15.190 ± 0.009 h found by Garlitz (2013).

3248 Farinella. Previously (Ditteon, 2012), we reported a period of 6.676 ± 0.002 h for this minor planet. The new data have a better fit with a period of 3.339 ± 0.005 h, which agrees with half the previous period. The shorter period is almost certainly correct.

3819 Robinson. We collected data for 3819 Robinson in 2009 (Krotz, et al. 2010) but were unable to determine a rotation period. We were also unsuccessful in 2018.

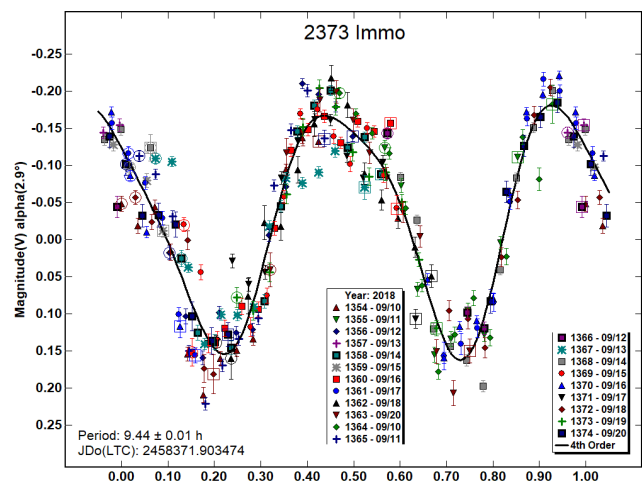
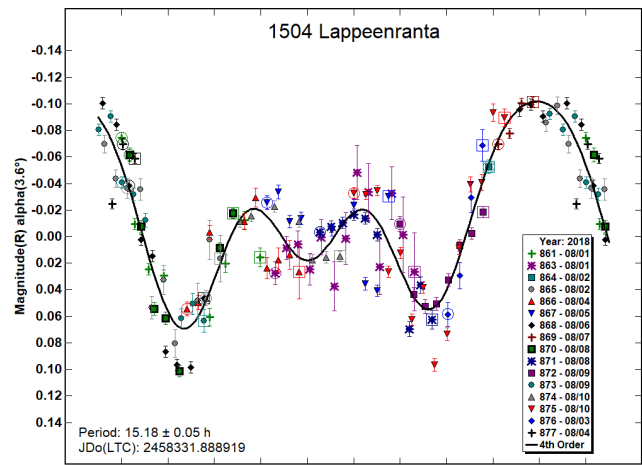
References

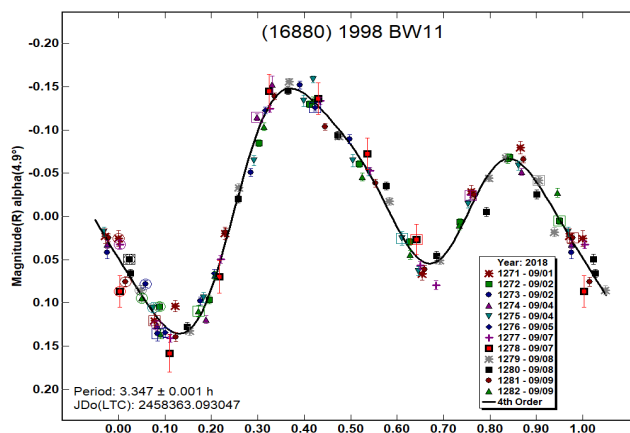
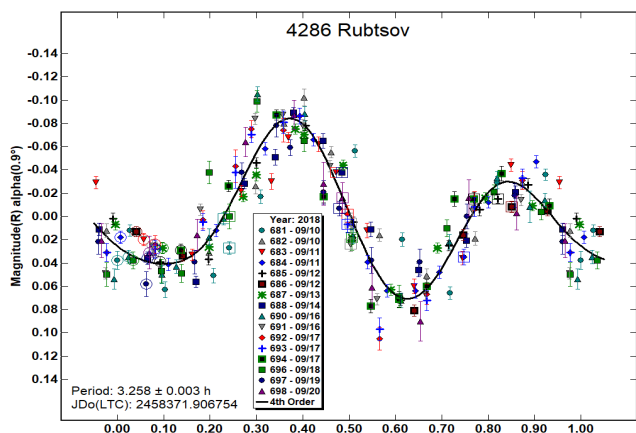
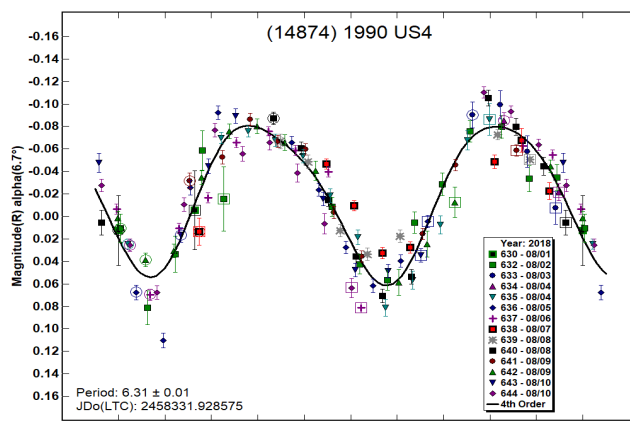
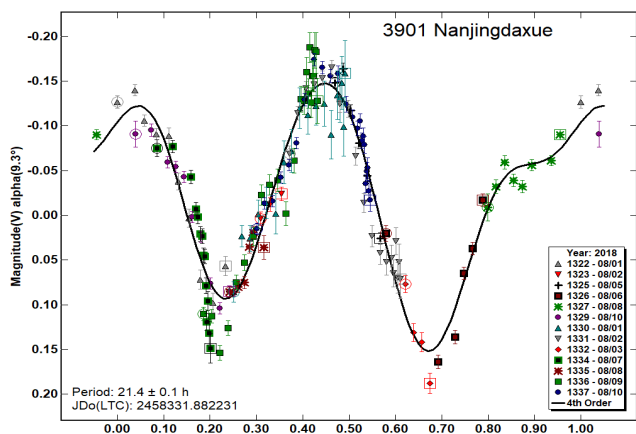
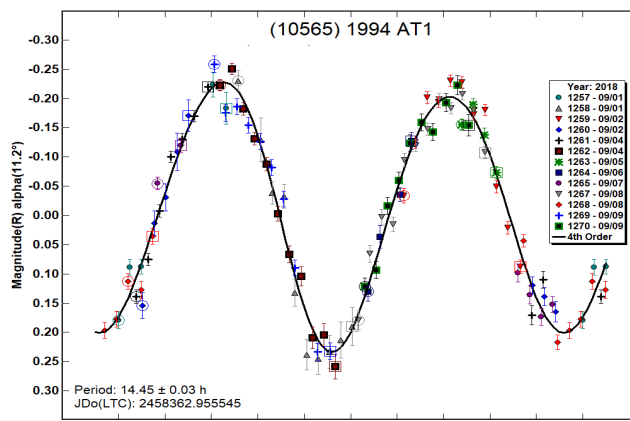
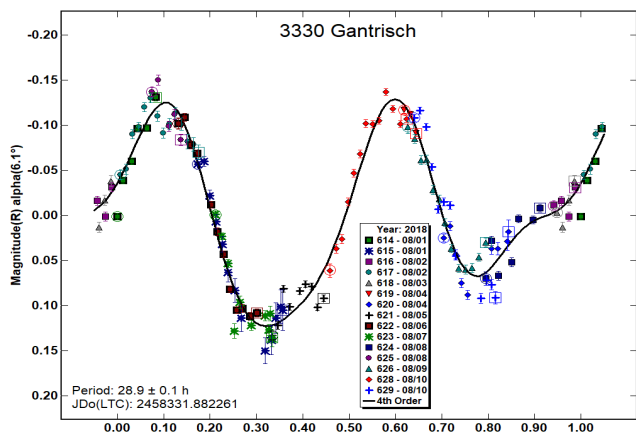
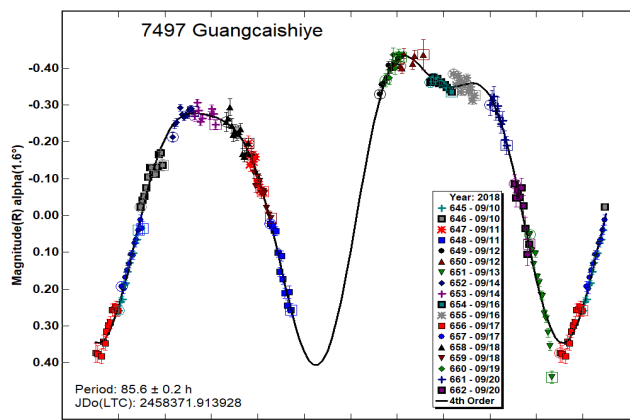
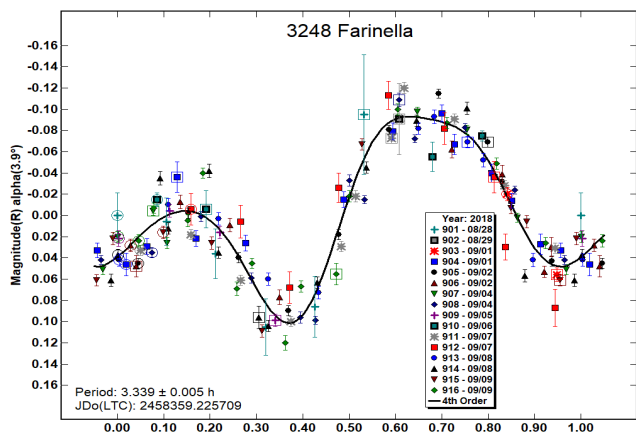
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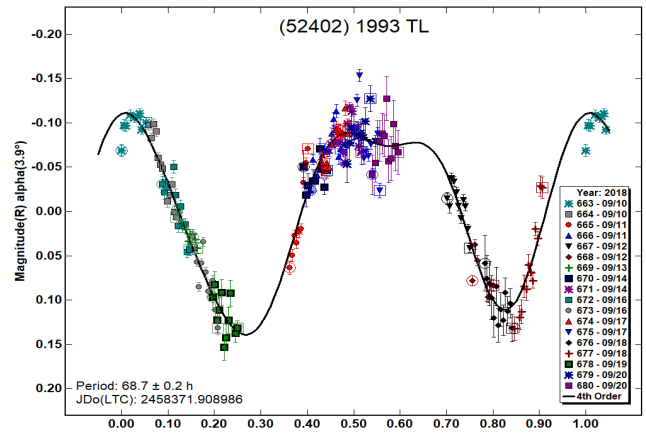
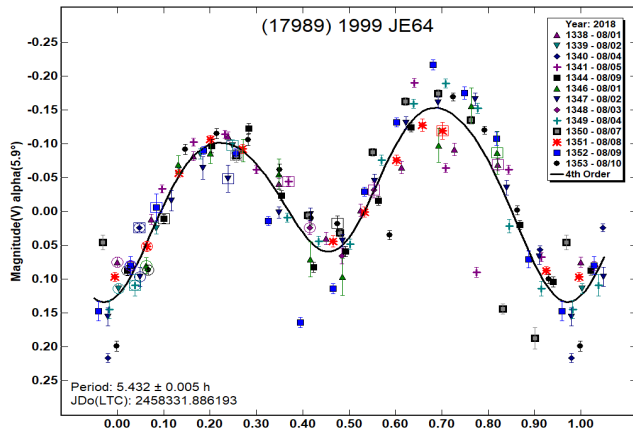
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Number	Name	2018 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.
1359	Prieska	08/28-09/09	151	5.5, 5.4, 6.3	337	-14			0.20	0.03
1504	Lappeenranta	08/01-08/10	130	3.5, 5.7	307	-8	15.18	0.05	0.18	0.03
2373	Immo	09/10-09/20	237	2.7, 6.8	345	-5	9.44	0.01	0.36	0.05
3248	Farinella	08/28-09/09	133	3.9, 3.6, 5.2	337	-8	3.339	0.005	0.18	0.03
3330	Gantrisch	08/01-08/10	134	6.0, 7.5	307	-12	28.9	0.1	0.24	0.03
3819	Robinson	09/10-09/20	286	6.3, 7.8	346	-13			0.15	0.05
3901	Nanjingdaxue	08/01-08/10	150	9.3, 9.2, 9.8	309	-15	21.4	0.1	0.28	0.05
4286	Rubstov	09/10-09/20	186	0.9, 4.4	347	-2	3.258	0.003	0.12	0.03
6086	Vrchlicky	09/01-09/09	127	6.9, 9.1	333	-12			0.10	0.05
7291	Hyakutake	09/01-09/09	103	5.6, 7.9	333	-10			0.06	0.03
7497	Guangcaishiye	09/10-09/20	196	1.4, 6.7	346	-2	85.6	0.2	0.80	0.03
10565	1994 AT1	09/01-09/09	107	11.1, 12.4	335	-19	14.45	0.03	0.48	0.03
14874	1990 US4	08/01-08/10	132	6.5, 9.7	306	-9	6.31	0.01	0.14	0.03
16880	1998 BW11	09/01-09/09	104	4.6, 8.3	336	-5	3.347	0.001	0.27	0.03
17989	1999 JE64	08/01-08/10	126	5.8, 8.1	306	-10	5.432	0.005	0.25	0.05
52402	1993 TL	09/10-09/20	200	3.7, 8.6	345	-4	68.7	0.2	0.2	0.1

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date, unless there are three values. If so, the middle value is for the minimum phase angle during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range.

RESULTS OF THE FIRST SEMESTER OF THE 2018 MEXICAN ASTEROID PHOTOMETRY CAMPAIGN

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We report results from the first half of the 2018 Mexican Photometry Campaign. This period consisted of a total of 42 observing nights distributed on three observatories. From these data we have obtained lightcurves and synodic rotational periods for 6 asteroids. 1491 Balduinus resulted in a period of $P = 15.3044 \pm 0.0057$ hr; 1856 Ružena, $P = 5.957 \pm 0.001$ hr; 3394 Banno $P = 7.344 \pm 0.0002$ hr; 3877 Braes $P = 5.8155 \pm 0.0005$ hr; 7430 Kogure, $P = 17.998 \pm 0.076$ hr; and for 2001 KB67, $P = 6.357 \pm 0.0012$ hr.

The Mexican Asteroid Photometry Campaign began in 2015 as an effort to study asteroids and to establish a collaborative network among researchers from different Mexican institutions. Since then, we have improved our observing techniques and processing methods; see Sada et al. (2016) and Sada et al. (2017). All our targets were selected from the MPC CALL website.

Thirty one observing nights were recorded at the Carl Sagan Observatory from Universidad de Sonora (UNISON) in Hermosillo, Sonora. This observatory operates a Meade LX-200GPS 0.41-m $f/10$ telescope equipped with a 3056×3056 pixel 12 μm Apogee Alta F9000 CCD for imaging. The image frame was trimmed to a subframe of 2000×2000 pixels to avoid vignetting and then binned 2×2 yielding an effective 1000×1000 pixel, $\sim 20' \times 20'$ FOV with an image scale of about 1.2 arcsec/pix. The images at this site were obtained unguided (using only mount tracking) and unfiltered. The exposure time used was 240 s in all cases.

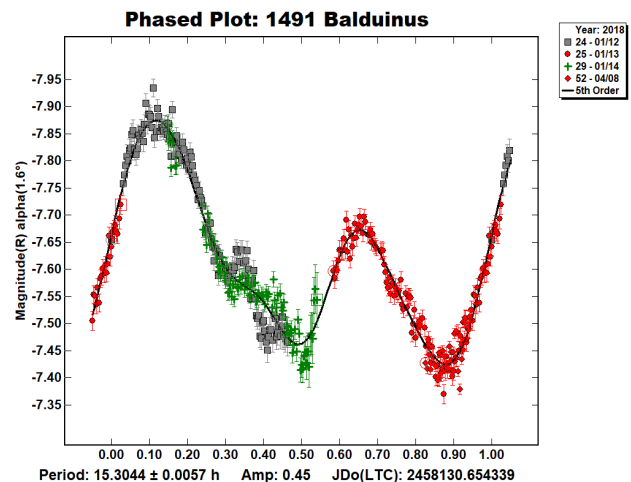
Two one-week scheduled observing runs were carried out throughout the period with the 0.84-m $f/15$ Ritchey-Chretien telescope at the Observatorio Astronómico Nacional in the Sierra de San Pedro Mártir (OAN-SPM; MPC 679) Baja California. On top of that, a few additional observing nights not originally scheduled were made available to this project. This telescope uses a 2048×2048-13.4 μm Spectral Instruments CCD for regular imaging. This combination yields a FOV of $\sim 6.3' \times 6.3'$ with an approximate image scale of 0.185 arcsec/pix. All images were 2×2 binned, unfiltered and obtained using an off-axis guide star for stability (although the field drifted a little during the observing sessions due to telescope sag). The exposure times for each

asteroid ranged between 20 s and 480 s, depending on target brightness.

At the Universidad de Monterrey (UdeM) Observatory (MPC 720) we observed 2 asteroids on 5 nights using a Meade 0.36-m $f/8$ LX600-ACF telescope and a SBIG STL-1301E CCD. The camera uses a 1280×1024-16 μm KAF-1301E/LE chip which covers a $\sim 26.3' \times 21.1'$ field-of-view (FOV) with an image scale of about 1.24 arcsec/pix. All asteroids were observed unfiltered for maximum SNR and the CCD images were read in 2×2 binned format for faster download time and observing efficiency. The FOV was maintained fixed on the chip by using an on-axis guide star at all times. The exposure time was 180 s. Occasionally, the telescope was slightly defocused in order to spread the object over a few binned pixels allowing slightly longer exposure times.

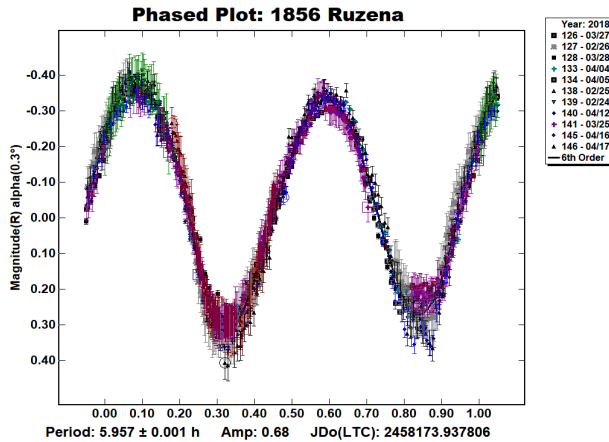
All images were processed following standard procedures for data reduction, mainly applying dark current and flat field corrections. Photometric measurements and lightcurve analysis were performed using MPO Canopus (version 10.7.3.0). Although all observations were unfiltered, differential magnitudes were calculated based on R band stellar magnitudes.

1491 Balduinus. Discovered at Uccle by E. Delporte on 1938 February 23 and named after Baudouin, then king of the Belgians as a way to honor his patronage. The asteroid was observed during 4 nights in 2018: January 12 to 14 and on April 8. Data were taken during three nights at UDEM Observatory (2018 January 12 to 14) and an additional session (2018 April 8) was taken from three nights observed at the UNISON Observatory, but the first two nights had considerably crowded star fields and were not used for the lightcurve. A period of $P = 15.3044 \pm 0.0057$ hr with an amplitude of $A = 0.45 \pm 0.08$ mag was found. This result is similar to the published result by Odden et al. (2018) of 15.315 ± 0.003 hr. The lightcurve shows a two maxima and two minima structure with the first maximum-minimum pair having considerably larger amplitude than the second. Structure in the shape of an elbow located just before the first minimum was seen at the 5th order fit. In order to obtain a more complete lightcurve, additional coverage is needed after the first minimum (between sessions 29 and 25).

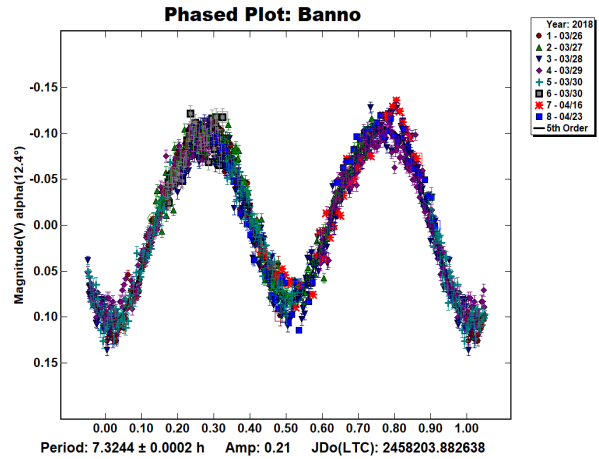


1856 Ružena. This S-Class asteroid was discovered on 1969 Oct. 8 by L.I. Chernykh of the Klet Observatory in Nauchnyj was named in honor of Miss Ružena Petrovicova (Schmadel, 2003). This asteroid was observed in the OAN-SPM Observatory (2018 February 24, 25, 26 and March 18), in the UNISON Observatory (2018 March 27, 28 and April 4, 5, 12) and in the UDEM

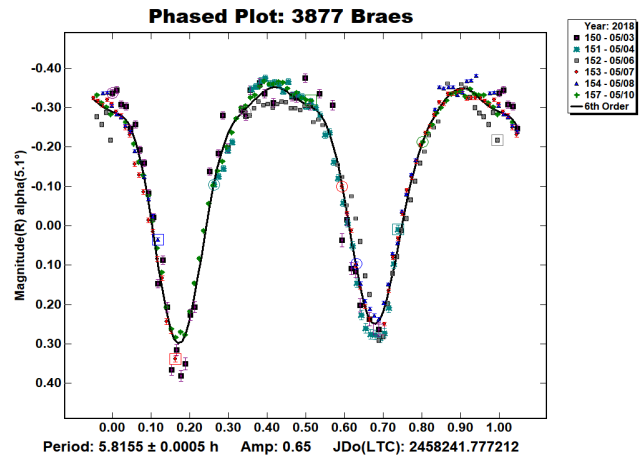
Observatory (2018 April 16 and 17) for a total of 51 h 05 m of observing time. We used a single session per night to derive a period of $P = 5.957 \pm 0.001$ hr with an amplitude of $A = 0.68$ mag. Observing the period spectrum we found a minimum of ≈ 3 hr as well as one of 5.957 hr, which along with the apparent symmetry of the lightcurve led to a possible period of 3 hr; however, the difference grew in favor of the longer period (5.957 hr) as more data were added and the two maxima and two minima structure took shape with the second maximum-minimum having a slightly lower amplitude than the first. Also, the second minima (at 0.8 - 0.9) showed a small flattening not seen in the first one. Our result concurs with a previous result for the period of 1856 Ružena obtained by Hayes-Gehrke et al. (2018a) with a value for $P = 5.96 \pm 0.003$ hr and $A = 0.65 \pm 0.09$ mag.



3394 Banno. This main-belt asteroid was discovered in 1986 Feb. 16 and was named in honor of Yoshiaki Banno (Schmadel, 2003). 3394 Banno was observed during 5 nights at OAN-SPM Observatory (2018 March 26, 27, 28, 29 & 30). Due to an adjustment in the field of view during the night of March 30, two separate data sessions are shown. Additional data were taken at UNISON Observatory on 2018 April 16 and 23. The lightcurve shows a two maxima and two minima shape, and the period derived from this data was $P = 7.3244 \pm 0.0002$ hr (the RMS error was ≤ 0.04) and an amplitude of $A = 0.21$ mag using a 5th order Fourier fit. This result is very close to the value published by Marchini et al. (2018) of $P = 7.324 \pm 0.001$ hr and $A = 0.22 \pm 0.02$ mag, a result obtained with 194 data points in a 4th order fit. The following results for 3394 Banno were found in the Minor Planet Bulletin: Zeigler et al. (2018) have $P = 7.34 \pm 0.01$ hr with an amplitude of 0.21 mag, Hayes-Gehrke et al. (2018b) reported $P = 7.321 \pm 0.025$ hr, Mollica et al. (2018) reported a period of $P = 7.324 \pm 0.002$ hr and an amplitude of 0.24 mag.



3877 Braes. This S-Class main-belt asteroid was discovered on 1960 Sept. 24 by C. J. van Houten and I. van Houten-Groeneveld at Palomar Observatory (Schmadel, 2003). Data for this object were collected during 7 nights at the UNISON Observatory (2018 May 2, 3, 4, 6, 7, 8 & 10). The data from May 2 was not used due to degrading observing conditions during the night leaving 6 nights for a total of 293 data points left after eliminating low-quality data (high air mass, etc.) covering a total of 19.53 hr observing time. After an analysis with MPO Canopus we found that the result is a period of $P = 5.8155 \pm 0.0005$ hr and an amplitude of 0.65 ± 0.1 mag with a 6th order fit showing two maximum-and-minimum pairs. The two maximum points are similar in magnitude but the two minima differ slightly. No other results were found for the period or amplitude of 3877 Braes as of writing this paper.

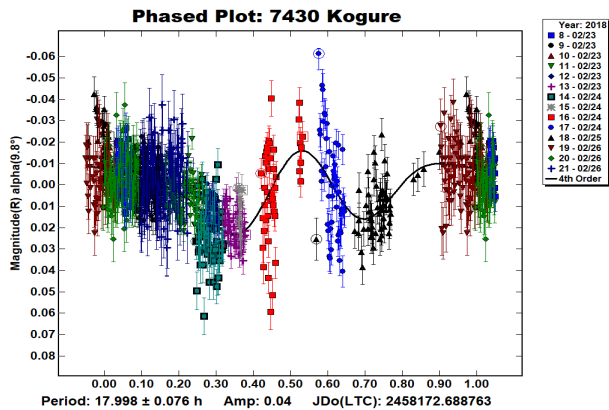


7430 Kogure. It is a main-belt asteroid and was discovered 1993 Jan. 23 by K. Endate and K. Watanabe at Kitami (Schmadel, 2003). We observed 7430 Kogure during four nights (2018

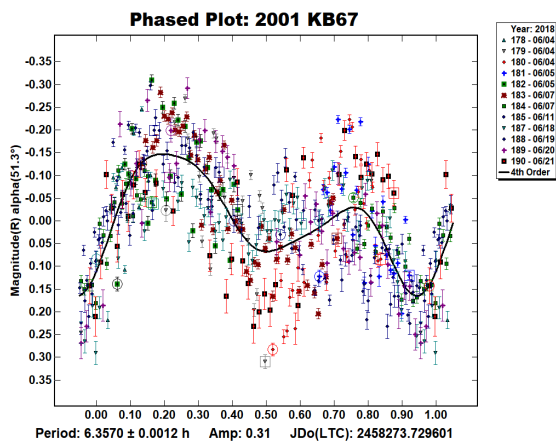
Number	Name	2018 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1491	Balduinus	01/12-04/08	375	1.7, 20.6	116.6	0.7	15.3044	0.0057	0.45	0.08	EMB
1856	Ružena	02/24-04/17	1048	16.3, 11.6	186.6	-0.1	5.957	0.001	0.68	0.09	MBO
3394	Banno	03/26-04/23	1162	12.5, 5.4	203.4	1	7.3244	0.0002	0.21	0.04	MBO
3877	Braes	05/03-05/10	293	12.2, 14.0	232.6	1.7	5.8155	0.0005	0.65	0.1	MBO
7430	Kogure	02/23-02/26	896	9.7, 11.2	139.3	-4.1	17.998	0.076	0.04	0.03	MBO
68347	2001 KB67	07/04-07/21	467	10.5, 8.4	96.1	18.6	6.357	0.0012	0.31	0.14	ATN

Table I. Observing circumstances and results. 2018 mm/dd is the range of dates for the observations, 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). P.E. is error in the period (h). A.E. is the error in amplitude. Grp is the asteroid family/group (Warner et al., 2009).

February 23, 24, 25 & 26) at AON-SPM and one at the UNISON Observatory (also on the 25th of February). In most nights we used several sessions with MPO Canopus. When a 4th order fit was made a resulting period of $P = 17.998 \pm 0.076$ hr and $A = 0.04 \pm 0.03$ mag was obtained. It is worth noting that this lightcurve is not complete and hence the period is not considered trustworthy. A clear contrast can be seen with the $P = 335.9 \pm 0.8$ hr and $A = 0.57$ mag result from Polakis (2018) which he also obtained from a partial lightcurve. From the poor alignment of the data points, Polakis (2018) suggests that 7430 Kogure is tumbling.



2001 KB67. This body was discovered in 2001 May 30 by Linear at Socorro (Park & Chamberlain, 2018), it belongs to the Aten group, and is classified as NEO and PHA. It was observed during 8 nights at UNISON Observatory (2018 July 4, 5, 7, 11, 18, 19, 20, & 21). Measurements were affected by weather resulting in a large scatter. During the first three nights (July 4, 5 & 7) several sessions were associated to many observing fields because of the high angular speed of the asteroid during closest approach. A 4th order fit was adjusted to obtain a period of $P = 6.357 \pm 0.0012$ hr and an amplitude of $A = 0.31$ mag. This result agrees closely with the $P = 6.354 \pm 0.004$ h and $A = 0.19$ obtained by Warner (2018).



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ROTATION PERIOD OF ASTEROID 1394 ALGOA

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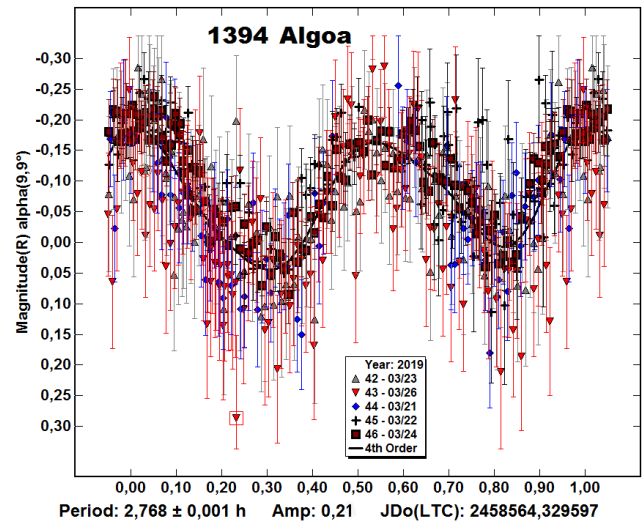
(Received: 2019 April 2)

During 2019 March we made five observing sessions of 1394 Algoa from our very light-polluted urban site in northern Italy. Despite this severe limit, our survey confirms previous results with an estimated period $P = 2.768 \pm 0.001$ h and amplitude $A = 0.21 \pm 0.05$ mag.

The minor planet Algoa, discovered by Cyril Jackson in 1936 June at Union Observatory of Johannesburg (Schmadel, 2007), belongs to the inner regions of the main-belt. According to the LCDB database (Warner et al., 2009), it has a standard albedo for stony S type of 0.20, an estimated diameter of 14.2 km, and an absolute magnitude H of 11.6.

From 2019 March 21-26, five sets of CCD observations were made over about 14 hours for a total of 540 data points. We used a 0.20-m $f/4.5$ Newtonian reflector equipped with an Atik 314L+ b/w CCD and a 0.23-m $f/10$ Schmidt-Cassegrain with an Atik 414 EX b/w CCD. The V mag of Algoa was in the range of 15.0-15.3 with a sky motion of 0.50-0.53 arcsec/min (MPC ephemerides service). Exposures were 90 s with a clear filter.

To reach a S/N of at least 100 for the target and the comparison stars, images were binned 2x2. The result plate scales were 2.96 arcsec/pix for the Newtonian and 1.60 arcsec/pix for the S-C. The images were dark subtracted and flat field corrected using *Maxim DL v 3.04* (2001) and *Astro Art 4* (1998-2006). Lightcurves and rotation periods on processed images were obtained with *MPO Canopus v10.7.8.1* (Warner, 2016). The lightcurves show a bimodal shape with the same ~ 0.05 mag difference in minimum depth, as observed by Klinglesmith et al. (2013) and Hills (2012).



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Number	Name	2019 mm/dd	Pts	Phase	LPAB	BPAB	Period(h)	P.E.	Amp	A.E.	Grp
1394	Algoa	03/21-03/26	540	9.0,10.7	162	-0.7	2.768	0.001	0.21	0.05	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. 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).

LIGHTCURVES OF TWELVE MAIN-BELT MINOR PLANETS

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Synodic rotation periods were determined for twelve main-belt asteroids: 394 Burdigala, 399.8 ± 0.7 h; 464 Megaira, 12.860 ± 0.012 h; 858 El Djezair, 14.830 ± 0.015 h; 1269 Rollandia, 28.277 ± 0.017 h; 1585 Union, 12.798 ± 0.005 h; 1603 Neva, 6.423 ± 0.002 h; 1614 Goldschmidt, 16.540 ± 0.013 h; 1720 Niels, 250.9 ± 0.9 h; 2162 Anhui, 8.090 ± 0.005 h; 3040 Kozai, 4.512 ± 0.008 h; 5321 Jagraas, 2.6370 ± 0.0004 h; and (18736) 1998 NU, 2.4755 ± 0.0002 h. All the data have been submitted to the ALCDEF database.

CCD photometric observations of twelve main-belt asteroids were performed at Command Module Observatory (MPC V02) in Tempe, AZ. 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 images was 2 minutes. The image scale after 2x2 binning was 1.76 arcsec/pixel. Table I shows the observing circumstances and results. With one exception, all of the images for these twelve asteroids were obtained between 2019 January and March.

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, 2019). The $45^\circ \times 30'$ field 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.

Since the sensitivity of the KAF-6303 chip peaks in the red, the Clear-filtered images were reduced to Sloan r' to minimize error with respect to a color term. Comp star magnitudes were derived from a combination of CMC15 (Muñoz et al., 2014), APASS DR9 (Munari et al., 2015), and GAIA2 G (Sloan $r' = G$ 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.

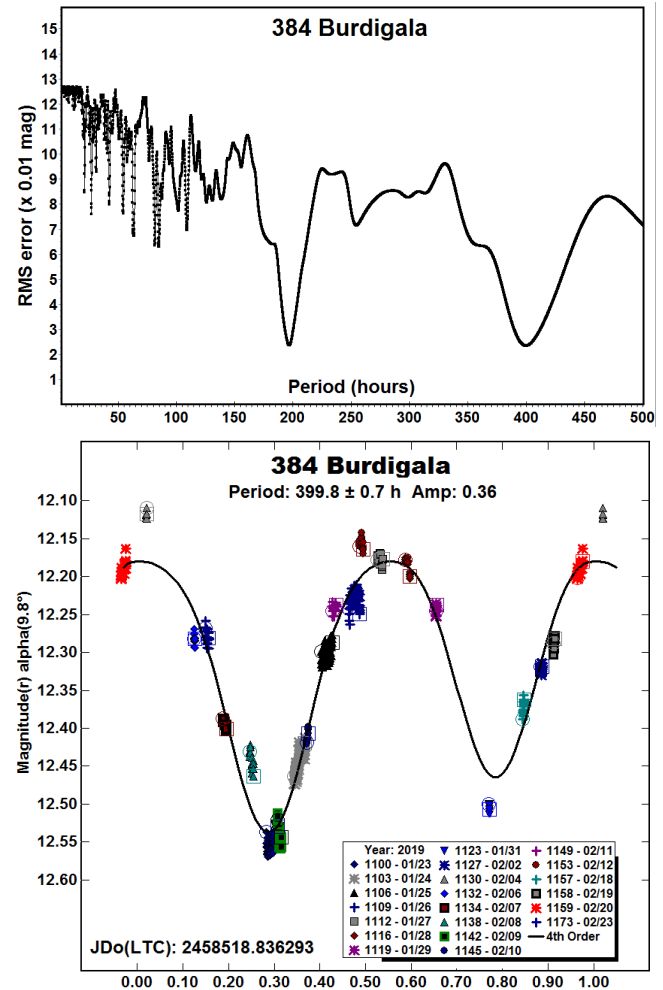
A 9-pixel (16 arcsec) diameter measuring aperture was used for asteroids and comp stars. It was typically necessary to employ star subtraction to remove contamination by field stars. For the asteroids described here, I note the RMS scatter on the phased

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 (Harris et al., 1989). Phased lightcurves show the maximum at phase zero. Magnitudes in these plots are apparent and scaled by *MPO Canopus* to the first night.

Asteroids were selected from the CALL website (Warner, 2011) using the criteria of magnitude greater than 15.0 and quality of results, U, less than 2+. In this set of observations, seven of the 11 asteroids had no previous period analysis. The Asteroid Lightcurve Database (LCDB; Warner et al., 2009) was consulted to locate previously published results. All the new data for these twelve asteroids can be found in the ALCDEF database.

384 Burdigala was discovered by Fernand Courty at Bordeaux in 1894. The LCDB gives two rotation periods, both based on rather sparse data; Robinson (2011) obtained a period of >17 h, and Behrend (2011) shows 21.1 ± 0.1 h. It would come to a perihelic opposition in early 2019.

The first three nights of observations at V02 showed a steady rise in brightness, indicating that the period would be much longer than published values. In all, 594 images were gathered over the course of 21 nights. The minimum in the period spectrum at 399.8 ± 0.7 h produced a satisfactory, bi-modal lightcurve. The amplitude is 0.36 ± 0.02 mag, and the RMS scatter on the fit shown in the phased plot is 0.023 mag.

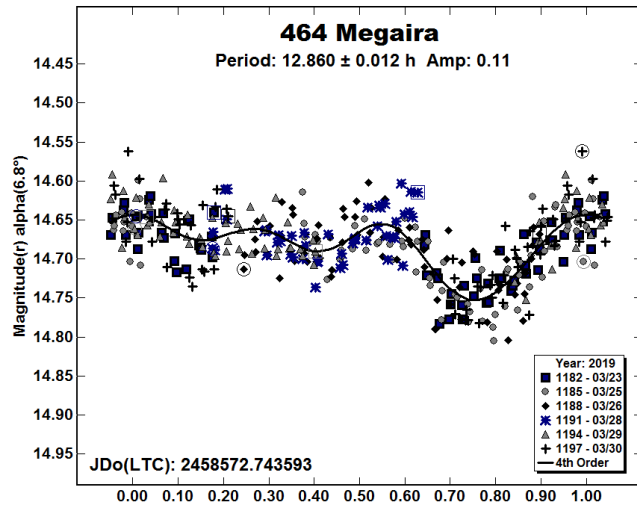


Number	Name	yyyy mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
384	Burdigala	2019 01/23-02/23	594	9.7, 20.6	107	7	399.8	0.7	0.36	0.02	MB-M
464	Megaira	2019 03/23-03/30	387	6.8, 8.6	165	11	12.860	0.012	0.11	0.03	MB-O
858	El Djezair	2019 03/23-03/31	539	4.9, 6.5	180	11	14.830	0.015	0.07	0.02	MB-O
1269	Rollandia	2019 02/10-02/28	422	2.7, 8.2	132	0	28.277	0.017	0.13	0.02	HIL
1585	Union	2019 02/23-02/28	414	9.1, 10.9	135	-6	12.798	0.005	0.24	0.02	MB-O
1603	Neva	2019 01/29-02/09	302	10.9, 14.5	103	-4	6.423	0.002	0.25	0.04	MB-O
1614	Goldschmidt	2019 03/23-03/30	315	8.6, 11.1	161	1	16.540	0.013	0.15	0.04	MB-O
1720	Niels	2019 01/23-02/12	482	3.7, 15.0	117	0	250.9	0.9	0.61	0.05	MB-I
2162	Anhui	2019 01/23-01/28	482	7.0, 9.8	111	-1	8.090	0.005	0.14	0.03	FLOR
3040	Kozai	2019 02/24-02/25	207	16.2, 16.4	158	22	4.512	0.008	0.25	0.06	MC
5321	Jagras	2018 10/10-10/18	274	3.5, 5.8	16	5	2.6370	0.0004	0.06	0.03	EUN
18736	1998 NU1	2019 01/27-02/08	290	9.9, 19.5	121	-1	2.4755	0.0002	0.12	0.02	NEA

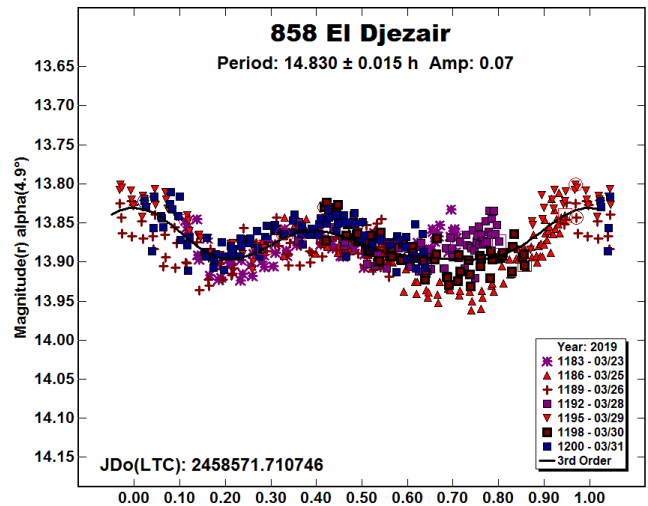
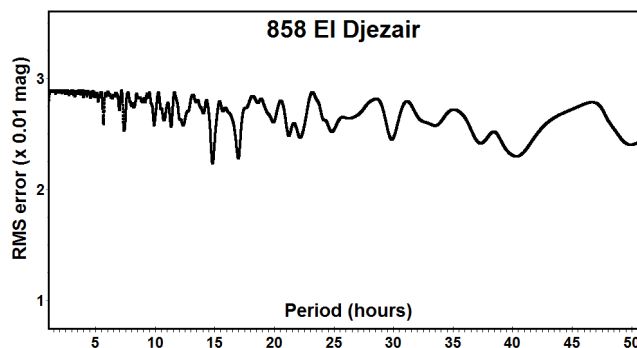
Table I. Observing circumstances and results. The phase angle (α) is given at the start and end of each date range, unless it reached a minimum or maximum, which is then the second of three values. LPAB and BPAB are each the average phase angle bisector longitude and latitude (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

464 Megaira. This outer-belt asteroid was discovered by Max Wolf while at Heidelberg in 1901. Harris and Young (1989) derived a period of 12.726 ± 0.003 h while Waszczak et al. (2015) found 12.871 ± 0.0073 h.

A total of 387 images were gathered during six nights. The low amplitude of the lightcurve presented difficulty in obtaining a satisfactory period solution; the RMS scatter of 0.030 mag. is nearly one fourth of the amplitude of 0.11 ± 0.03 mag. The fourth-order solution produced a period of 12.860 ± 0.012 h, which agrees with previous assessments.

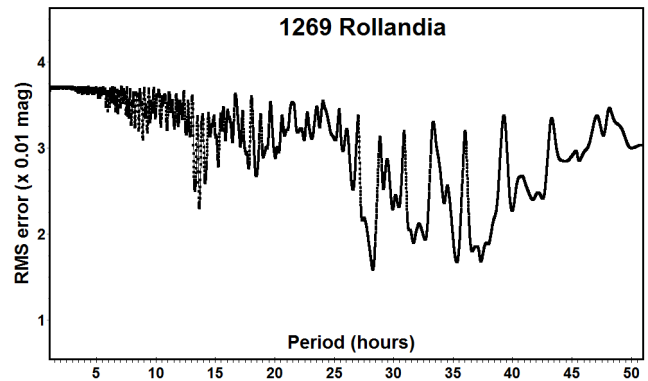


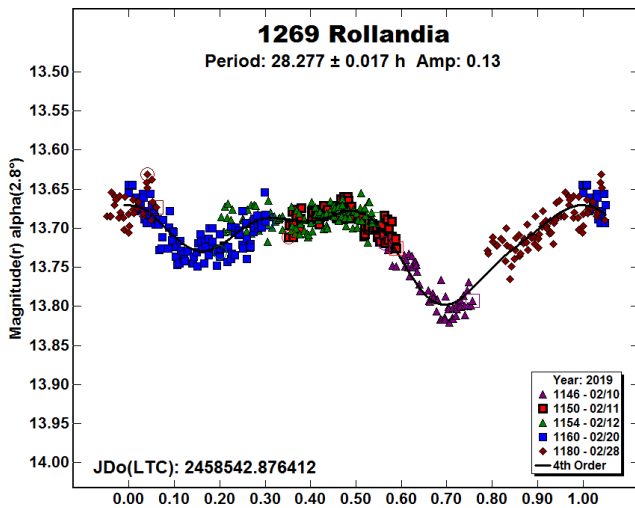
858 El Djezair is one of Frédéric Sy's discoveries while working at Agiers in 1916. Warner (2005) published a period of 22.31 ± 0.2 h. Behrend (2007) obtained 19.0 ± 1.0 h.



Over the course of nine nights, seven were useable, resulting in 539 data points. The lowest trough in the period spectrum occurs at 14.830 ± 0.015 h, which does not agree with published values. The full amplitude is 0.07 ± 0.02 mag, and the RMS scatter of the fit is 0.023 mag.

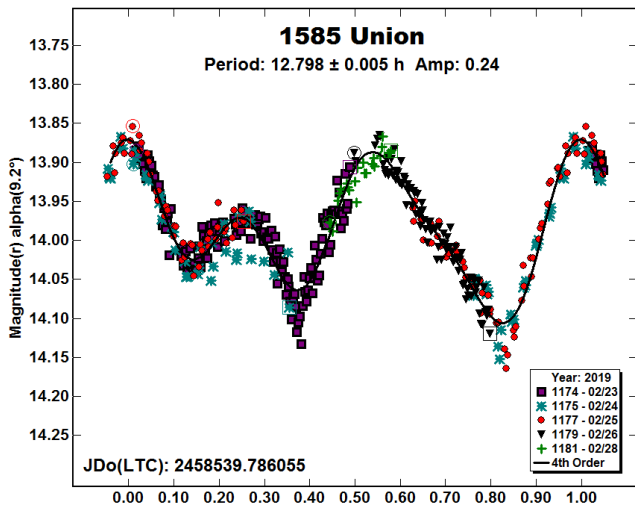
1269 Rollandia. Grigory Neujmin discovered this Hilda asteroid from Simeis in 1930. Several period solutions have been published: Franco (2012, 15.4 ± 0.1 h), Slyusarev (2012, 30.98 ± 0.93 h), and Fauvuad (2013, 15.32 ± 0.03 h).





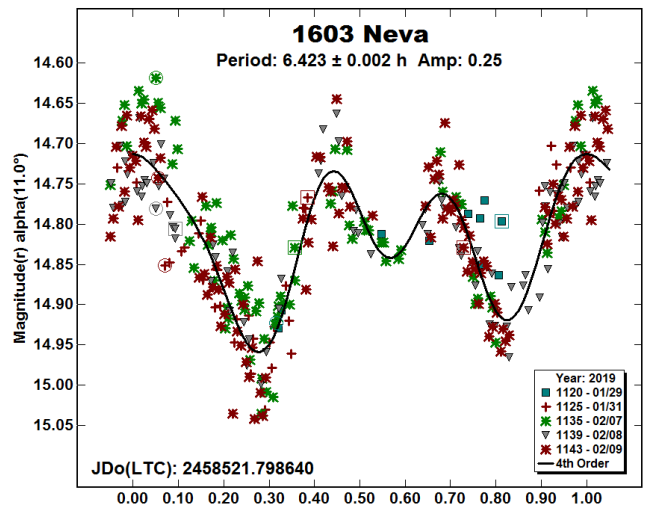
During five nights in February, 422 images were taken. The most prominent solution in the period spectrum occurs at 28.277 ± 0.017 h, differing from values in the LCDB. The lightcurve has an amplitude of 0.13 ± 0.02 mag and an RMS error on the fit of 0.016 mag.

1585 Union. Ernest Johnson discovered this minor planet at Union Observatory in 1947. *Binzel (1987) published a period of 9.38 h* and Behrend (2004) computed 24 h. The generous amplitude of the lightcurve results in a robust period solution at 12.798 ± 0.005 h, disagreeing with the two previous assessments. The RMS scatter on the fit is 0.018 mag. The amplitude is 0.24 ± 0.02 mag.



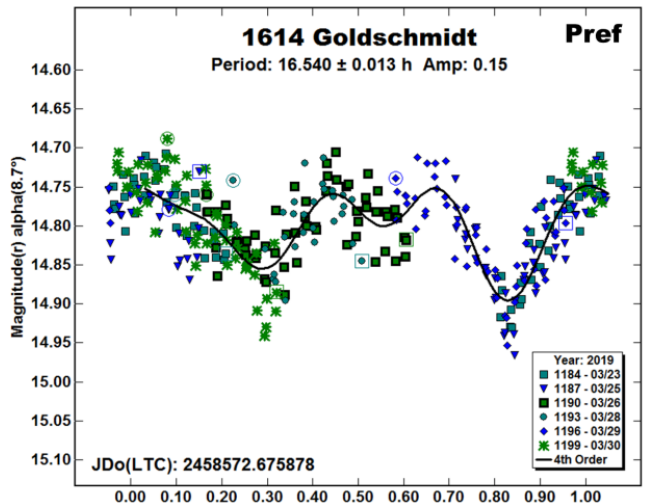
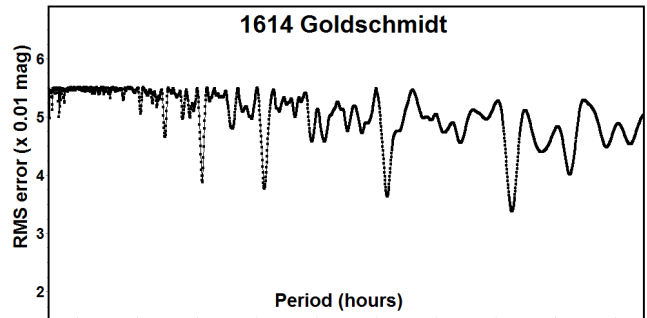
1603 Neva is another of Grigory Neujmin's finds, made while working at Simeis in 1926. Several authors have published periods, all roughly in agreement with each other: Behrend (2004, 6.4249 ± 0.0001 h), Aznar (2016, 6.430 ± 0.015 h), and Fuller (2019, 6.426 ± 0.001 h).

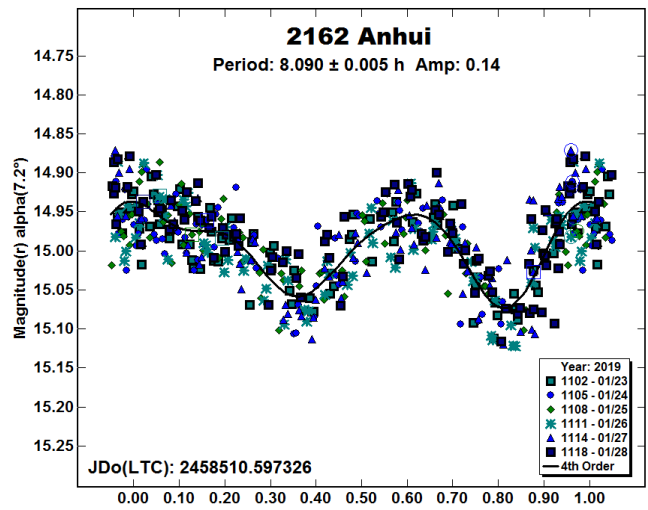
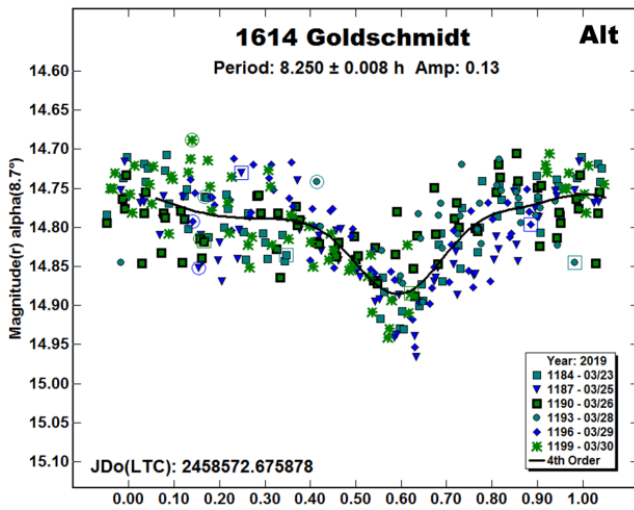
Five observing nights were sufficient to obtain a synodic period of 6.423 ± 0.002 h, which is in agreement with the previous values. The amplitude of the lightcurve is 0.25 ± 0.04 mag and the RMS error on the fit is 0.044 mag.



1614 Goldschmidt. Alfred Schmitt discovered this minor planet at Uccle in 1952. He named it after Hermann Goldschmidt, who by 1861 had discovered 14 asteroids. The LCDB lists two period solutions: Warell (2015) with 7.74 ± 0.02 h and Kozdon (2016) with 8.873 ± 0.002 h.

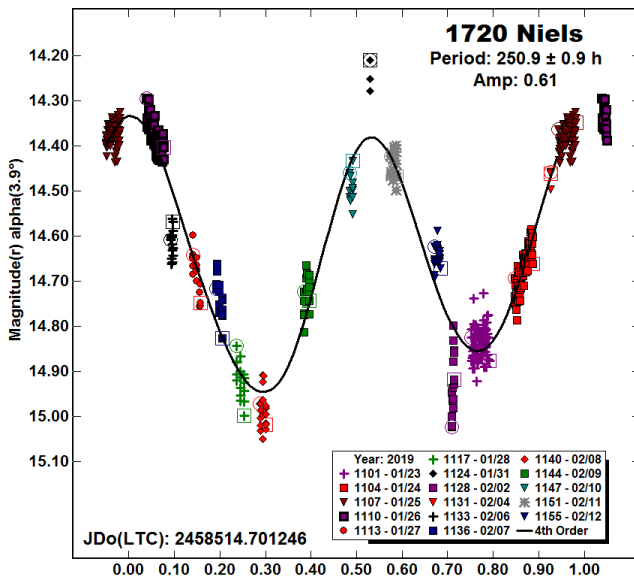
After six nights, 315 data points were collected. The period spectrum shows prominent troughs at roughly 16 h and the half-period of 8 h, but the fit reveals quite a bit of uncertainty, as previous authors noted. The best fit occurs at 16.540 ± 0.013 h. The monomodal solution of 8.250 ± 0.008 cannot be ruled out.





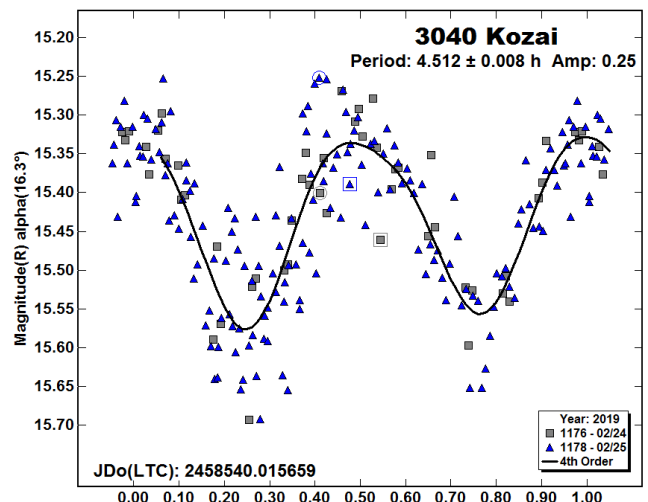
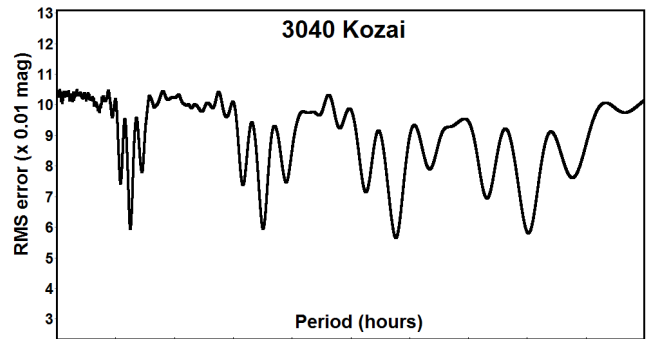
1720 Niels is an inner-belt asteroid, discovered at Heidelberg in 1935 by Karl Reinmuth. Using an incomplete dataset, Clark (2007) obtained a synodic period of 9.976 h. Behrend (2008) shows 19.2 h.

During a three-week period, 482 images were gathered on 16 nights in 2019 January to February. The photometry revealed a much longer period than the previous assessments: 250.9 ± 0.9 h. RMS scatter on the fit is 0.054 mag. The amplitude of the lightcurve is 0.61 ± 0.05 mag.



3040 Kozai is a Mars crosser with an orbital inclination of 47 deg. Its discovery was made by William Liller at Cerro Tololo in 1979. Recent period evaluations made by Pravec (2019) and Stephens and Warner (2019) show periods of 4.515 ± 0.002 h and 4.518 ± 0.001 h, respectively.

After two nights, the 207 images were sufficient to obtain a rough period estimate of 4.512 ± 0.008 h, albeit with large scatter due to the brightness being below the comfortable limit for this telescope and site. This period is in line with those from Pravec and Stephens and Warner. The amplitude of the lightcurve is 0.25 \pm 0.06 mag and the RMS error of the fit is 0.059 mag.

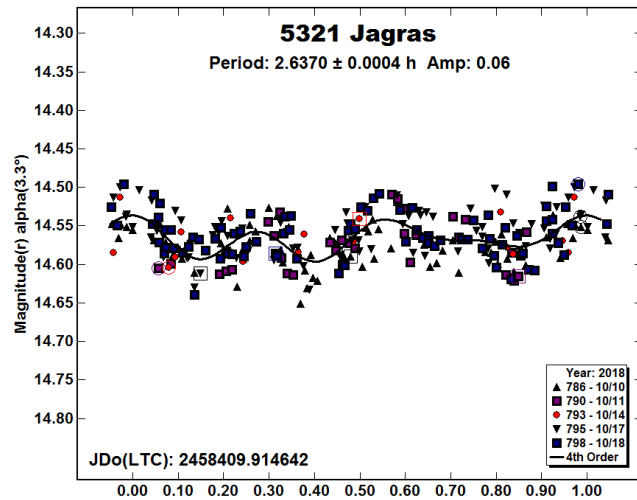


2162 Anhui is a Flora-family asteroid, discovered in 1966 at Purple Mountain Observatory. Behrend (2018) obtained a period of 8.106 ± 0.001 h and Pravec (2018) computed a similar period of 8.1048 ± 0.0005 h.

During six January nights, 471 images of the asteroid were taken. A synodic period of 8.090 ± 0.005 h was obtained, which is in line with the two previous values. The lightcurve amplitude is 0.14 \pm 0.03 mag and the RMS error of the curve fit is 0.034 mag.

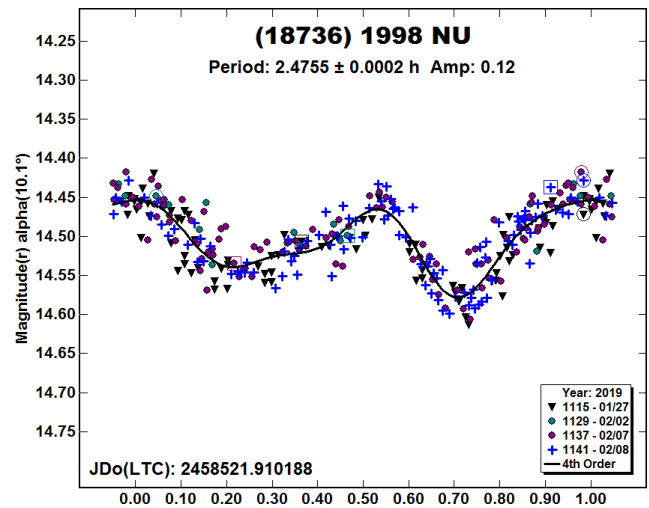
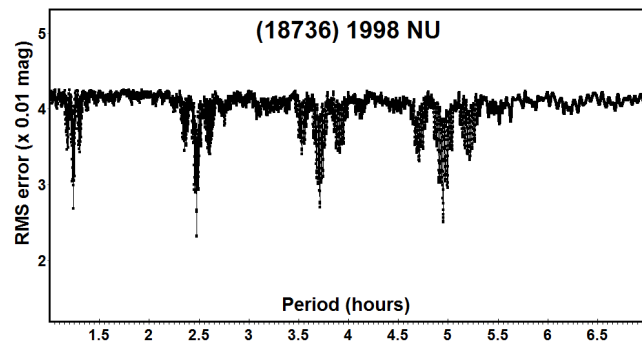
5321 Jagras This Eunomia-family asteroid was discovered in 1985 by Kaare Jensen and Karl Augustesen at Brorfelde. Again, only two, very recent period assessments have been published, both consistent with each other. Mollica (2019) published a period of 2.6375 ± 0.0001 h and Papini (2019) computed 2.638 ± 0.001 h. The author gave up on this asteroid after five nights and 274 images in 2018 October that showed mostly flat raw lightcurve morphology. Only after learning about the recent work were the data resurrected for period analysis.

Consistent with the recent calculations, a rotational period of 2.6370 ± 0.0004 h appears as a small trough in the period spectrum. Since the RMS scatter of 0.025 mag is nearly half of the amplitude, the lightcurve is very crude; observations would benefit from a larger telescope and a darker site.



(18736) 1998 NU is a near-earth asteroid that was discovered by the Spacewatch telescope. Its high eccentricity orbit brought it to a very favorable 2019 opposition distance of 0.27 AU. The LCDB shows four consistent period solutions: Carreno (2019, 2.473 ± 0.003 h); Pravec (2019, 2.47542 ± 0.00003 h); and Warner and Stephens (2019b, 2.471 ± 0.002 h and 2.4753 ± 0.0003 h). The first result of Warner and Stephens (2019b) is a revision of a previously reported period of 3.796 h (Warner and Stephens, 2019a).

Four nights and 290 images were sufficient to assess its short period, which came out to 2.4755 ± 0.0002 h. The amplitude of the fit is 0.12 ± 0.02 mag, and the RMS scatter of the curve fit is 0.023 mag.



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A RE-EVALUATION OF ASTEROID 4181 KIVI

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Asteroid 4181 Kivi was reported by the author (Rowe, 2019) as having a rotational period of 89.1 h and a monomodal lightcurve; this was incorrect. The reported period should be 178.2 h.

The 89.1 h period reported for 4181 Kivi was based on a similar split halves plot for the 178 h period. However, Tom Polakis (private communication) called attention to the fact that it is almost impossible to have a monomodal lightcurve with an amplitude greater than 0.3 mag at low to moderate phase angles (Harris et al., 2014). The reported amplitude for the 89.1 h period was 0.77 mag.

Using a 4th order solution with the same data points gives the revised plot shown here. The author was aware of the magnitude limit for monomodal lightcurves but forgot it in the analysis. Many thanks to Tom Polakis for pointing this out.

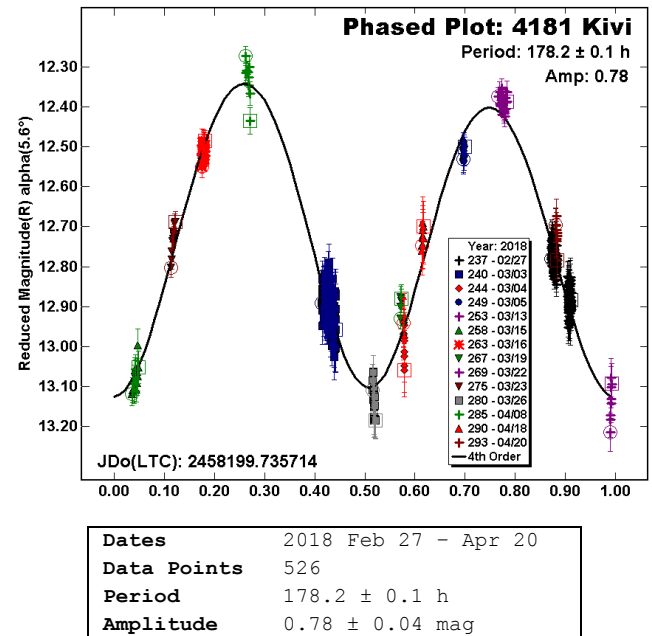


Table I. Revised results for 4181 Kivi. See Table I in Rowe (2019) for the full set of observing circumstances.

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LIGHTCURVE AND PERIOD DETERMINATION FOR ASTEROID 4148 MCCARTNEY

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(Received: 2019 April 3)

Photometric observations for main-belt asteroid 4148 McCartney were taken from 2019 February 01 to 2019 February 26. The rotational period for this asteroid is determined to be $20.748 \pm .003$ hours, with amplitude 0.16 ± 0.05 mag.

4148 McCartney is a main-belt asteroid discovered 1983 July 11 by E. Bowell at the Anderson Mesa Station of the Lowell Observatory. Photometric observations of 4148 McCartney were commenced as a part of an astronomy research class taught at Phillips Academy, a high school in Andover, Massachusetts. Students used the CALL website to identify asteroids with previously unmeasured periods and favored candidates with high declinations, apparent visual magnitudes between 15 and 17, and appealing names. Asteroid 4148 was named for Sir Paul McCartney, and the asteroids numbered 4147, 4148, 4149 and 4150, are named Lennon, McCartney, Harrison and Starr, after members of The Beatles.

Initial observations of McCartney indicated a longer rotation period. Hoping to constrain the period quickly and also to demonstrate the power of taking observations from a variety of longitudes, Odden had her group utilized telescopes on the iTelescope network in Italy and California to take additional observations. In addition, she requested collaboration from authors KlingleSmith and Pilcher, who kindly agreed to join the campaign. Based on the early sessions, the period was of 20.748 hours was favored. Additional observation windows were selected to achieve double coverage of the lightcurve and further constrain the period.

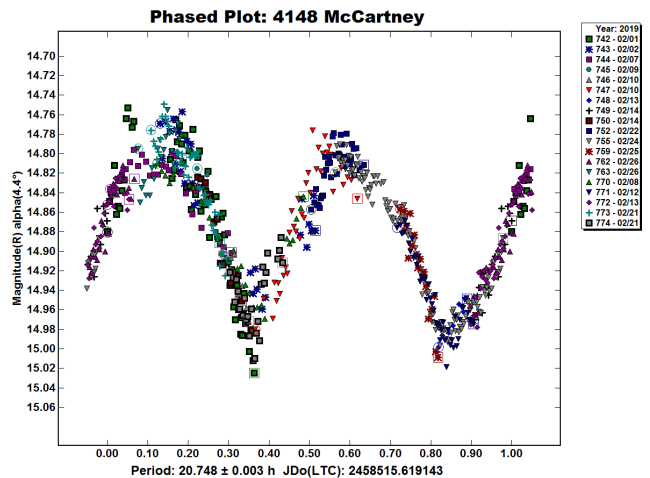
Table I lists the equipment used by the various observers. All images were corrected with appropriate bias, dark, and flat-field frames. Images were then measured using MPO Canopus (Bdw Publishing) using a differential photometry technique. Comparison stars were chosen to have near solar color using the Comp Selector tool in MPO Canopus. Fourier analysis (FALC; Harris et al., 1989) was performed in *MPO Canopus* (Warner,

Observer	Telescope	CCD Camera
KlingleSmith	0.35-m f/11 SCT	SBIG STL 1001E SBIG ST-10
Odden	0.40-m f/8 R-C	Andor Tech iKon DW 436 C
Pilcher	0.35-m f/10 SCT	SBIG STL-1001E
iTelescope, T18, Spain	0.32-m f/8 CDK	SBIG STL-11000M
iTelescope, T24, CA	0.61-m f/6.5 CDK	FLI-PL09000

Table I. Observers and equipment. SCT: Schmidt-Cassegrain Telescope; R-C: Ritchey-Chrétien; CDK: Corrected Dall-Kirkham Astrograph

2013) to produce a period-fitted graph. Discordant data was removed in circumstances where (1) data was acquired under poor conditions, (2) sets of data points exhibited scatter that was significantly greater than for other lightcurves or sections of a lightcurve, (3) bumps in the lightcurve were timed with passages near stars and may have resulted from incomplete star subtraction, or (4) the start or end of session data points were acquired at lower altitude where photometric accuracy is reduced. In addition, data points were binned up to three as long as data points were not separated by more than five minutes. Thus, 1175 original data points are displayed as 652 points on the lightcurve included in this report.

The lightcurve curve shows a period of $20.748 \pm .003$ hours, with amplitude 0.16 ± 0.05 mag. The period spectrum strongly favors this bimodal result. 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. Funding for the Andor Tech camera was generously provided by the Abbot Academy Association.

Number	Name	2019 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.
4148	McCartney	02/01-02/26	652	4.5, 10.4	139.2	0.6	20.748	0.003	0.16	0.05

Table II. 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).

The Etscorn Campus Observatory operations are supported by the Research and Economic Development Office of New Mexico Institute of Mining and Technology (NMIMT).

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

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LIGHTCURVE ANALYSIS OF HILDA ASTEROIDS AT THE CENTER FOR SOLAR SYSTEM STUDIES: 2019 JANUARY-MARCH

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(Received: 2019 April 8)

CCD photometric observations of three Hilda asteroids were made at the Center for Solar System Studies (CS3) from 2019 January-March. For 1038 Tuckia, the period solution was ambiguous at either $P = 18.020$ h, amplitude 0.22 mag or $P = 14.401$ h, amplitude 0.20 mag. For 2246 Bowell, the analysis found $P = 4.997$ and amplitude 0.46 mag. For 4317 Garibaldi, we found a dual-period solution with $P_1 = 17.843$ or 8.92 h and $P_2 = 11.426$ h. The shorter value for P_1 is similar to previously reported results but this is the first time a true dual-period solution, i.e., not an ambiguous single period solution, has been reported.

CCD photometric observations of three Hilda asteroids were made at the Center for Solar System Studies (CS3) from 2019 January-March. 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 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.

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.

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.

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. Comp star magnitudes were taken from ATLAS catalog (Tonry et al., 2018),

which has Sloan *griz* magnitudes that were derived from the GAIA and Pan-STARR catalogs, among others. The authors state that systematic errors are generally no larger than 0.005 mag, although they can reach 0.02 mag in small areas near the Galactic plane. BVRI magnitudes were derived by Warner using formulae from Kostov and Bonev (2017). The overall errors for the BVRI magnitudes, when combining those in the ATLAS catalog and the conversion formulae, are on the order of 0.04-0.05.

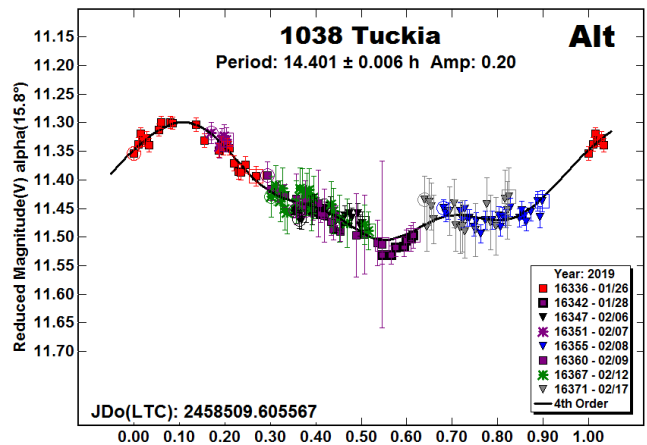
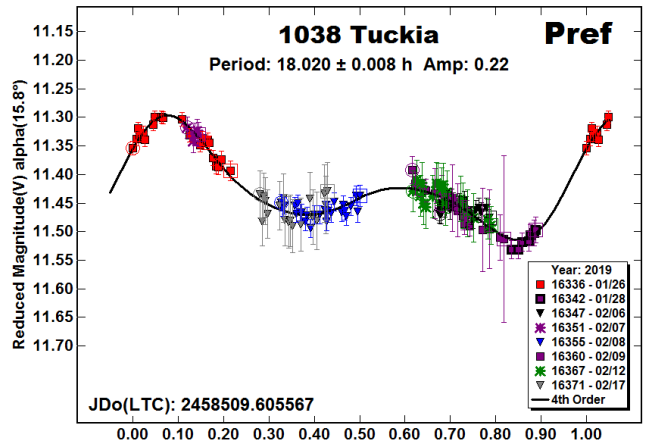
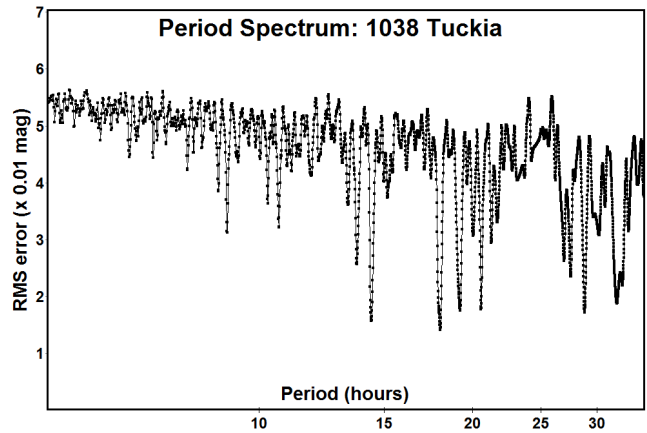
Even so, we found in most cases that nightly zero point adjustments on the order of only 0.02-0.03 mag were required during period analysis. There were occasional exceptions that required up to 0.10 mag. These may have been related in part to using unfiltered observations, poor centroid fitting of the reference stars, and not correcting for second-order extinction terms. Regardless, the systematic errors seem to be considerably less than other catalogs, which reduces the uncertainty in the results when analysis involves data from extended periods or the asteroid is tumbling.

Period analysis was done with *MPO Canopus*, which implements the FALC algorithm by Harris (Harris *et al.*, 1989). The same algorithm is used in an iterative fashion when it appears there is more than one period. This works well for binary but not for tumbling asteroids.

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 $-5 \cdot \log(r\Delta)$ with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. 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*.

Our initial search for previous results started with the asteroid lightcurve database (LCDB; Warner *et al.*, 2009) found on-line at <http://www.minorplanet.info/lightcurvedatabase.html>. Readers are strongly encouraged to obtain, when possible, the original references listed in the LCDB.

1038 Tuckia. The only previous result in the LCDB was from Dahlgren *et al.* (1998). They reported a period of 23.2 h and amplitude of only 0.1 mag. They stressed, however, that a different bimodal and even monomodal solution could not be ruled out. Analysis of our 2019 data found two possible periods, $P = 18.020$ h or 14.401 h, with the period spectrum slightly favoring the longer period. Despite the “Pref” and “Alt” labels in the lightcurves, either one – or even something else – is possible.

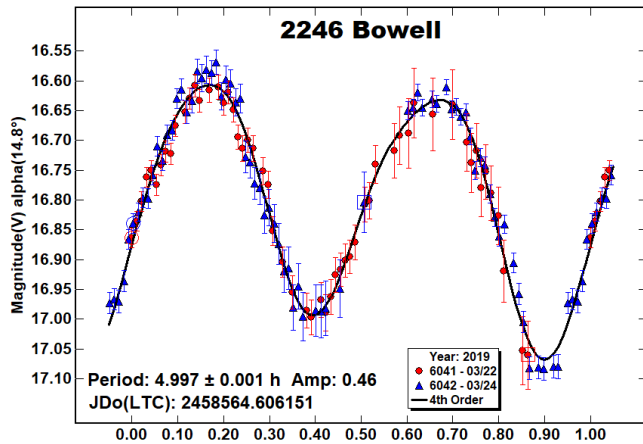


2246 Bowell. Previous results by the authors include 4.993 h (Warner and Stephens, 2017) and 4.990 h (Warner and Stephens, 2018). The results from the 2019 observations are in good agreement. The phase angle bisector longitude distribution covers a range of nearly 100°. With sparse data from surveys, it should be

Number	Name	2019/mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
1038	Tuckia	01/26-02/17	141	15.8,16.3	62	2	18.020	0.008	0.22	0.01
							14.401	0.006	0.20	0.01
2246	Bowell	03/22-03/24	130	14.8,14.9	117	-4	4.997	0.001	0.46	0.02
4317	Garibaldi	02/19-03/17	277	12.6,16.4	111	11	17.843	0.003	0.19	0.02
							11.426	0.002	0.11	0.02

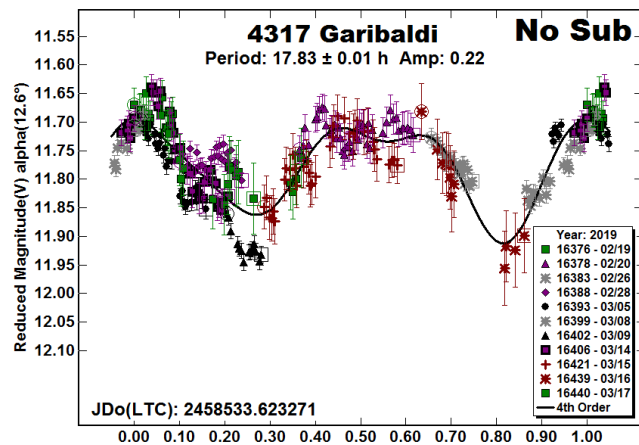
Table II. Observing circumstances. The phase angle (α) is given at the start and end of each date range. L_{PAB} and B_{PAB} are the average phase angle bisector longitude and latitude (see Harris *et al.*, 1984). The two lines for 1038 Tuckia give the preferred and alternate periods for an ambiguous solution. The lines for 4317 Garibaldi show the two periods of a dual-period solution (see text for additional information).

possible to find a first good estimate for the spin axis ecliptic coordinates and sidereal period.

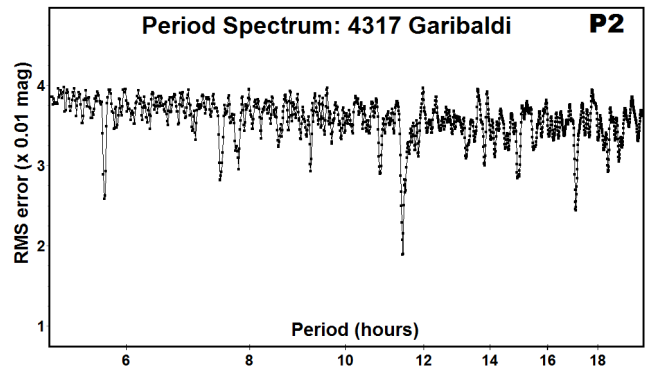
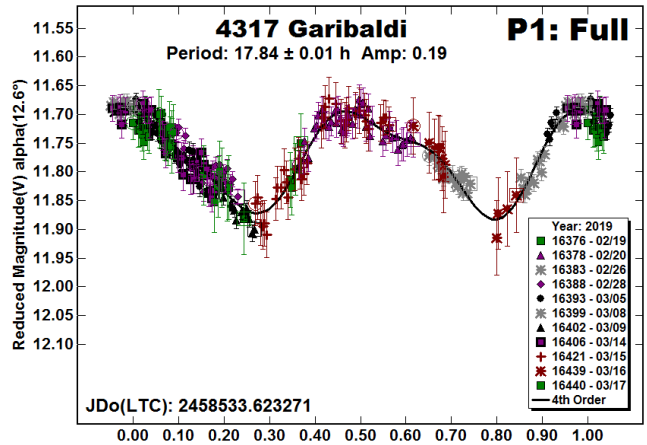
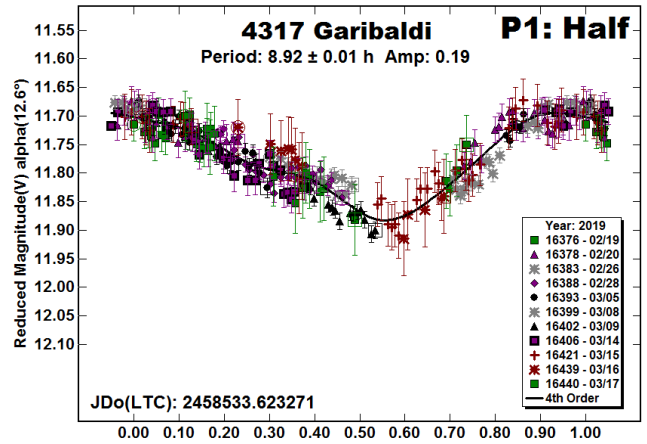
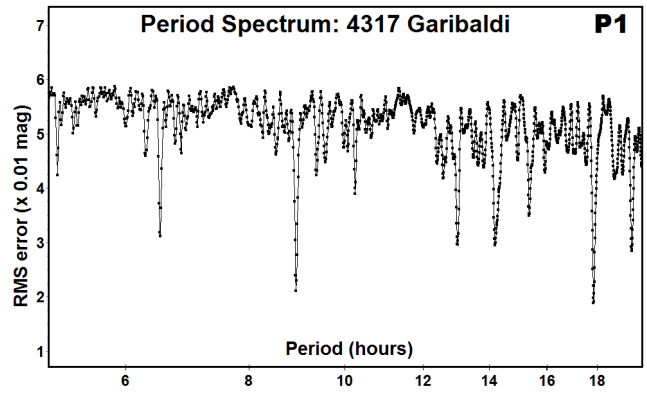


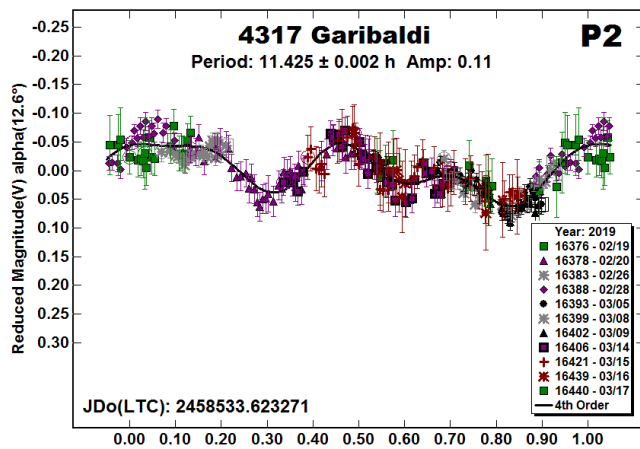
4317 Garibaldi. Dahlgren et al. (1998) found a period of 28.5 h for this 38-km Hilda (Maizner et al., 2016). However, it's rated U = 1 in the LCDB, meaning the solution is "probably wrong." Warner and Stephens (2018) found a $P = 8.959$ h when using data from 2016 and $P = 8.917$ h using data from 2017. While very similar, the periods are about 5 sigma apart using the stated errors.

The initial analysis of the 2019 data set with 277 observations led to a less than ideal $P = 17.83$ h when assuming a single period. The "No Sub" lightcurve showed indications of a dual-period solution, which we explored using *MPO Canopus*.



The period spectrum for P_1 favors 8.92 h (monomodal) or 17.84 h (bimodal). With an amplitude only 0.19 mag, Harris et al. (2014) showed that either solution is possible. We've adopted the "half" period solution of 8.92 h since it's close to the one from 2017.





Regardless of which period was used for P_1 , the dual-period analysis found a strong solution (see the “P2” period spectrum) at 11.425 h. The shape of the curve is not one expected for the rotation of a satellite that is tidally locked to its orbital period. The phase angle is not large enough to allow deep-shadowing effects to affect the shape. The two periods are close to, but not overly so, a 3:2 ratio. Assuming a true physical reason for the second period, tumbling seems to be the remaining possibility.

MPO Canopus cannot properly analyze tumbling asteroid lightcurves but, on occasion, it can find two suspect periods that are reasonably well-defined or a single “beat frequency” period that produces a lightcurve for a body that is physically improbable, if not impossible. We suspect that this may be the case here but considerably more data are needed to find the true solution.

Acknowledgements

Funding for observations at CS3 and work on the asteroid lightcurve database (Warner et al., 2009) and ALCDEF database (alcdef.org) are supported by NASA grant 80NSSC18K0851. This work includes data from the Asteroid Terrestrial-impact Last Alert System (ATLAS) project. ATLAS is primarily funded to search for near earth asteroids through NASA grants NN12AR55G, 80NSSC18K0284, and 80NSSC18K1575; byproducts of the NEO search include images and catalogs from the survey area. The ATLAS science products have been made possible through the contributions of the University of Hawaii Institute for Astronomy, the Queen's University Belfast, the Space Telescope Science Institute, and the South African Astronomical Observatory. 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.

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MAIN-BELT ASTEROIDS OBSERVED FROM CS3: 2019 JANUARY - MARCH

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(Received: 2019 April 10)

CCD photometric observations of 10 main-belt asteroids were obtained from the Center for Solar System Studies from 2019 January to March. In light of recent period analysis, images of 2120 Tyumenia obtained in 2004 were re-examined. The resulting analysis found a period of 17.515 h, which is consistent with the recent results.

The Center for Solar System Studies (CS3) has seven telescopes which are normally used in program asteroid family studies. The focus is on near-Earth asteroids, but when suitable targets are not available, Jovian Trojans and Hildas are observed. When a nearly full moon is too close to the family targets being studied, targets of opportunity amongst the main-belt families were selected.

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. Images were unbinned with no filter and had master flats and darks applied. The exposure duration varied depending on the asteroid's brightness and sky motion.

Telescope	Camera
0.30-m f/6.3 Schmidt-Cass	FLI Microline 1001E
0.35-m f/9.1 Schmidt-Cass	FLI Microline 1001E
0.35-m f/9.1 Schmidt-Cass	FLI Microline 1001E
0.35-m f/9.1 Schmidt-Cass	FLI Microline 1001E
0.40-m f/10 Schmidt-Cass	FLI Microline 1001E
0.40-m f/10 Schmidt-Cass	FLI Proline 1001E
0.50-m F8.1 R-C	FLI Proline 1001E

Table I: List of CS3 telescope/CCD camera combinations.

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). 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 ATLAS catalog (Tonry et al., 2018), which has Sloan *griz* magnitudes that were derived from the GAIA and Pan-STARR catalogs, among others. The authors state that systematic errors are generally no larger than 0.005 mag, although they can reach 0.02 mag in small areas near the Galactic plane. BVRI magnitudes were derived by Warner using formulae from Kostov and Bonev (2017). The overall errors for the BVRI magnitudes, when combining those in the ATLAS catalog and the conversion formulae, are on the order of 0.04-0.05 mag.

Even so, we found in most cases that nightly zero point adjustments on the order of only 0.02-0.03 mag were required during period analysis. There were occasional exceptions that required up to 0.10 mag. These may have been related in part to

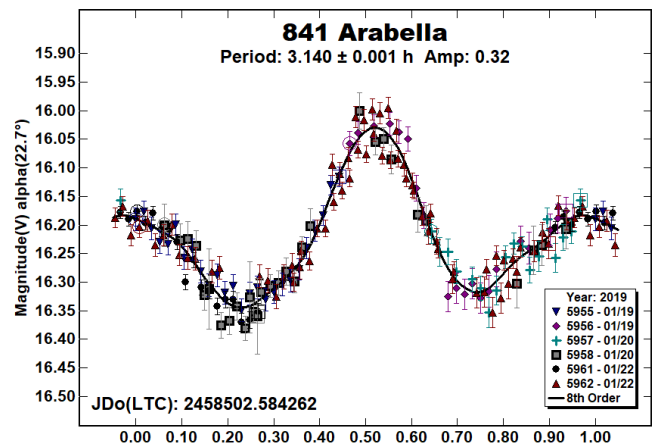
using unfiltered observations, poor centroiding of the reference stars, and not correcting for second-order extinction terms. Regardless, the systematic errors seem to be considerably less than other catalogs, which reduces the uncertainty in the results when analysis involves data from extended periods or the asteroid is tumbling.

In the lightcurve plots, the “Reduced Magnitude” is Johnson V corrected to a unity distance by applying $-5 \cdot \log(r\Delta)$ 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 gives the rotational phase from -0.05 to 1.05 .

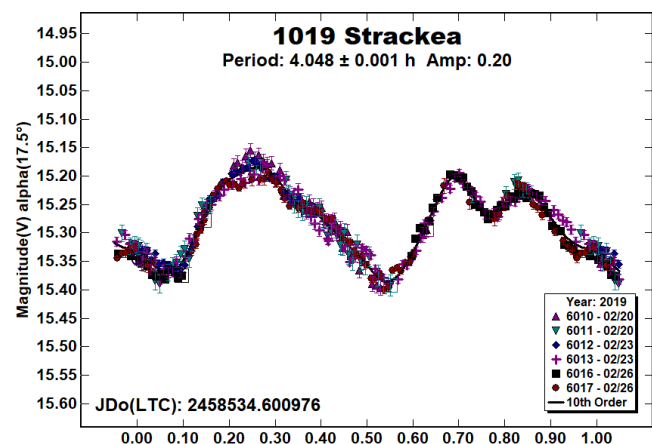
The amplitude indicated in the plots (e.g. Amp. 0.20) is the amplitude of the Fourier model curve and not necessarily the adopted amplitude of the lightcurve.

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

841 Arabella, Klinglesmith et al. (2016) previously observed this Flora family member, finding a rotational period of 3.142 h. This year's result is in good agreement with their period.

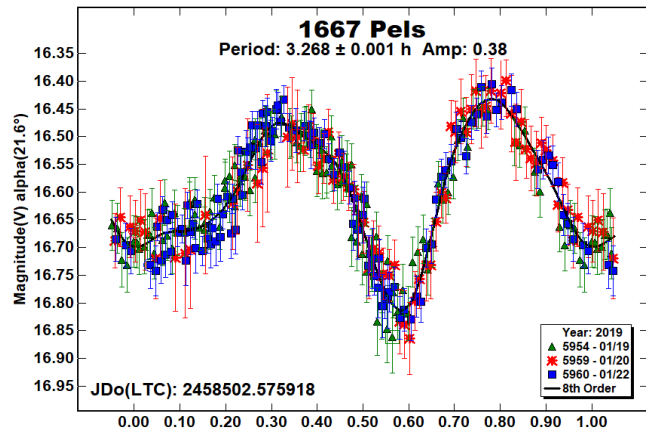


1019 Strackea. We studied this member of the Hungaria family three times in the past (Warner, 2009; 2011a; 2014a), each time finding a rotational period near 4.05 h. The result found this year is consistent with those findings.

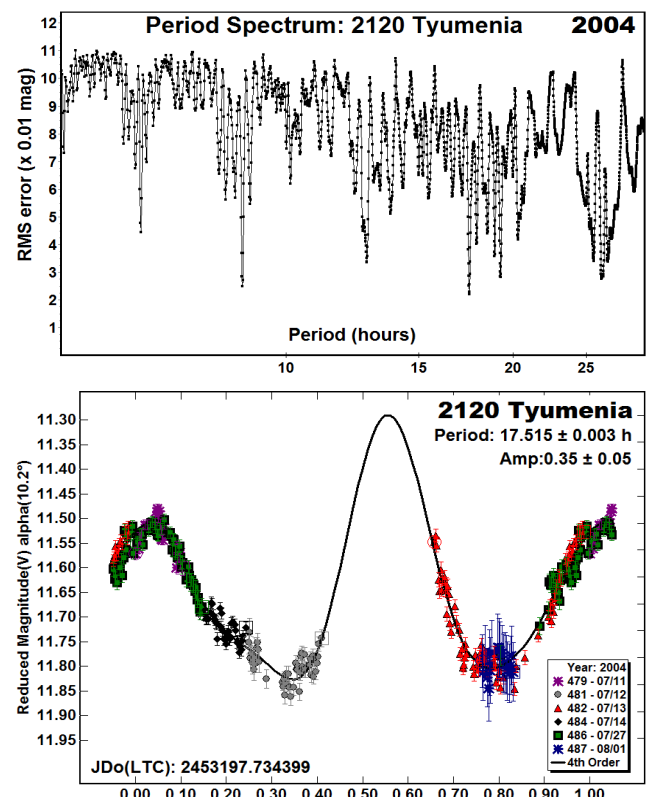


A previous shape and spin model (Warner 2019) found $(\lambda, \beta) = (227^\circ, -52^\circ)$ or $(219^\circ, +54^\circ)$ and $P_{SIDEREAL} = 4.047270$ h. It is hoped that this year's data will improve upon that model.

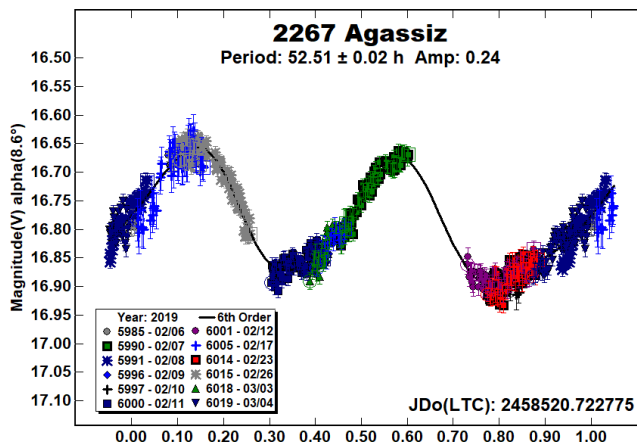
1667 Pels. Wisniewski et al. (1997) and Kryszczynska et al. (2012) found a rotational period near 3.27 h for this inner main-belt asteroid. The rotational period found this year is in good agreement with those results.



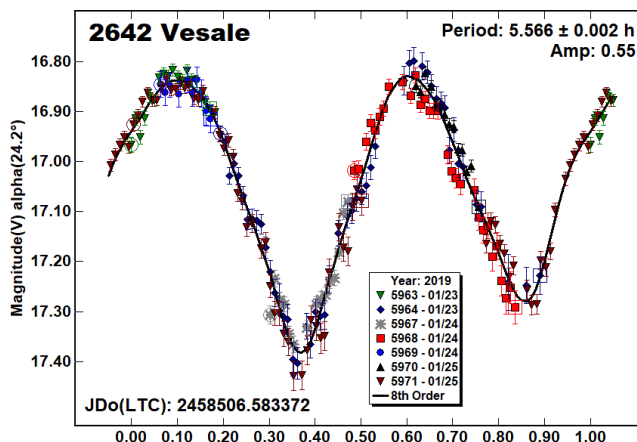
2120 Tyumenia. This outer main-belt asteroid has been observed several times. Oliver et al. (2008) and Pligge et al. (2011) both found results near 17.5 h. Warner (2005) observed the asteroid in 2004 July and found a period of 2.769h. Āurech et al. (2018) used sparse-in-time photometry from the Lowell Observatory Database to find a sidereal period of 17.4991 ± 0.0002 h and pole solution $(\lambda, \beta) = (244^\circ, +45^\circ)$ or $(92^\circ, +23^\circ)$. They alerted Warner to the discrepancy; he then re-measured the original images using modern photometric catalogs and found a result consistent with the Āurech et al. sidereal period.



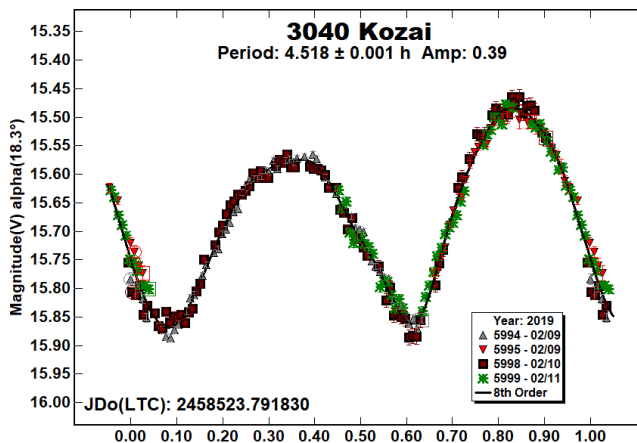
2267 Agassiz. No entry was found in the LCDB for this member of the Flora family/group.



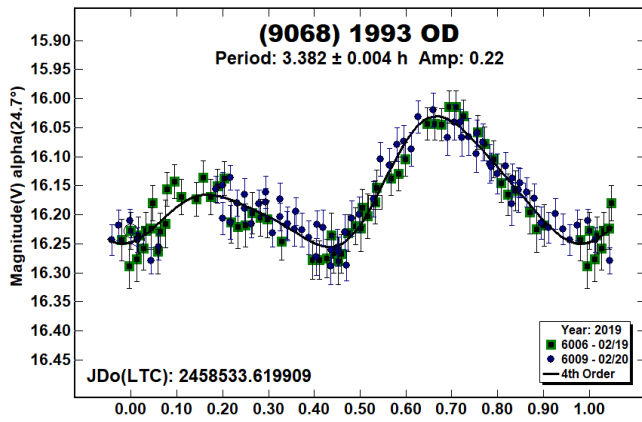
2642 Vesale. Warner (2011b) and Waszczak et al. (2015) both found periods near 5.56 h. The results this year are in good agreement with those findings.



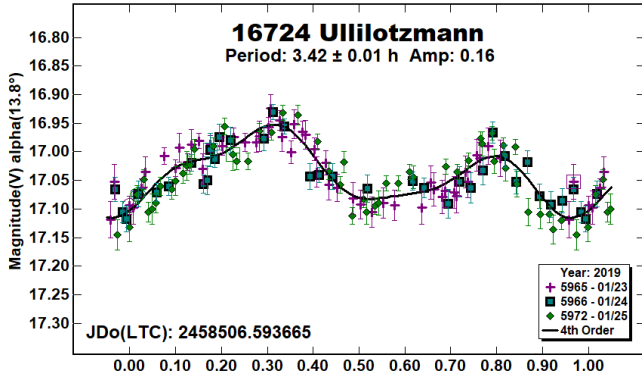
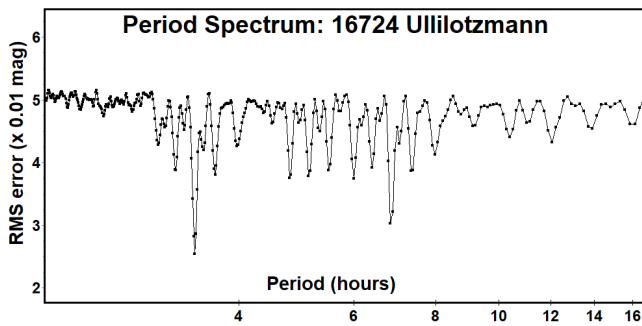
3040 Kozai. Pravec et al. (2019) found $P = 4.515$ h for this Mars-crosser during the Photometric Survey for Asynchronous Binary Asteroids. The period found this year agrees with Pravec et al.



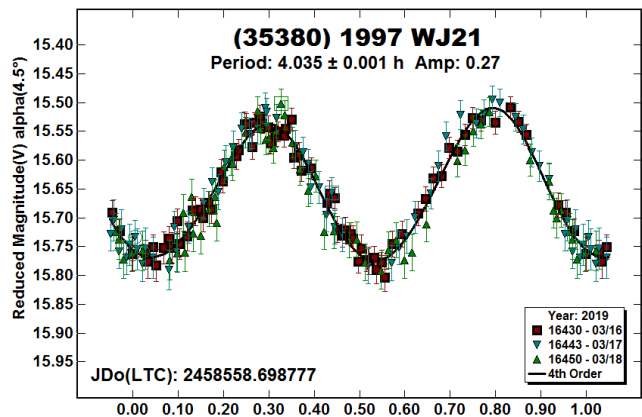
(9068) 1993 OD. This Hungaria family member has been observed several times in the past. Behrend (2019), Warner (2009; 2014b) and Pravec (2019) all reported periods 3.40 h. This result is in good agreement.



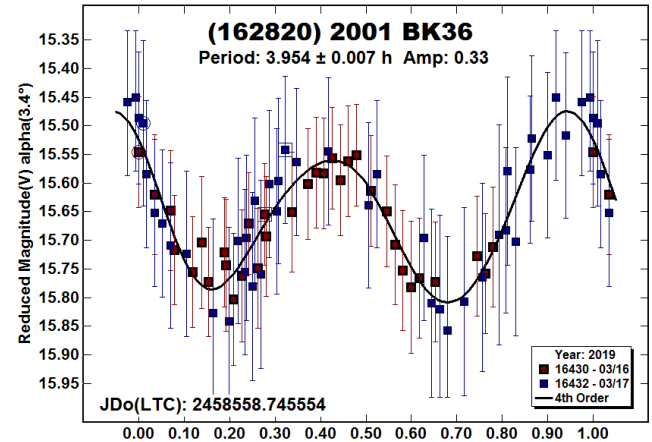
16724 Ulliloztmann. No entry was found in the LCDB for this Mars-crosser.



(35380) 1997 WJ21. No entry was found in the LCDB for this member of the Flora Family.



(162820) 2001 BK36. No entry was found in the LCDB for this member of the Eunomia family.



Acknowledgements

Funding for observations at CS3 and work on the asteroid lightcurve database (LCDB; Warner et al., 2009) and ALCDEF database (*alcdef.org*) are supported by NASA grant 80NSSC18K0851. This work includes data from the Asteroid Terrestrial-impact Last Alert System (ATLAS) project. ATLAS is primarily funded to search for near earth asteroids through NASA grants NN12AR55G, 80NSSC18K0284, and 80NSSC18K1575; byproducts of the NEO search include images and catalogs from the survey area. The ATLAS science products have been made possible through the contributions of the University of Hawaii Institute for Astronomy, the Queen's University Belfast, the Space Telescope Science Institute, and the South African Astronomical Observatory. 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.

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Number	Name	2019/mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period	P.E.	Amp	A.E.	Grp
841	Arabella	01/19-01/22	184	22.8,23.6	74	5	3.140	0.001	0.32	0.02	FLOR
1019	Strackea	02/20-02/26	362	17.6,20.2	124	-8	4.048	0.001	0.20	0.01	H
1667	Pels	01/19-01/22	301	21.6,22.0	61	-1	3.268	0.001	0.38	0.02	FLOR
2120	Tyumenia	⁰⁴ 07/11-08/01	293	10.29,7,10.9	0	21	17.515	0.003	0.35	0.05	MB-O
2267	Agassiz	02/06-03/04	595	8.6,0.4,5.3	153	297	52.51	0.02	0.24	0.02	FLOR
2642	Vesale	01/23-01/25	203	24.2,24.5	68	-15	5.566	0.002	0.55	0.02	MB-I
3040	Kozai	02/09-02/11	243	18.3,17.5	160	15	4.518	0.001	0.39	0.02	MC
9068	1993 OD	02/19-02/20	127	24.8,25.2	115	-3	3.382	0.004	0.22	0.02	H
16724	Ullilotzmann	01/23-01/25	135	13.9,14.7	102	-8	3.42	0.01	0.16	0.02	MC
35380	1997 WJ21	03/16-03/18	178	4.5,3.9	178	-5	4.035	0.001	0.27	0.02	FLOR
162820	2001 BK36	03/16-03/17	73	3.4,3.2	178	-5	3.954	0.007	0.33	0.03	EUN

Table II. Observing circumstances and results. ⁰⁴ Observations in 2004. 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): H, Hungaria; MB-I/O, main belt inner/outer; MC, Mars-crosser; FLOR, Flora; EUN Eunomia.

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NEAR-EARTH ASTEROID (152931) 2000 EA107: A PROBABLE BINARY

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(Received: 2019 April 8)

CCD photometric observations of the near-Earth asteroid (152931) 2000 EA107 were made in 2019 March and April at the Center for Solar System Studies (CS3). Analysis of the data found that the asteroid is likely a binary. The primary period is $P_1 = 4.1367 \pm 0.0002$ h with a lightcurve amplitude of $A_1 = 0.29 \pm 0.02$ mag. The secondary period is $P_2 = 16.079 \pm 0.006$ h with a lightcurve amplitude of $A_2 = 0.16 \pm 0.01$ mag. No mutual events (occultations and/or eclipses) were seen to confirm the presence of a satellite.

According to Mainzer et al. (2016), the near-Earth asteroid (152931) 2000 EA107 has an effective diameter of $D = 1.65$ km and albedo $p_V = 0.237$ based on $H = 16.10$. Thomas et al. (2014) classified it as taxonomic type Q, which is an intermediate class between S and V that shows the presence of metal. On the other hand, Carry et al. (2016) gave a type S classification.

The only previously reported period we found was by Polishook (2012), who found a period of $P = 4.137$ h and amplitude $A = 0.28$ mag. The observations in 2010 were made at a solar phase angle of about 49° and phase angle bisector longitude (see Harris et al., 1984) of 188° .

Observations of 2000 EA107 at the Center for Solar System Studies (CS3) were started on 2019 March 14 and continued through April 4. Table I gives the instrumentation used by each observer, the exposure time (seconds), and the corresponding session (observing run) numbers in the lightcurves below.

Obs	Scope	CCD	Exp	Sess
RDS	0.40-m f/10 SCT	FLI PL-1001E	300	1-11
BDW	0.35-m f/9.1 SCT	FLI ML-1001E	240	12-13

Table I. List of equipment and exposure times for each observer. The Sess column gives the data subsets each observer produced.

All observations were unfiltered since a clear filter can cause a 0.1-0.3 mag loss.

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 taken from ATLAS catalog (Tonry et al., 2018), which has Sloan *griz* magnitudes that were derived from the

GAIA and Pan-STARR catalogs, among others. The authors state that systematic errors are generally no larger than 0.005 mag, although they can reach 0.02 mag in small areas near the Galactic plane. BVRI magnitudes were derived by Warner using formulae by Kostov and Bonev (2017). The overall errors for the BVRI magnitudes, when combining those in the ATLAS catalog and the conversion formulae, are on the order of 0.04-0.05.

Even so, we found in most cases that nightly zero point adjustments on the order of only 0.02-0.03 mag were required during period analysis. There were occasional exceptions that required up to 0.10 mag. These may have been related in part to using unfiltered observations, poor centroid fitting of the reference stars, and not correcting for second-order extinction terms. Regardless, the systematic errors seem to be considerably less than other catalogs, which reduces the uncertainty in the results when analysis involves data from extended periods or the asteroid is tumbling.

Period analysis was done with *MPO Canopus*, which implements the FALC algorithm by Harris (Harris et al., 1989). The same algorithm is used in an iterative fashion when it appears there is more than one period. This works well for binary but not for tumbling asteroids.

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 $-5 \cdot \log(r\Delta)$ 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*.

Data Analysis

The initial observations almost immediately indicated a secondary period in the data. This is clearly demonstrated in the “No Sub” plot, which shows the full data set phased to a single period. Using the dual-period analysis in *MPO Canopus*, we were able to settle on a primary period of about 4.137 h (“P1”). The secondary period was harder to establish since it seemed to be nearly commensurate with an Earth day at a 3:2 ratio. This meant that almost exactly the same part of the secondary lightcurve was observed every other night.

The problem would not have been insurmountable for a single station save for unusually poor weather. We were eventually able to cover most of the secondary lightcurve. Continued poor weather and shortened nightly runs due to the asteroid’s sky location forced closing the campaign sooner than we would have liked.

Number	Name	2019 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
152931	2000 EA107	03/14-04/03	254	54.6, 66.2	211	44	4.1367 16.079	0.0002 0.006	0.29 0.16	0.02 0.01

Table II. Observing circumstances. The first line gives the rotation period for the primary of the presumed binary asteroid. The second line is the secondary period presumed to be to a satellite. The phase angle (α) is given at the start and end of each date range. If there are three values, the middle one is the minimum phase angle reached during the period. L_{PAB} and B_{PAB} are, respectively the average phase angle bisector longitude and latitude.

Acknowledgements

Funding for observations at CS3 and work on the asteroid lightcurve database (Warner et al., 2009) and ALCDEF database (*alcdef.org*) are supported by NASA grant 80NSSC18K0851. This work includes data from the Asteroid Terrestrial-impact Last Alert System (ATLAS) project. ATLAS is primarily funded to search for near earth asteroids through NASA grants NN12AR55G, 80NSSC18K0284, and 80NSSC18K1575; byproducts of the NEO search include images and catalogs from the survey area. The ATLAS science products have been made possible through the contributions of the University of Hawaii Institute for Astronomy, the Queen's University Belfast, the Space Telescope Science Institute, and the South African Astronomical Observatory. 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.

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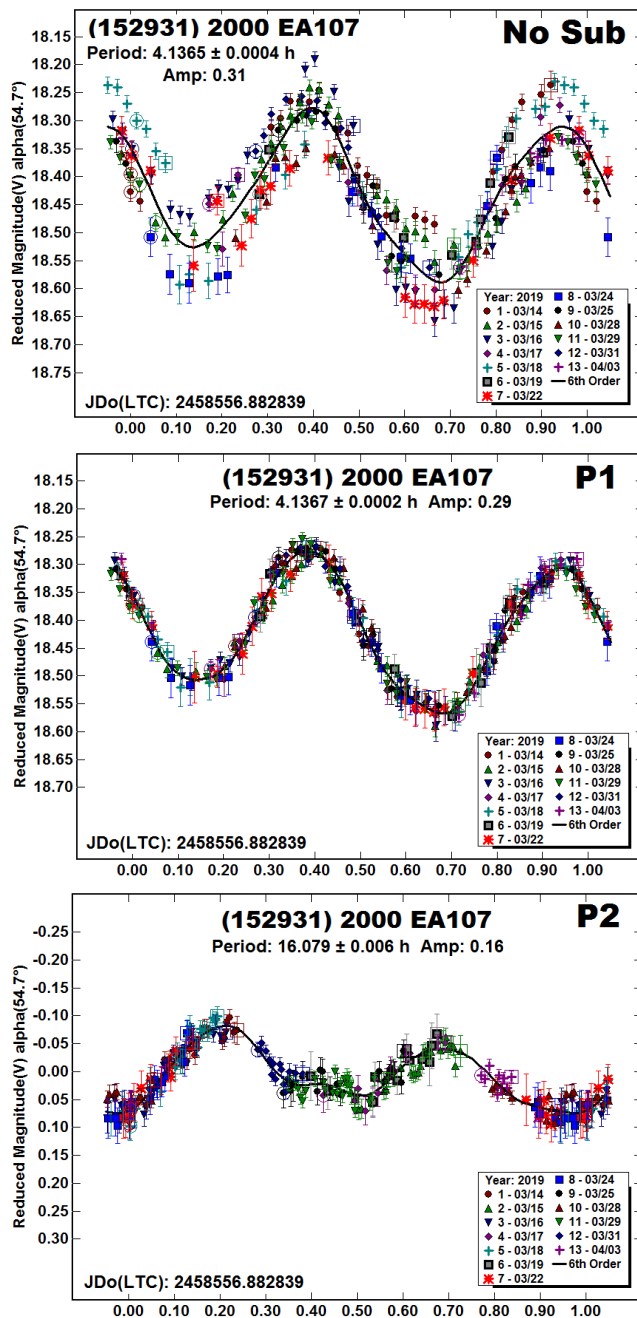
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The phase angle bisector longitude during our observations differed by almost 23° from when Polishook (2012) observed the asteroid in 2010. He did not report signs of a secondary period at the time. It's possible that the difference in longitudes allowed the viewing geometry in 2019 to be less pole-on and so the secondary variations could be seen. The longitude evolves slowly from one apparition to the next. It won't be until the mid-2020's that the longitude will favor viewing geometries that might be even more equatorial *and* the asteroid won't be in rich star fields.

Despite what seems convincing evidence for a satellite, 2000 EA107 is not a confirmed binary since mutual events (occultations/eclipses) were not seen.

**NEAR-EARTH ASTEROID LIGHTCURVE ANALYSIS
AT THE CENTER FOR SOLAR SYSTEM STUDIES:
2019 JANUARY-APRIL**

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Lightcurves for 24 near-Earth asteroids (NEAs) obtained at the Center for Solar System Studies (CS3) from 2019 January-April were analyzed for rotation period, peak-to-peak amplitude, and signs of satellites or tumbling. Two asteroids, (381677) 2009 BJ81 and (454177) 2013 GJ35, were found to have two periods that make them additional candidates for the class of *very wide binary* asteroids. Another object with two periods was (18736) 1998 NU, 2.4753 h and 11.95 h. The second period solution is weak but does not seem to be systematic in nature. Potential tumblers include (88254) 2001 FM129, (90403) 2003 YE45, and 2006 SK134.

CCD photometric observations of 24 near-Earth asteroids (NEAs) were made at the Center for Solar System Studies (CS3) from 2019 January-April. 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.

Telescopes	Cameras
0.30-m f/6.3 Schmidt-Cass	FLI Microline 1001E
0.35-m f/9.1 Schmidt-Cass	FLI Proline 1001E
0.40-m f/10 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.

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. Comp star magnitudes were taken from ATLAS catalog (Tonry et al., 2018), which has Sloan *griz* magnitudes that were derived from the GAIA and Pan-STARR catalogs, among others. The authors state that systematic errors are generally no larger than 0.005 mag, although they can reach 0.02 mag in small areas near the Galactic plane. BVRI magnitudes were derived by Warner using formulae from Kostov and Bonev (2017). The overall errors for the BVRI magnitudes, when combining those in the ATLAS catalog and the conversion formulae, are on the order of 0.04-0.05.

Even so, we found in most cases that nightly zero point adjustments on the order of only 0.02-0.03 mag were required during period analysis. There were occasional exceptions that required up to 0.10 mag. These may have been related in part to using unfiltered observations, poor centroiding of the reference stars, and not correcting for second-order extinction terms. Regardless, the systematic errors seem to be considerably less than other catalogs, which reduces the uncertainty in the results when analysis involves data from extended periods or the asteroid is tumbling.

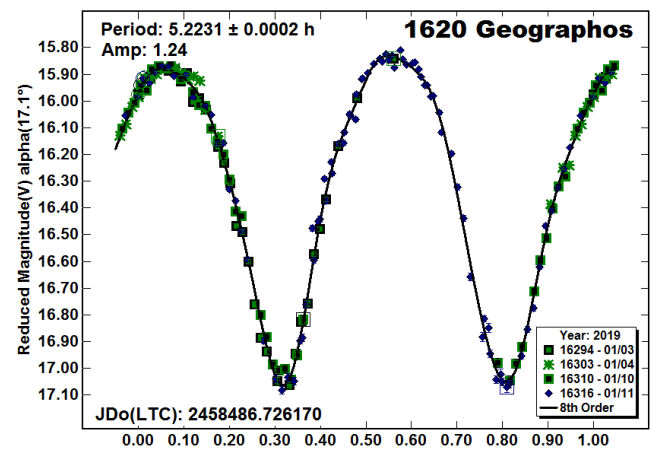
In the plots below, the "Reduced Magnitude" is Johnson V as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distances by applying $-5 \cdot \log(r\Delta)$ to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid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

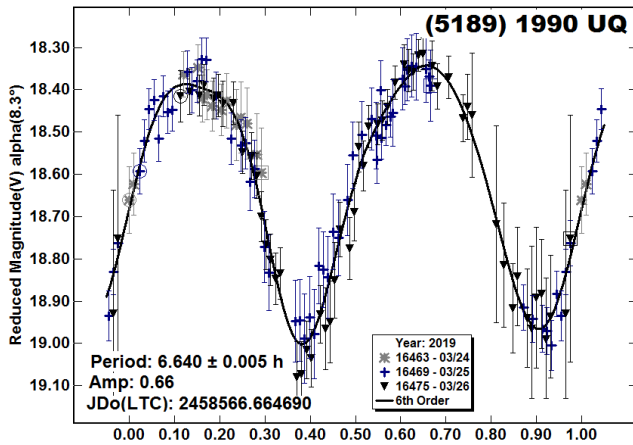
Our initial search for previous results started with the asteroid lightcurve database (LCDB; Warner *et al.*, 2009) found on-line at <http://www.minorplanet.info/lightcurvedatabase.html>. Readers are strongly encouraged to obtain, when possible, the original references listed in the LCDB.

1620 Geographos. The rotation period of this 2.5-km NEA has been well-established for some years. However, also known is that YORP (Rubincam, 2000) is causing the rotation rate to increase (period decrease) by $\sim 1.15 \times 10^{-8} \text{ rad}^{-1} \text{ d}^{-2}$ (Durech et al., 2008). In more practical terms, that is 0.027 s y^{-1} . That may not seem like much, but it amounts to an actual rotation shift from the model of about $0.51^\circ \text{ y}^{-1}$, meaning that in just 5 years, the asteroid will be about 133 s ahead of schedule!

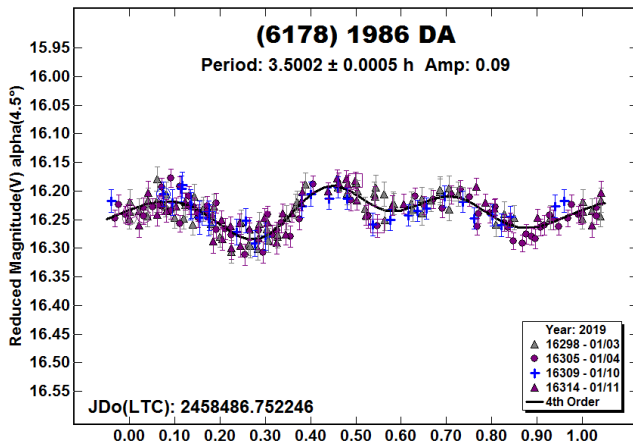
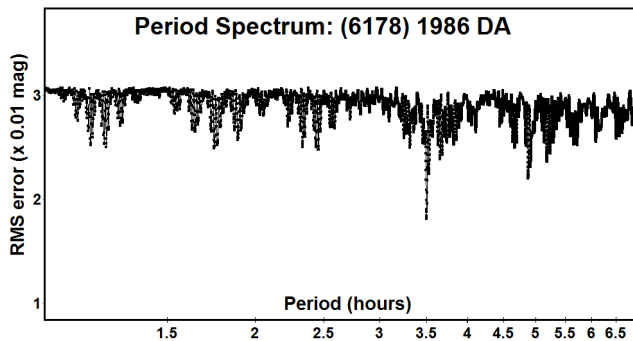
These numbers are based on data through 2008. The data from our observations adds another 11 years to the range, which should allow refining the YORP numbers.



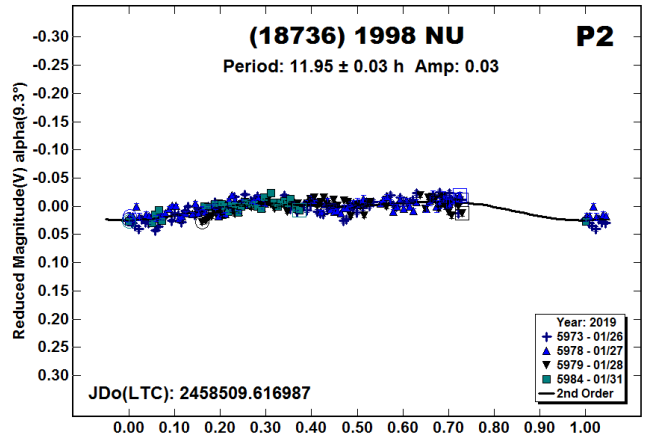
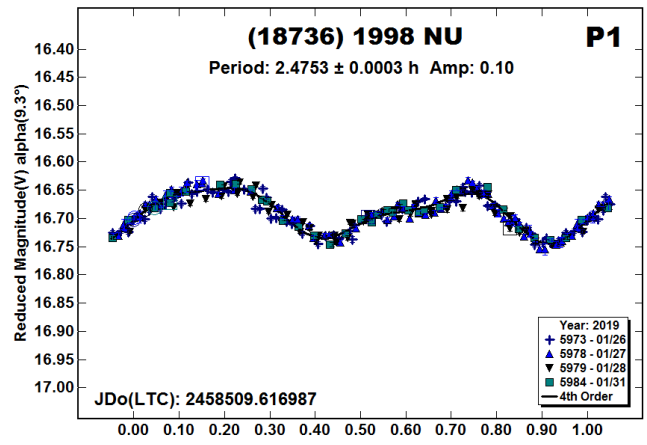
(5189) 1990 UQ. The only previous rotation period entry in the LCDB was by Warner (2018), who found a period of 6.676 h. The data from the latest observations provide a more secure period despite the relatively large error bars.



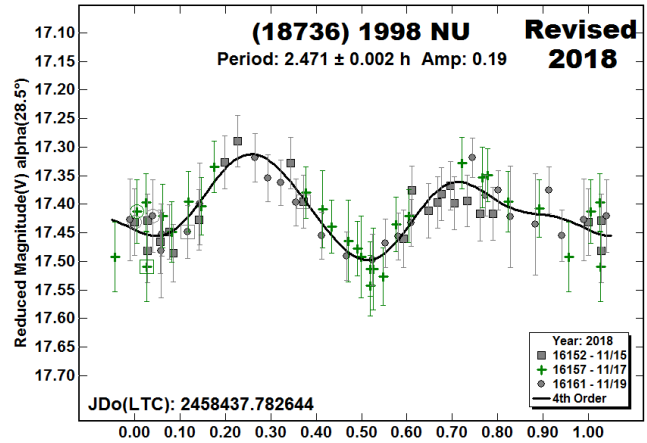
(6178) 1986 DA. A lightcurve with a small amplitude, such as seen in 2019 (0.09 mag), often leads to several ambiguous solutions. The period spectrum shows otherwise in this case. Our result is in close agreement with Zeigler (1990, 3.50 h) and Pravec et al. (1999, 3.50 h). However, those earlier results featured large amplitudes from 0.3 to 0.48 mag. This suggests that the asteroid’s spin axis has a longitude somewhat near 107° (or 287°), the first being the phase angle bisector longitude of our observations.



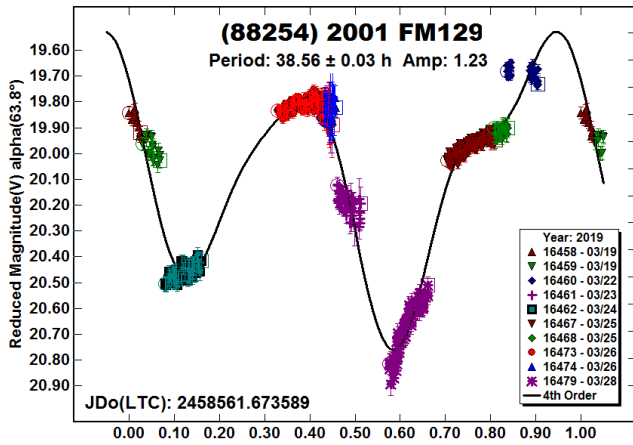
(18736) 1998 NU. We previously reported a period of 3.796 h (Warner and Stephens, 2019). However, that contradicted early results, such as those from Pravec et al. (2019, 2.47542 h). New observations at CS3 in 2019 January led to a period of 2.4753 h, in good agreement with Pravec et al. A secondary period ($P_2 = 11.95$ h, $A_2 = 0.03$ mag) that clearly stood out in the period spectrum noticeably improved the primary (P_1) period. Carreno et al. (2019) also found a secondary period ($P_2 = 12.513$ h, $A_2 = 0.05$ mag) when they observed the asteroid about two weeks earlier.



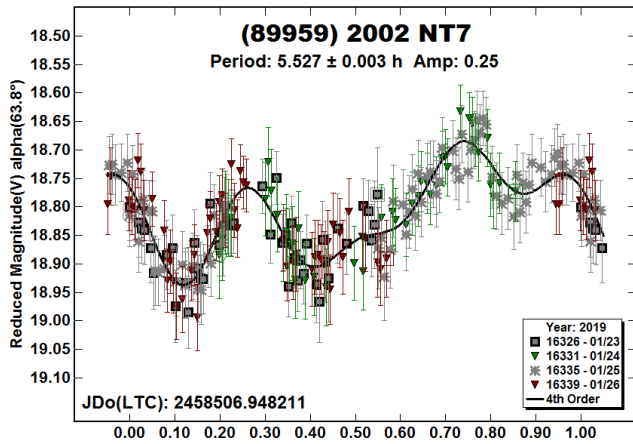
With the additional confirmation of a primary period near 2.47 h, our 2019 January data were reanalyzed, leading to a revised period of $P = 2.471$ h.



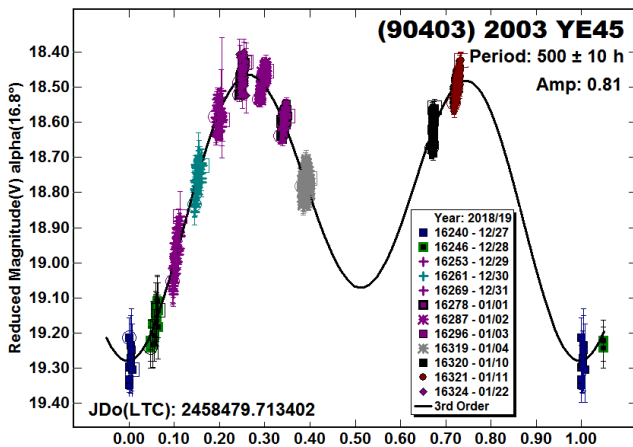
(88254) 2001 FM129. There were no previously reported rotation periods found in the LCDB. While the lightcurve is incomplete, the odd shape and “out of place” sessions give a good indication that the asteroid is in non-principal axis rotation (NPAR, tumbling). Given the size and period, this is not unexpected (see Pravec et al., 2014; 2005).



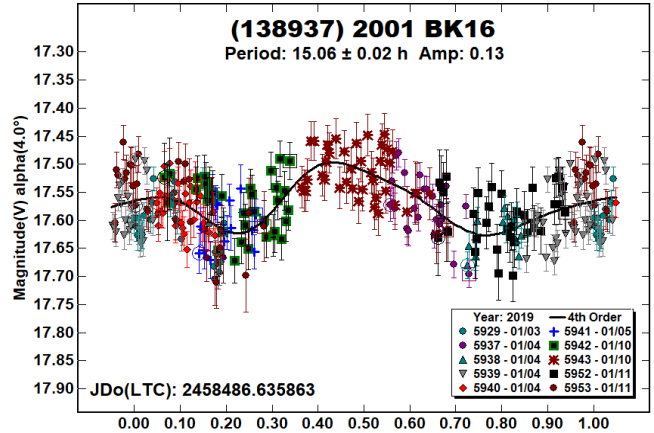
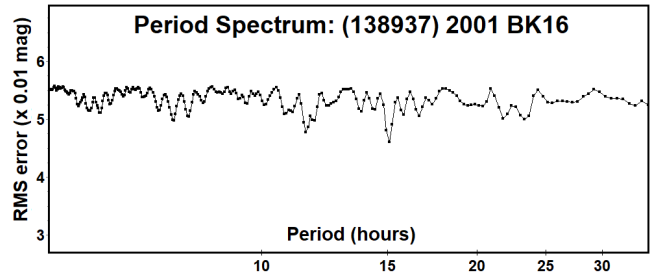
(89959) 2002 NT7. The period spectrum strongly favors a period of 5.527 h. The unusual lightcurve shape is possibly due to shadowing effects at the large solar phase angle of 63°.



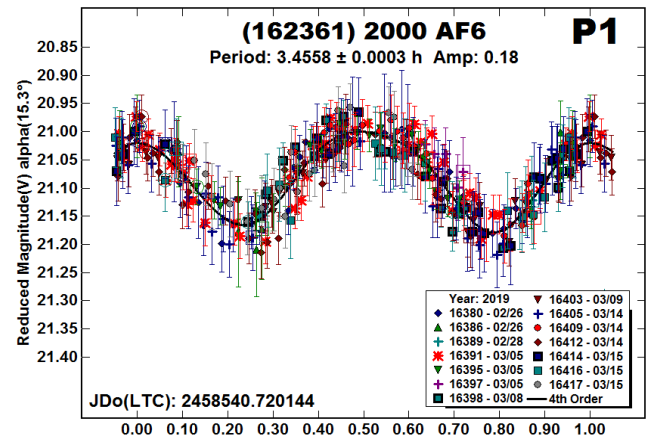
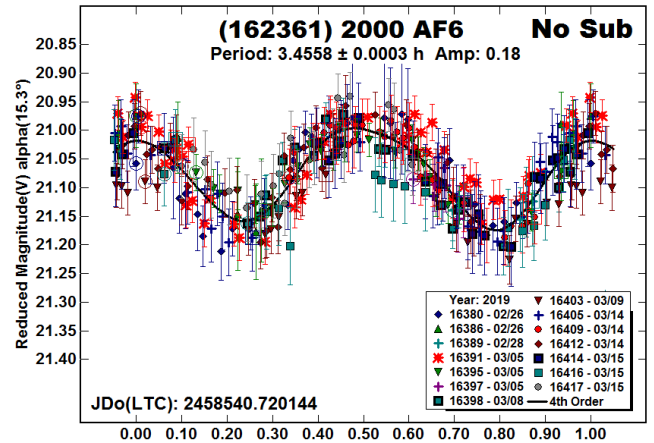
(90403) 2003 YE45. This appears to be the first reported rotation period for this NEA, which has an estimated diameter of 900 meters (LCDB). Tumbling is suggested by the slopes of some sessions not agreeing with the slope of the Fourier curve. With a period of 500 h, tumbling would be very likely (Pravec et al., 2014; 2005).

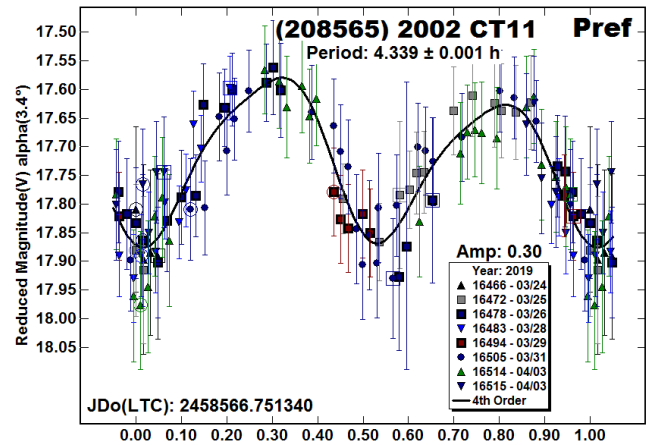
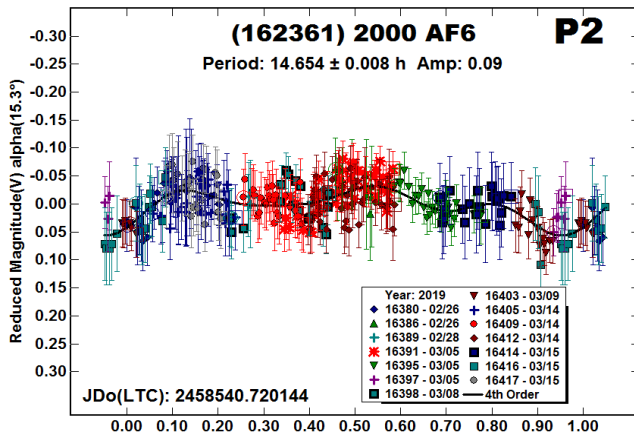


(138937) 2001 BK16. The period spectrum favors the adopted period of 15.06 hours but it can hardly be considered conclusive. There were no previous rotation period entries in the LCDB.

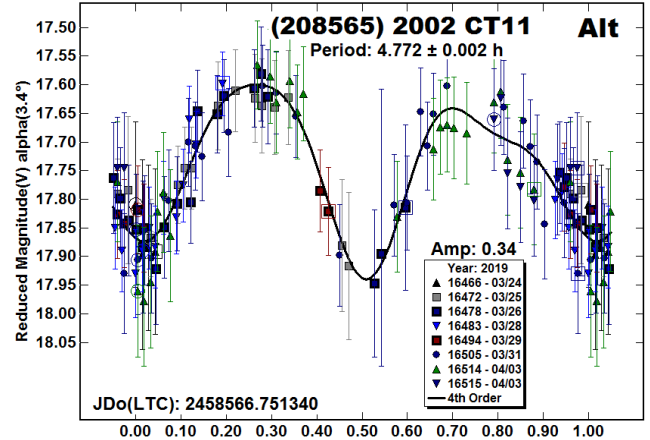
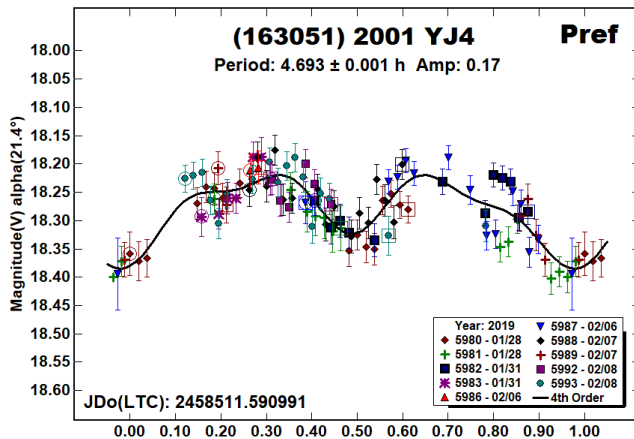


(162361) 2000 AF6. Removing a weak secondary period of $P_2 = 14.654$ h significantly reduces the RMS fit of the Fourier solution. The two periods have an almost exact 17:4 ratio, making it possible that the secondary lightcurve is just “garbage cleaning” by the Fourier analysis.

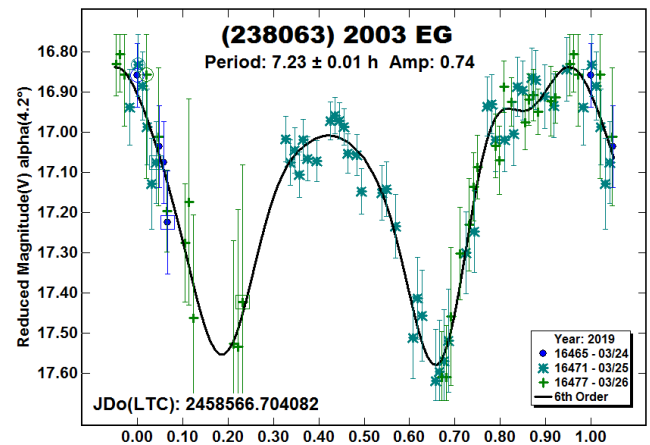
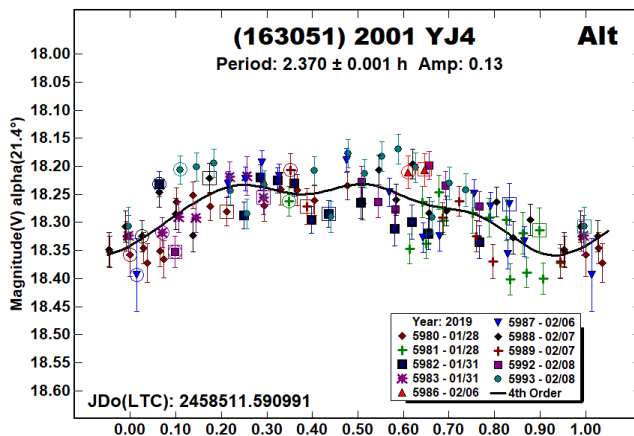




(163051) 2001 YJ4. The period spectrum showed several possibilities, the more prominent being 4.693 h and 2.370 h. The RMS fit was slightly better for the adopted longer period. However, the half-period cannot be formally excluded. There were no previous entries in the LCDB for this 1.6 km NEA.



(238063) 2003 EG. There were no previous entries in the LCDB for this 1.6 km NEA. While the coverage is incomplete, the solution is mostly secure by virtue of the low phase angle and large amplitude (Harris et al., 2014).

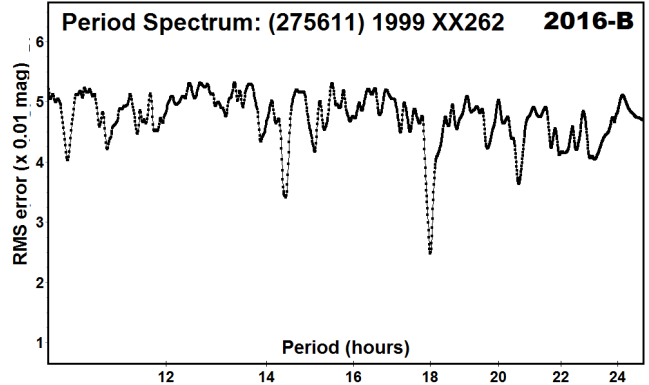
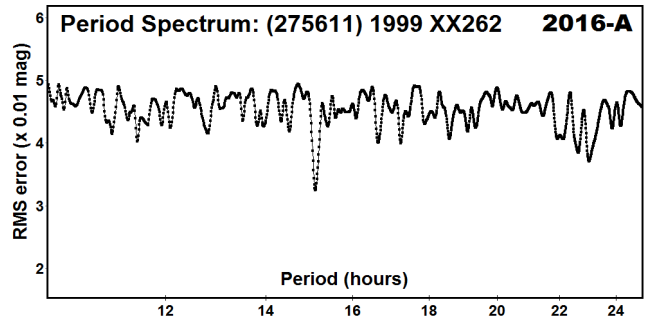
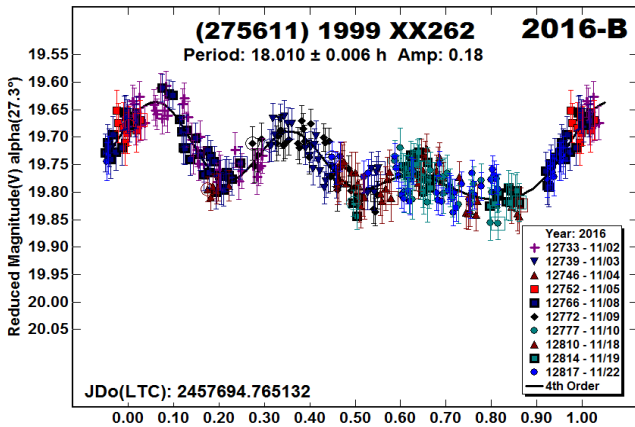
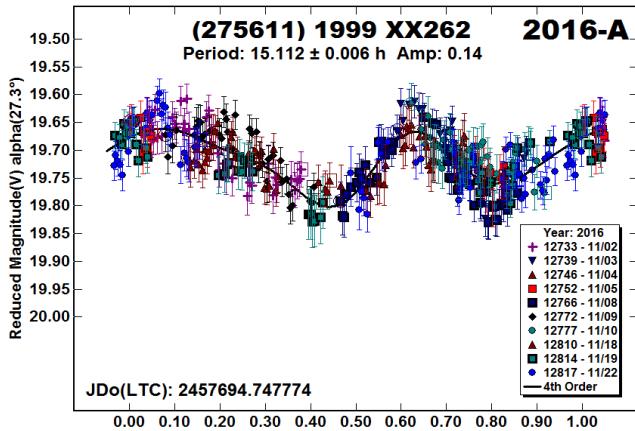
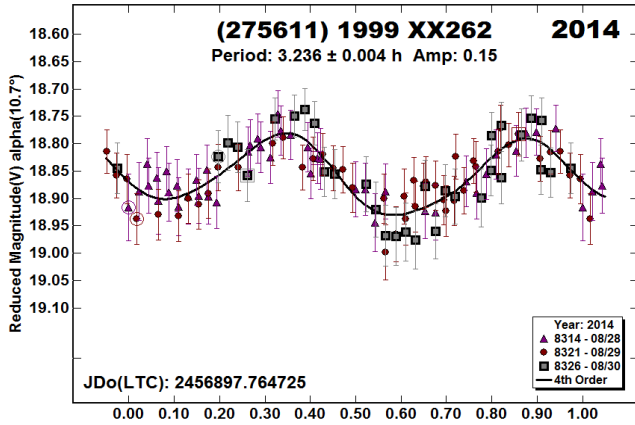
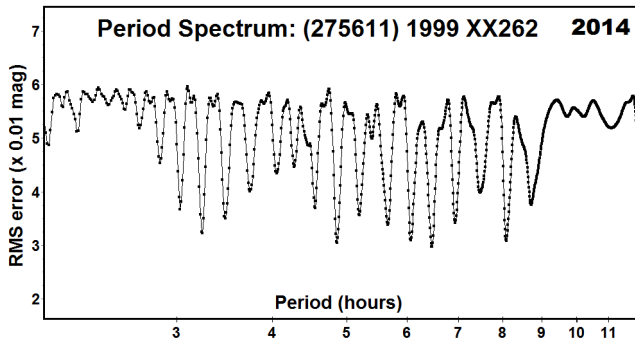


(208565) 2002 CT11. The period spectrum showed numerous nearly-equal solutions, most being due to *rotational aliasing*, which is when the true number of rotation periods over the span of the data set is uncertain. For the two more likely solutions given here, the difference over 24 hours is almost exactly 0.5 rotations. The shorter solution was adopted because the data cover the lightcurve more completely. The longer period could be a *fit by exclusion*, which is when the Fourier analysis minimizes the number of overlapping data points and so finds a local minimum in the RMS fit.

(275611) 1999 XX262. When observed the first time in 2014 (Warner, 2015a), a period of about 3.23 h was reported. There seemed little reason to doubt that the solution was correct based on the period spectrum, which slightly favored a solution of 4.87 h. That produced a trimodal lightcurve with some small gaps and considered to be a *fit by exclusion*.

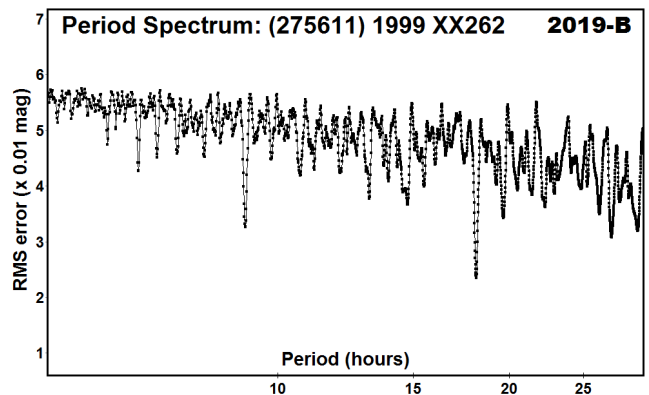
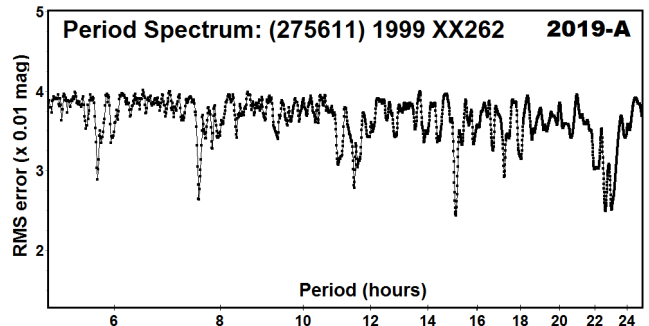
When observed again in 2016 November, two possible periods were found. The one for 15.112 h was with one set of zero point

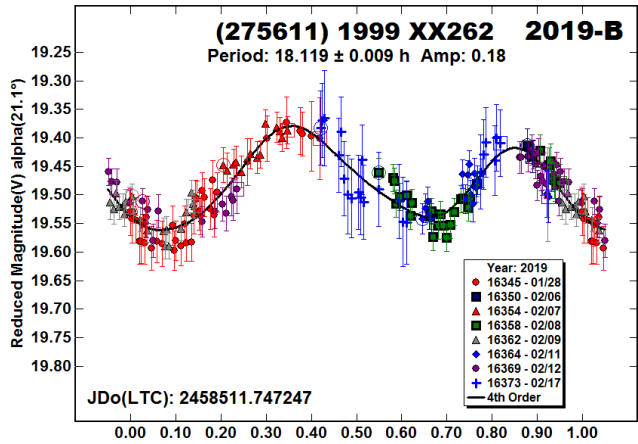
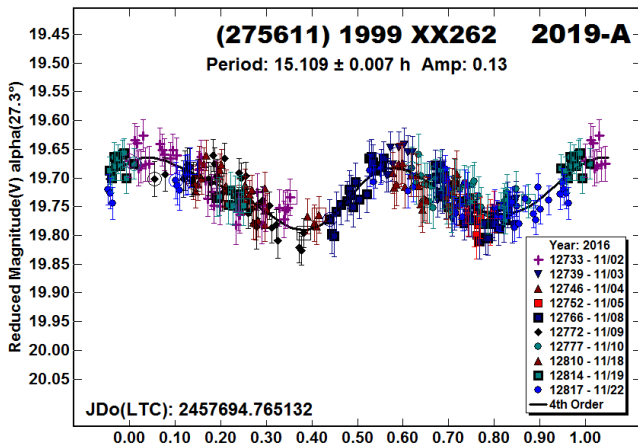
adjustments. With a second zero point adjustments (minor in both cases), a period of 18.010 h was found.



The most recent observations, made in 2019 February, initially found a period of 19.665 h but there were significant gaps in the resulting lightcurve. Again working with two different sets of zero point adjustments, also both minor, solutions of 18.119 h and 15.109 h were found.

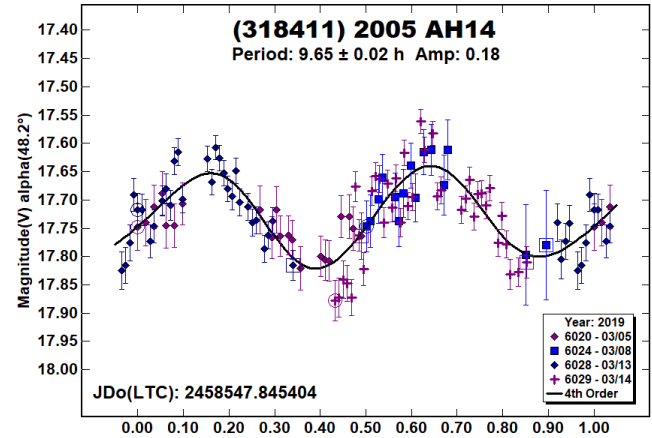
Obviously, only one period, within error bars, is right – unless tumbling is involved. Looking at the various solutions, we note that the 2019 results of 15.109 h and 18.119 h have an almost exact integral ratio of $6:5 \pm 0.3\%$.





This leaves open to speculation about the nature of the asteroid that would allow the data sets to have significantly different solutions based on the viewing aspect. What that might be cannot be determined without more detailed observations in the future.

(318411) 2005 AH14. The adopted period of 9.65 h produced a bimodal lightcurve but it is one of several nearly equal solutions from the period spectrum. The ambiguities are likely due to the sparse data set and several-day intervals between observing sessions.



(381677) 2009 BJ81. There were no rotation periods found in the LCDB. Despite the incomplete coverage, what overlap there is from one rotation to another seems to be consistent with a single period, even though the period and diameter make tumbling very likely (Pravec et al., 2014; 2005).

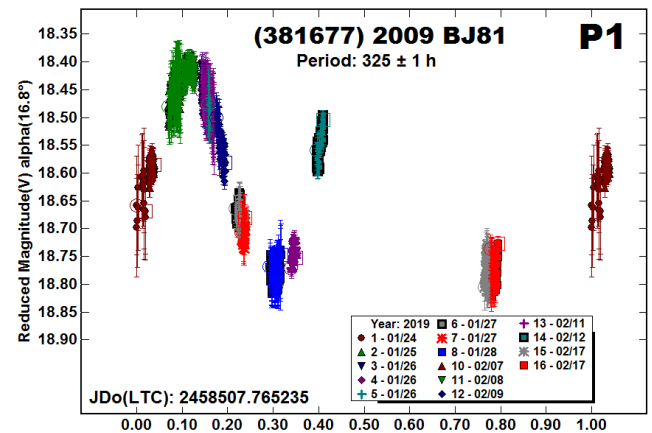
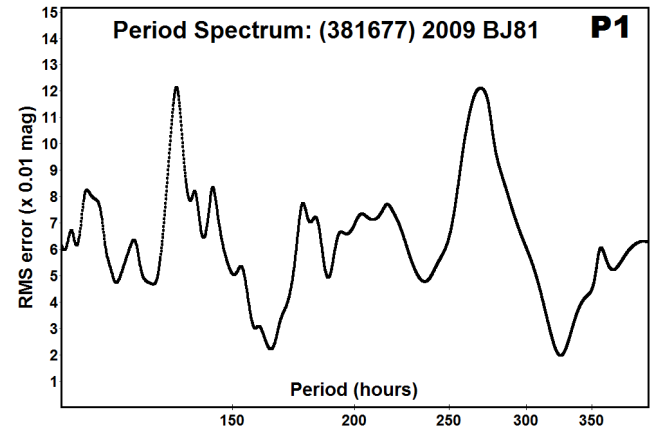
The close to harmonic (integral ratio) solutions suggests that the Fourier analysis found a local instead of global minimum. However, the period spectra for the two periods using the 2016 data set do not support this. Each one shows a distinct minimum at the adopted period and, more so, does not show the other period to be a likely alternate solution.

One explanation for the ambiguous solutions is that the asteroid is in a state of low amplitude tumbling. All the periods from 2016 and 2019 have tumbling damping times $T > 1$ Gyr if assuming the shorter values derived by Pravec et al. (2014), so this assumption has some standing.

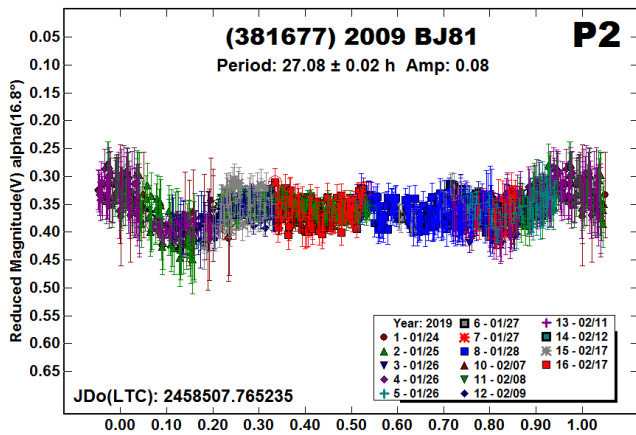
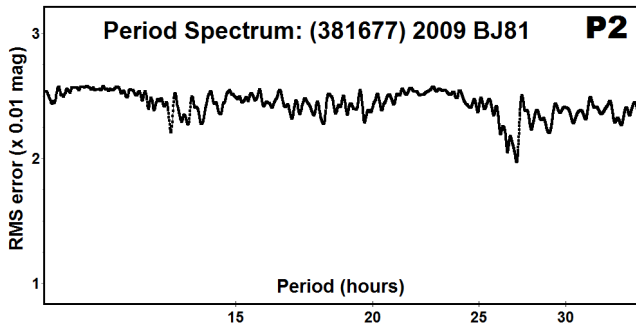
MPO Canopus does not implement the required algorithm to do a simultaneous dual-period solution when working with tumblers. However, it can sometimes find a single-period solution that is a “beat frequency” of the rotation and precession periods or can almost isolate the two periods if the level of tumbling is low.

Because of the nearly perfect integral ratio between 15.109 h and 18.119 h, we are adopting those periods for this paper. However, we do not claim whether the two are due to tumbling or are simply ambiguous due to uncertain zero point calibrations and/or the density and time distribution of the data sets.

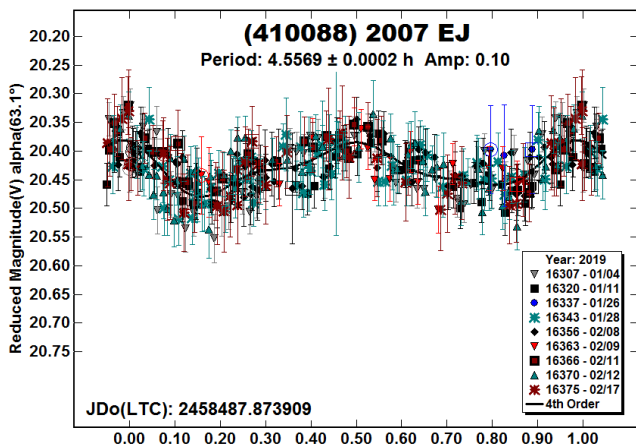
This still leaves the 3.23 h period from 2014 as unexplained. The data sets from 2016 and 2019 were examined for that period to no avail. The phase angle bisector longitude difference between 2014 and 2019 was 80°, presenting a viewing aspect at nearly right angles to one another. The 2014 and 2016 longitudes were 290° apart (or 110° if making the aspect looking towards the same pole). This is also close to a right-angles aspect change.



That said, a weak secondary period was found when subtracting the long period Fourier curve from the data. The noise and asymmetry of the lightcurve cast some suspicion on the reality of the solution. Assuming it is valid, this would make 2009 BJ81 a candidate for the list of *very wide binary* asteroids (see, e.g., Warner, 2016).

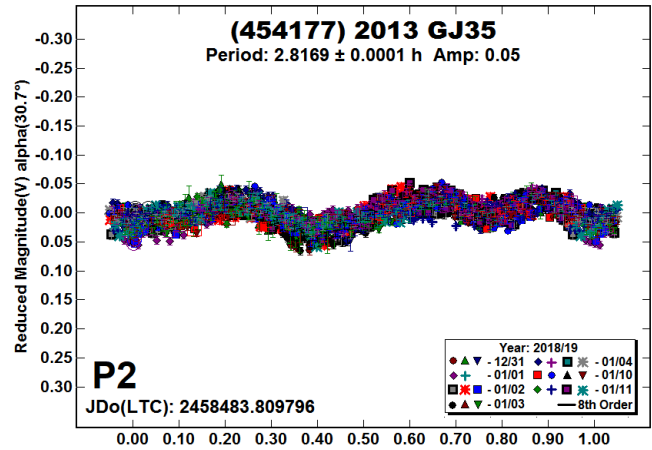
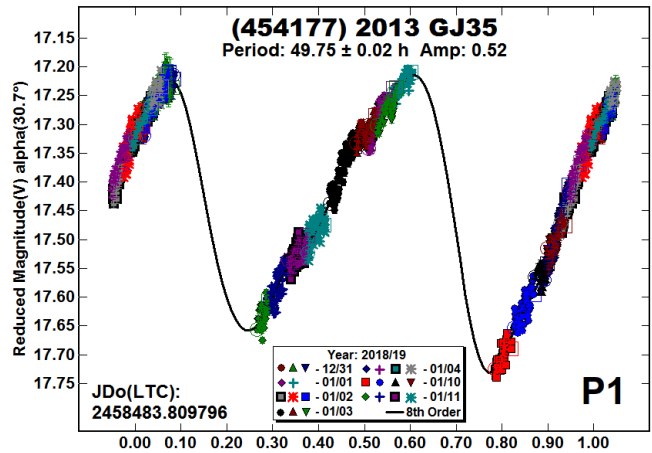


(410088) 2007 EJ. Warner (2015b) found a period of 4.781 h, which is very close to the double-period of 2.377 h found by Vaduvescu et al. (2017). The 2019 observations at CS3 led to a period of 4.5569 h, well outside the error bars for each. Neither data set produced by the authors could be fit to the period from the other data set.

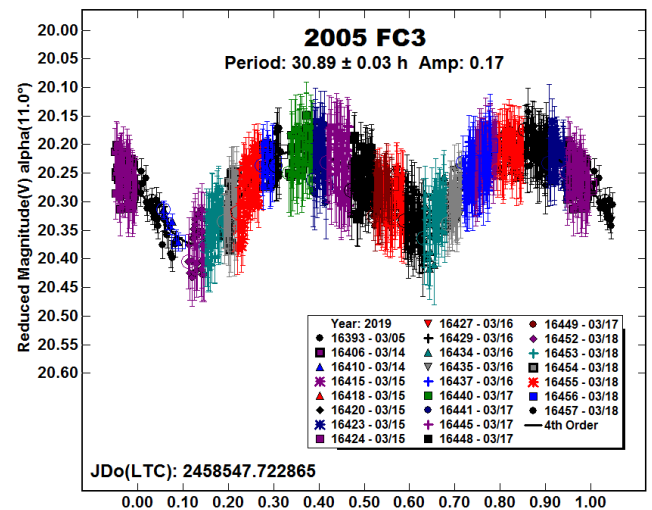


(454177) 2013 GJ35. This 2-km NEA (Warner et al., 2009) is a stronger candidate for the class of *very wide binary* asteroids than 2009 BJ81 (see above). Pravec et al. (2019) observed the asteroid about the same time (2019 January) and found a single period of 2.817 h, which is essentially the same as our secondary period of 2.8169 h. However, they observed the asteroid for only two

nights: January 6 and 7. Our observations spanned 12 nights, which gave a better opportunity to find a long-term component to the asteroid's lightcurve.

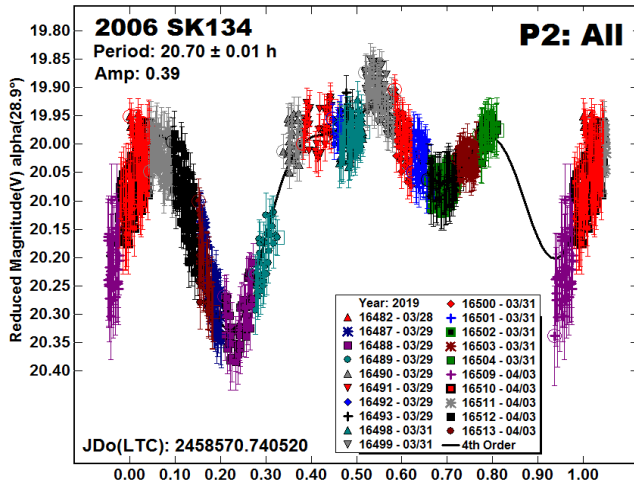
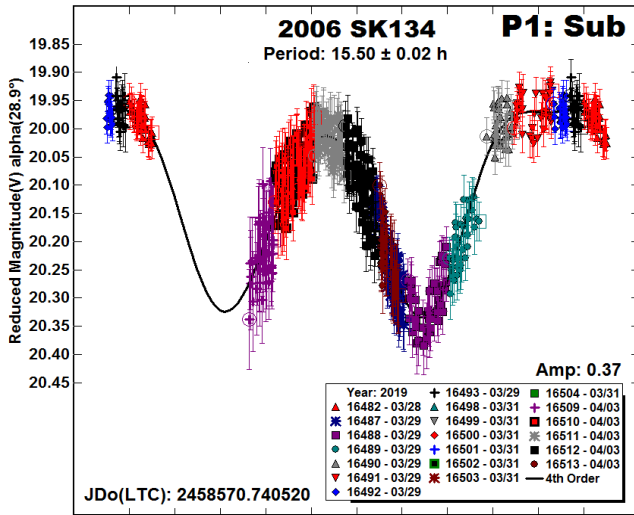
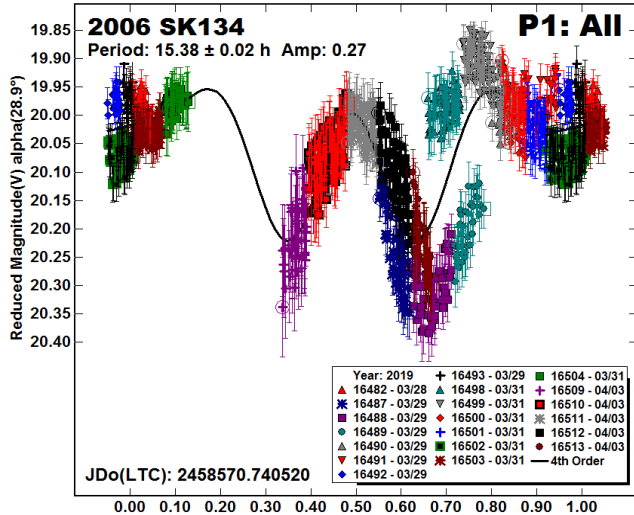


2005 FC3. Despite the noisy data, the solution of 30.89 h is considered mostly secure because almost all parts of the lightcurve were covered more than once. The size (400 m; Warner et al., 2009) and period make it a good tumbling candidate (Pravec et al., 2014) but if it is, any signs were hidden within the noise.



2006 SK134. This NEA is almost certain to be in a tumbling state. As discussed previously for (318411) 2005 AH14, MPO Canopus likely found the two dominant periods of tumbling. These are not

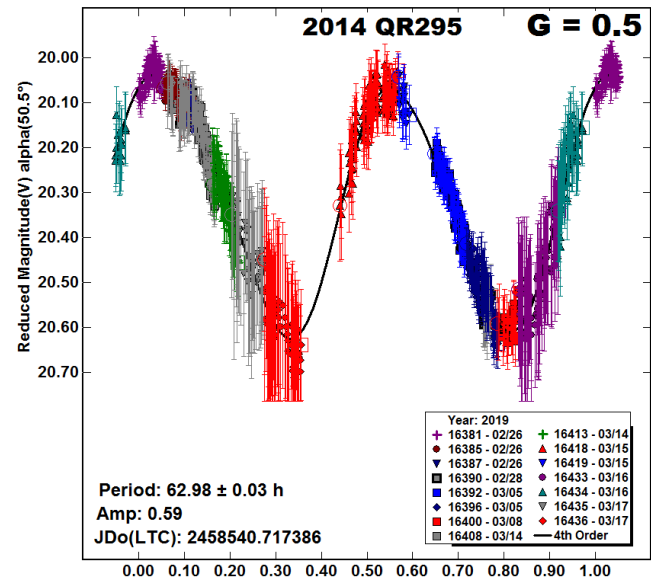
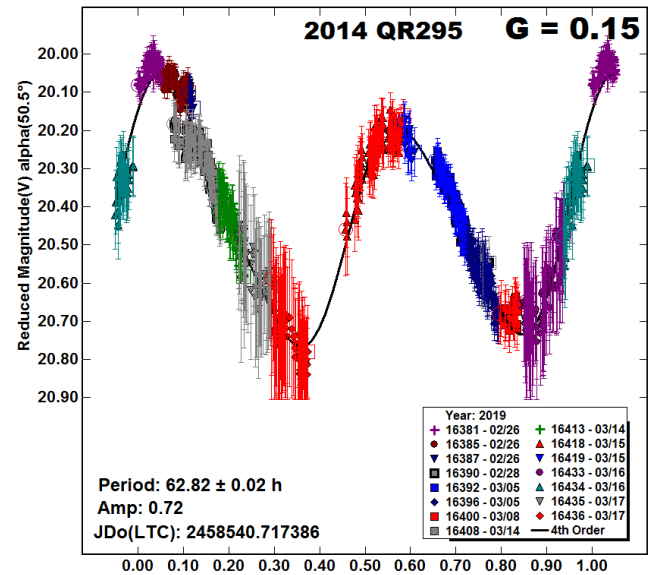
necessarily the actual periods of rotation and precession. The attempt find a single period gives good reason for suspecting tumbling. By subtracting the secondary period of 20.70 h, what appears to be a reasonably good single-period solution of 15.50 h is revealed. However, when subtracting that period from the data set, a poor-fitting solution of 20.70 h is found, which is one good indication of tumbling.



2014 QR295. There were no rotation periods found in the LCDB. Usually, a default value of $G = 0.15$ is used for the phase slope parameter to normalize the data set to a fixed phase angle. When the zero points were untouched, this produced an *almost* good fit to the data. However, by setting $G = 0.5$, the RMS fit was dramatically improved.

The issue is that $G = 0.5$ is usually associated with high-albedo objects (Warner et al., 2009), e.g., family members of the Hungarias. While most NEAs have moderate albedos of ~ 0.2 associated with taxonomic type S, the LCDB lists 13 NEAs with an albedo > 0.4 , which would also have large G values (> 0.3). On the other hand, Thomas et al. (2014) determined that the asteroid is a type Cgh on the Bus-Demeo taxonomic system. These types have low albedos and correspondingly low values of G .

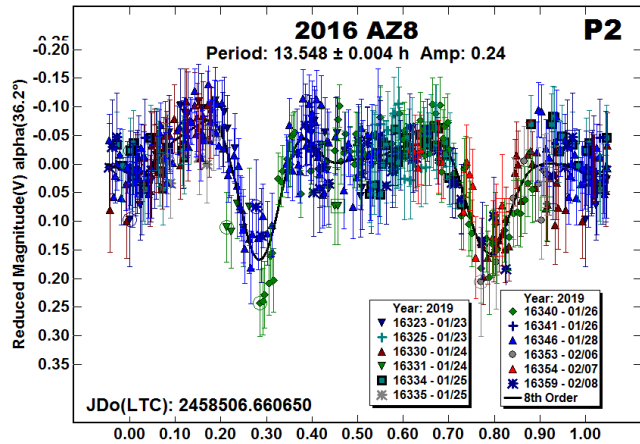
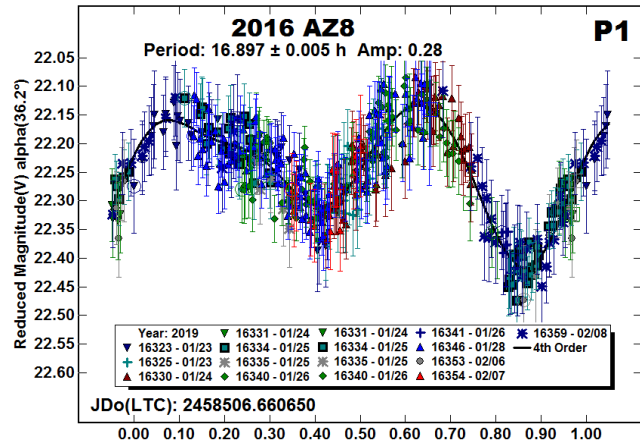
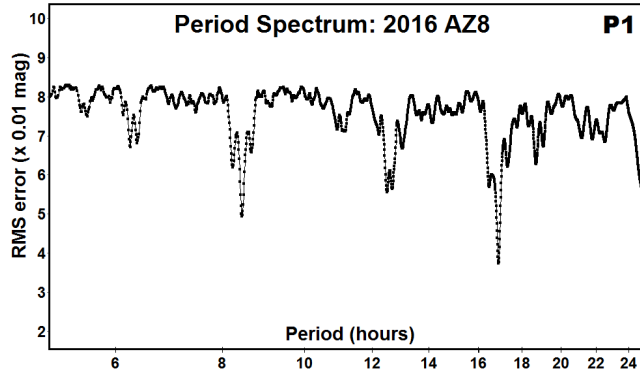
2014 QR295 is an enigmatic puzzle that will remain a mystery pending future observations.



2016 AZ8. Virkki et al. (2019) used radar observations to determine that the asteroid is a binary and suggested that the primary rotation period would be between 2-4 hours and the orbital period of the satellite between 12 and 24 hours. Then the

lightcurves came. Analysis of our observations did find two periods, but they were not in alignment with the radar analysis.

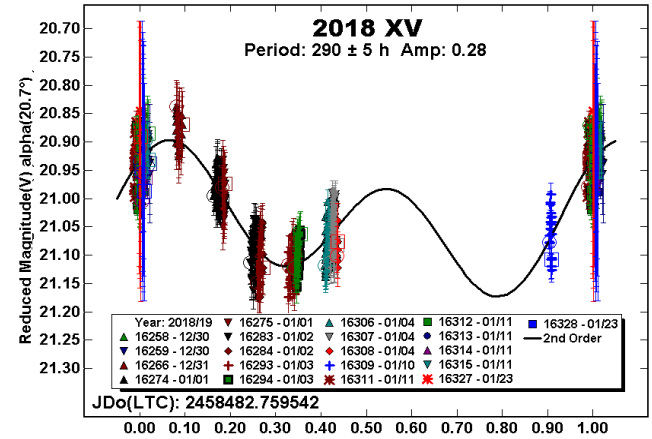
We did find a secondary lightcurve with a period of 13.548 h that showed attenuations normally seen for mutual events (occultations/eclipses) due to a satellite. That period is in the range expected by Virkki et al. However, there were no significant signs of a short primary period. Instead, we found a dominant primary period of 16.897 h (“P1”), or 4-6 times the expected period.



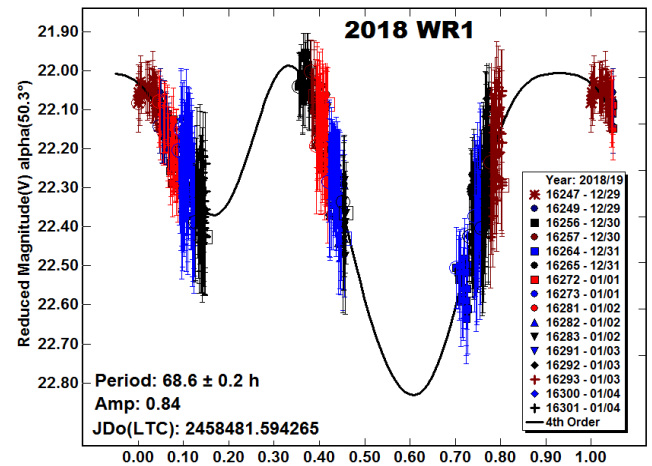
No amount of zero point adjustments or data manipulation, not even those that were highly improbable, led to a period in the range for 2-4 hours after removing P_2 . We cannot offer an explanation for the anomalous primary period at this time.

2018 XV. Pravec et al. (2019) found a period of 31.2 h for 2018 XV but it is rated $U = 1+$ in the LCDB, meaning there is very low confidence in the result. Even though we followed the asteroid on

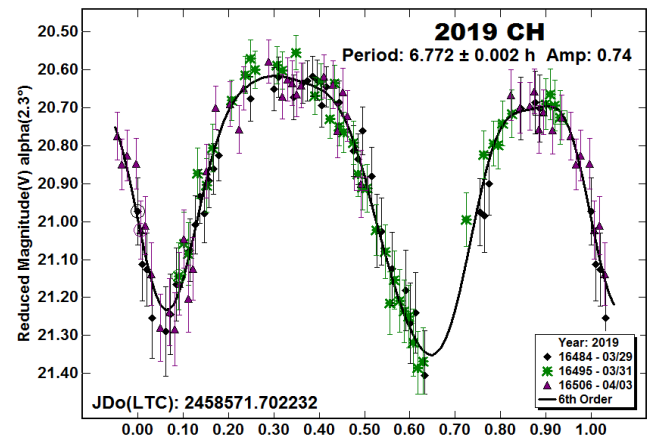
and off for more than 3 weeks, we were not able to complete the lightcurve for the adopted period. What parts do have overlap seem to repeat themselves within the limits of the noise, which can be taken to say that there are no obvious signs of tumbling.



2018 WR1. Our period of 68.6 h is based on the assumption of a bimodal lightcurve, the data having reasonable slopes, and the projected extrema being nearly symmetrical distributed.

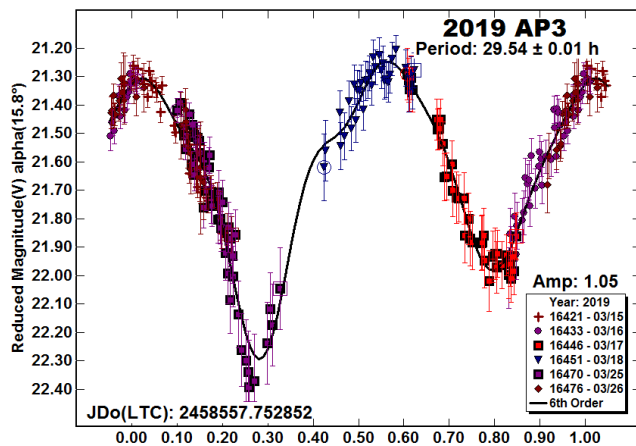


2019 CH, 2019 AP3. There were no previous entries in the LCDB for 2019 CH or 2019 AP3. Both solutions are considered mostly secure, the small doubt caused by incomplete lightcurve coverage and an unusual shape for the lightcurve for 2019 AP3.



Number	Name	2019 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.
1620	Geographos	01/03-01/11	170	17.1,18.2	103	19	5.2231	0.0002	1.22	0.03
5189	1990 UQ	03/24-03/26	140	8.4,10.3	176	5	6.640	0.005	0.66	0.04
6178	1986 DA	01/03-01/11	192	4.5,4.1,4.7	107	5	3.5002	0.0005	0.09	0.01
18736	1998 NU	¹⁸ 11/15-11/19	101	28.5,27.8	93	3	2.471	0.002	0.16	0.02
		01/26-01/31	259	9.3,13.4	119	-1	2.4753	0.0003	0.10	0.01
88254	2001 FM129	03/19-03/26	575	63.2,46.5	150	-7	38.56	0.03	1.2	0.1
89959	2002 NT7	01/23-01/26	213	64.0,61.2	174	23	5.527	0.003	0.25	0.03
90403	2003 YE45	12/28-01/22	735	15.8,3.6,18.3	111	-1	500	10	0.81	0.05
138937	2001 BK16	01/03-01/11	296	4.2,12.6	99	4	15.06	0.02	0.13	0.02
162361	2000 AF6	02/26-03/15	315	15.2,14.2,45.4	157	11	3.4558	0.0003	0.18	0.02
163051	2001 YJ4	01/28-02/08	112	21.2,29.5	103	-11	4.693	0.001	0.17	0.02
208565	2002 CT11	03/24-04/03	115	3.3,1.7,8.4	184	1	4.339	0.001	0.30	0.03
238063	2003 EG	03/25-03/26	77	4.1,4.2	185	-6	7.23	0.01	0.74	0.05
275611	1999 XX262	01/28-02/17	201	21.2,2.4	148	4	15.109	0.007	0.13	0.02
		¹⁶ 11/02-11/22	380	27.3,26.0,26.2	55	20	18.119	0.009	0.18	0.02
		¹⁴ 08/28-08/30	115	10.7,9.1	345	2	15.112	0.006	0.14	0.02
							18.010	0.006	0.18	0.02
							3.236	0.004	0.15	0.03
318411	2005 AH14	03/05-03/14	176	47.9,54.8	206	24	9.65	0.02	0.18	0.03
381677	2009 BJ81	01/26-02/17	1187	16.1,15.4,23.0	142	9	325	1	0.40	0.05
							27.08	0.02	0.08	0.01
410088	2007 EJ	01/26-02/17	348	37.0,5.3,18.2	171	14	4.5569	0.0002	0.10	0.02
454177	2013 GJ35	^{18,19} 12/31-01/11	1322	30.7,13.6,21.3	111	-1	49.75	0.02	0.52	0.05
	2005 FC3	02/26-03/18	1044	10.9,8.5,36.6	171	13	30.89	0.03	0.17	0.03
	2006 SK134	03/28-04/03	989	29.1,52.9	200	22	15.50	0.02	0.37	0.03
							20.70	0.01	0.39	0.03
	2014 QR295	02/26-03/17	956	50.4,25.8	163	25	62.98	0.03	0.59	0.04
	2016 AZ8	01/23-02/08	419	36.1,25.6	129	18	16.897	0.005	0.28	0.03
							13.548	0.004	0.24	0.03
	2018 XV	12/30-01/23	540	20.7,16.4,78.2	116	3	290	5	0.28	0.03
	2018 WR1	12/29-01/04	520	50.8,69.0	63	2	66.7	0.4	0.69	0.05
	2019 CH	03/29-04/03	124	2.3,4.3	190	-2	6.772	0.002	0.74	0.03
	2019 AP3	03/15-03/26	220	15.8,17.1	187	7	29.54	0.01	1.05	0.05

Table II. Observing circumstances. ^{14,16,18,19} Observations made in 2014, 2016, 2018, or 2019, respectively. The phase angle (α) is given at the start and end of each date range. If there are three values, the middle one is the minimum phase angle reached during the period. L_{PAB} and B_{PAB} are, respectively the average phase angle bisector longitude and latitude. See the text for details about objects with multiple lines.



Acknowledgements

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ATLAS science products have been made possible through the contributions of the University of Hawaii Institute for Astronomy, the Queen's University Belfast, the Space Telescope Science Institute, and the South African Astronomical Observatory.

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**LIGHTCURVE ANALYSIS OF L₅ TROJAN ASTEROIDS
AT THE CENTER FOR SOLAR SYSTEM STUDIES:
2019 JANUARY TO MARCH**

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Lightcurves for four L₅ Jovian Trojan asteroids were obtained at the Center for Solar System Studies (CS3) from 2019 January to March. The suspected binary Trojan, 2207 Antenor was observed again and a single attenuation event was detected.

CCD Photometric observations of four Trojan asteroids from the L₅ (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 analysis 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 all of these targets we were able to get preliminary pole positions and create shape models from sparse data and the dense lightcurves obtained to date. These preliminary models will be improved as more data are acquired at future oppositions and will be published at a later date.

Table 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.

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

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

Image processing, measurement, and period analysis were done using *MPO Canopus* (Bdw Publishing), which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris et al., 1989). The Comp Star Selector feature in *MPO Canopus* was used to limit the comparison stars to near solar color. Night-to-night calibration was done using field stars from the CMC-15 or the ATLAS catalog (Tonry et al., 2018), which has Sloan griz

magnitudes that were derived from the GAIA and Pan-STARR catalogs, among others. The authors state that systematic errors are generally no larger than 0.005 mag, although they can reach 0.02 mag in small areas near the Galactic plane. BVRI magnitudes were derived by Warner using formulae from Kostov and Bonev (2017). The overall errors for the BVRI magnitudes, when combining those in the ATLAS catalog and the conversion formulae, are on the order of 0.04-0.05 mag.

Even so, we found in most cases that nightly zero point adjustments for the ATLAS catalog to be on the order of only 0.02-0.03 mag were required during period analysis. There were occasional exceptions that required up to 0.10 mag. These may have been related in part to using unfiltered observations, poor centroiding of the reference stars, and not correcting for second-order extinction terms. Regardless, the systematic errors seem to be considerably less than other catalogs, which reduces the uncertainty in the results when analysis involves data from extended periods or the asteroid is tumbling.

In the lightcurve plots, the “Reduced Magnitude” is Johnson V corrected to a unity distance by applying $-5 \cdot \log(r\Delta)$ 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 L₅ 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.

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).

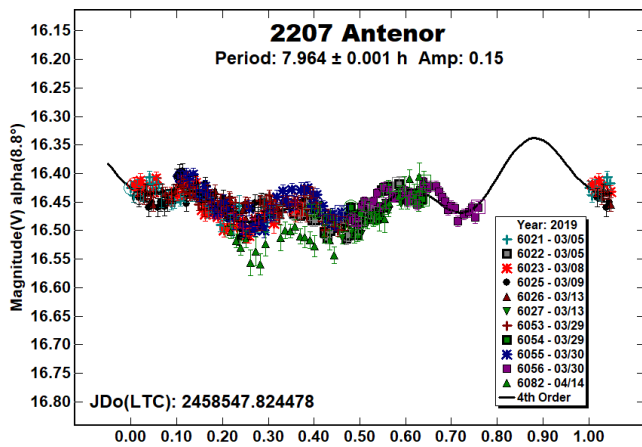
To evaluate the quality of the data obtained to determine how much more data might be needed, preliminary pole and shape models were created for all of these targets. Sparse data observations were obtained from the Catalina Sky Survey and USNO-Flagstaff survey using the AstDyS-3 site (<http://hamilton.dm.unipi.it/asdys2/>). 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 Kassalainin *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.

Number	Name	2019 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.
2207	Antenor	03/05-04/14	390	8.8, 5.0, 5.9	188	5	7.964	0.001	0.15	0.02
2893	Peiroos	02/12-02/19	217	6.8, 5.8	176	14	8.945	0.001	0.34	0.02
3317	Paris	02/19-03/14	236	7.5, 5.2	184	23	7.0812	0.0004	0.12	0.01
5144	Achates	03/25-03/28	123	5.3, 5.7	153	-2	5.956	0.002	0.18	0.02

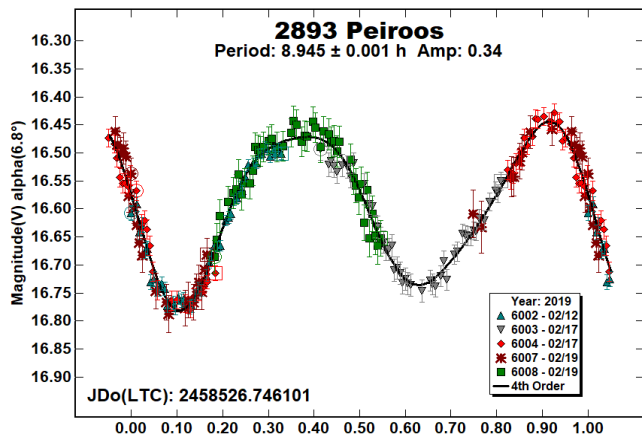
Table II. Observing circumstances and results. Pts is the number of data points. Phase is the solar phase angle for the first and last date. If there are three values, the middle value is the minimum phase angle. L_{PAB} and B_{PAB} are, respectively, the approximate phase angle bisector longitude and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

2207 Antenor. Antenor has been observed several times in the past (Stephens et al. 2018 and references therein) with reported rotational periods near 7.964 h. In 2018 observed deviations from the lightcurve suggested mutual events from a binary system. Help was sought from a network of observers at significantly different longitudes. As many as five prominent events and a few shallower ones were observed, but we could not get all of the five events to line up with any secondary period. The orbital period is possibly in the order of a few hundred hours.

The observing circumstances in 2019 were not as favorable as 2018 for the Northern Hemisphere. Because of its altitude, observing runs were limited to 5-6 h limiting the ability to detect attenuation events. Poor weather further limited the amount of data that could be gathered. At the end of the observing window, a single suspected attenuation event was detected, which is not enough to estimate an orbital period. 2207 Antenor will not be well placed for observing from the Northern Hemisphere until 2023 September.

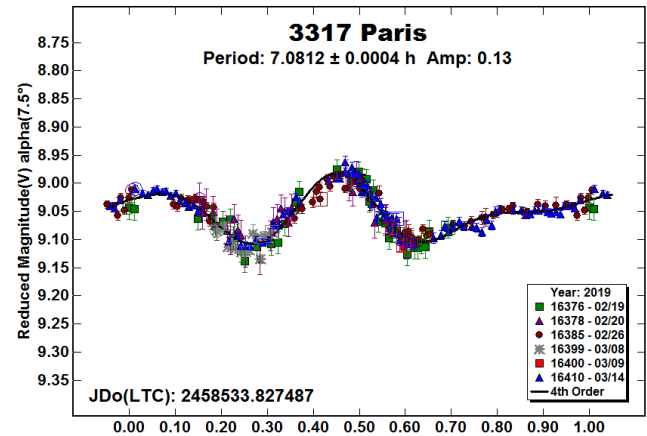


2893 Peiroos. We observed Peiroos three times in the past (Stephens et al. 2016; 2017a; 2018) each time finding a period near 8.95 h. The data collected this year, when combined with our previous data and available sparse data, were used to create a preliminary shape model with a sidereal rotational period of 8.94893 ± 0.00001 h.

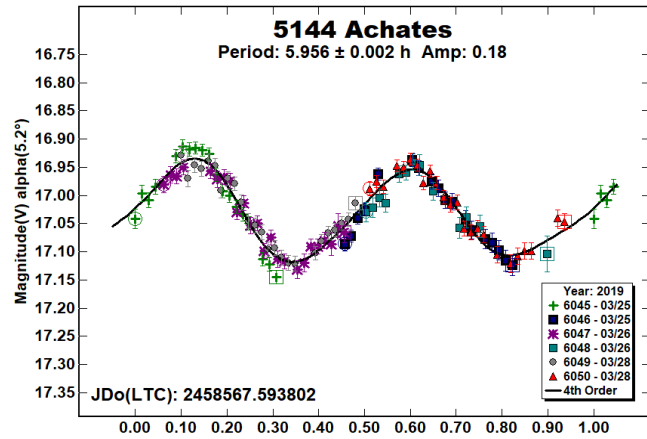


3317 Paris. The synodic period found in 2018 using CS3 data agrees with previous synodic results (Stephens et al., 2016, 2017b; Mottola et al., 2011; Stephens and Warner, 2017). All of these previous periods were near 7.08 h. The results in 2019 are in good agreement and when combined with our previous data and

available sparse data, were used to create a preliminary shape model with a sidereal rotational period of 7.08147 ± 0.00001 h.



5144 Achates. This Trojan was observed four times in the past (Molnar et al., 2008, Mottola et al., 2011 Stephens et al., 2015 and 2018), each time finding a period near 5.95 h. The 2019 results are in good agreement and were used to create a preliminary shape model with a sidereal rotational period of 5.95392 ± 0.00001 h.



Acknowledgements

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**LIGHTCURVES OF 153 HILDA
AT LARGE PHASE ANGLES**

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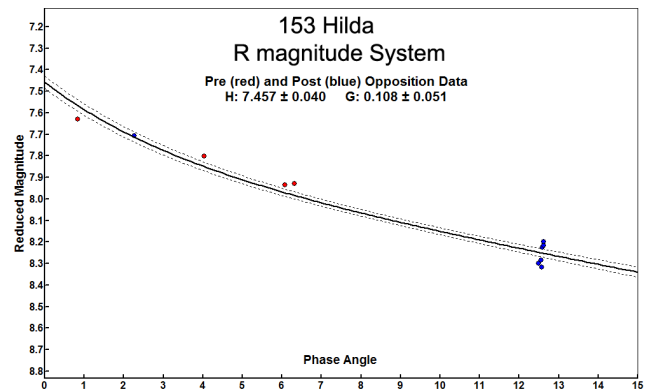
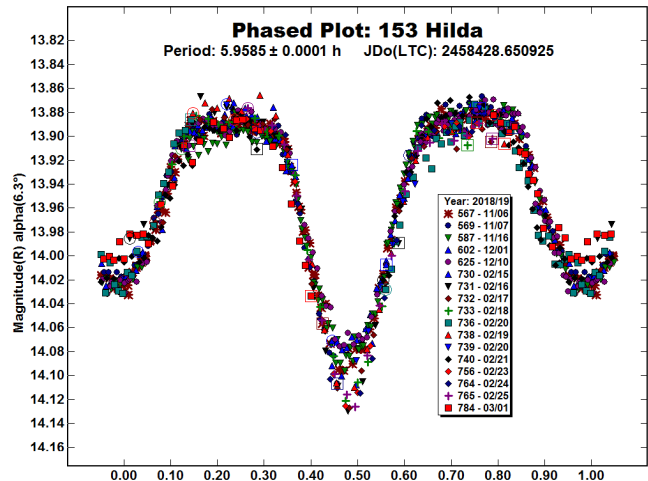
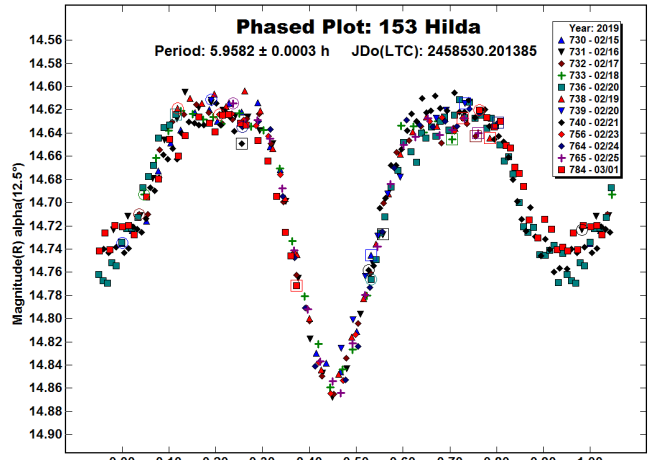
At phase angle 12.5 degrees the synodic rotation period and amplitude of 153 Hilda are 5.9582 ± 0.003 hours, 0.23 ± 0.02 magnitudes, respectively. An H-G plot in the R magnitude system is also presented with $H_R = 7.457 \pm 0.040$ and $G_R = 0.108 \pm 0.051$. Using an assumed V-R = 0.376 gives $H = 7.833$ with $G = 0.108$.

More than two months after opposition the Hilda-type asteroid 153 Hilda, $a = 3.9$ AU, is at nearly its largest possible phase angle near 12.6 degrees. It could be observed at any one location less than four hours between the end of nautical twilight and declining to low altitude. The two observers, separated by about 8 hours in longitude, collaborated to obtain full phase coverage of the 5.958-hour rotational cycle. Pilcher at the Organ Mesa Observatory used a 0.35-meter $f/10$ Meade LX200 GPS Schmidt-Cassegrain (SCT), SBIG STL-1001E CCD, 60 second exposures, unguided, with a clear filter. Benishek at Sopot Observatory used a 0.35-meter $f/6.3$ Meade LX200 GPS SCT, SBIG ST-10XME CCD, 180 to 240 second exposures, unguided and unfiltered, Photometric measurement and lightcurve construction was done with *MPO Canopus* software. This software identifies stars with near solar colors from the Carlsberg Meridian Catalog 15 (CMC15) and converts the Sloan r' magnitudes to Johnson R magnitudes by $R = r' - 0.22$ (Dymock and Miles 2009). All lightcurves were plotted in the R magnitude system. Data points were binned in sets of 3 with a maximum time difference of 5 minutes to reduce the number of points in the lightcurve and make the lightcurves easier to read.

Pilcher (2019 and references therein, most with periods near 5.957 hours) observed 153 Hilda near opposition in late 2018, at much smaller phase angle. The year 2018 lightcurve was previously published Pilcher (2019) and is republished here. New observations on 12 nights between 2019 Feb 15 and Mar 1 provide a good fit to an almost identical rotation period of 5.9582 ± 0.0003 h but the amplitude increased to 0.23 ± 0.02 mag. A lightcurve based on all observations between 2018 Nov 6 and 2019 Mar 1 fit a period of 5.9585 ± 0.0001 h.

The range of phase angles covered by observations between 2018 Nov 6 and 2019 Mar 1, 0.8 to 12.6 degrees, is nearly the largest possible for a Hilda-type asteroid. For each session, the magnitude at mid-light, half way between maximum and minimum, was used

to construct an H-G plot. The mid-light H-G plot is in the R rather than the standard V magnitude system. We find $H_R = 7.457 \pm 0.040$ and $G_R = 0.108 \pm 0.051$. Dandy et al. (2003) suggest V-R = 0.376 as an acceptable value of V-R for D/P taxonomic class asteroids. Applying this value to our H_R yields $H = 7.833$. The values in MPCORB (2019) are $H = 7.48$, $G = 0.15$.



Number	Name	yyyy/mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E	Amp	A.E
153	Hilda	2018/11/06-12/10	1840	6.3, 0.8, 2.3	70	-3	5.9586	0.00010	0.20	0.02
153	Hilda	2019/02/15-03/01	874	12.5, 12.6	71	-4	5.9582	0.0003	0.23	0.02

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

Acknowledgements

Observational work at Sopot Astronomical Observatory is supported by a 2018 Gene Shoemaker NEO Grant from The Planetary Society.

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LOW PHASE ANGLE OBSERVATIONS OF ASTEROID 291 ALICE

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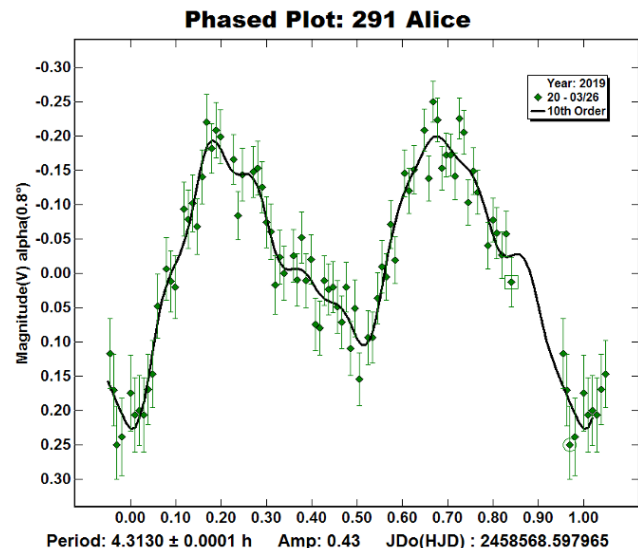
(Received: 2019 April 7)

A low phase angle lightcurve of Flora family asteroid 291 Alice was obtained at Shadowbox Observatory (H60) on 2019-03-26 UT. Period results are consistent with previous observations, $P = 4.313$ h. Phase angle was 0.8 degrees.

Flora family asteroid 291 Alice has been the subject of many investigations including Behrend (1983, 2009, 2015), Binzel and Mullholland (1983), Hanus et al. (2001), Kryszczyńska et al. (1996 and 2012), Lagerkvist (1976), Masiero et al. (2012), Oey (2006), Piironen et al. (1998), Ruthroff (2009), Tedesco et al. (2004), Usui et al. (2011), Veres et al. (2015). This paper concerns observations by the author on 2019-03-06 UT. Observations were made with a 0.3-m Schmidt-Cassegrain (SCT) operating at f/5 on a fork mount. Images were taken through a Johnson V-band filter. The camera was a SBIG STT-1603, binned 2x2 and working at an image scale of 2.18 arc seconds/pixel. Integration time for each image was 120 seconds and camera temperature -25 C.

The low altitude of the target and light interference from ground sources resulted in rather noisy data. SNR never rose above 45.

Images were reduced with dark and flat frames. MPO Canopus 10.7.11.1 was used for differential photometry and period analysis (See Ruthroff, 2010, for technique details). All companion star V-R magnitudes were in the range of 0.4 to 0.7 (Warner 2006).



Number	Name	2019 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
291	Alice	03/26	79	0.8	184.2	1.0	4.313	0.0001	0.50	0.05	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).

Acknowledgments

This paper makes use of data products from the Fourth U.S. Naval Observatory CCD Astrograph Catalog (UCAC4). This research has made use of NASA's Astrophysics Data System.

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THE NEA FAST ROTATOR 2019 EA2

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We report on the results of photometric observations of the near-Earth asteroid (NEA) 2019 EA2. The synodic rotation period is 0.02882 ± 0.00003 h, with a lightcurve amplitude of 0.57 ± 0.18 mag.

The near-Earth asteroid 2019 EA2 was discovered by H. Groeller, Mt. Lemmon Survey, on 2019 March 9 and announced on MPEC 2019-E83. Astrometric observations continued until 2019 March 21 with a total of 159 observations. The flyby with Earth occurred on 2019 March 22.078 at a distance of on 0.0020 AU. Based on its orbital parameters ($a = 0.841$ AU, $q = 0.675$ AU), the asteroid belongs to the Aten class of NEAs. The absolute magnitude $H = 25.8$ (JPL Small-body Database Browser) gives a diameter ranging from 10 to 40 meters, depending on the assumed albedo.

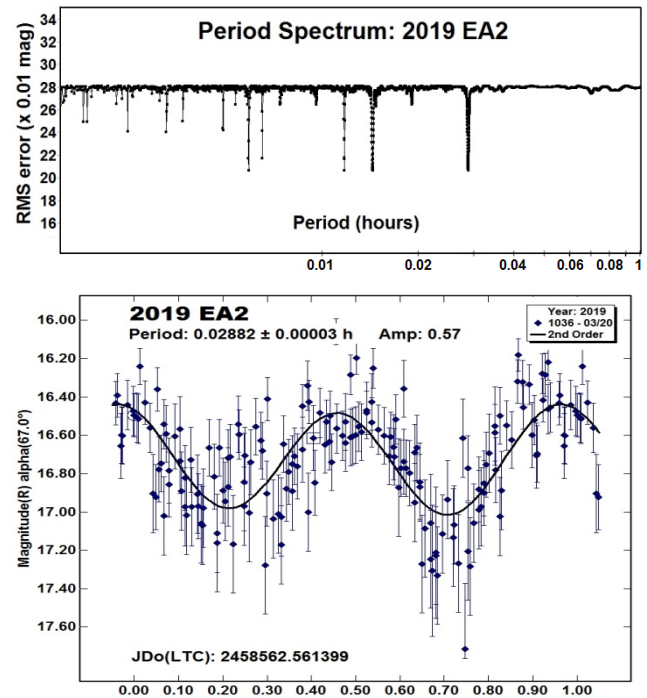
Here we present a lightcurve obtained from 2019 March 20.0611 to 20.1000 (about 60 min) at G.V. Schiaparelli Astronomical Observatory and analyzed at OAVdA. A total of 219 images, each of 10-s exposure at an approximate air mass of $X = 1.6$, were obtained with a 0.84-m $f/3.5$ reflector and CCD SBIG STX-16803 (4096×4096, 9.0 micron pixels). No filter was used and the camera was binned 3×3. This gave a field-of-view of 43.1×43.1 arcmin and image scale of 1.9 arcsec/pixel. At the time of the observations, the asteroid was 0.0063 AU from Earth and 0.998 AU from the Sun, at phase angle $\alpha = 67^\circ$. The average sky motion was 20.5 arcsec/minute in PA 153°.

We used *MPO Canopus*, version 10.7.11.3, to measure the images and do the period analysis of the lightcurve. Solar type stars from CMC15 catalog in R band were used as comparison stars. All the 219 images were used, except for the few where the asteroid passed near background stars. The SNR was about 10-15 during the session.

The bimodal lightcurve has a period of 0.02882 ± 0.00003 h (103.7 ± 0.1 s) and amplitude $A(67^\circ) = 0.57 \pm 0.18$. The period is about 9 times longer than for 2017 QG18, the fastest known rotator ($P = 0.003298$ h; Warner et al., 2009). If we correct the amplitude to zero phase angle using the empirical formula by Zappala et al. (1990) using $m = 0.03/\text{deg}$, the mean value for S-type asteroids and common among NEAs, we have $A(0^\circ) = 0.2 \pm 0.07$ mag. Assuming a triaxial abc ellipsoid viewed equatorially, this gives $a/b \geq 1.2 \pm 0.1$ (Warner, 2006).

The rotation period is under the spin-barrier value of about 2.2 h, which is consistent with its small size (Pravec and Harris, 2000).

The period and the lower limit for the a/b ratio provide constraints on the internal structure of the asteroid, i.e. it is most likely an elongated body that is strength-bound rather than gravity-bound, or a so-called “rubble pile.”



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Number	Name	2019 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period	P.E.	Amp	A.E.	D	a/b
2019	EA2	03/20-03/20	219	67.0	209	16	0.02882	0.00003	0.57	0.18	0.01-0.04	1.20

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). Period is in hours. D is estimated diameter (km). The last column gives the a/b ratio based on the amplitude for an assumed triaxial ellipsoid viewed equatorially.

**GENERAL REPORT OF POSITION OBSERVATIONS
BY THE ALPO MINOR PLANETS SECTION
FOR THE YEAR 2018**

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Observations of positions of minor planets by members of the Minor Planets Section in calendar year 2018 are summarized.

During the year 2018 a total of 2264 observations of 667 different minor planets were reported by members of the Minor Planets Section. Of these, 2207 are approximate visual positions denoted V, and 57 are images by APN cameras denoted APN.

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 below the column for the number of positions. The year is 2018 in each case.

Positional observations were contributed by the following observers:

Observer, Instrument	Location	Planets	Positions
Faure, Gerard 35 cm Meade S-C, 8 cm refractor, 10 cm refractor APN Panasonic TZ 101 camera	Col d'Arlezier, France	35	90V, 9 APN
Faure, Gerard; Salemo, Paul 10 cm refractor 8 cm refractor+APN Panasonic TZ 101 camera	Lacanau Ocean, France	2	2V, 2APN
Harvey, G. Roger 81 cm Newtonian, 38 cm Celestron SC	Concord, North Carolina, USA	577	1911V
Pryal, Jim 20 cm f/10 SCT	Ellensburg, WA USA	4	18V
Rayon, Jean-Michel 20 cm Vixen R200SS 30 cm Meade LX90 35 cm Orion XX14G APN Sony A6000 camera	Meylan, France	16	46APN
Werner, Robert 20 cm Celestron	Pasadena, CA USA	33	186V

CCD observations are labeled C; APN camera observations are labeled APN, all others are visual

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2018)	NO. OBS.
1 Ceres	Faure and Salemo, 8	Apr 24-26	2APN
3 Juno	Faure, 8 Faure, 8 Pryal, 20	Dec 25 Dec 26 Nov 11	3 2APN 2
4 Vesta	Werner, 20	Jul 11-15	3
5 Astraea	Werner, 20	Sep 30-Oct 15	5
6 Hebe	Faure, 8 Faure, 8	Dec 26 Dec 26	2 5APN
9 Metis	Werner, 20	Jul 11-15	3
10 Hygiea	Werner, 20	Sep 30-Nov 13	7
13 Egeria	Werner, 20	Jun 2-19	10
14 Irene	Werner, 20	Aug 4-5	2

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2018)	NO. OBS.
15 Eunomia	Werner, 20	Jun 3-19	10
16 Psyche	Werner, 20	May 5-Jul 15	17
18 Melpomene	Werner, 20	Jun 2-13	7
21 Lutetia	Werner, 20	May 5-16	5
22 Kalliope	Werner, 20	May 5-16	5
27 Euterpe	Werner, 20	Sep 1-Nov 13	7
29 Amphitrite	Werner, 20	Jul 11-15	3
30 Urania	Werner, 20	Sep 30-Nov 13	6
32 Pomona	Werner, 20	Feb 8-18	4
37 Fides	Werner, 20	Sep 1-Oct 16	5
39 Laetitia	Werner, 20	May 5-Jun 19	15
43 Ariadne	Werner, 20	Nov 10-13	2
49 Pales	Harvey, 81	May 2	6
57 Mnemosyne	Werner, 20	Feb 17-18	2
88 Thisbe	Werner, 20	Aug 4-5	2
103 Hera	Werner, 20	May 5-Jun 12	9
113 Amalthea	Werner, 20	Jun 7-13	4
115 Thyra	Werner, 20	Aug 4-Nov 14	10
145 Adeona	Werner, 20	Feb 8-18	5
172 Baucis	Werner, 20	Oct 5-16	3
173 Ino	Werner, 20	Oct 5-16	4
187 Lambertia	Werner, 20	May 5-Jun 12	13
198 Ampella	Werner, 20	Aug 4-5	2
230 Athamantis	Werner, 20	Sep 1-Nov 13	3
393 Lampetia	Werner, 20	May 8-10	2
433 Eros	Faure and Salemo, 10 Pryal, 20 Werner, 20	Sep 10 Sep 18-Nov 11 Dec 26-31	2 4 5
451 Patientia	Werner, 20	Feb 8-18	4
511 Davida	Werner, 20	Oct 5-Nov 13	2
961 Gunnie	Harvey, 81	Sep 19	3
1006 Lagrangea	Faure, 35	Aug 16	2
1026 Ingrid	Faure, 35	Oct 5	3
1033 Simona	Faure, 35	Oct 14	5
1045 Michela	Faure, 35 Rayon, 20	Oct 13 Oct 4	2 1APN
1049 Gotha	Faure, 35	Nov 15	3
1053 Vigdis	Faure, 35	Oct 4	2
1079 Mimosa	Faure, 35	Nov 16	3
1094 Siberia	Faure, 35	Nov 16	3
1154 Astronomia	Faure, 35	Oct 13-14	2
1202 Marina	Faure, 35	Nov 15	2
1225 Ariane	Harvey, 81	Oct 4	3
1285 Julietta	Rayon, 35	Feb 3	1APN
1568 Aisleen	Faure, 35	Aug 10	3
1627 Ivar	Pryal, 20	May 14-Jul 12	6
1732 Heike	Faure, 35	Aug 10-11	2
1946 Walraven	Faure, 35	Sep 4	2
1971 Hagihara	Harvey, 81	Dec 27	3
1981 Midas	Pryal, 20	Mar 15-19	6

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2018)	NO. OBS.	PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2018)	NO. OBS.
1996 Adams	Rayon, 20	Oct 4	1	3423 Slouka	Harvey, 81	Jan 14	3 0.3b@16.1
2018 Schuster	Harvey, 81	Sep 7	3	3435 Boury	Harvey, 81	Feb 23	3 0.5f@16.2
2061 Anza	Faure, 35 Harvey, 81	Aug 11 Aug 5	3 6	3437 Kapista	Harvey, 81	Mar 8	3
2079 Jacchia	Harvey, 81	Mar 9	3	3465 Trevires	Harvey, 81	Mar 24	3
2095 Parsifal	Harvey, 81	Jan 25	3	3466 Ritina	Harvey, 81	Feb 24	3
2125 Karl-Ontjes	Harvey, 81	Jan 21	3	3505 Byrd	Harvey, 81	Nov 11	3
2155 Wodan	Harvey, 81	Sep 19	3	3507 Vilas	Harvey, 81	Jan 22	3
2160 Spitzer	Harvey, 81	Feb 22	3	3515 Jindra	Harvey, 81	Mar 16	3
2326 Tololo	Faure, 35	Aug 16	2	3532 Tracie	Harvey, 81	Jan 22	3
2338 Bokhan	Harvey, 81	Mar 17	4	3545 Gaffey	Harvey, 81	Mar 24	3
2351 O'Higgins	Harvey, 81	Feb 9	3	3552 Don Quixote	Faure, 35	Aug 11-Sep 5	10
2449 Kenos	Faure, 35	Aug 15	2	3563 Canterbury	Harvey, 81	May 10	3
2462 Nehalennia	Harvey, 81	Jan 15	3	3570 Wuyeesun	Harvey, 81	Mar 8	3
2465 Wilson	Harvey, 81	Oct 16	3	3592 Nedbal	Harvey, 81	Nov 28	3
2500 Alascattalo	Faure, 35	Nov 15	2	3638 Davis	Harvey, 81	Mar 15	3
2508 Alupka	Harvey, 81	Aug 14	3	3640 Gostin	Rayon, 20	Oct 4	1APN
2541 Edeboro	Harvey, 81	Jan 19	3	3677 Magnusson	Harvey, 81	Nov 28	3
2703 Rodari	Harvey, 81	Apr 18	3 0.4f@16.0	3690 Larson	Harvey, 81	Aug 5	3
2726 Kotelnikov	Harvey, 81	Dec 6	3	3706 Sinnott	Harvey, 81	Jan 15	3 0.5f@16.2
2749 Waltherhorn	Harvey, 81	Jan 7	3	3740 Menge	Harvey, 81	Oct 1	3
2837 Griboedov	Harvey, 81	Feb 23	3	3766 Junepatterson	Harvey, 81	Jan 16	3
2840 Kallavesi	Harvey, 81	Jun 6	3	3780 Maury	Harvey, 81	May 10	3
2877 Likhachev	Harvey, 81	Oct 1	3	3791 Marci	Harvey, 81	Mar 24	3
2893 Peiroos	Harvey, 81	Feb 9	3	3800 Karayusuf	Harvey, 81	May 7	3
2915 Moskvina	Harvey, 81	Sep 19	3	3846 Hazel	Harvey, 81	Mar 23	3
2926 Caldeira	Harvey, 81	Jun 19	3	3854 George	Harvey, 81	Oct 1	3
2952 Lilliputia	Harvey, 81	Dec 17	3	3876 Quaide	Harvey, 81	Jan 20	3
2968 Iliya	Harvey, 81	Jul 11	3	3880 Kaisarman	Harvey, 81	Jan 15	3
2972 Nillo	Harvey, 81	Nov 11	3	3886 Shcherbakovia	Harvey, 81	Oct 16	3
3001 Michelangelo	Harvey, 81	Jan 14	3	3890 Bunin	Harvey, 81	Aug 6	3
3049 Kuzbass	Harvey, 81	May 13	3	3900 Knezevic	Harvey, 81	Oct 14	3
3069 Heyrovsky	Harvey, 81	Oct 1	3	3936 Elst	Harvey, 81	Jul 9	3
3110 Wagman	Harvey, 81	Feb 22	3	3937 Bretagnon	Harvey, 81	Feb 24	3
3196 Maklaj	Harvey, 81	Mar 23	3	3967 Shekhtelia	Harvey, 81	Jan 6	3
3213 Smolensk	Harvey, 81	Oct 31	3	3979 Brorsen	Harvey, 81	Feb 23	3
3225 Hoag	Rayon, 20	Oct 2-4	5APN	3996 Fugaku	Faure, 35	Sep 4	2
3231 Mila	Harvey, 81	Sep 19	3	4001 Ptolemaeus	Harvey, 81	Jul 4	3
3256 Daguerre	Harvey, 81	Oct 1	3	4090 Risehvezd	Harvey, 81	Apr 17	3
3264 Bounty	Harvey, 81	Jan 21	3	4091 Lowe	Harvey, 81	Apr 18	3
3287 Olmstead	Harvey, 81	Aug 6	3	4100 Sumiko	Harvey, 81	Dec 6	3
3299 Hall	Harvey, 81	Oct 30	3	4104 Alu	Harvey, 81	May 10	3
3315 Chant	Harvey, 81	Jan 14	3	4108 Rakos	Harvey, 81	Mar 15	3
3325 Tardis	Harvey, 81	Apr 20	3	4129 Richelen	Harvey, 81	Aug 5	3
3348 Pokryshkin	Harvey, 81	May 9	3 0.5f@16.3	4151 Alanhale	Harvey, 81	Mar 5	3
3355 Onizuka	Harvey, 81	Nov 11	3	4166 Pontryagin	Harvey, 81	Feb 9	3
3381 Mikkola	Harvey, 81	Oct 1	3	4180 Anaxagoras	Harvey, 81	Apr 17	3
3390 Demanet	Harvey, 81	Apr 21	3	4195 Esambaev	Harvey, 81	Mar 15	3

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2018)	NO. OBS.	PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2018)	NO. OBS.
4199 Andreev	Harvey, 81	Oct 5	3	4855 Tenpyou	Harvey, 81	Jul 9	3
4208 Kiselev	Harvey, 81	Mar 9	3	4863 Yasutani	Harvey, 81	Feb 9	3
4231 Fireman	Harvey, 81	Jan 21	3	4870 Shcherban'	Harvey, 81	Dec 12	3
			0.5b@15.8	4882 Divari	Harvey, 81	Jan 15	3
4234 Evtushenko	Harvey, 81	May 3	3	4885 Grange	Harvey, 81	Jul 9	3
4237 Raushenbakh	Harvey, 81	Oct 30	3	4894 Ask	Rayon, 20	Oct 4	1APN
4259 McCoy	Harvey, 81	Nov 11	3	4915 Solzhenitsyn	Harvey, 81	Dec 27	3
4260 Yanai	Harvey, 81	Jan 21	3	4920 Gromov	Harvey, 81	Oct 14	3
4269 Bogaso	Harvey, 81	Aug 24	3	4952 Kibeshigemaro	Harvey, 81	Mar 8	3
4271 Novosibirsk	Harvey, 81	Apr 20	3	4953 1990 MU	Harvey, 81	Oct 6	3
4277 Holubov	Harvey, 81	Jan 15	3	4983 Schroeteria	Harvey, 81	Mar 9	3
			0.3f@16.4	4992 Kalman	Harvey, 81	May 14	3
4291 Kodiasasu	Harvey, 81	May 10	3	4999 MPC	Harvey, 81	Jan 20	3
			0.8f@16.2	5003 Silvanominuto	Harvey, 81	Jan 19	3
4303 Savitskij	Harvey, 81	Nov 28	3	5009 Sethos	Harvey, 81	Jan 14	3
4310 Stromholm	Harvey, 81	Jan 15	3	5016 Migirenko	Harvey, 81	Jun 6	3
4325 Guest	Harvey, 81	Feb 23	3	5019 Erfjord	Harvey, 81	Dec 12	3
4347 Reger	Harvey, 81	Mar 9	3	5022 Roccapalumba	Harvey, 81	May 14	3
4370 Dickens	Harvey, 81	Nov 28	3	5075 Goryachev	Harvey, 81	Nov 28	3
4400 Bagryana	Harvey, 81	Sep 19	3	5076 Lebedev-Kumach	Faure, 35 Rayon, 20	Oct 4 Oct 2-4	2 3APN
4426 Roerich	Harvey, 81	May 10	3	5099 Iainbanks	Harvey, 81	Oct 14	3
4449 Sobinov	Harvey, 81	Feb 22	3	5136 Baggaley	Harvey, 81	Jan 15	3
4460 Bihoro	Harvey, 81	Dec 12	3	5173 Stjerneborg	Harvey, 81	Jan 15	3
4504 Jenkinson	Harvey, 81	Oct 4	3				0.4f@16.3
4509 Gorbatskij	Faure, 35	Aug 16	2	5180 Ohno	Harvey, 81	Jan 16	3
4524 Barklajdetolli	Harvey, 81	Jan 7	3	5190 Fry	Harvey, 81	Dec 12	3
4531 Asaro	Harvey, 81	Mar 9	4	5208 Royer	Harvey, 81	Jan 15	3
4538 Vishyanand	Harvey, 81	Oct 1	3	5217 Chaozhou	Harvey, 81	Jun 6	3
4556 Gumilyov	Harvey, 81	May 10	3	5239 Reiki	Harvey, 81	Dec 6	3
4565 Grossman	Harvey, 81	Mar 5	3	5243 Clasién	Harvey, 81	Mar 23	3
4568 Menkaure	Harvey, 81	Feb 22	3	5251 Bradwood	Faure, 35 Harvey, 81	Aug 15 Jul 10	2 3
4586 Gunvor	Harvey, 81	Feb 24	3	5278 Polly	Harvey, 81	May 3	3
4620 Bickley	Harvey, 81	Jan 15	3				0.5f@16.0
4638 Estens	Harvey, 81	Jan 14	3	5322 1986 QB1	Harvey, 81	Feb 24	3
4668 Rayjay	Harvey, 81	Jan 16	3	5334 Mishima	Harvey, 81	Jan 7	3
4680 Lohrmann	Harvey, 81	Oct 16	3	5386 Bajaja	Harvey, 81	Apr 21	3
4685 Karetnikov	Harvey, 81	Dec 6	3	5387 Casleo	Harvey, 81	Jun 6	3
4746 Doi	Harvey, 81	Oct 31	3	5393 Goldstein	Harvey, 81	Jan 20	3
4748 Tokiwagozen	Harvey, 81	Jan 16	3	5396 1988 SH1	Harvey, 81	Nov 11	3
4764 Joneberhart	Harvey, 81	Feb 24	3	5402 Kejosmith	Harvey, 81	Aug 5	3
4767 Sutoku	Harvey, 81	Apr 18	3	5420 Jancis	Harvey, 81	Oct 16	3
4770 Lane	Harvey, 81	Jun 7 - Jul 9	4	5441 Andymurray	Harvey, 81	Jun 5	3
4781 Sladkovic	Harvey, 81	Oct 14	3	5471 Tunguska	Harvey, 81	May 9	3
			0.5f@15.8	5482 Korankei	Harvey, 81	Mar 8	3
4782 Gembloux	Harvey, 81	Oct 1	3	5517 Johnerogers	Harvey, 81	Apr 20	3
4807 Noboru	Harvey, 81	Dec 6	3	5547 Acadiau	Harvey, 81	May 10	3
			0.5f@15.8				0.7f@16.1
4823 Libenice	Harvey, 81	Dec 12	3	5568 Mufson	Harvey, 81	Nov 28	3
4833 Meges	Harvey, 81	Jul 9	3	5579 Uhlherr	Harvey, 81	May 7	3
4838 Billmclaughlin	Harvey, 81	Jul 14	3				
4839 Daisetsuzan	Harvey, 81	Mar 17	3				

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2018)	NO. OBS.	PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2018)	NO. OBS.
5583 Braunerova	Harvey, 81	Jan 21	3	6710 Apostel	Harvey, 81	Aug 6	3
5623 Iwamori	Harvey, 81	Jan 20	3	6714 Montreal	Harvey, 81	May 10	3
5668 Foucault	Harvey, 81	Jan 19	3	6733 1992 EF	Harvey, 81	Feb 9	3
5699 Munch	Harvey, 81	Oct 4	3	6753 Fursenko	Harvey, 81	Oct 16	3
5705 Ericsterken	Harvey, 81	Nov 28	3	6776 Dix	Harvey, 81	Apr 13	3
5739 Robertburns	Harvey, 81	Jan 14	3	6780 Borodin	Harvey, 81	Oct 4	3
			0.3f@16.0	6801 Strekov	Harvey, 81	Oct 31	3
5762 Wanke	Harvey, 81	Oct 4	3	6809 Sakauma	Harvey, 81	Mar 8	3
5775 Inuyama	Harvey, 81	Oct 31	3				0.4f@16.3
5853 1992 OG	Harvey, 81	Aug 5	3	6828 Elbsteel	Harvey, 81	Jan 14	3
5871 Bobbell	Harvey, 81	Oct 4	3	6833 1993 FC1	Harvey, 81	Mar 24	3
5881 Akashi	Harvey, 81	Jan 16	3	6868 Seiyauyeda	Harvey, 81	Apr 20	3
5906 1989 SN5	Harvey, 81	Jan 14	3	6893 Sanderson	Harvey, 81	Jan 16	3
5910 Zatopek	Harvey, 81	Feb 19	3	6894 Macreid	Harvey, 81	Jan 21	3
5915 Yoshihiro	Harvey, 81	Mar 15	3	6909 Levison	Harvey, 81	Jan 21	3
5930 Zhiganov	Harvey, 81	May 3	3				0.4b@16.2
5940 Feliksobolev	Harvey, 81	Nov 4	3	6920 Esaki	Harvey, 81	Jan 15	3
5952 Davemonet	Harvey, 81	May 9	3	6932 Tanigawadake	Harvey, 81	Sep 19	3
			0.5f@16.2	6937 Valadon	Harvey, 81	Apr 21	3
6018 Pierssac	Harvey, 81	Jul 10	3	6941 Dalgarn	Harvey, 81	Dec 27	3
6029 Edithrand	Harvey, 81	Jun 5	3	6949 Zissell	Harvey, 81	Jun 6	3
6067 1990 QR11	Harvey, 81	Aug 14	3	6976 Kanatsu	Harvey, 81	May 10	3
6078 Burt	Harvey, 81	Nov 28	3	6984 Lewiscarroll	Harvey, 81	Jan 14	3
6152 Empedocles	Harvey, 81	Jun 5	3	7011 Worley	Harvey, 81	Oct 30	3
6160 Minakata	Harvey, 81	Jul 14	3	7085 1991 PE	Harvey, 81	Aug 5	3
6189 Volk	Harvey, 81	Jun 6	3	7090 1992 HY4	Harvey, 81	Jan 5	3
			0.3f@16.3	7105 Yousyozan	Harvey, 81	Jan 16	3
6192 Javiergorosabel	Faure, 35	Sep 4	3	7109 Heine	Harvey, 81	Oct 30	3
6201 Khiroshimizu	Harvey, 81	May 3	3	7133 Kasahara	Harvey, 81	May 10	3
6238 1989 NM	Harvey, 81	Sep 19	3	7223 Dolgoruku	Harvey, 81	Oct 30	3
6245 Ikufumi	Harvey, 81	Nov 4	3	7249 1992 SN	Harvey, 81	Oct 30	3
6249 Jennifer	Rayon, 20, 30	Oct 2-Nov 29	3APN	7257 Yoshiya	Harvey, 81	Dec 6	3
6297 1988 VZ1	Harvey, 81	Feb 9	3	7286 1990 QZ4	Harvey, 81	Sep 19	3
6301 1989 BR1	Harvey, 81	Apr 13	3	7293 Kazuyuki	Harvey, 81	Apr 18	3
6330 Koen	Harvey, 81	Jan 16	3	7363 Esquibel	Harvey, 81	Jan 7	3
6331 1992 FZ1	Harvey, 81	Jul 4	3				0.3f@16.2
6358 Chertok	Harvey, 81	Dec 6	3	7399 Somme	Harvey, 81	Jan 19	3
6359 Dubinin	Harvey, 81	Mar 9	3	7426 1992 US4	Harvey, 81	Oct 4	3
6424 Ando	Harvey, 81	Dec 17	3				0.5f@16.2
6426 Vanysek	Harvey, 81	May 10	3	7435 Sagamihara	Harvey, 81	Jan 21	3
6499 Michiko	Harvey, 81	Apr 21	3	7462 Grenoble	Faure, 35 Rayon, 20, 30	Oct 14 Oct 2-Dec 4	2 7APN
6529 Rhoads	Harvey, 81	Dec 17	3	7472 Kumakiri	Harvey, 81	Feb 9	3
6540 Stepling	Harvey, 81	Oct 30	3	7475 Kaizuka	Harvey, 81	Apr 13	3
6550 Parler	Harvey, 81	Nov 11	3	7559 Kirstinemeyer	Harvey, 81	May 10	3
6574 Gvishiani	Harvey, 81	Mar 15	3	7576 1990 BN	Harvey, 81	Feb 24	3
			0.7f@16.3	7611 Hashitatsu	Harvey, 81	Jun 19	3
6602 Gilclark	Harvey, 81	Sep 7	3	7614 Masatomi	Harvey, 81	May 10	3
6655 Nagahama	Harvey, 81	Mar 23	3	7723 Luggier	Harvey, 81	Aug 5	3
6668 1994 GY8	Harvey, 81	Oct 4	3	7784 Watterson	Harvey, 81	Oct 1	3
6681 Prokopovich	Harvey, 81	Nov 4	3	7794 Sanvito	Harvey, 81	Jun 19	3

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2018)	NO. OBS.	PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2018)	NO. OBS.
7834 1993 JL	Harvey, 81	Apr 18	3	9369 1993 DB1	Harvey, 81	Apr 17	3
7851 Azumino	Harvey, 81	Aug 24	3	9512 Feijunlong	Harvey, 81	May 3	3
7853 Confucius	Harvey, 81	Feb 9	3	9531 Jean-Luc	Harvey, 81	Nov 28	3
7891 Fuchie	Harvey, 81	Nov 28	3	9536 Statler	Harvey, 81	Feb 9	3 0.6f@16.4
7948 Whitaker	Harvey, 81	Jan 16	3	9538 1982 UM2	Harvey, 81	Oct 30	3
7949 1992 SU	Harvey, 81	Dec 6	3	9556 Gaywray	Harvey, 81	May 9	3
7952 1992 XB	Harvey, 81	Oct 14	3	9656 1996 DK1	Harvey, 81	Mar 9	3
7954 Kitao	Harvey, 81	Jul 11	3	9659 1996 EJ	Harvey, 81	Apr 18	3
8018 1990 SW	Harvey, 81	May 10	3	9873 1992 GH	Faure, 35 Rayon, 20,30	Oct 4 Oct 4-Nov 29	2 2APN
8025 Forrestpeterson	Harvey, 81	Mar 15	3	9891 Stephensmith	Harvey, 81	Apr 20	3
8032 Michaeladams	Harvey, 81	Apr 21	3	9899 1996 EH	Harvey, 81	May 3	3
8053 Kleist	Harvey, 81	May 7	3 0.6f@16.0	9931 Herbhauptman	Harvey, 81	Apr 21	3
8085 1989 CD8	Harvey, 81	Oct 14	3	9957 Raffaellosanti	Harvey, 81	Aug 5	3
8105 1994 WH2	Harvey, 81	Dec 12	3	10013 Stenholm	Harvey, 81	Jan 20	3
8190 Bouguer	Harvey, 81	Jan 14	3	10031 Valdarnolda	Harvey, 81	Jun 5	3
8244 Mikolaichuk	Harvey, 81	Oct 1	3	10042 Budstewart	Harvey, 81	Aug 6	3
8257 Andycheng	Harvey, 81	Apr 13	3	10044 Squyres	Harvey, 81	Nov 4	3
8289 An-Eefje	Harvey, 81	May 7	3	10050 Rayman	Harvey, 81	Aug 6	3
8297 Gerardfaure	Rayon, 35	Jan 13	3APN	10059 1988 FS2	Harvey, 81	Apr 13	3
8333 1982 VF	Harvey, 81	Oct 1	3	10108 Tomlinson	Harvey, 81	Apr 19	3
8340 Mumma	Harvey, 81	Jan 20	3	10109 1992 HQ	Harvey, 81	May 9	3
8379 Straczynski	Harvey, 81	Nov 28	3	10124 Hemse	Harvey, 81	Oct 14	3
8416 Okada	Harvey, 81	Oct 4	3	10128 Bro	Harvey, 81	Sep 19	3
8505 1990 YK	Harvey, 81	Jan 20	3	10140 Villon	Harvey, 81	Feb 22	3
8528 1992 SC24	Harvey, 81	Nov 14	3	10151 Rubens	Harvey, 81	Nov 11	3
8647 Populus	Harvey, 81	Jan 14	3	10177 Ellison	Harvey, 81	Jul 14	3
8654 1990 KC1	Harvey, 81	Jan 16	3	10260 1972 TC	Harvey, 81	Dec 6	3
8663 Davidjohnston	Harvey, 81	Feb 24	3	10269 Tusi	Harvey, 81	Oct 16	3
8722 Schirra	Faure, 35	Aug 10-11	2	10271 1980 TV2	Harvey, 81	Dec 6	3
8750 Nettarufina	Harvey, 81	Jun 19	3	10304 Iwaki	Harvey, 81	Dec 27	3
8761 Crane	Harvey, 81	Mar 23	3	10358 Kirchhoff	Harvey, 81	May 10	3
8809 Roversimonaco	Harvey, 81	Oct 14	3	10385 Amaterasu	Harvey, 81	Oct 5	3
8825 1988 MF	Harvey, 81	Jan 10	3	10441 van Rijckevorsel	Harvey, 81	Oct 14	3
8860 Rohloff	Harvey, 81	Apr 20	3	10450 Girard	Harvey, 81	Mar 9	3 0.5f@16.4
8865 Yakiimo	Harvey, 81	Jan 7	3	10500 Nishi-koen	Harvey, 81	Apr 18	3 0.6f@15.7
8866 Tanegashima	Harvey, 81	Dec 6	3	10515 Old Joe	Harvey, 81	Dec 12	3
8876 1992 WU3	Harvey, 81	Nov 4	3 0.4f@16.0	10523 D'Haveloose	Harvey, 81	Dec 6	3
8895 Nha	Harvey, 81	Apr 20	3	10597 1996 TR10	Harvey, 81	Jul 4	3
8901 1995 UJ4	Harvey, 81	Feb 22	3	10644 1999 DM2	Harvey, 81	Jan 20	3
8948 1997 CW27	Harvey, 81	Oct 30	3	10766 1990 UB1	Harvey, 81	Nov 11	3
8954 Baral	Harvey, 81	Jan 20	3	10793 Quito	Rayon, 20,30	Oct 4-Dec 4	6APN
9012 Benner	Harvey, 81	Oct 31	3	10946 1999 HR2	Harvey, 81	Mar 9	3
9090 Chirotenmondai	Harvey, 81	Dec 12	3	10972 Merbold	Harvey, 81	May 10	3
9092 Nanyang	Harvey, 81	Apr 21	3	11053 1991 CQ6	Harvey, 81	Oct 4	3
9128 Takatumuzi	Harvey, 81	Jul 9	3 0.5f@15.6	11055 Honduras	Faure, 35 Rayon, 20	Oct 4 Oct 4	2 2APN
9233 Itagijun	Harvey, 81	Apr 20	3	11072 Hiraoka	Harvey, 81	May 9	3 0.3f@16.3
9356 Elineke	Harvey, 81	Mar 8	3				

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11200 1999 CV121	Harvey, 81	Apr 18	3	15633 2000 JZ1	Harvey, 81	Apr 17	3
11307 Erikolsson	Harvey, 81	Nov 11	3	15754 1992 EP	Harvey, 81	May 10	3
11478 1985 CD	Harvey, 81	Jan 22	3	15764 1992 UL8	Harvey, 81	Oct 28	3
11542 Solikamsk	Harvey, 81	Jan 16	3	15786 1993 RS	Harvey, 81	Mar 9	3
11830 Jessenius	Harvey, 81	Mar 15	3	15805 Murakamitakehiko	Harvey, 81	Apr 20	3
11910 1992 KJ	Harvey, 81	Mar 23	3				0.5f@16.1
11931 1993 DD2	Harvey, 81	Mar 24	3	15856 Yanokoji	Harvey, 81	Apr 20	3
11932 1993 EP	Harvey, 81	Mar 15	3	15949 Rhaeticus	Harvey, 81	Dec 12	3
12051 Picha	Harvey, 81	Mar 23	3	16052 1999 JX36	Harvey, 81	Oct 14	3
12229 Paulsson	Harvey, 81	May 3	3	16182 2000 AH137	Harvey, 81	Dec 12	3
12237 Coughlin	Harvey, 81	Feb 9	3	16424 Davaine	Rayon, 20	Oct 4	2APN
12282 Crombecq	Harvey, 81	Feb 24	3	16461 1990 BO	Harvey, 81	Jan 7	3
12376 Cochabamba	Harvey, 81	Feb 22	3				0.6b@15.7
12411 Tannokayo	Harvey, 81	Jan 20	3	16785 1997 AL1	Harvey, 81	Dec 12	3
12453 1996 YY	Harvey, 81	May 3	3	16976 1999 AC2	Harvey, 81	May 9	3
			0.5f@16.1	17071 1999 GK21	Harvey, 81	Apr 21	3
12550 1998 QR30	Harvey, 81	Apr 20	3	17109 1999 JF52	Harvey, 81	Aug 6	3
12562 Briangrazer	Harvey, 81	Feb 24	3				0.3f@16.0
12667 1979 DF	Harvey, 81	Mar 9	3	17175 1999 SS3	Harvey, 81	Mar 15	3
12700 1990 FH	Harvey, 81	Apr 18	3	17276 2000 LU22	Harvey, 81	Dec 12	3
12709 Bergen op Zoom	Harvey, 81	May 9	3	17356 Vityazev	Harvey, 81	Aug 14	3
12720 1991 NU3	Harvey, 81	Nov 11	3				0.5f@16.1
12769 Kandakurenai	Harvey, 81	May 9	3	17408 McAdams	Harvey, 81	Oct 30	3
12789 Salvadoraguirre	Harvey, 81	Jan 15	3	17430 1989 KE	Harvey, 81	May 9	3
12867 Joeloic	Rayon, 35	Mar 3	3APN	17441 1989 UE	Harvey, 81	Nov 4	3
12908 Yagudina	Harvey, 81	Apr 18	3	17483 1991 RA	Harvey, 81	Mar 5	3
12914 1998 SJ141	Harvey, 81	Mar 23	3	17700 1997 GM40	Harvey, 81	Mar 5	3
12915 1998 SL161	Harvey, 81	May 10	3	17783 1998 FO29	Harvey, 81	Jan 25	3
13022 1988 RL9	Harvey, 81	Oct 14	3	17835 Anoelsuri	Harvey, 81	Nov 4	3
13029 1989 HA	Harvey, 81	Apr 21	3	17912 1999 FV44	Harvey, 81	Oct 1	3
13154 Petermrva	Harvey, 81	Oct 14	3	17924 1999 GA17	Harvey, 81	Jun 7	3
13163 Koyamachuya	Harvey, 81	May 3	3	17973 1999 JP51	Harvey, 81	Jul 11	3
13290 1998 QN75	Harvey, 81	Mar 17	3	18109 2000 NG11	Faure, 35 Harvey, 81	Sep 4 Sep 7	2 3
13359 1998 UC4	Harvey, 81	May 7	3	18871 Grauer	Harvey, 81	Jan 21	3
13553 Masaakikoyama	Faure, 35	Oct 11	3	18896 2000 GN113	Harvey, 81	May 10	3
13698 1998 KF35	Harvey, 81	Oct 16	3	19123 Stephenlevine	Harvey, 81	Aug 5	3
13864 1998 XU116	Harvey, 81	Mar 15	3	19124 1986 TH3	Harvey, 81	Dec 6	3
13900 5211 T-2	Harvey, 81	Dec 6	3				0.3f@16.1
			0.3f@16.2	19138 1989 EJ1	Harvey, 81	May 9	3
13918 Tsukinada	Harvey, 81	Sep 20	3	19444 Addicott	Harvey, 81	Jan 14	3
14121 Stuwe	Harvey, 81	Oct 1	3	19502 1998 KB51	Harvey, 81	Jun 6	3
14142 1998 SG10	Harvey, 81	Apr 17	3	19633 Rusjan	Harvey, 81	Aug 14	3
14201 1998 XR92	Harvey, 81	Jul 11	3	19911 Rigaux	Harvey, 81	Mar 8	3
14469 Komatsuataka	Harvey, 81	Oct 4	3	20024 Mayremartinez	Harvey, 81	Feb 9	3
14471 1995 SG1	Harvey, 81	Oct 5	3	20520 1999 RC38	Harvey, 81	Mar 8	3
14515 Koichisato	Harvey, 81	Nov 28	3	20602 1999 RC18	Harvey, 81	Mar 15	3
14846 Lampedusa	Harvey, 81	Jan 9	3	20712 1999 XF13	Harvey, 81	Apr 20	3
14961 Hidatakayama	Harvey, 81	Jul 4	3	20862 Jenngoedhart	Harvey, 81	Jan 21	3
15288 1991 RN27	Harvey, 81	Feb 22	3	20882 2000 VH57	Harvey, 81	Oct 5	3
15321 Donnadean	Harvey, 81	Jul 11	6	21183 1994 EO2	Harvey, 81	Jan 6	3

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21414 Blumenthal	Harvey, 81	Oct 1	3	32209 2000 OW9	Harvey, 81	Oct 4	3
21518 Maysunhasan	Harvey, 81	Jan 20	3	32460 2000 SY92	Harvey, 81	Jan 25	3
21688 1999 RK37	Harvey, 81	Oct 1	3	33275 1998 HD115	Harvey, 81	Jan 7	3
21709 Sethmurray	Harvey, 81	Mar 16	3	35657 1998 QE5	Harvey, 81	Jan 25	3
21787 1994 SG4	Harvey, 81	May 7	3				0.3b@16.0
21814 Shanawolff	Harvey, 81	May 10	3	37384 2001 WU1	Harvey, 81	Dec 17	3
21904 1999 VV12	Harvey, 81	Mar 15	3	40315 1999 LS	Harvey, 81	Jul 10	3
21922 Mocz	Harvey, 81	Mar 23	3	41396 2000 AG175	Harvey, 81	Nov 4	3
21935 1999 VZ77	Harvey, 81	Mar 17	3	41920 2000 WA158	Harvey, 81	Oct 30	3
			0.3f@16.3				0.5f@16.1
21996 1999 XP31	Harvey, 81	Jun 19	3	42701 1998 MD13	Harvey, 81	Apr 30	3
22160 2000 WP120	Harvey, 81	Jan 25	3	45248 1999 XO258	Harvey, 81	Apr 13	3
22281 Popescu	Harvey, 81	Apr 20	3	45251 1999 YN	Harvey, 81	Jan 20	3
22301 1990 OB1	Harvey, 81	May 3	3	45877 2000 WR29	Harvey, 81	Jan 14	3
22345 1992 SP2	Harvey, 81	Oct 1	3	46635 1994 WK2	Harvey, 81	Jan 21	3
23160 2000 EN201	Harvey, 81	Mar 24	3	50379 2000 CB89	Harvey, 81	Dec 6	3
23177 2000 JD58	Harvey, 81	May 9	3	54419 2000 LA20	Harvey, 81	Mar 9	3
23222 2000 VZ53	Harvey, 81	Jan 16	3	54857 2000 OY22	Harvey, 81	May 7	3
23303 2000 AD17	Harvey, 81	Mar 9	4	55567 2002 CS6	Harvey, 81	Sep 19	4
23411 Bayanova	Harvey, 81	Jan 22	3	55758 1991 XR	Harvey, 81	Jan 6	3
23478 1991 BZ	Harvey, 81	Dec 17	3	58044 2002 WF	Harvey, 81	Aug 14	3
23615 1996 FK12	Harvey, 81	Apr 20	3	65733 1993 PC	Harvey, 81	Oct 16	6
24074 Thomasjohnson	Harvey, 81	Mar 23	3	66209 1999 CC14	Harvey, 81	Oct 4	3
24110 1999 VP20	Harvey, 81	Jan 7	3	68347 2001 KB67	Harvey, 81	Jun 3	6
24252 1999 XW117	Harvey, 81	Mar 9	3				0.7f@16.1
24779 Presque Isle	Harvey, 81	Jul 10	3	72396 2001 CU20	Harvey, 81	Dec 12	3
25317 1999 BL12	Harvey, 81	Nov 4	3	73689 1991 FK	Harvey, 81	Mar 23	3
26029 5565 P-L	Harvey, 81	Oct 14	3	75079 1999 VN24	Harvey, 81	Mar 9	3
26187 1996 XA27	Harvey, 81	Nov 4	3	91007 Ianfleming	Rayon, 20, 30	Oct 4-Nov 29	6APN
26347 1998 XU93	Harvey, 81	Oct 5	3	97034 1999 UK7	Harvey, 81	Jan 24	3
26377 1999 FH4	Harvey, 81	Sep 19	3	100088 1993 DC	Harvey, 81	Dec 26	3
26380 1999 JY65	Harvey, 81	Aug 14	3	112493 2002 PR6	Harvey, 81	Dec 26	3
26449 2000 AJ85	Harvey, 81	Jan 16	3	134340 Pluto	Harvey, 81	Aug 15	3
26571 2000 EN84	Harvey, 81	Feb 22	3	138847 2000 VE62	Harvey, 81	Apr 12	6
26850 1992 JL	Harvey, 81	Jun 7	3	144332 2004 DV24	Harvey, 81	Sep 2	6
27064 1998 SY63	Harvey, 81	May 9	3	153957 2002 AB29	Harvey, 81	Jun 16	6
27229 1999 JX37	Harvey, 81	Nov 28	3	154347 2002 XK4	Harvey, 81	Jan 4	6
27231 1999 JM57	Harvey, 81	Dec 6	3	155140 2005 UD	Harvey, 81	Oct 1	6
27995 1997 WL2	Harvey, 81	Jun 3	6	162882 2001 FD58	Harvey, 81	Feb 19	6
28281 1999 CT29	Harvey, 81	Aug 24	3	194126 2001 SG276	Harvey, 81	Apr 13	6
28424 1999 XA	Harvey, 81	Oct 5-30	4	220839 2004 VA	Harvey, 81	May 13	6
29227 Wegener	Harvey, 81	Mar 23	3	276033 2002 AJ129	Harvey, 81	Feb 6	6
29309 1993 VF1	Harvey, 81	Dec 12	3	302311 2002 AA	Harvey, 81	Jan 10	6
29684 1998 XF51	Harvey, 81	Nov 11	3	308680 2006 DY62	Harvey, 81	Jun 6	3
29934 1999 JL46	Harvey, 81	Jan 9	3	311554 2006 BQ147	Harvey, 81	Feb 9	6
29989 1999 XS204	Harvey, 81	May 13	3	388945 2008 TZ3	Harvey, 81	Apr 28	6
			0.4f@16.0	418849 2008 WM64	Harvey, 81	Dec 23	6
30885 1992 UU4	Harvey, 81	Nov 11	3	443923 2002 RU25	Harvey, 81	Sep 20	6
							0.4f@16.1
31685 1999 JB25	Harvey, 81	Oct 14	3	444193 2005 SE71	Harvey, 81	Apr 18	6

PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2018)	NO. OBS.
450648 2006 UC63	Harvey, 81	May 2	6
			0.7f@16.0
467309 1996 AW1	Harvey, 81	Jun 16	6
505657 2014 SR339	Harvey, 81	Feb 9	6
508912 2004 BB	Harvey, 81	Jan 30	6
511684 2015 BN509	Harvey, 81	Feb 6	6
513165 2004 CK39	Harvey, 81	Feb 21	6
523604 2004 QB17	Harvey, 81	Dec 6	6
523788 2015 FP118	Harvey, 81	Sep 7	6
2003 NW1	Harvey, 81	Dec 12	6
2007 YQ56	Harvey, 81	Dec 27	6
2010 WC9	Harvey, 81	May 14	6
2011 UA	Harvey, 81	Sep 7	6
2011 UG1	Harvey, 81	Oct 19	6
2013 US3	Harvey, 81	Apr 26	6
2015 DP155	Harvey, 81	Jun 5	6
2015 NJ3	Harvey, 81	Jan 24	6
2016 WD49	Harvey, 81	Jan 22	3
			1.2f@16.5
2017 QL33	Harvey, 81	Jan 6	6
2017 SR32	Harvey, 81	Feb 6	6
2017 VR12	Harvey, 81	Feb 27	6
2017 YN3	Harvey, 81	Jan 10	6
2018 AJ	Harvey, 81	Jan 21	6
			0.5b@16.0
2018 BY2	Harvey, 81	Apr 12	6
2018 BE6	Harvey, 81	Jan 30	6
2018 CB	Harvey, 81	Feb 9	6
2018 CC	Harvey, 81	Feb 6	6
2018 DH1	Harvey, 81	Mar 23	6
2018 DX3	Harvey, 81	Apr 19	6
2018 EB	Harvey, 81	Apr 5	6
2018 EB4	Harvey, 81	Mar 15	6
2018 EJ4	Harvey, 81	Jun 3	6
2018 HM2	Harvey, 81	May 2	6
2018 JX	Harvey, 81	May 14	6
2018 NB	Harvey, 81	Jul 4	6
2018 RC	Harvey, 81	Sep 7	6
2018 TF3	Harvey, 81	Oct 31	6
2018 UR2	Harvey, 81	Nov 4	6
2018 WX1	Harvey, 81	Dec 6	6
2018 XS4	Harvey, 81	Dec 17	3

ETSCORN LIGHTCURVES: JANUARY 2019 - APRIL 2019

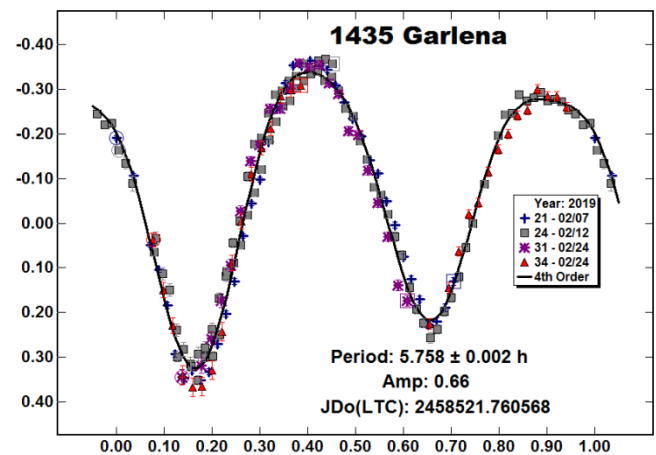
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(Received: 2019 April 13)

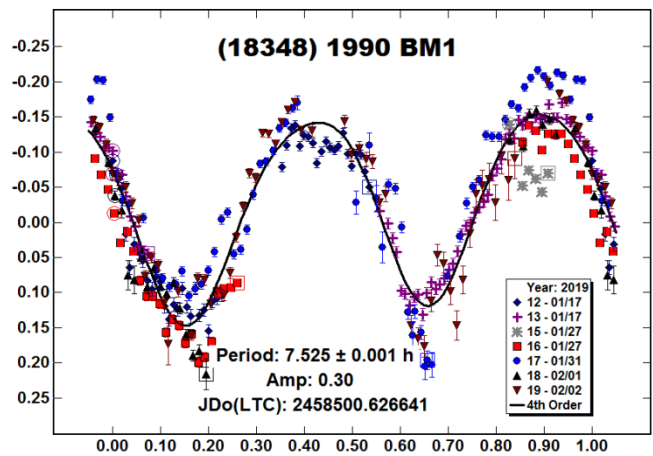
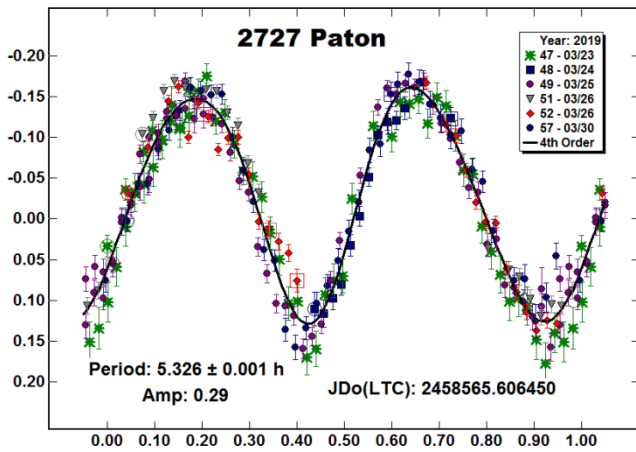
In the first quarter of 2019 we obtained the synodic period for 4 asteroids: 1435 Garlena, 2727 Paton, (7520) 1190 BV and (18348) 1990 BM1.

Our observations of the four asteroids reported here were obtained with two Celestron 0.35-m telescopes equipped with SBIG STL1001E CCD camera systems at the Etscorn Campus Observatory. (Klinglesmith and Franco, 2016). The images were processed and calibrated using MPO Canopus 10.7.12.9 (Warner, 2019). Exposures were between 300 and 420 seconds through clear filters depending on the brightness of the asteroids. The multi-night data sets for each asteroid were combined with the FALC algorithm (Harris et al., 1989) within MPO Canopus to provide synodic periods for each asteroid. Discovery information was obtained from the JPL Small Bodies Node (JPL, 2019). Table I contains the observation circumstances and results.

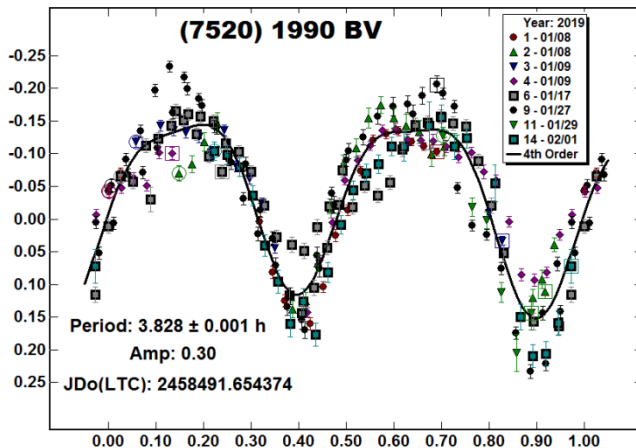
1435 Garlena is a main-belt asteroid discovered by K. Reinmuth at Heidelberg on 1936-Nov-23. It is also known as 1936 WE and 1953 UM. We observed it on 3 nights between 2019-Feb-07 and Feb 24. We obtained a synodic period of 5.758 ± 0.002 h with an amplitude of 0.66 mag. We found no other published periods.



2727 Paton is a main-belt asteroid discovered by N. Chernyjh at Nauchnyj on 1979-Sep-22. It is also known as 1979 SO9, 1939 DG, 1934 EX, 1949 QL1, 1952 HG3, 1964 CH, 1975 VE10 and 1977 FR2. We observed 2727 Paton on 5 nights between 2019-Mar-23 and Mar 30. We obtained a synodic period of 5.326 h \pm 0.002 h with an amplitude of 0.29 mag. We found no other published periods.



(7520) 1990 BV is a main-belt asteroid discovered by T. Hioki and S. Hayakawa at Okutama on 1990-Jan-21. It is also known as 1990 BV, 1979 AB, 1979 BJ1 and 1990 BO2. We observed it on 5 nights between 2019-Jan-01 and Feb 01. We obtained a synodic period of 3.828 ± 0.001 h with an amplitude of 0.30 mag. Three others have observed this object and obtained periods of 3.83 ± 0.01 h with an amplitude of 0.28 mag. (Zeigler, 2019) ; 3.83 ± 0.01 h with an amplitude of 0.29 mag. (Carreno,2019) and 3.828 ± 0.26 mag. (Marchini, 2019). All in close agreement with each other.



(18348) 1990 BM1 is a main-belt asteroid discovered by E.F. Helin at Palomar on 1990-Jan 22. It is also known as 1999 LN7. We observed it on 5 nights between 2019-Jan-17 and Feb 02. We obtained a synodic period of 7.525 ± 0.001 h with an amplitude of 0.30 mag. We found no other published periods.

Acknowledgements

The Etscorn Campus Observatory operations are supported by the Research and Economic Development Office of New Mexico Institute of Mining and Engineering.

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Marhini,A., Papini, R., Banfi, M., Salvafaggio, F, (2019) "Rotation Period Determination of Three Main-Belt Asteroids: 3769 Arthurmiller, 3995 Sakaino and (7520) 1990 BV", *Minor Planet Bul.*, 46, 213-214.

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Zeigler, K., Barnhard,T., Moser, A.Rockafellow, T.,(2019)," CCD Photometric Observations of Asteroids 2678 Aavasaksa, 3769 Arthurmiller, 4807 Noboru, (7520) 1990 BV, and (14510) 1996 ES2", *Minor Planet Bul.*, 46, 191-193.

Number	Name	2019 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1435	Garlena	02/07-02/24	179	7.6,14.3	126	-4.7	5.758	0.002	0.66	0.3	
2727	Paton	03/23-03/30	231	11.0,13.8	160	-3	5.326	0.002	0.29	0.05	
(7520)	1990 BV	01/08-02/01	212	2.7,15.6	104	+2	3.828	0.001	0.30	0.10	MB-1
(18348)	1990 BM1	01/17-02/02	287	2.2,10.4	116	-1	7.525	0.001	0.30	0.10	

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

LIGHTCURVE ANALYSIS AND ROTATION PERIOD FOR (37652) 1994 JS1

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(Received: 2019 April 12)

From 2019 March 8-23, CCD images were taken with the aim to measure the rotation period of (37652) 1994 JS1. The data analysis gives a light curve with a rotation period of 17.4501 ± 0.0014 hours.

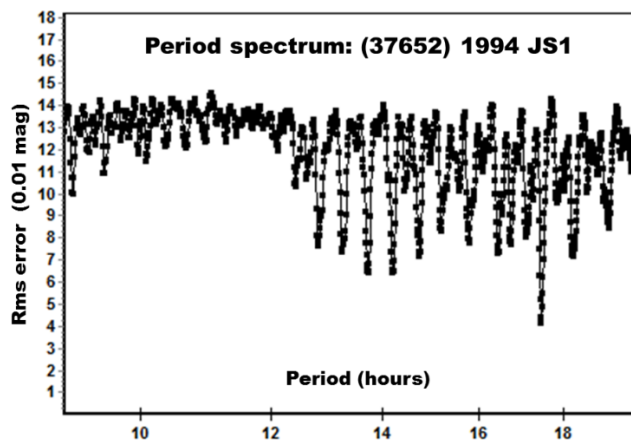
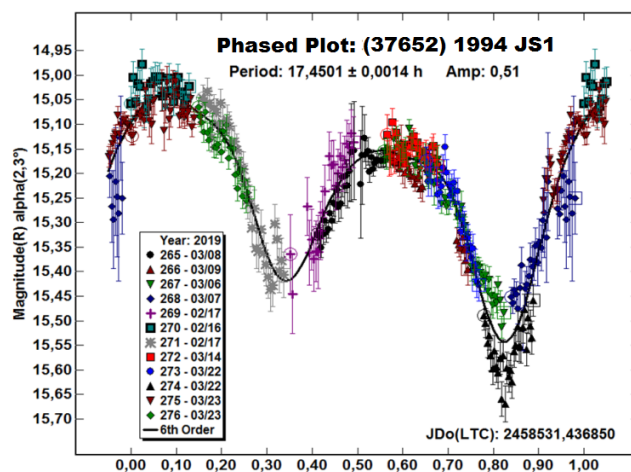
The main-belt asteroid (37652) 1994 JS1 was discovered on 1994 May 4 by C.W. Hergenrother and T.B. Spahr at Catalina Station. The diameter is about 3.6 km and the orbital period is approximately 1537 days. The geometric albedo is 0.26 (JPL, 2019).

CCD photometric observations of (37652) 1994 JS1 were made from 2019 March 8-23 to measure its lightcurve and rotation period. There were no entries in the LCDB (Warner et al., 2009) for this asteroid at the time of the observations. Observations were conducted at Elianto observatory (MPC code K68) using a 0.30-m $f/4$ Newtonian reflector equipped with a KAF 1603 ME CCD camera (1536x1024x9-micron pixels). No filter was used.

A total of 420 data points were collected in the 12 observing sessions that used exposure times ranging from 240 s to 300 s. Table I gives the observing circumstances and results.

All images were astrometrically aligned, and dark and flat-field corrected. *MPO Canopus* (Warner, 2017) was used to measure the magnitudes, perform Fourier analysis, and produce the final lightcurve. In particular, data were derived in *MPO Canopus* 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 CMC15 star catalog (<http://svo2.cab.inta-csic.es/vocats/cmc15/>) 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 employs the FALC Fourier analysis algorithm developed by Harris (Harris, 1989). Our analysis found a period of 17.4501 ± 0.0014 h. The lightcurve has an asymmetrical bimodal shape and peak-to-peak amplitude of 0.51 mag.



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- Warner, B.D., Harris, A.W., Pravec, P. (2009). “The Asteroid Lightcurve Database.” *Icarus* **202**, 134-146. Updated 2018 April. <http://www.minorplanet.info/lightcurvedatabase.html>
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Number	Name	2019 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Exp
37652	1994 JS1	03/08-03/23	420	2.3, 8.5	171	3	17.4501	0.0014	0.51	0.01	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 average exposure, seconds.

PHYSICAL PROPERTIES OF HILDA BINARY ASTEROID CANDIDATES

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We determine the rotation periods, lightcurve amplitudes, and H-G parameters for three potentially binary Hilda asteroids. We measured a rotation period of 40.06 ± 0.06 h, amplitude of 0.82 ± 0.02 mag, $H_r = 11.74 \pm 0.01$ mag, and $G_r = 0.73 \pm 0.07$ for 3923 Radzievskij. For (307321) 2002 QA123, we measure a rotation period of 26.502 ± 0.006 h, an amplitude of 0.79 ± 0.06 mag, $H_R = 15.12 \pm 0.01$ mag, and $G_R = 0.71 \pm 0.04$. For (445068) 2008 SE268, we determine a rotation period of 7.903 ± 0.003 h and amplitude of 1.1 mag, with $H_R = 15.40 \pm 0.03$ mag and $G_R = 0.44 \pm 0.14$.

The goal of this study is to determine physical properties of Hilda asteroids that were flagged as binary system candidates by their large brightness variations (Sonnett *et al.* 2015). Determining these properties will enable further understanding and characterization of these systems and their potentially binary nature.

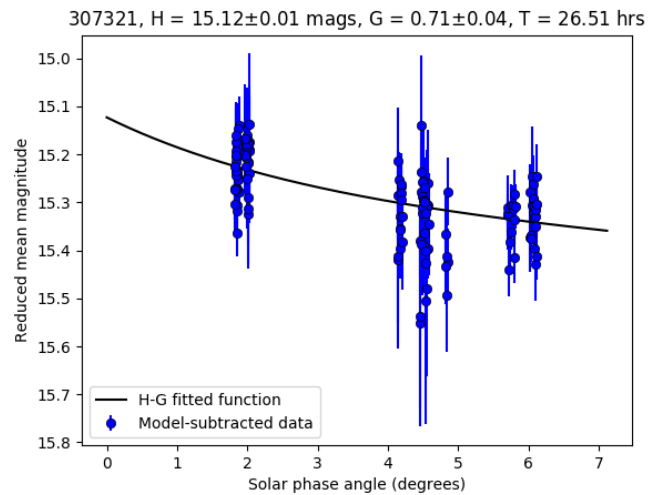
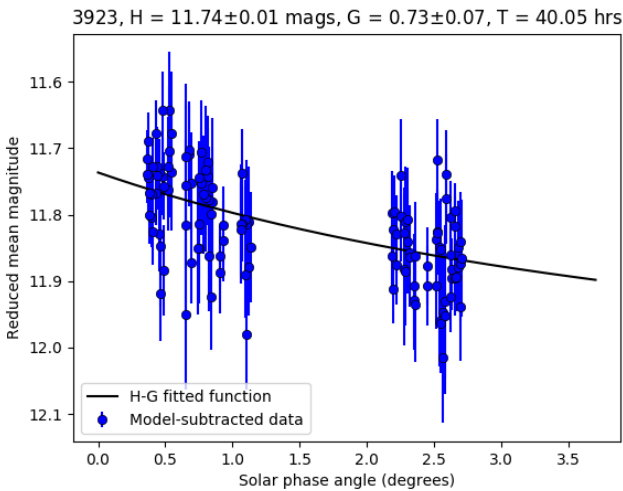
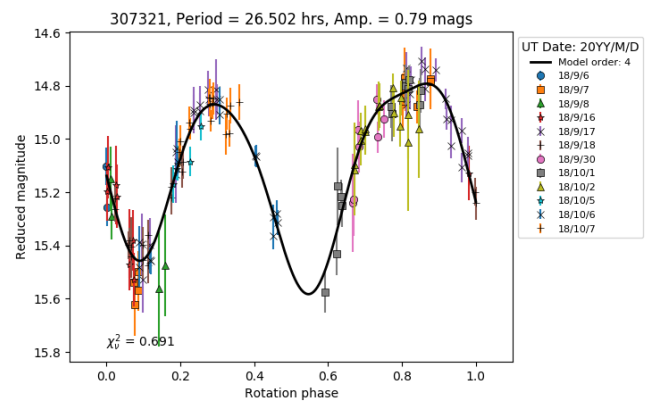
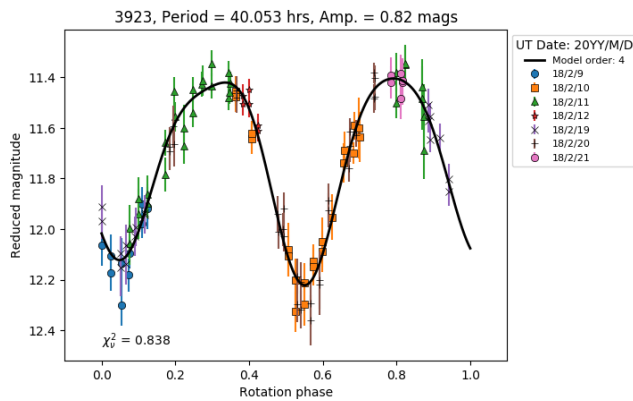
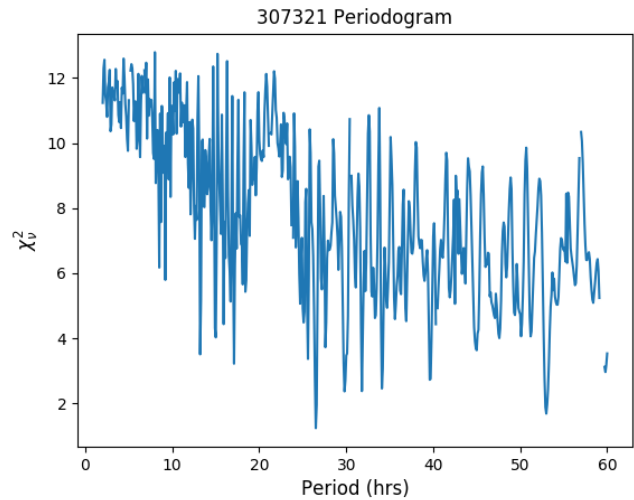
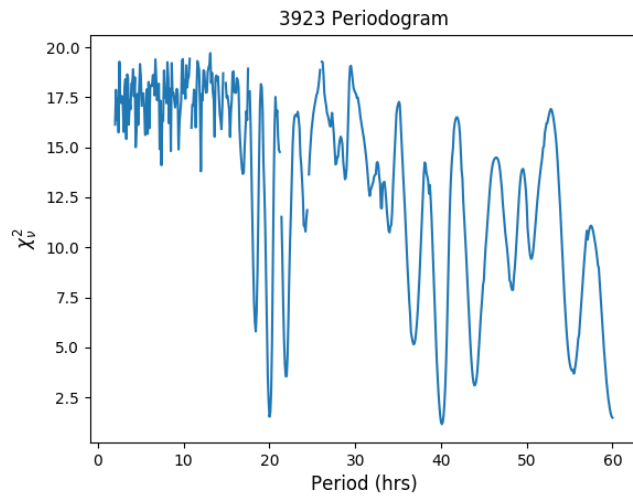
CCD observations of three Hilda asteroids were gathered at the Las Cumbres Observatory (LCO) using 0.4-, 1-, and 2-m telescopes. The 0.4-m telescopes used have a 3kx2k SBIG STL-6303 camera with a pixel scale of 0.571 arcsec/pixel and field-of-view of $29' \times 19'$. The 1-m telescope network employs 4kx4k

Sinistro cameras with a pixel scale of 0.389 arcsec/pixel and field-of-view of $26' \times 26'$, while the 2-m telescopes have a 4kx4k spectral camera with a pixel scale of 0.152 arcsec/pixel and field-of-view of $10' \times 10'$. Exposure times were chosen to reach $S/N \sim 30$ in order to resolve lightcurve extrema. All 3923 Radzievskij data were taken in the Sloan r' -band, and the remaining two targets were observed in the Bessell-R filter.

Image reduction and astrometry were performed automatically as part of the LCO processing pipeline. All images were visually inspected for background source blending and adequate focus. Photometry was performed on acceptable images using the PSF-fitting routine of the tphot software (Sonnett *et al.* 2013). We included corrections for the orbital lightcurve and light-time travel. Magnitude calibration of field stars was done by matching field stars to those in the AAVSO Photometric All Sky Survey catalog (APASS; data release 10) and, when needed to convert from APASS r' mags to the Bessel-R filter, transformations from R. Lupton (2005) were used. Only field stars isolated by 10 full-width-half-maxima of the average point source PSF and within three median-deviations from the median magnitude offset were used in the final magnitude offset calculation per frame. Systematic uncertainties were determined by the dispersion in magnitude residuals of calibrated field stars and were added in quadrature to the statistical uncertainties rendered by tphot.

The period, H-, and G-parameters were fit iteratively until we converged upon a solution that minimized the reduced χ^2 statistic. An optimized n th-order Fourier series was used to calculate the reduced χ^2 and to determine the lightcurve peak-to-peak amplitude. We repeated this iterative fitting process for a range of Fourier n -orders. The properties reported in this paper are from the lowest order Fourier series that converged upon a solution to all three fitted physical parameters. We then used a bootstrapping technique to determine the uncertainty on the rotation period and lightcurve amplitude. The H-G function fit and corresponding uncertainties were computed by the SciPy “curve_fit” routine, with magnitude uncertainties taken into consideration.

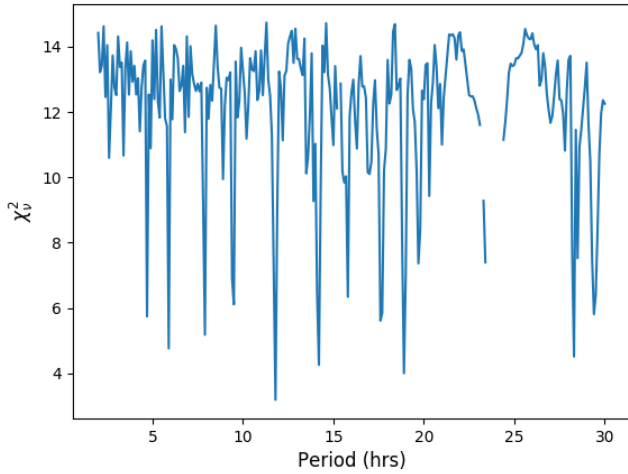
3923 Radzievskij. Dahlgren *et al.* (1998) reported a period of 39 ± 4 h and a minimum amplitude of 0.61 mag. Sonnett *et al.* (2015) reported a minimum amplitude of 0.98 ± 0.02 mag from sparse lightcurve sampling at thermal-IR wavelengths. Warner *et al.* (2017) reported a period of 39.93 ± 0.02 and a minimum amplitude of 0.95 ± 0.03 mag. A 4th-order Fourier fit of this object’s lightcurve to our Sloan r' data gives a period solution of 40.05 ± 0.03 h and an amplitude of 0.82 ± 0.02 mag, with $H_r = 11.74 \pm 0.01$ mag, $G_r = 0.73 \pm 0.07$. The disagreement between our period and amplitude results and those of Warner *et al.* (2017) could be partially due to changes in the viewing geometry and sparseness of rotation phase coverage of the previous publications, making it more difficult to constrain the lightcurve amplitude.



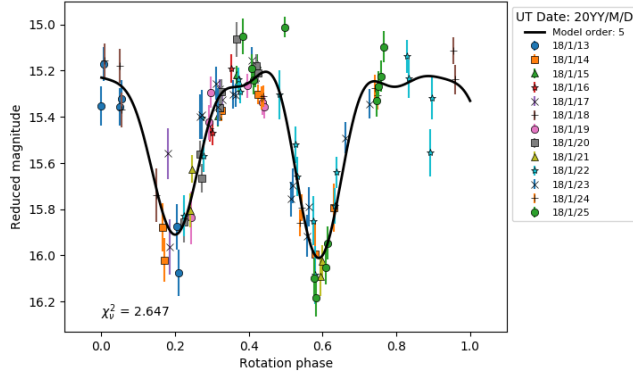
(307321) 2002 QA123. Sonnett *et al.* (2015) reported a minimum amplitude of 1.0 ± 0.2 mag in the thermal-IR for this object. A search of the Asteroid Lightcurve Database (LCDB; Warner *et al.* 2009) rendered no other published rotation information for this object. A 4th-order Fourier fit of this object's lightcurve gives a period solution of 26.502 ± 0.006 h and an amplitude of 0.79 ± 0.06 mag in the Bessel-R filter. We also fit $H_R = 15.12 \pm 0.01$ mag and $G_R = 0.71 \pm 0.04$. Differences in lightcurve amplitude between our solution and Sonnett *et al.* (2015) may be due to different viewing geometries.

(445068) 2008 SE268. A search of the LCDB yielded no previously published rotation properties for this object. Rotation analysis of our data (taken in the Bessel-R filter) rendered many solutions with comparable χ^2 values, slightly favoring a period of 11.817 ± 0.008 h and amplitude of 0.81 ± 0.04 mag. Visual inspection of the lightcurve phased to other minima indicated in the periodogram proved to be either clear or highly suspect aliases. We do note that double-peaked solutions at ~ 7.9 and ~ 9.45 h were also somewhat convincing by eye but rendered poorer χ^2 values. With the 11.817 h solution, we also fit $H_R = 15.45 \pm 0.03$ mag and $G_R = 0.56 \pm 0.13$.

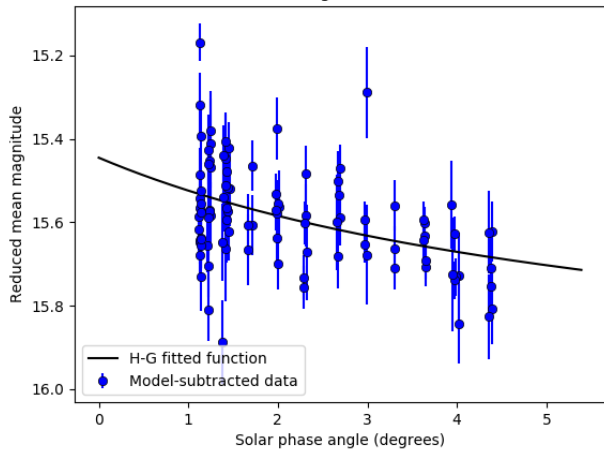
445068 Periodogram



445068, Period = 11.817 hrs, Amp. = 0.81 mags



445068, H = 15.45 ± 0.03 mags, G = 0.56 ± 0.13, T = 11.81 hrs



Acknowledgements

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Number	Name	2018 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period	P.E.	Amp	A.E.	H	H.E.	G	G.E.
3923	Radzievskij	02/08-02/21	237	0.2, 2.5	144.4	-0.5	40.05	0.03	0.82	0.02	11.74	0.01	0.73	0.07
307321	2002 QA123	09/07-10/06	154	1.8, 6.1	357.2	-4.7	26.502	0.006	0.79	0.05	15.12	0.01	0.71	0.04
445068	2008 SE268	01/13-01/25	112	1.1, 4.8	125.2	-3.1	11.817	0.008	0.81	0.04	15.45	0.03	0.56	0.13

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). H is the absolute magnitude and G the slope parameter of the solar phase function in r' for 3923 Radzievskij and in Bessel-R for (307321) 2002 QA123 and (445068) 2008 SE268.

ROTATION PROPERTIES OF LARGE-AMPLITUDE HILDA ASTEROIDS

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Lightcurve data for 3 potential binary asteroids belonging to the Hilda population were obtained from 2015 to 2018. For (46629) 1994 PS38, we obtained two epochs of coverage, rendering consistent rotation solutions of 8.39 ± 0.01 h (1st epoch in 2015) and 8.41 ± 0.02 h (2nd epoch in 2018), with amplitudes of 0.86 ± 0.05 R-mag and 0.90 ± 0.04 r'-mag, respectively. We obtain best-fit rotation periods of 12.228 ± 0.008 h with an amplitude of 0.80 ± 0.04 R-mag for (247405) 2002 CU1, and 8.44 ± 0.01 h with an amplitude of 0.74 ± 0.06 R-mag for (250139) 2002 RK68.

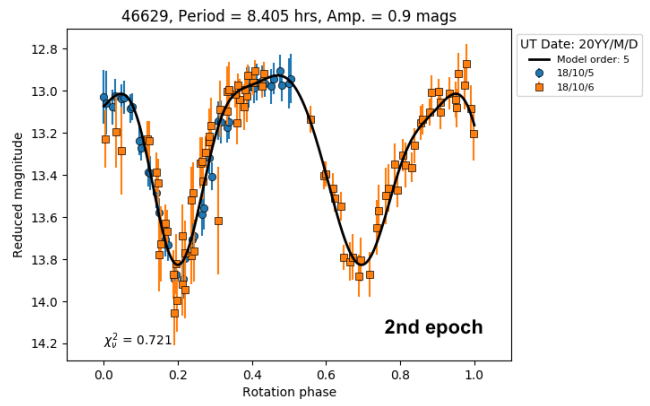
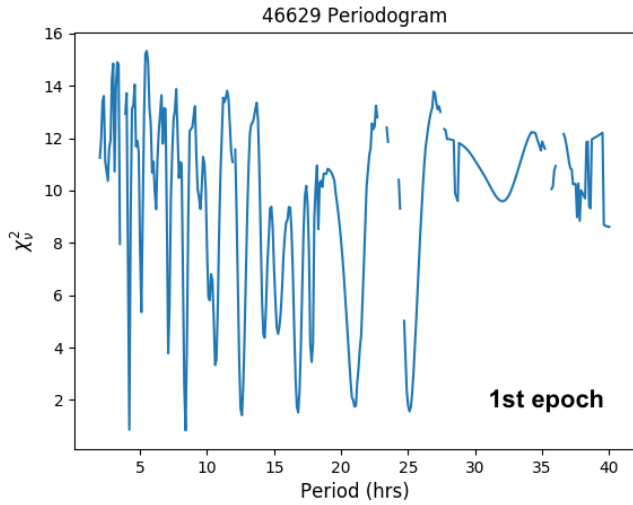
We obtained CCD observations of 3 potentially binary asteroids belonging to the Hilda dynamical population at the Las Cumbres Observatory (LCO) telescope network and the WIYN 0.9-meter telescope at the National Optical Astronomy Observatory (NOAO). This manuscript reports on an ongoing campaign to determine rotation properties of Trojan and Hilda asteroids that have previously shown large enough brightness variation to qualify them as close or contact binary systems. If binarity of these targets is confirmed, bulk density calculations can then be made from the rotation properties to provide key insights as to where the targets formed (Sonnett et al. 2015).

The LCO data were collected on the 0.4-m telescopes using a 3kx2k SBIG STL-6303 camera with a pixel scale of 0.571 arcsec/pixel (field-of-view of $29' \times 19'$), and on the 1-m telescopes using 4kx4k Sinistro cameras with a pixel scale of 0.389 arcsec/pixel (field-of-view of $26' \times 26'$). For the WIYN 0.9-m telescope data, we employed the Half-Degree Imager, with a pixel scale of 0.43 arcsec/pixel (a $29.5' \times 29.5'$ field-of-view).

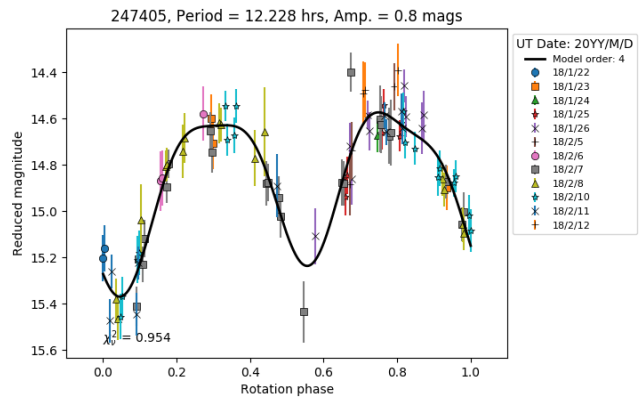
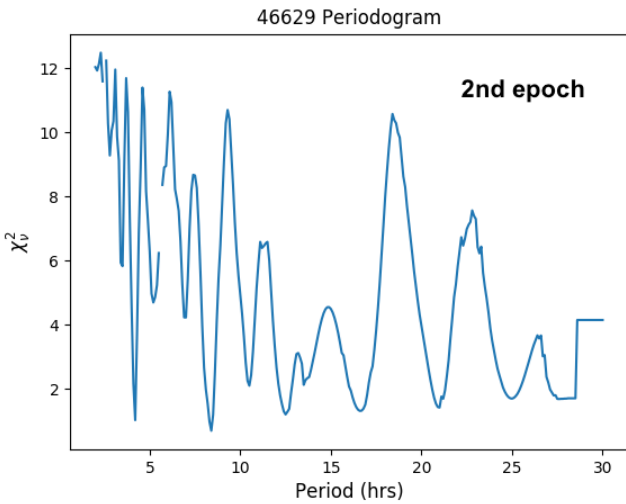
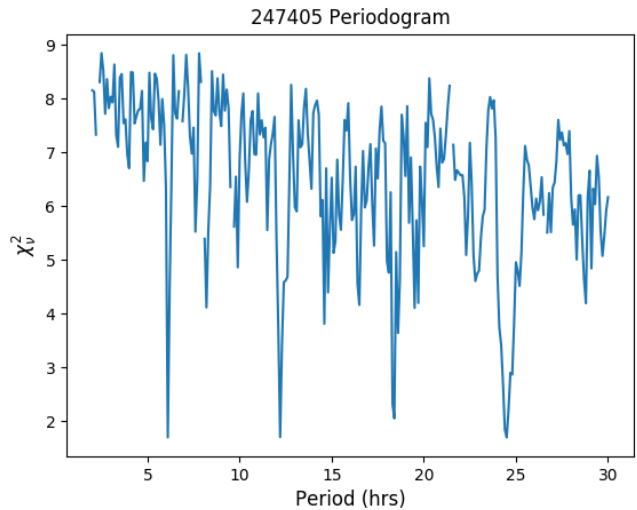
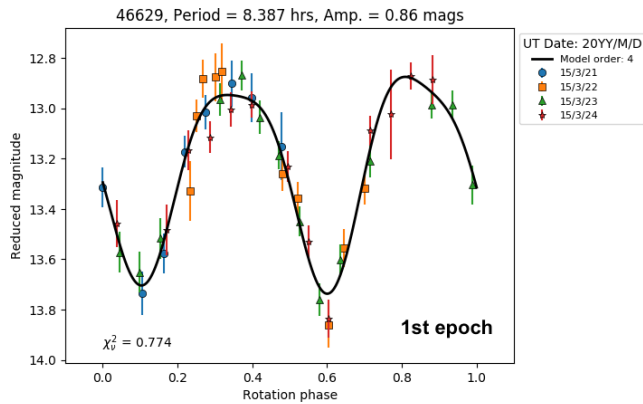
Image reduction was performed and astrometry measured for the LCO data automatically as part of the LCO processing pipeline. The WIYN 0.9-m data were reduced with IRAF's CCDPROC routine, and astrometry was obtained using the Astrometry.net software (Lang et al. 2010). Photometry for all data was measured using the tphot PSF-fitting algorithm (Sonnett et al. 2013). We included corrections for light-time travel, brightness differences from changes in heliocentric and geocentric distances, and a preliminary notion of the solar phase function (though the data were taken over such a small phase angle range that this last effect was always smaller than the photometric uncertainties). Magnitude calibration offsets were determined by matching field stars to those the AAVSO Photometric All Sky Survey catalog (APASS; data release 10). Only field stars isolated by 10 full-width-half-maxima of the average point source PSF and within three median-deviations from the median magnitude offset were used in the final magnitude offset calculation per frame. We used photometric transformations from R. Lupton (2005) to convert between the Sloan r' filters used in the APASS catalog and our Bessel-R data. We also computed systematic uncertainties for each image by measuring the dispersion in calibrated field star magnitudes (within 0.5 magnitudes of the target) compared to the median magnitude for those stars over at least 3 additional images. These systematic uncertainties were added in quadrature to the statistical uncertainties given by tphot.

Rotation periods were determined by iteratively calculating which period minimized the reduced χ^2 between the rotationally phased data and an n th-order Fourier series. The order of the Fourier fit for the reported rotation solution was selected to be the lowest order (to protect against over-fitting) at which the period and amplitude converged upon a solution. We used a bootstrapping algorithm to determine the uncertainty in rotation period and lightcurve peak-to-peak amplitude. Lightcurve amplitudes reported are from the Fourier fits, not the photometric range of the data. We show the periodogram and phased lightcurve for the optimal period solution for each of our 3 targets.

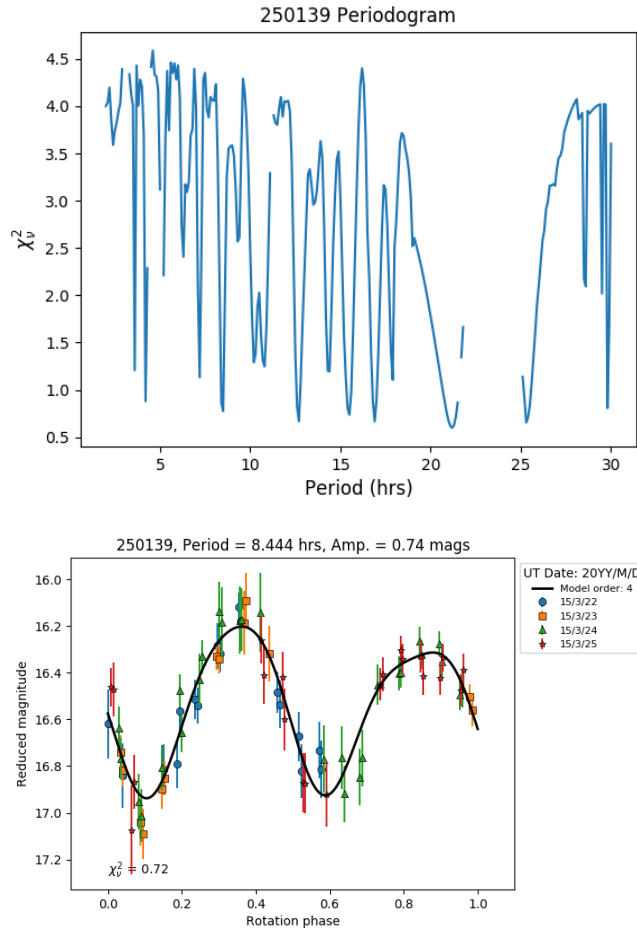
(46629) 1994 PS38 was observed over two epochs, one in 2015 with the WIYN 0.9-m HDI (Harris-R filter) and another in 2018 with the LCO 0.4-m network (Sloan- r' filter). The best-fit rotation solutions consistent between both epochs are 8.39 ± 0.01 and 8.41 ± 0.02 h with 0.86 ± 0.05 and 0.90 ± 0.04 mag amplitudes, respectively. The periodogram for this object favors several other rotation solutions, notably ~ 11.8 h. However, upon visual inspection, all of these slower rotation solutions appeared to be aliases, with the number of lightcurve minima clearly or heavily implied to exceed two. With such a large amplitude, we judged an object or system with more than two minima to be unphysical. Sonnett et al. (2015) found a minimum amplitude of 1.35 ± 0.03 mag from thermal-IR data taken in 2010. It is possible that the viewing geometry may have changed significantly between the 2010 thermal-IR data and the 2015 and 2018 optical data, rendering a different observed photometric range. The Asteroid Lightcurve Database (LCDB; Warner et al. 2009) does not have a published period for this object.



(247405) 2002 CU1. A search of the LCDB returned no previously published rotation period information for this object. Sonnett et al. (2015) reported an amplitude of 1.2 ± 0.2 mag at thermal-IR wavelengths. Our data for (247405) 2002 CU1 come from the LCO 1-m network and were taken with the Bessel-R filter. Rotation analysis shows a period of 12.228 ± 0.008 h, and an amplitude of 0.80 ± 0.04 mag. As with (46629) 1994 PS38, differences in viewing geometry over which the data were taken may be responsible for the difference in amplitudes between Sonnett et al. (2015) and our dataset.



(250139) 2002 RK68. Waszczak et al. (2015) reported a period of 8.445 ± 0.008 h and an amplitude of 0.84 mag. Sonnett et al. (2015) reported an amplitude of 1.5 ± 0.1 mag using thermal-IR observations. Our data come from the WIYN 0.9-m telescope and were taken with the Harris-R filter. Rotation analysis of our data rendered a period of 8.44 ± 0.01 h and an amplitude of 0.74 ± 0.06 mag from a 4-th order best-fit Fourier series. Our rotation period is consistent with the Waszczak et al. (2015) results.



Acknowledgements

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Number	Name	20yy/mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.
46629	1994 PS38	15/03/22-15/03/25	55	1.9, 1.2	188.9	-1.7	8.39	0.01	0.86	0.05
46629	1994 PS38	18/10/05-18/10/06	128	1.4, 1.8	8.4	1.9	8.41	0.02	0.90	0.04
247405	2002 CU1	18/01/22-18/02/12	96	6.6, 3.8	138.0	9.1	12.228	0.008	0.80	0.04
250139	2002 RK68	15/03/22-15/03/25	80	2.5, 2.2	185.9	-8.8	8.44	0.01	0.74	0.06

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). H is the absolute magnitude in Harris-R-filter for the 1st epoch of (46629) 1994 PS38 and (250139) 2002 RK68, in Sloan-r' for the 2nd epoch of (46629) 1994 PS38 data, and Bessel-R for (247405) 2002 CU1.

ROTATION PERIOD DETERMINATION FOR THE ASTEROIDS 3329 GOLAY AND (37652) 1994 JS1

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(Received: 2019 April 15)

CCD photometric observations of two main-belt asteroids were conducted from the Astronomical Observatory of the University of Siena and the Wild Boar Remote Observatory, both located in Italy, in order to determine their synodic rotation periods. For 3329 Golay we found a period of 7.129 ± 0.003 h and lightcurve amplitude of 0.57 ± 0.03 mag; for (37652) 1994 JS1 we found a period of 17.459 ± 0.002 h and lightcurve amplitude of 0.40 ± 0.03 mag.

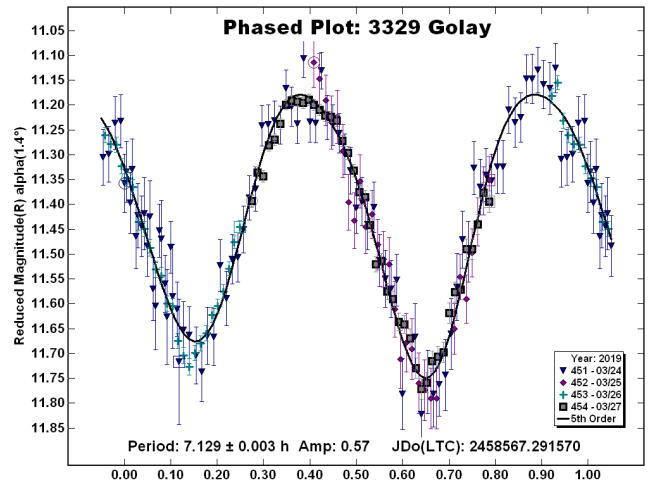
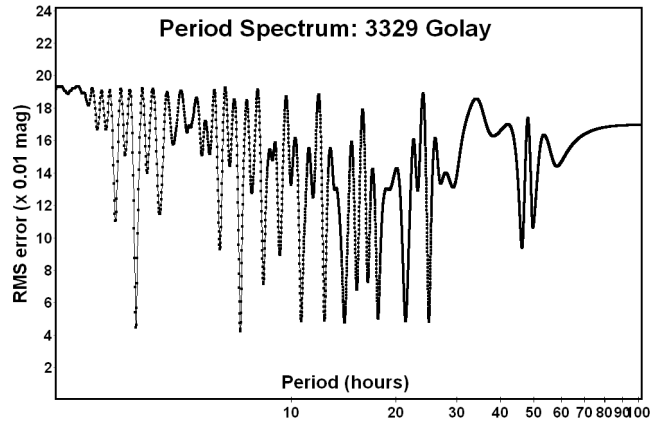
CCD photometric observations of two main-belt asteroids were carried out in 2019 March at the Astronomical Observatory of the University of Siena (K54) and at the Wild Boar Remote Observatory (K49) in San Casciano in Val di Pesa (Florence). At the Astronomical Observatory of the University of Siena, a facility inside the Department of Physical Sciences, Earth and Environment (DSFTA, 2019), data were obtained with a 0.30-m $f/5.6$ Maksutov-Cassegrain telescope, SBIG STL-6303E NABG CCD camera, and clear filter; the pixel scale was 2.30 arcsec when binned at 2x2 pixels. At the Wild Boar Remote Observatory, data were obtained with a 0.235-m $f/10$ (SCT) telescope, SBIG ST8-XME NABG CCD camera, unfiltered; the pixel scale was 1.6 arcsec in binning 2x2. All exposures were 300 seconds.

Data processing and analysis were made with *MPO Canopus* (Warner, 2018). 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 asteroids. (37652) 1994 JS1 was reported as lightcurve photometry opportunity in the *Minor Planet Bulletin* (Warner et al., 2019).

3329 Golay (1985 RT1) was discovered at Zimmerwald on 1985 Sept. 12 by P. Wild. It was named in honor of Marcel Golay who, from 1956 to 1992, was director of the Observatoire de Genève. He developed a seven-color system of stellar photometry that

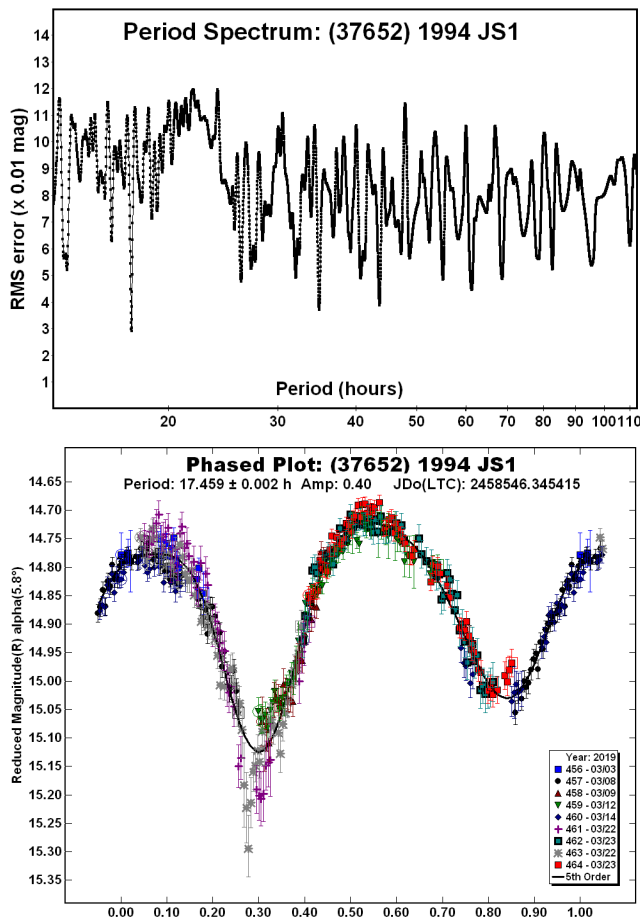
allows precise and relatively rapid determination of temperature, gravity, rotation and chemistry. Thanks to Golay, Switzerland joined the ESO and ESA, giving access to the most modern observing methods and instruments. [Ref: Minor Planet Circ. 22497] It is an outer main-belt asteroid with a semi-major axis of 2.996 AU, eccentricity 0.086, inclination 10.396 deg, and orbital period of 5.19 yr. Its absolute magnitude is $H = 11.5$ (JPL, 2019; MPC, 2019) while its diameter is $D = 18.365 \pm 0.240$ km (Masiero et al., 2011). Observations of this asteroid were conducted on three nights that produced 188 data points. The period analysis shows a bimodal solution for the rotational period $P = 7.129 \pm 0.003$ h and lightcurve amplitude $A = 0.57 \pm 0.03$ mag.



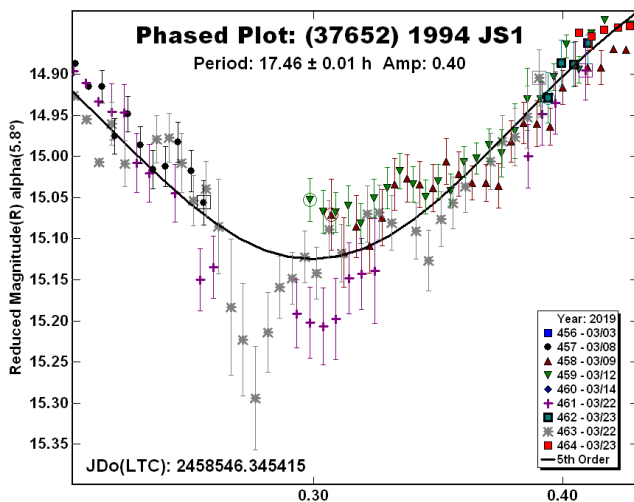
(37652) 1994 JS1 was discovered at Catalina Station on 1994 May 4 by C.W. Hergenrother and T.B. Spahr. It is a middle main-belt asteroid with a semi-major axis of 2.607 AU, eccentricity 0.348, inclination 19.413 deg, and orbital period of 4.21 yr. Its absolute magnitude is $H = 14.2$ (JPL, 2019; MPC, 2019) and its diameter is $D = 3.567 \pm 0.176$ km (Masiero et al., 2011). Observations of this asteroid were conducted on nine nights, which produced 469 data points. The data analysis shows a period $P = 17.459 \pm 0.002$ h as the most likely bimodal solution; the lightcurve amplitude is $A = 0.40 \pm 0.03$ mag.

Number	Name	2019/mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.
3329	Golay	03/24-03/27	188	1.5,0.7	187	1	7.129	0.003	0.57	0.03
37652	1994 JS1	03/03-03/24	469	5.9,9.9	171	2	17.459	0.002	0.40	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. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984).



A sudden fall of light is clearly visible in the lightcurve between phases 0.26 and 0.32; it is better shown in the plot expanded on the phase interval. Both telescopes recorded the drop in magnitude. The error bars are too large to say more about the cause of the attenuation. Additional observations of this asteroid would be welcome in order to verify its actual nature.



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https://www.minorplanetcenter.net/iau/ECS/MPCArchive/MPCArchive_TBL.html

The authors want to thank a group of high school students from Liceo "Galileo Galilei" (Siena) involved in an interesting vocational guidance project about astronomy at the Astronomical Observatory of the University of Siena. They attended some observing sessions of the asteroid (37652) 1994 JS1 and participated in data analysis: G. Bagnolesi, G. Baldaccini, M. Bandini, E. Belardinelli, V. Bernardi, M. Bernardoni, E. Bianciardi, A. Bova, E. Bracalente, C. Brogi, F. Capitani, A. Cerchia, P. Chiereghin, T. Chiereghin, I. Collaku, E. Cometti, A. Cosmiuc, R.F. Di Cioccio, G. Dominici, M. Dragoni, J. Gaanan, L. Guazzini, A. Lilli, F. Mancini, D. Marconcini, R. Martini, M. Massai, N. Mauri, F. Mecheroni, R. Meloni, L. Mercati, M.P. Nastasi, L. Nepi, M. Paci, C. Pennisi, E. Petraglia, T. Petrucci, A. Picchi, S. Pinti, M. Popa, F. Ravagni, D. Regoli, G. Ricci, F. Russo, G. Sani, L. Sisinni, J. Tanzini, L. Tenti, C. Tognini, S. Vannucci, E. Vedovini, G. Zalaffi, G. Zanotti.

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LIGHTCURVE AND ROTATION PERIOD DETERMINATION FOR 2496 FERNANDUS, 2727 PATON, AND 69971 TANZI

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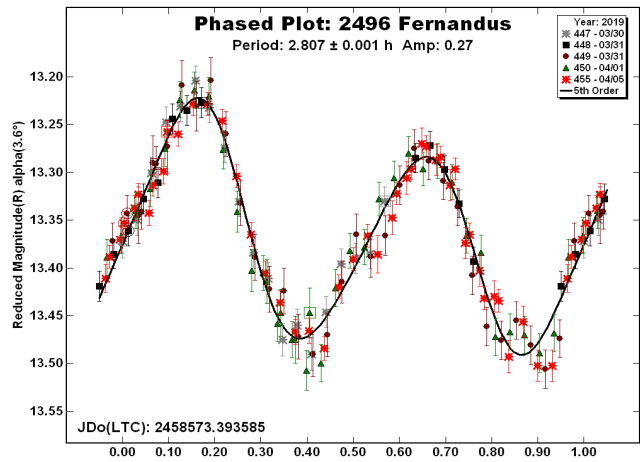
Photometric observations of the main-belt asteroids 2496 Fernandus, 2727 Paton, and 69971 Tanzi were made by the authors from 2019 January 3 to April 5. Analysis found bimodal lightcurves for each one. The most likely synodic periods are: 2496 Fernandus, 2.807 ± 0.001 h; 2727 Paton, 5.324 ± 0.001 h; and 69971 Tanzi, 32.540 ± 0.009 h.

Lightcurve analysis of three asteroids was performed using images taken at the Astronomical Observatory of the University of Siena (Italy) and at the Wild Boar Remote Observatory (K49). At the Astronomical Observatory of the University of Siena, data were obtained with a 0.30-m *f*/5.6 Maksutov-Cassegrain telescope, SBIG STL-6303E NABG CCD camera, and clear filter; the image scale was 2.26 arcsec in binning 2x2. Exposures were 300 s. At the Wild Boar Remote Observatory (K49), data were obtained with a 0.235-m *f*/10 (SCT) telescope, SBIG ST8-XME NABG CCD camera, and no filter; the image scale was 1.6 arcsec in binning 2x2. Exposures were 300 s. Table I lists the observing circumstances and analysis results.

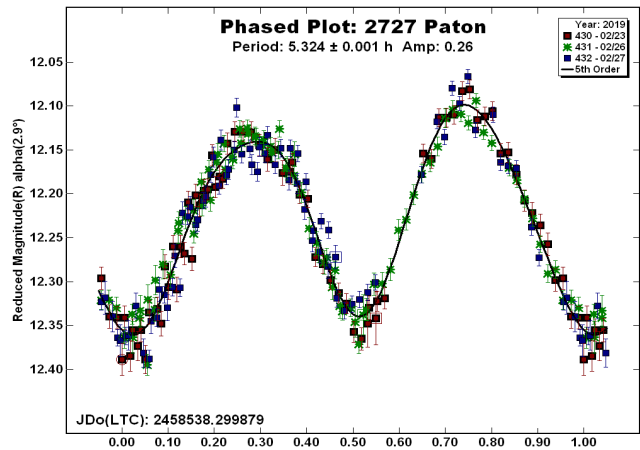
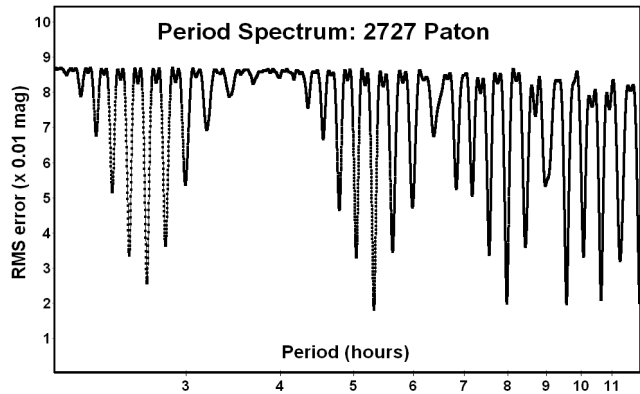
MPO Canopus (Warner, 2013) was used to measure the images, do Fourier analysis, and produce the lightcurves.

In the following, orbital data and discovery circumstances were taken from the JPL Small Bodies Node (JPL, 2017).

2496 Fernandus (1953 TC1) is a main-belt asteroid discovered on 1953 Oct 8 at the Goethe Link Observatory (Brooklyn). It's a typical main-belt asteroid with a semi-major axis of about 2.17 AU, eccentricity 0.033, and orbital period of about 3.20 yr. Observations were made from 2019 March 30 to April 5. They produced three sessions with a total of 147 data points. Analysis found a bimodal lightcurve with a synodic period of 2.807 ± 0.001 h and peak-to-peak amplitude of 0.27 ± 0.01 mag.



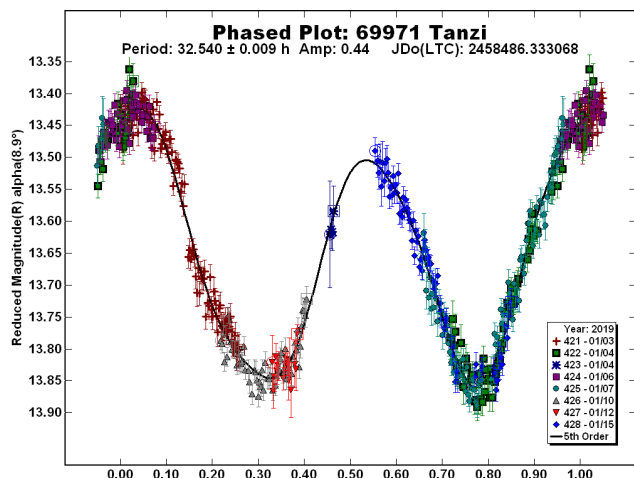
2727 Paton (1979 SO9) is a main-belt asteroid discovered on 1979 Sept 22 by N. Chernykh at Nauchnyj. The orbit has a semi-major axis of 2.61 AU, eccentricity 0.102, and period about 4.21 yr. We observed the asteroid from 2019 Feb 23-27. This resulted in three sessions with a total of 228 data points. Analysis found a bimodal lightcurve with a synodic period of 5.324 ± 0.001 h and amplitude of 0.26 ± 0.02 mag.



Number	Name	2019 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2496	Fernandus	03/30-04/05	147	2.7, 3.7	196	1	2.807	0.001	0.27	0.01	EUN
2727	Paton	02/23-02/27	228	3.0, 4.3	159	-3	5.324	0.001	0.26	0.02	EUN
69971	Tanzi	01/03-01/15	475	7.4, 7.2	117	1	32.540	0.009	0.44	0.04	EUN

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).

69971 Tanzi (1998 WD2) is a main-belt asteroid discovered on 1998 Nov 18 by M. Cavagna at Sormano. The orbit has a semi-major axis of 2.91 AU, eccentricity 0.284, and period of about 4.96 yr. Our observations from 2019 January 2-15 produced 8 sessions and a total of 475 data points. The resulting bimodal lightcurve has a synodic period 32.540 ± 0.009 h and amplitude of 0.44 ± 0.04 mag.



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All the authors want to thank a group of high school students from Liceo “Enea Silvio Piccolomini” (Siena) who were involved in an interesting vocational guidance project about astronomy at the Astronomical Observatory of the University of Siena. They attended some observing sessions on asteroids 2727 Paton and 69971 Tanzi and relative analysis: A. Bogi, G. Bozza, L. Brizzi, E. Governi, A. Monari, M. Ruffoli, C. Valenti, E. Zaccaria and from Liceo Scientifico “Tito Sarocchi” (Siena), A. Bellocchi, G. Bichi, T. Bindi, F. Bogi, G. Borghi, S. Brocchi, T. Busonero, M. Capannoli, L. Cerpi, B. Cosmi, L. Fanti, E. Giorgi, D. Lalli, A. Montesi, N. Moscadelli, D. Rondini, G. Semplici, G. Tessicini, F. Tirinnanzi, N. Tozzi, J. Trisciani, L. Tucci.

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<http://minorplanetobserver.com>

SYNODIC ROTATION PERIODS AND LIGHTCURVES FOR 13 ASTEROIDS: 2018 OCTOBER - 2019 MARCH

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Results on lightcurve and synodic rotation period determinations for 13 asteroids from data collected at Sopot Astronomical Observatory in the time span 2018 October - 2019 March are presented.

Photometric observations of 13 asteroids were conducted at Sopot Astronomical Observatory (SAO) between 2018 October - 2019 March in order to determine the asteroids’ synodic rotation periods. For this purpose, two 0.35-m *f*/6.3 Meade LX200GPS Schmidt-Cassegrain telescopes were employed. The telescopes are equipped with a SBIG ST-8 XME and a SBIG ST-10 XME CCD cameras. The exposures were unfiltered and unguided for all targets. Both cameras were operated in 2x2 binning mode, which produces image scales of 1.66 arcsec/pixel and 1.25 arcsec/pixel for ST-8 XME and ST-10 XME cameras, respectively. Prior to measurements, all images were corrected using dark and flat field frames.

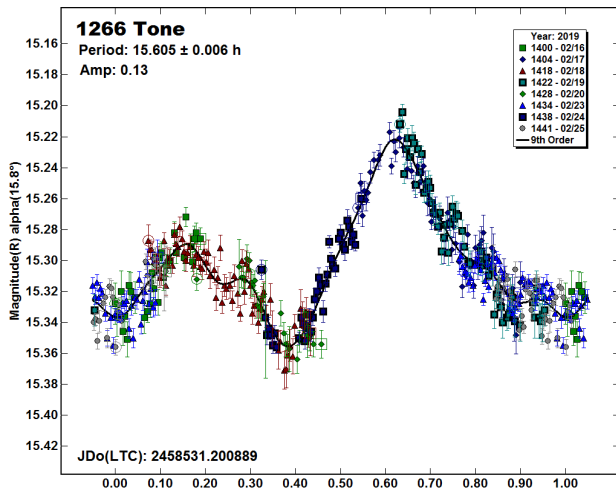
Photometric reduction, lightcurve construction, and period analysis were conducted using *MPO Canopus* (Warner, 2018). Differential photometry with up to five comparison stars of near solar color ($0.5 \leq B-V \leq 0.9$) was performed using the Comparison Star Selector (CSS) utility. This helped ensure a satisfactory quality level of night-to-night zero point calibrations and correlation of the measurements within the standard magnitude framework. Field comparison stars were calibrated using standard Cousins R magnitudes derived from the Carlsberg Meridian Catalog 15 (VizieR, 2019) Sloan *r'* magnitudes using the formula: $R = r' - 0.22$ in all cases presented in this paper. In some instances, small zero point adjustments were necessary in order to achieve the best match between individual data sets in terms of minimum RMS residual of a Fourier fit.

Some of the targets presented in this paper were observed within the Photometric Survey for Asynchronous Binary Asteroids (BinAstPhot Survey) under the leadership of Dr Petr Pravec from Ondřejov Observatory, Czech Republic.

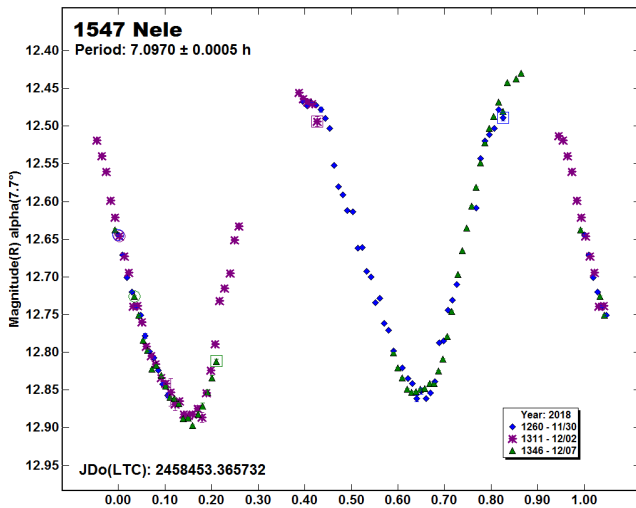
Table I gives the observing circumstances and results.

Observations and results

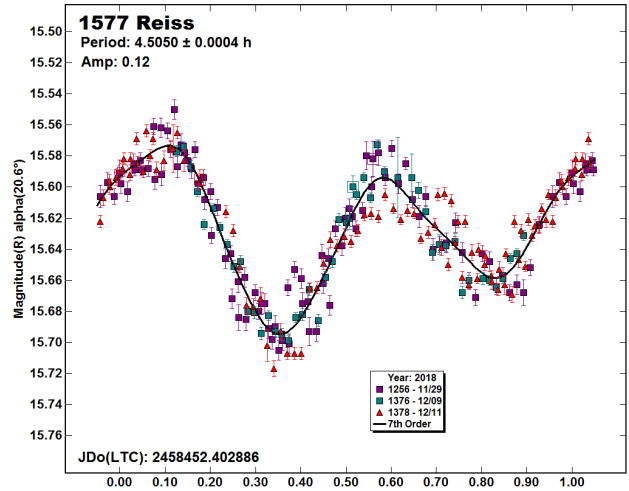
1266 Tone. Several fairly different previous rotation period determination results were found in the Asteroid Lightcurve Database (LCDB; Warner et al., 2009) prior to the 2019 SAO photometric observations of this main-belt asteroid (MBA). These are the results obtained by: Warner 2003, 11.82 h; Behrend 2005, 12.9 h; Warner 2010, 7.40 h and Montminy et al. 2018, 15.55 h. The observations at SAO were carried out over eight nights in the second half of 2019 February and resulted in a rather dense combined dataset with a total of 409 data points. Period analysis found a bimodal period of 15.605 ± 0.006 h as the most likely one, which is in good with the result by Montminy et al. (2018).



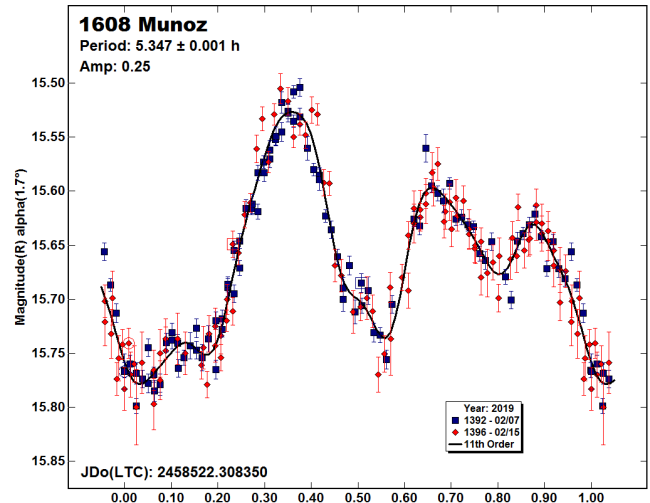
1547 Nele. A number of quite consistent values for a rotation period were found for this MBA since 2002, some of which are listed here: Behrend (2002), 7.1006 h; Licchelli (2006), 7.100 h; Durech et al. (2016), 7.09742 h (sidereal period); Behrend (2018), 7.0998 h. Period analysis upon the SAO data obtained in 2018 November - December indicate a result for period of 7.0970 ± 0.0005 h. Obviously, this is fully consistent with the previous values, although the corresponding bimodal lightcurve contains some gaps.



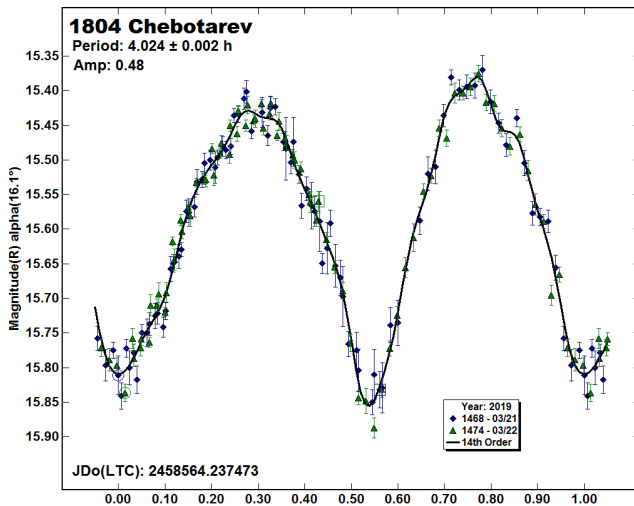
1577 Reiss. A BinAstPhot Survey target observed at SAO in 2018 December over three nights. A unique bimodal period result of $P = 4.5050 \pm 0.0005$ h was found, which is in excellent agreement with the 2011 apparition BinAstPhot result: 4.5050 h (Pravec, 2011), as well as with a period of 4.505 h by Melton et al. (2012).



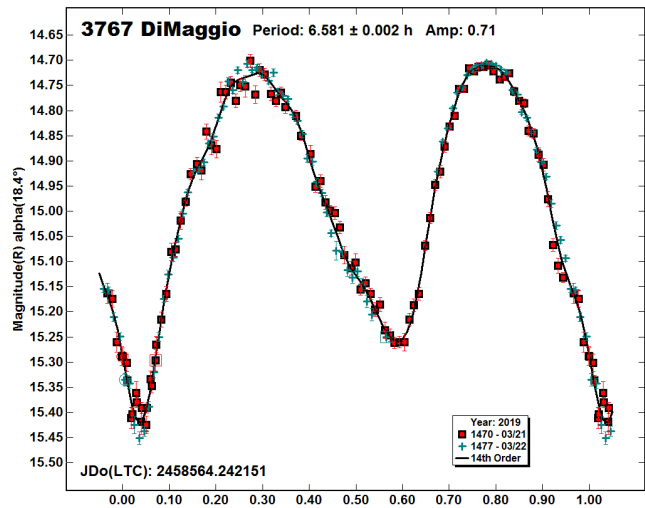
1608 Munoz. Another BinAstPhot target observed on two nights in 2019 February and was worked within this Survey in 2017 September (Benishek, 2018). The newly found result for a rotation period (5.347 ± 0.001 h) is fully consistent with the previously established one (5.3451 h). Using the SAO data in both these apparitions Pravec found values that differ only slightly from those by Benishek: 5.3456 h (Pravec, 2017) and 5.3466 (Pravec, 2019a).



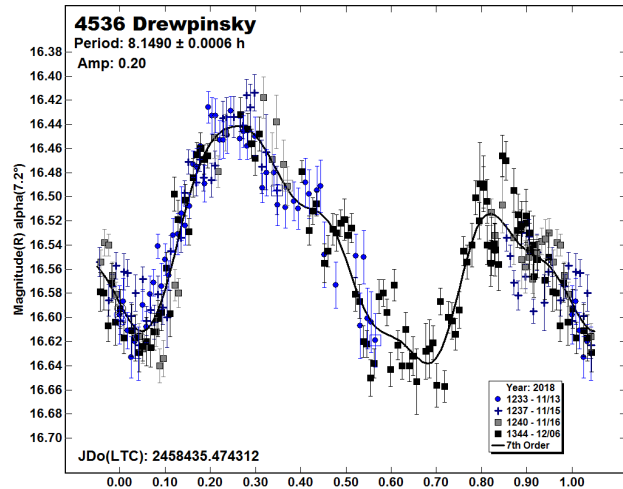
1804 Chebotarev. The only previously known rotation period determination for this MBA was by Behrend (2004): 4.026 h. The SAO data collected in 2019 March yielded a fairly large amplitude (0.48 mag.) bimodal lightcurve phased to exactly the same period previously reported by Behrend (4.024 ± 0.002 h) as an unambiguous solution.



3767 DiMaggio. Another asteroid with a well-established rotation period. A search of the LCDB records finds the following period determination results: Almeida et al. (2004), 6.14 h; Behrend (2007), 6.581 h; Waszczak et al. (2015), 6.578 h; Durech et al. (2018), 6.57887 h (sidereal period). Period found from the SAO data gathered on two consecutive nights in 2019 March is: 6.581 ± 0.002 h.



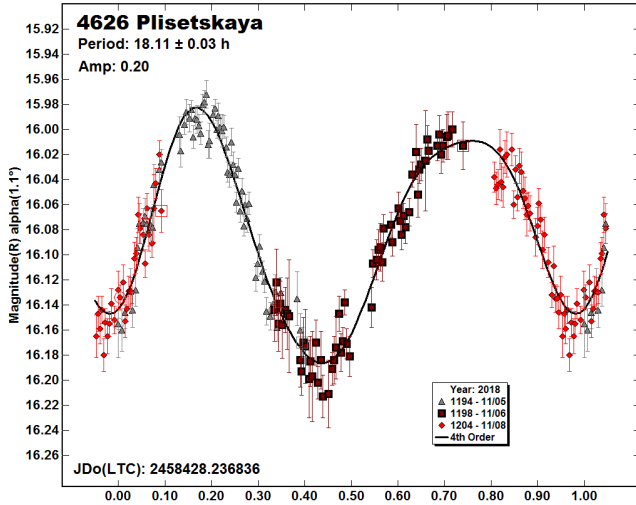
4536 Drewpinsky. No previous rotation period determination results are known on this Flora-group asteroid. Four datasets obtained in 2018 November–December revealed a rotation period of 8.1490 ± 0.0006 h associated with a bimodal lightcurve showing a moderate amplitude of 0.20 mag.



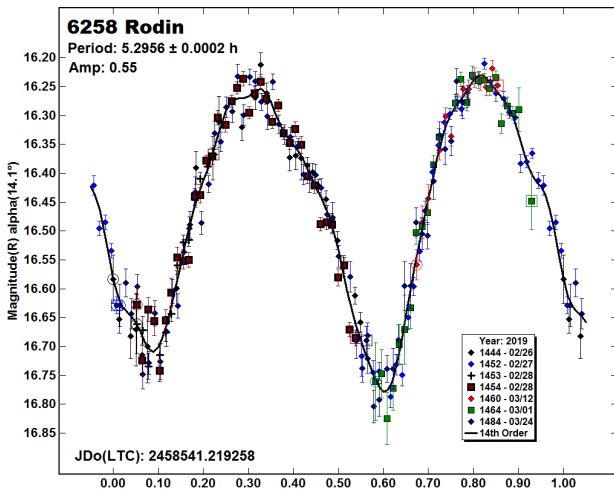
Number	Name	20(yy)/mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
1266	Tone	19/02/16–19/02/25	409	15.8, 16.2	80	15	15.605	0.006	0.13	0.02	MB–O
1547	Nele	18/11/30–18/12/07	139	7.7, 8.1	69	12	7.0970	0.0005	0.45	0.01	MB–M
1577	Reiss	18/11/29–18/12/11	228	20.6, 15.5	104	–3	4.5050	0.0004	0.12	0.02	FLOR
1608	Munoz	19/02/07–19/02/16	204	1.7, 3.5	140	3	5.347	0.001	0.25	0.02	FLOR
1804	Chebotarev	19/03/21–19/03/22	164	11.4, 6.2	146	–1	4.024	0.002	0.48	0.01	MB–I
3767	DiMaggio	19/03/21–19/03/23	182	18.4, 18.8	143	9	6.581	0.002	0.71	0.01	EUN
4536	Drewpinsky	18/11/12–18/12/07	235	7.2, 3.0, 7.1	63	5	8.1490	0.0006	0.20	0.03	FLOR
4626	Plisetskaya	18/11/05–18/11/08	191	1.1, 2.1	42	1	18.11	0.03	0.20	0.02	FLOR
6258	Rodin	19/02/26–19/03/24	211	14.1, 23.9	136	1	5.2956	0.0002	0.55	0.02	FLOR
11852	Shoumen	19/02/07–19/02/09	172	13.3, 13.5	132	26	6.005	0.004	0.23	0.02	PHO
16529	Dangoldin	18/10/13–18/10/16	113	15.9, 15.0	37	–12	2.8871	0.0006	0.17	0.01	MC
100088	1993 DC	18/12/07–18/12/11	117	22.6, 20.4	96	6	2.775	0.002	0.17	0.02	MC
152931	2000 EA107	19/03/22–19/03/25	161	57.8, 59.4	211	44	4.135	0.003	0.27	0.03	NEA

Table I. 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. Grp is the asteroid family/group (Warner et al., 2009): EUN = Eunomia, FLOR = Flora, MB–I/M/O = main-belt inner/middle/outer, MC = Mars - crosser, NEA = near-Earth asteroid, PHO = Phocaea.

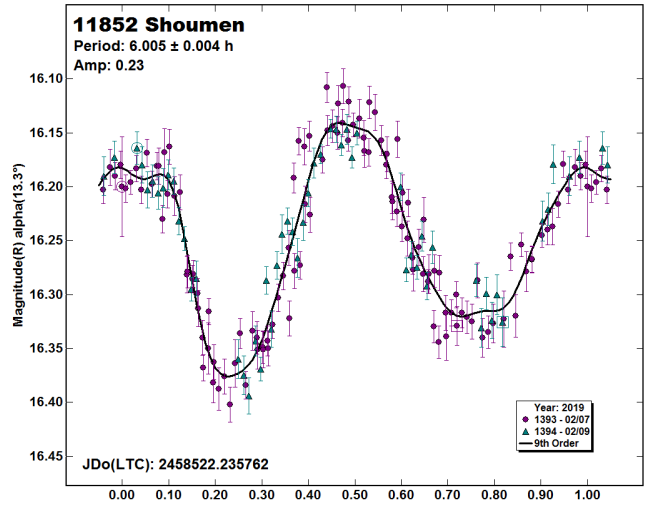
4626 Plisetskaya. Rotation period has not been determined previously in this case, as well. The SAO data obtained in 2018 November strongly point out a period of 18.11 h as a likely solution, although double coverage of the rotational cycle was not provided. Therefore, this value should be taken with a certain caution and its further confirmation would be desirable in the future.



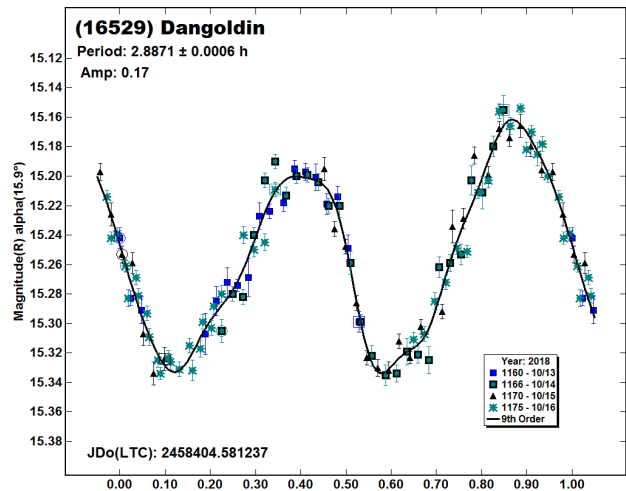
6258 Rodin. The LCDB database lists only one, uncertain ($U=1$) rotation period reported by Pravec (2016; 6.1 h), which is based on an incomplete lightcurve and single-night data. A pretty dense combined data set obtained in 2019 February-March over the time span of almost one month shows a different value as a solution for synodic rotation period: $P = 5.2956 \pm 0.0002$ h. Given a rather large bimodal lightcurve amplitude (0.55 mag.) at relatively small phase angles and good coverage of the full rotational cycle, this new period result should be considered as a reliable one.



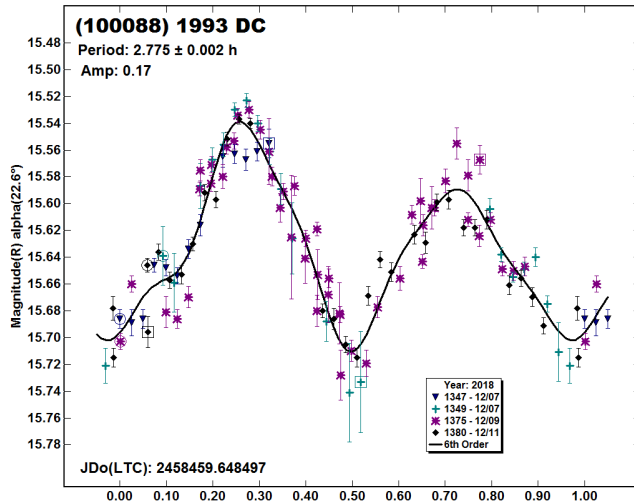
11852 Shoumen. A BinAstPhot Survey target with no previously known rotation period. Data from the two nights in 2019 February led to a period of 6.005 ± 0.004 h, associated with a bimodal lightcurve. An independent analysis of the same combined dataset by Pravec (2019b) finds almost the same value (6.003 h).



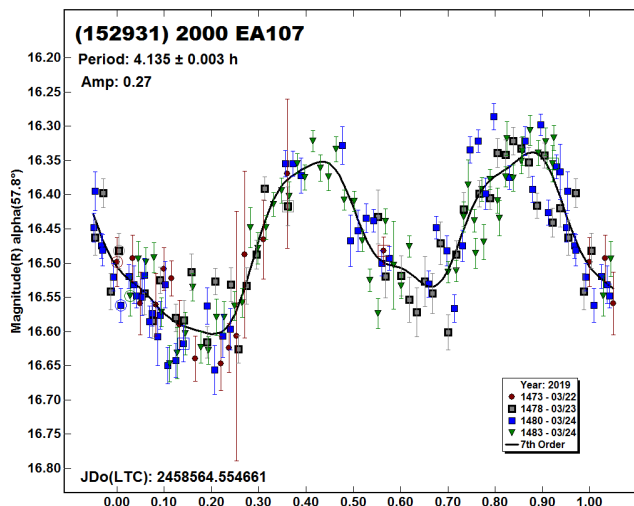
16529 Dangoldin. No previous records of a rotation period for this Mars-crossing asteroid were found. The 2019 February SAO photometric observations conducted on two nights were sufficient to reveal a quite short unique period of 2.8871 ± 0.0006 h.



(100088) 1993 DC. Another Mars-crosser observed in 2019 December on four nights at SAO within the BinAstPhot Survey. Previous period determinations were not found. Similarly, as in the previous case, period analysis found a short rotation period ($P = 2.775 \pm 0.002$ h). An analysis of the same dataset conducted independently by Pravec found a value of 2.7742 h for period (Pravec, 2018).



(152931) 2000 EA107. Polishook (2012) reported the only previously known rotation period value of 4.137 h. This result is assessed as a secure ($U=3$ in the LCDB). Period obtained from the 2019 March SAO data ($P = 4.135 \pm 0.003$ h) fully validates the previous result.



Acknowledgements

Observational work at Sopot Astronomical Observatory is supported by a 2018 Gene Shoemaker NEO Grant from The Planetary Society.

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ASTEROID PHOTOMETRY FROM THE PRESTON GOTT OBSERVATORY

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Asteroid period and amplitude results obtained at the Preston Gott Observatory during 2018 June and in previous years are presented.

During the first week of 2018 June, the author was able to spend several nights using the Preston Gott Observatory of the Texas Tech University to make CCD observations of a number of asteroids. Located about 20 km north of Lubbock, the main instrument is a 0.5-m *f*/6.8 Dall-Kirkam Cassegrain with an SBIG STL-1001E CCD. Also used were several 0.30-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*, in which period analysis was also done. The period search implements the FALC algorithm developed by Harris (Harris et al., 1989). Differential magnitudes were calculated using reference stars from the USNO-A 2.0 and UCAC4 catalogs. Observing circumstances and results are summarized in Table I. The data and curves are presented without additional comment except where circumstances warrant.

1187 Afra. The result presented here is in broad agreement with the results reported by several other observers in the LCDB (Warner et al., 2019)

2384 Schulhof. The result presented here is in broad agreement with the results reported by other observers in the LCDB.

3569 Kumon. Despite four nights of observations, the scatter in the data precluded any reasonable period determination. The result presented here is as a guide for future observations.

12593 Shashlov was observed on only one night. Since the full period was not observed, the result presented here is uncertain.

15438 Joegotobed The data for this asteroid had considerable scatter. Therefore, the result presented here is uncertain.

(18895) 2000 GJ108 This asteroid was observed on only one night while it was in the field of another asteroid that was being observed. Only half of the rotation period was captured. This is based on a half-period of 2.33 h, or full period of 4.66 h. The lightcurve for the half-period is shown here.

(27331) 2000 CE58. The result presented here is in close agreement with that derived by Waszczak et al. (2015).

(33818) 2000 AK97 The result presented here is uncertain due to the scatter in the data.

(76978) 2001 BY60 This asteroid was difficult to analyze due to the scatter in the data, which could not be fit to the result obtained by Warner (2018).

(95260) 2002 CS59 The data for this asteroid proved difficult to analyze. No simple bimodal lightcurve could be found. The result presented here is the best that could be obtained. This asteroid needs more 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 D. Warner for all of his work with the program *MPO Canopus* and for his efforts in maintaining the CALL website.

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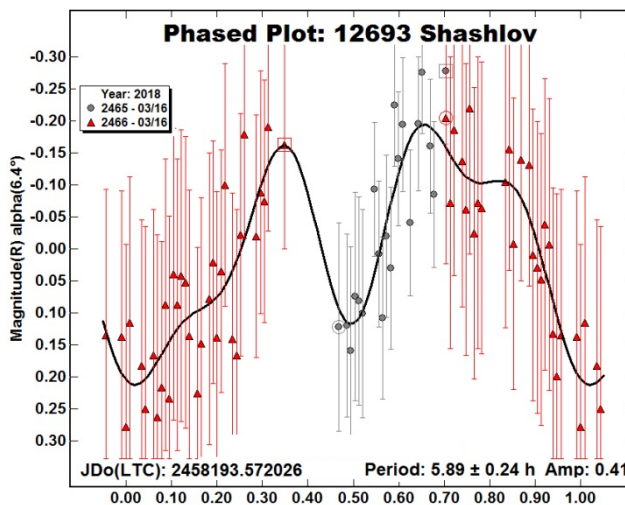
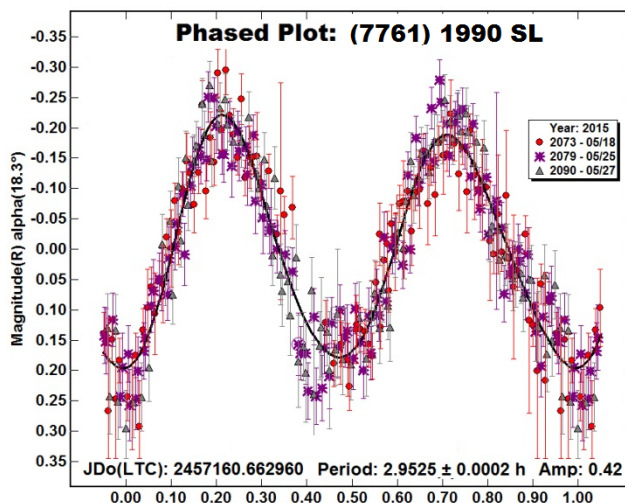
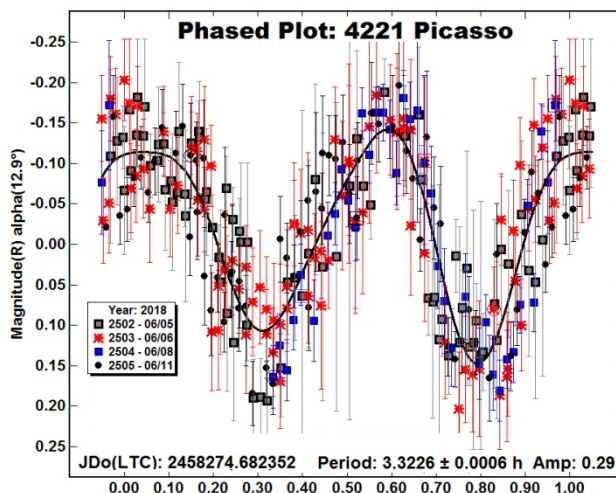
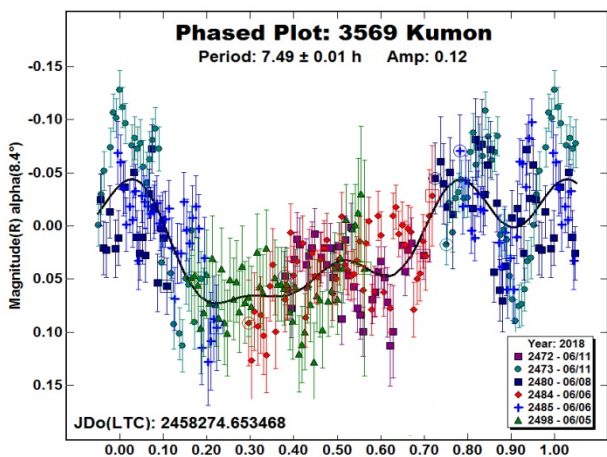
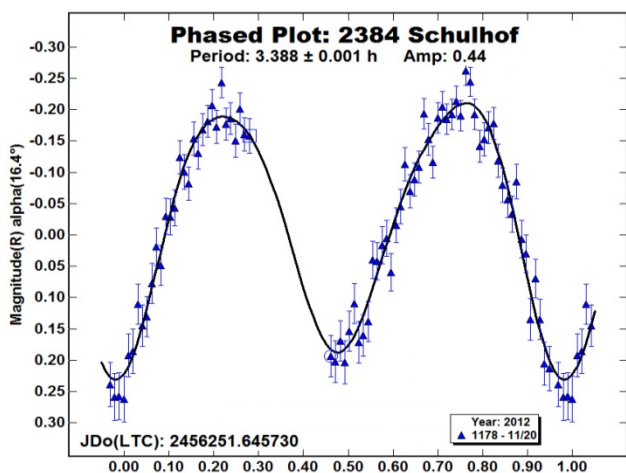
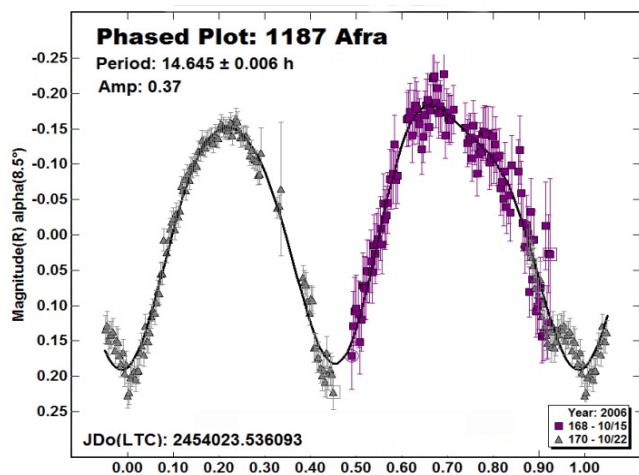
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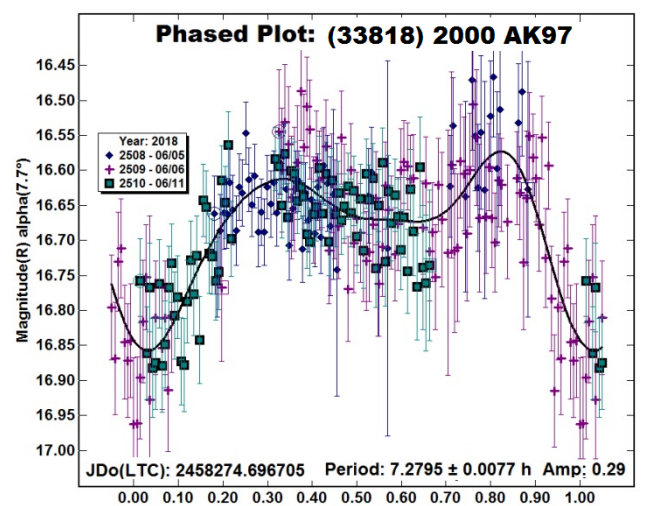
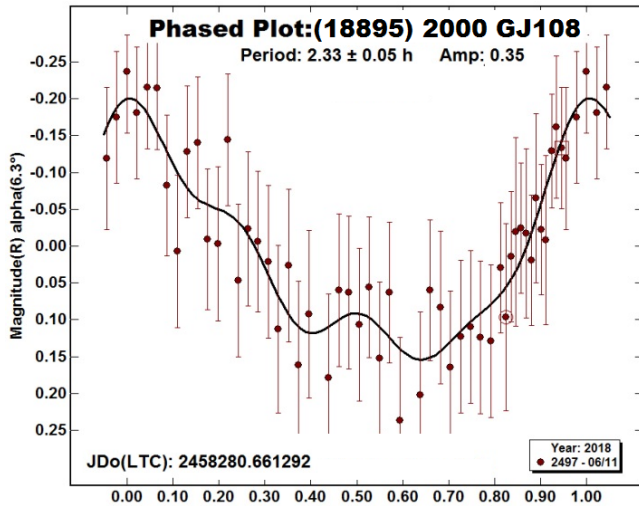
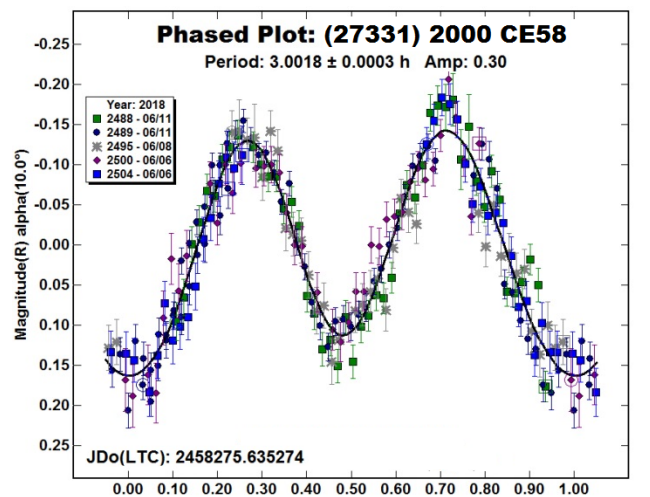
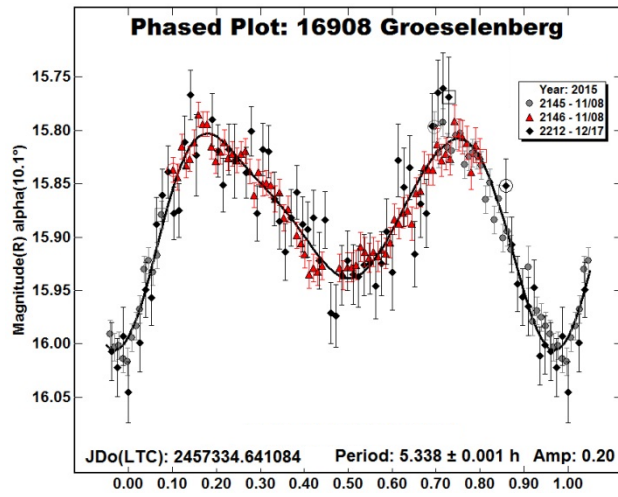
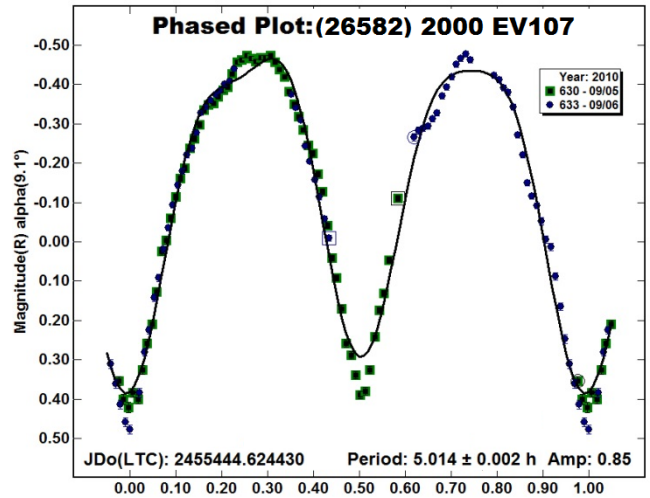
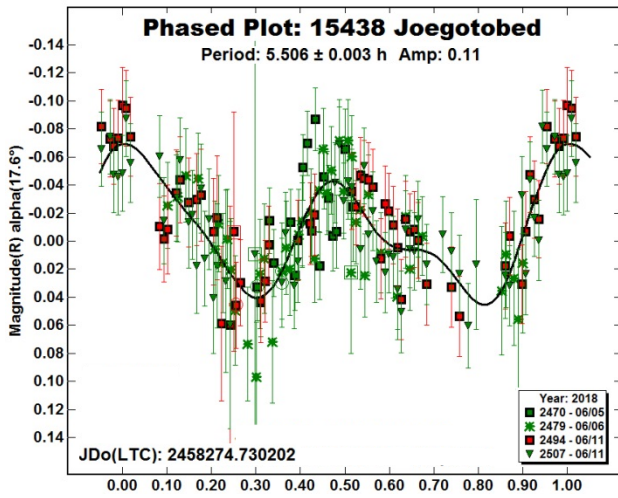
Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1187	Afra	2006 10/15-10/22	*8.5, 8.5	26	13	14.645	0.006	0.37	0.05	MB-M
2384	Schulhof	2012 11/20-11/20	16.3	10	3	3.388	0.001	0.44	0.02	EUN
3569	Kumon	2018 06/05-06/11	7.7, 8.3	252	18	7.49	0.01	0.12	0.05	EUN
4221	Picasso	2018 06/05-06/11	12.8, 14.4	240	20	3.3226	0.0006	0.29	0.05	MB-M
7761	1990 SL	2015 05/18-05/27	18.2, 21.0	213	20	2.9525	0.0002	0.42	0.05	PHO
12593	Shashlov	2018 03/16-03/16	6.3	337	0	5.89	0.24	0.41	0.10	MB-I
15438	Joegotobed	2018 06/05-06/11	17.5, 17.9	244	31	5.506	0.003	0.11	0.05	MB-M
16908	Groeselenberg	2015 11/08-12/17	9.9, 27.1	35	-8	5.338	0.001	0.20	0.05	MB-I
18895	2000 GJ108	2018 06/11-06/11	6.1	254	20	4.66	0.10	0.35	0.10	MB-O
26582	2000 EV107	2010 09/05-09/06	9.1, 8.9	348	14	5.014	0.002	0.85	0.02	MB-I
27331	2000 CE58	2018 06/06-06/11	9.4, 9.9	252	17	3.0018	0.0003	0.30	0.05	EUN
33818	2000 AK97	2018 06/05-06/11	12.7, 11.6	254	19	7.2795	0.0077	0.29	0.10	MB-O
44266	1998 QV55	2012 01/18-01/29	7.6, 2.0	130	3	5.3754	0.0005	0.29	0.05	MB-I
50149	2000 AU136	2018 06/05-06/11	8.7, 9.4	252	17	9.3677	0.0025	0.62	0.10	EUN
76978	2001 BY60	2018 06/05-06/11	36., 35.7	266	42	10.08	0.02	0.09	0.05	MC
95260	2002 CS59	2018 06/06-06/11	8.0, 8.6	252	18	4.5184	0.0014	0.44	0.10	MB-O

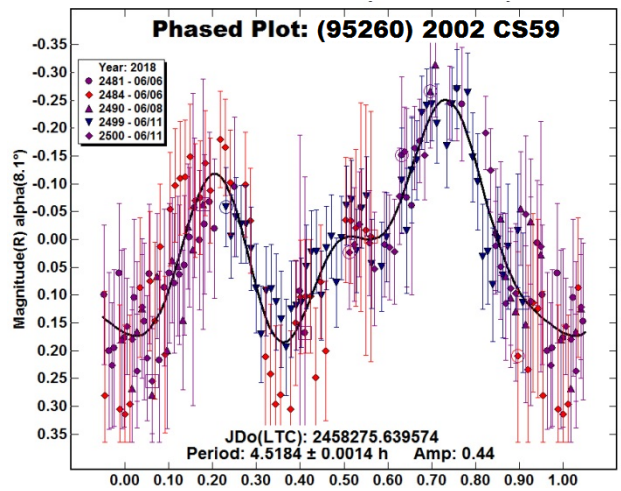
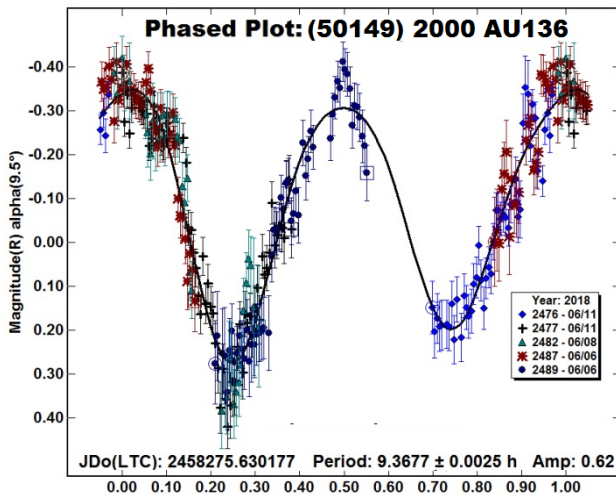
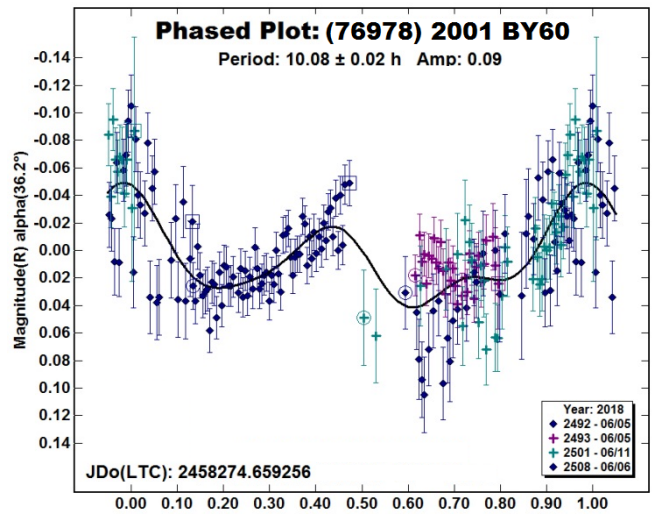
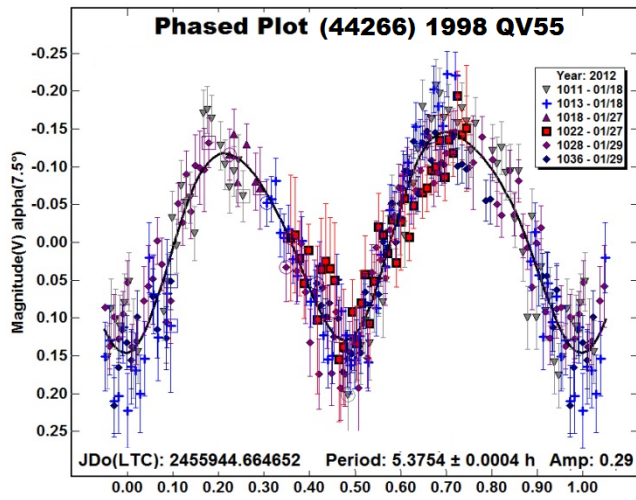
Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached a maximum or minimum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). Grp is the orbital group based on Warner et al. (2009).

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LIGHTCURVES FOR 224 OCEANA, 359 GEORGIA, 1453 FENNIA AND 1717 ARLON

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Iota Scorpis Observatory (K78), La Spezia, ITALY

Gianni Galli
GiaGa Observatory (203), Pogliano Milanese, ITALY

Paolo Bacci, Martina Maestripieri
San Marcello Pistoiese (104), Pistoia, ITALY

Adriano Valvasori, Catia Caselli, Pierluigi Punzo
AAB Felsina Observatory (L19), Montepastore, ITALY

Nico Montigiani, Massimiliano Mannucci
Margherita Hack Observatory (A57), Florence, ITALY

Mauro Bachini, Giacomo Succi
Santa Maria a Monte (A29), ITALY

Roberto Bacci
G. Pascoli Observatory (K63), Castelvecchio Pascoli, ITALY

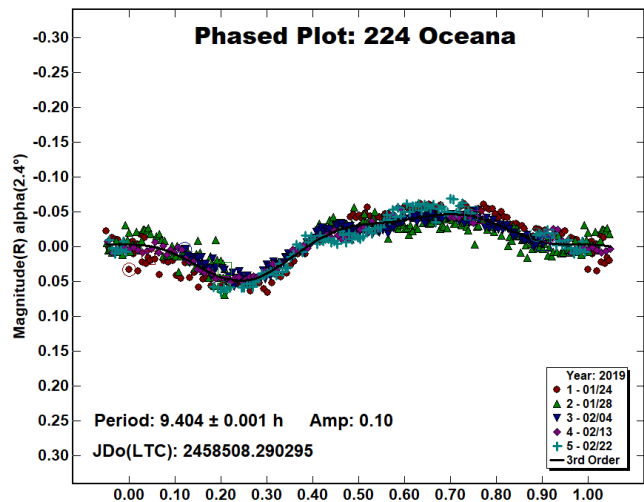
(Received: 2019 April 14)

Photometric observations of four main-belt asteroids were made in order to acquire lightcurves for shape/spin axis models. The synodic period and lightcurve amplitude were found for: 224 Oceana: 9.404 ± 0.001 h, 0.10 mag; 359 Georgia: 5.5329 ± 0.0001 h, 0.14 mag.; 1453 Fennia: 4.4120 ± 0.0002 h, 0.14 mag.; and 1717 Arlon: 5.1448 ± 0.0004 h, 0.10 mag. We also confirmed previous discoveries of a satellite for 1453 Fennia and 1717 Arlon.

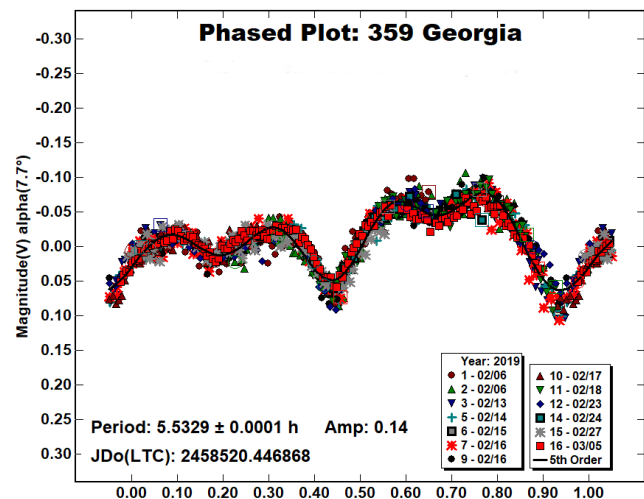
Collaborative observations of four asteroids were made inside the UAI (Italian Amateur Astronomers Union) group. The targets were selected from the Shape/Spin Modeling Opportunities list in a recent issue of the *Minor Planet Bulletin*. The CCD observations were made in 2019 January-March using the instrumentation 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 CMC15 catalogue, distributed with *MPO Canopus*. Table II shows the observing circumstances and results.

224 Oceana is an M-type middle main-belt asteroid discovered on 1882 March 30 by J. Palisa at Vienna. Collaborative observations were made over five nights. We found a synodic period of $P = 9.404 \pm 0.001$ h with an amplitude $A = 0.10 \pm 0.02$

mag. The period is close to the previously published results in the asteroid lightcurve database (LCDB; Warner et al., 2009).

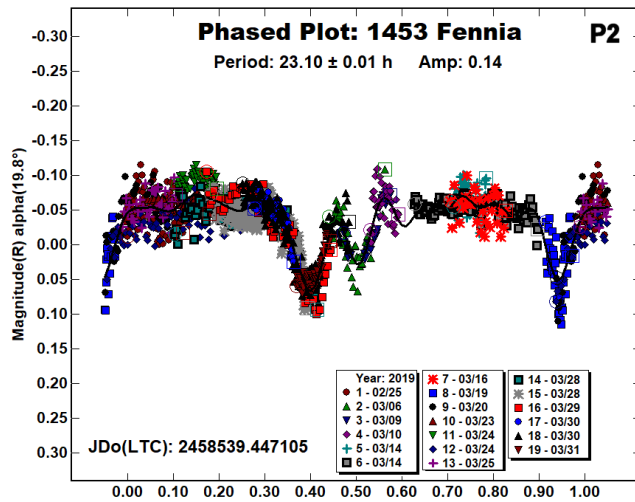
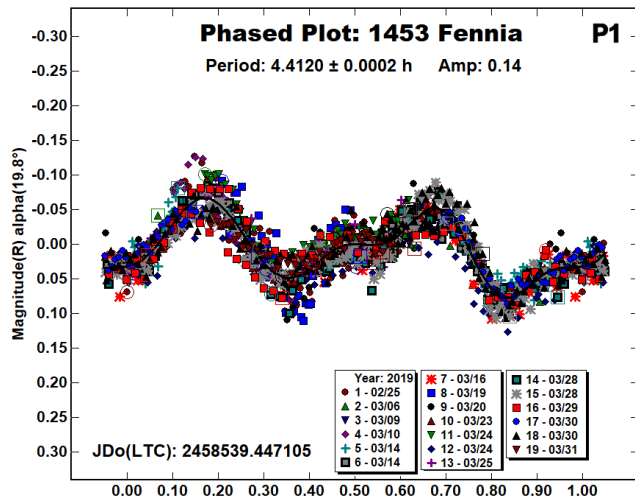
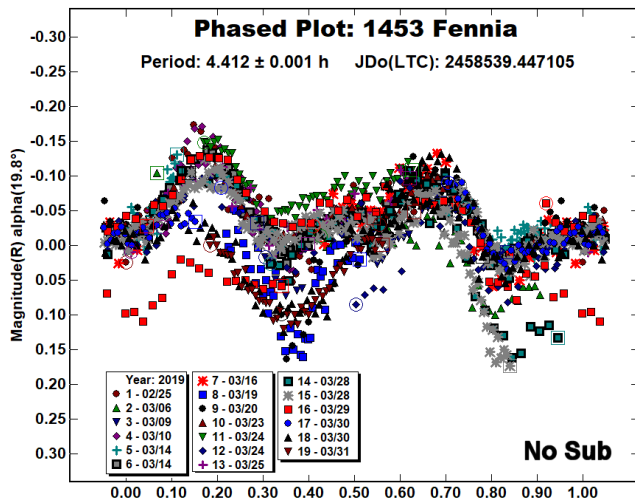


359 Georgia is an S-type inner main-belt asteroid, discovered on 1893 March 10 by A. Charlois at Nice. Collaborative observations were made over eleven nights. We found a synodic period of $P = 5.5329 \pm 0.0001$ h with an amplitude $A = 0.14 \pm 0.03$ mag. The period is close to the previously published results in the asteroid lightcurve database (LCDB; Warner et al., 2009).

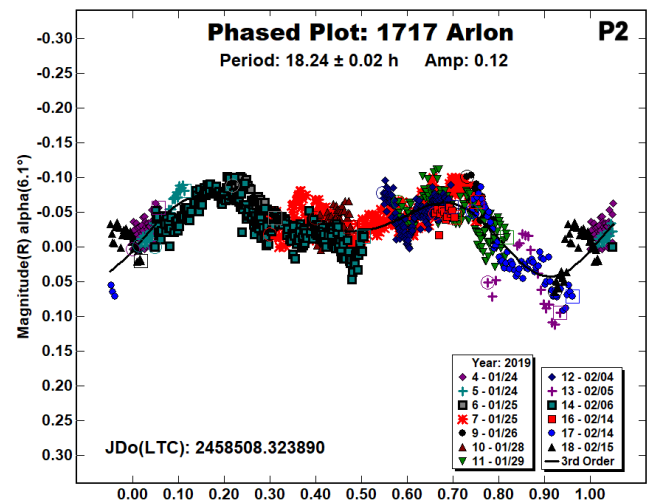
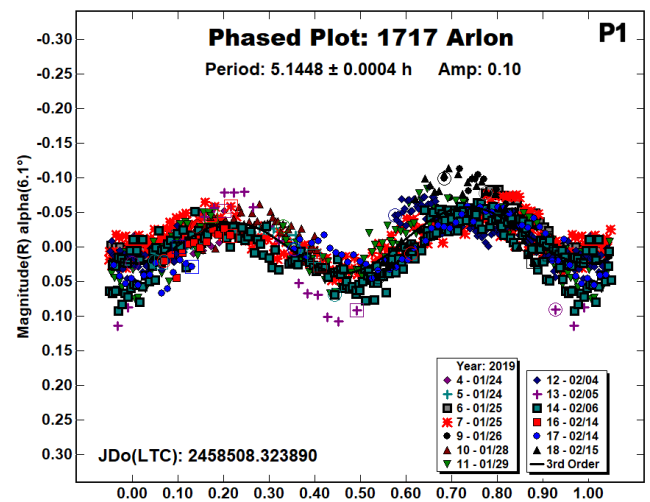
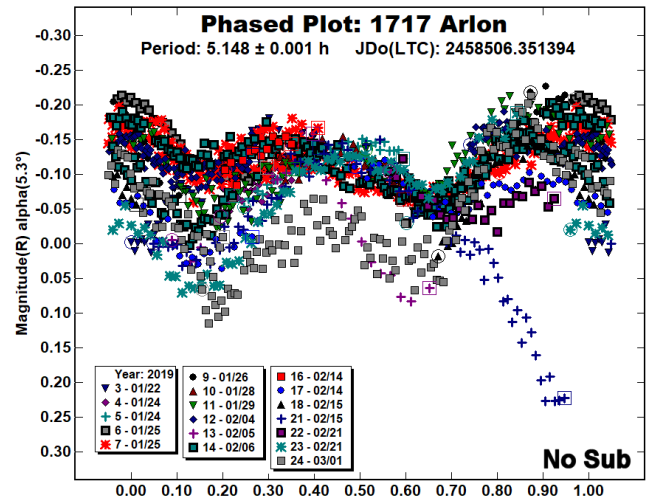


1453 Fennia is an S-type asteroid, and member of the Hungaria *group*; only objects in the region with a taxonomic type E are likely *family* members. It was discovered on 1920 March 10 by Reinmuth, K. at Heidelberg. The binary nature of this asteroid was discovered by B.D. Warner in 2007 (Warner et al., 2007).

Collaborative observations were made over thirteen nights in 2019. The analysis was done using the dual period search function implemented in *MPO Canopus*. We found a primary synodic rotational period of $P_1 = 4.4120 \pm 0.0002$ h with an amplitude $A_1 = 0.14 \pm 0.04$ mag. The orbital period was $P_2 = 23.10 \pm 0.01$ h with an amplitude $A_2 = 0.14 \pm 0.04$ mag. Those periods are consistent with the previously published results in the asteroid lightcurve database (LCDB; Warner et al., 2009).



excluded. Without them, we found the synodic rotational periods of the two components: $P_1 = 5.1448 \pm 0.0004$ h, $A_1 = 0.10 \pm 0.04$ mag and $P_2 = 18.24 \pm 0.02$ h, $A_2 = 0.12 \pm 0.04$ mag. These periods are consistent with previously published results in the LCDB (Warner et al., 2009). The “No Sub” plot shows *all* sessions phased to near the value for P_1 .



1717 Arlon is an S-type inner main-belt asteroid discovered on 1954 January 08 by Arend, S. at Uccle. This asteroid is a binary system as reported by Cooney et al. (2006a; 2006b) and Brinsfield (2009). Collaborative observations were made over thirteen nights in 2019.

The analysis was done using the dual period search function implemented in *MPO Canopus*. The five sessions with the deep attenuations made analysis difficult because they did not have sufficient data to find the orbital period and so they were

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Warner, B.D., Harris, A.W., Pravec, P. (2009). "The asteroid lightcurve database." *Icarus* **202**, 134-146. Updated 2019 January 31. <http://www.minorplanet.info/lightcurvedatabase.html>

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Observatory (MPC code)	Telescope	CCD	Filter	Observed Asteroids
Università Siena (K54)	0.30-m MCT f/5.6	SBIG STL-6303E (bin 2x2)	Rc	224, 359, 1453
Filzi School	0.35-m RCT f/8	QHY9 (KAF8300)	Rc	359, 1453, 1717
M57 (K38)	0.30-m RCT f/5.5	SBIG STT-1603	C	359, 1453, 1717
Iota Scorpii (K78)	0.40-m RCT f/8	SBIG STXL-6303E (bin 2x2)	Rc	224, 359, 1453, 1717
GiaGa Obs. (203)	0.36-m SCT f/5.8	Moravian G2-3200	C	1453, 1717
GAMP (104)	0.60-m NRT f/4	Apogee Alta	C	359, 1453
AAB (L19)	0.40-m NRT f/5	Atik KAI 04022	Rc	359
AAB (L19)	0.30-m SCT f/5.6	KAF1603ME	Rc	1453, 1717
Margherita Hack (A57)	0.35-m SCT f/8.3	SBIG ST10XME (bin 2x2)	C	359, 1453
Santa Maria a Monte (A29)	0.40-m NRT f/5	DTA Discovery plus KAF 260	Rc	359, 1717
G.Pascoli (K63)	0.40-m NRT f/3.2	QHY22 C 1318	C	1453, 1717

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

Number	Name	2019 mm/dd	Pts	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.
224	Oceana	01/24-02/22	710	2.4, 11.8	124	5	9.404	0.001	0.10	0.02
359	Georgia	02/06-03/05	1100	7.6, 1.5, 2.9	157	4	5.5329	0.0001	0.14	0.03
1453	Fennia	02/25-03/31	1311	19.7, 0.2, 2.2	187	4	4.4120	0.0002	0.14	0.04
1717	Arlon	01/22-03/01	1386	5.0, 22.5	119	5	5.1448	0.0004	0.10	0.04

Table II. 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).

LIGHTCURVE ANALYSIS OF 9 ASTEROIDS FROM RMS OBSERVATORY

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(Received: 2019 April 15)

CCD images of 9 asteroids were taken from 2018 August 5 to 2019 January 31 for the purpose of determining their synodic rotation periods. The asteroids were: 2678 Aavasaksa, 2727 Paton, 3769 Arthurmiller, 5703 Hevelius, 6801 Strekov, 7954 Kitao, 16198 Buzios, (17109) 1999JF52, and (26377) 1999FH4.

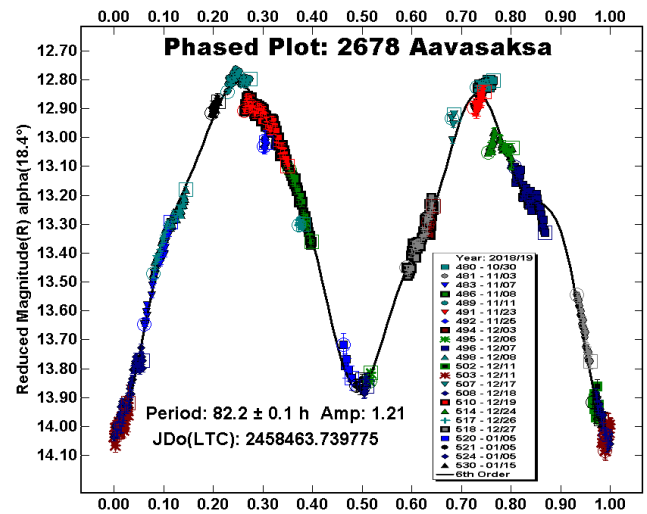
CCD photometric observations of 8 asteroids were made from the RMS Observatory (W25) from 2018 August 5 to 2019 January 31. Observations were taken with a 0.35-m SCT operating at f/11 using an SBIG STL-1001E CCD (unfiltered) binned at 1x1 with an image scale of 1.27 arcseconds per pixel. Exposure times were 300s. Note: this camera is a new addition.

The images were calibrated (bias, dark, and flat) and 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 were 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.

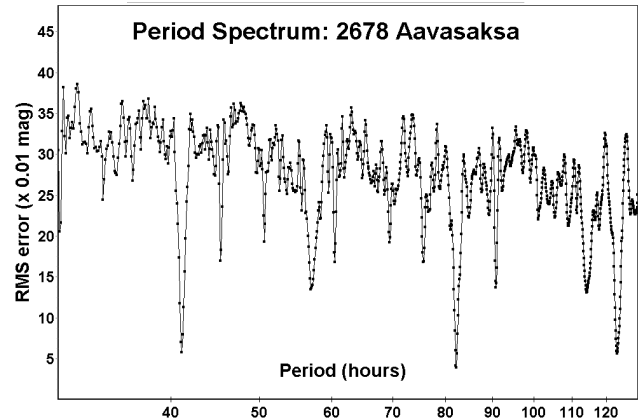
Table I lists the observing circumstances and the analysis results.

2678 Aavasaksa Previous work by Brinsfield (2009) indicated a period >24 h based on sparse data. During the 2018 apparition Zeigler *et al.* (2019) indicated a period of 124 h however those observations were based on 5 nights with no observations of a minimum and the data were fit to a simple sine curve.

These observations are based on a more complete set covering 20 nights over 2.5 months. The data indicate a period of 82.2 h with amplitude 1.21 mag using a 6th order fit. The coverage is fairly complete and a good fit.

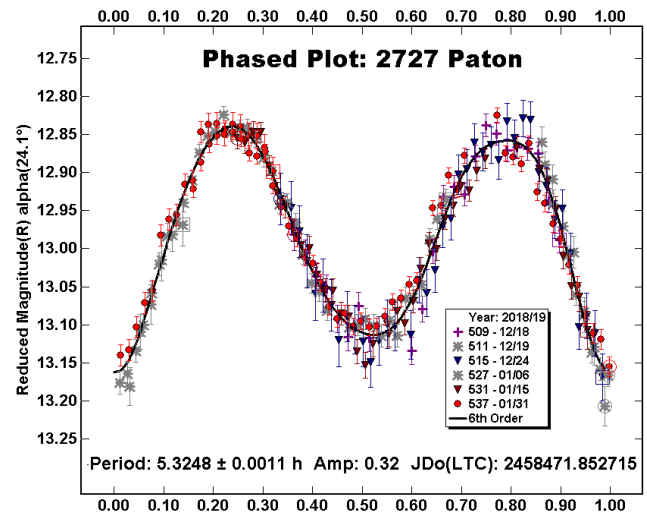


The period spectrum shows the 124 h period previously found, however it creates a trimodal solution. The period near 40 h creates a monomodal solution.

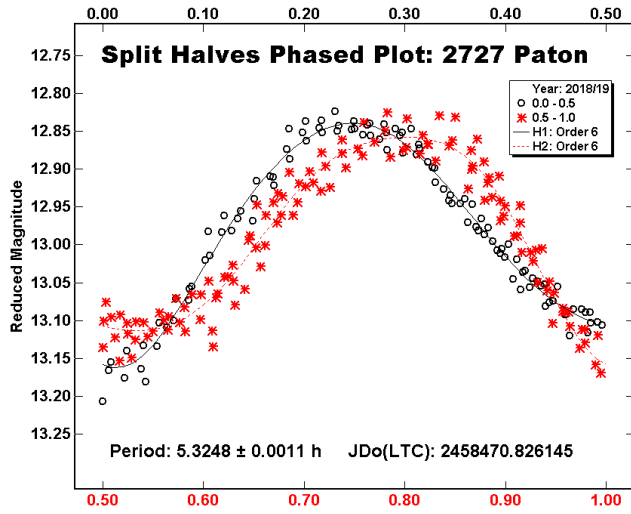


2727 Paton A search of the LCDB (Warner *et al.*, 2009) indicated no previous work on this asteroid.

Observations over 6 nights show a well-defined period of about 5.32 h, with amplitude 0.32 mag.

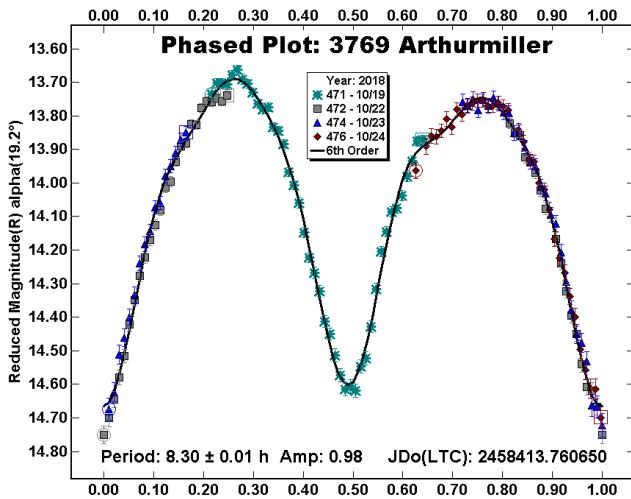


Despite the symmetric appearance, a split halves plot shows asymmetry, indicating this is the correct period.

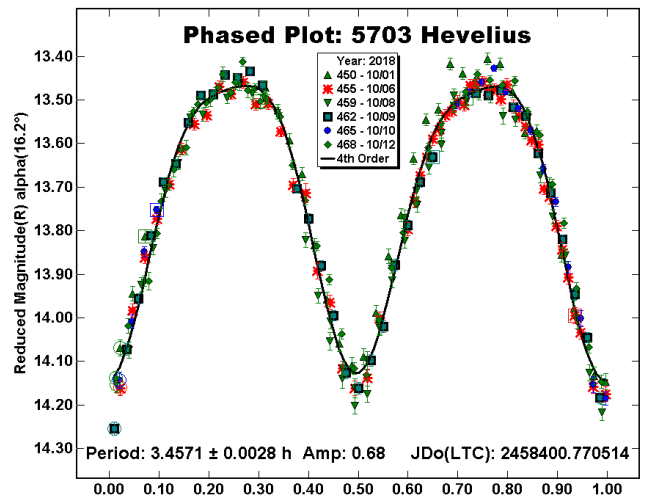


3769 Arthurmilller Previous work by Zeigler *et al.*, (2019) gives a period of 8.21 h, amplitude 0.81 mag and Marchini *et al.*, (2019) gives a period of 8.297 h, amplitude 0.78 mag.

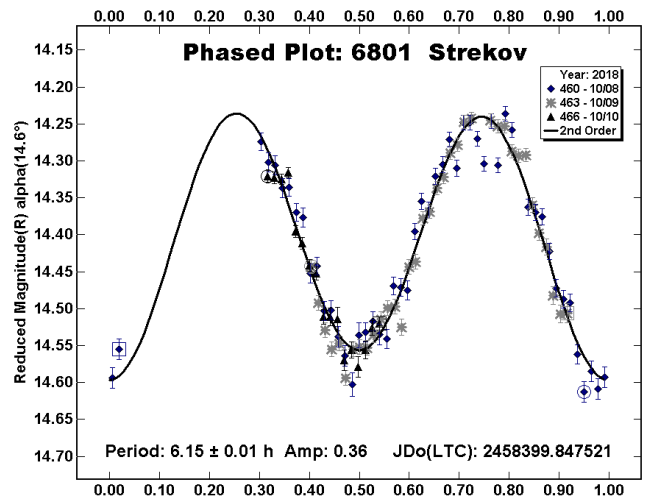
These observations are in good agreement, with slightly larger amplitude of 0.98 mag.



5703 Hevelius Previous work by Brincat (2018 web) indicated a period of 3.4576 h, amplitude 0.63 mag. Stone (2018 web) found a period of 3.4566 h, with amplitude 0.59 mag. These observations are in good agreement. A phased plot is also provided.



6801 Strekov This object was a target of opportunity, being in the same field of view with 5703 Hevelius on 2018-10-8, 9, and 10. Previous work by Carbo (2009) gives a period of 6.173 h, amplitude 0.17 mag. These observations are in agreement, despite incomplete coverage. The larger amplitude for these data is probably due to the larger phase angle (14 deg.) in 2018 vs (6 deg.) in 2008.



7954 Kitao was the first asteroid observed with the “new” SBIG STL-1001E camera. A search of the LCDB gave no previous work. The asteroid is a member of the Eunomia family and was observed for 2 months at galactic latitude of -14 deg., which resulted in several images being dropped from the analysis due to contamination from the numerous background stars. Also, nightly zero point shifts were applied, the largest being 0.1 mag. These

Number	Name	20xx mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2678	Aavasaksa	18/10/30-19/1/15	710	18.6,21.1	73	1	82.2	0.1	1.21	0.04	FLOR
2727	Paton	18/12/18-19/1/31	232	24.1,13.7	155	-4	5.3248	0.0011	0.32	0.02	MB
3769	Arthurmilller	18/10/19-18/10/24	163	19.3,17.3	59	-1	8.30	0.01	0.98	0.03	FLOR
5703	Hevelius	18/10/1-18/10/12	238	16.3,11.2	37	-2	3.4571	0.0028	0.68	0.03	EUN
6801	Strekov	18/10/8-18/10/10	104	14.7,13.6	36	-2	6.15	0.01	0.36	0.02	FLOR
7954	Kitao	18/8/5-18/10/1	368	10.7,25.8	309	12	129.5	0.1	0.78	0.06	EUN
16198	Buzios	18/9/22-18/10/12	801	12.0,19.5	341	6	103.6	0.1	1.06	0.06	EUN
(17109)	1999 JF52	18/8/13-18/9/5	206	8.8,17.5	306	8	3.1874	0.0008	0.32	0.03	GEF
(26377)	1999 FH4	18/10/18-18/10/25	202	17.3,19.8	355	-6	6.78	0.01	0.53	0.03	MB

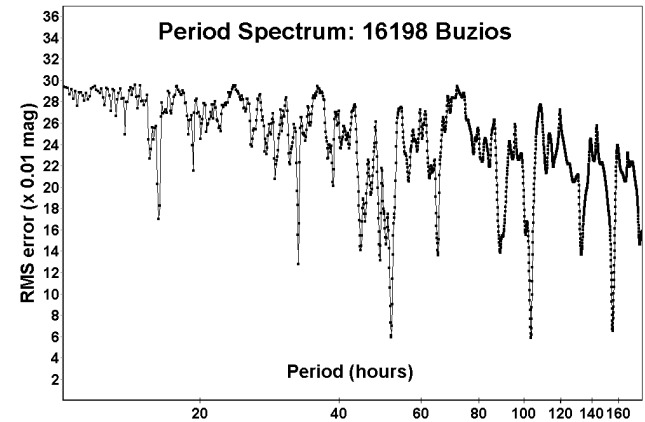
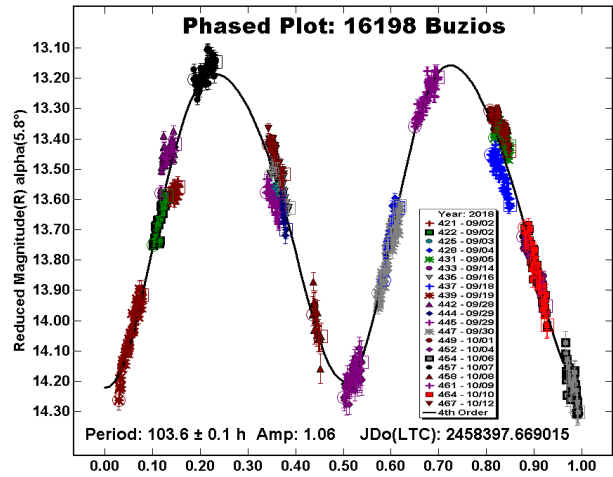
Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.* 1984). Grp is the asteroid family/group. The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

shifts were probably mostly due to interstellar reddening of comparison stars near the galactic plane.

Analysis indicates this is another slow rotator of about 130 h with a fairly large amplitude of 0.78 mag.

This asteroid has the largest tumbling damping time of all the ones reported in this paper ~ 1.8 Gyr (Pravec *et al.*, 2014). The Eunomia family is a collisional family with an estimated age of ~ 2.67 Gyr (Carruba *et al.*, 2016) which puts the asteroids damping time less than the age of the family. This would indicate any tumbling motion would have sufficient time to dampen since the formation of the family. However the assumptions made in the formulas used to estimate the damping time are still subject to refinement. With the damping time and age estimates being “relatively” close the author suggests it is possible this is a tumbler. This may be reflected at several places in the lightcurve where the nightly data do not match the shape of the Fourier curve (near phases 0.2, 0.45, and 0.85).

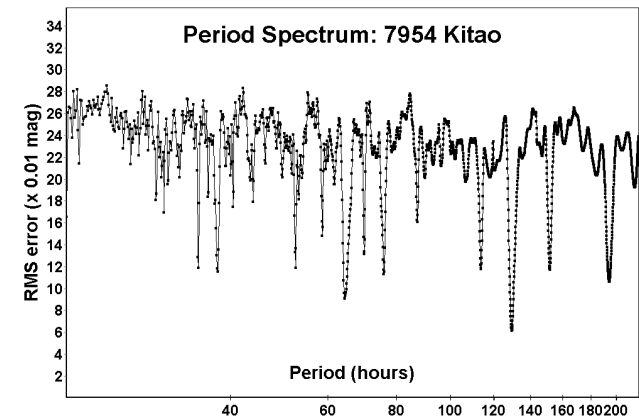
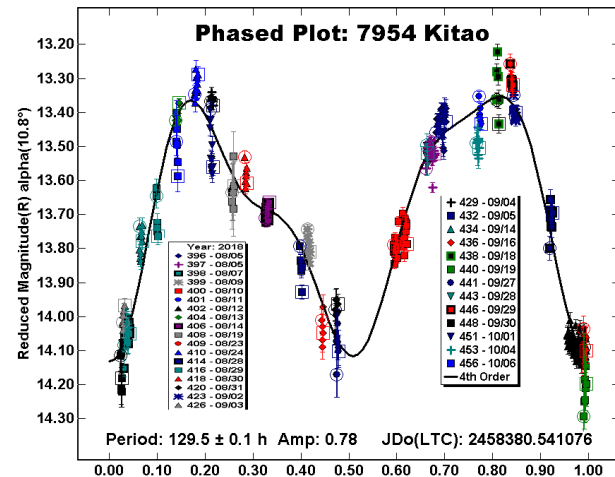
Further observations could help resolve the tumbling status. The next favorable opposition will be in mid-June 2022 where it will be at mag 16.3 and further away from the galactic plane at latitude +18 deg. Unfortunately there is a full moon on 2022-6-14.



The 103.6 h period is the only bimodal solution.

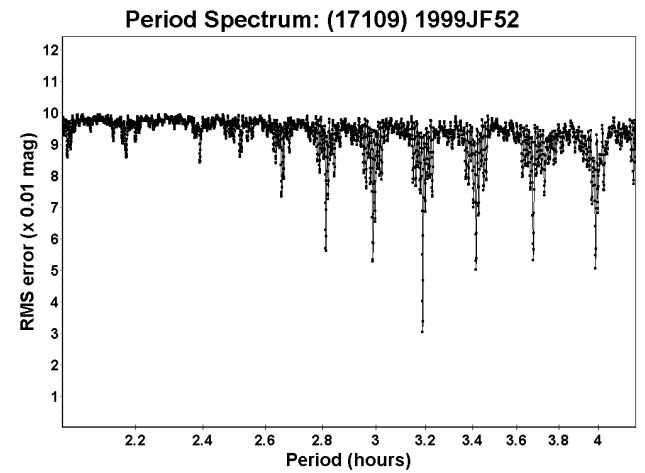
(17109) 1999JF52 This main belt asteroid is a member of the Gefion family. This family is subject to long term orbital dynamics from various resonances in addition to close encounters with Ceres (Nesvorný *et al.*, 2015). This family has also been proposed to be the possible the source for L chondrites; however this is still a subject of debate (McGraw *et al.*, 2018)

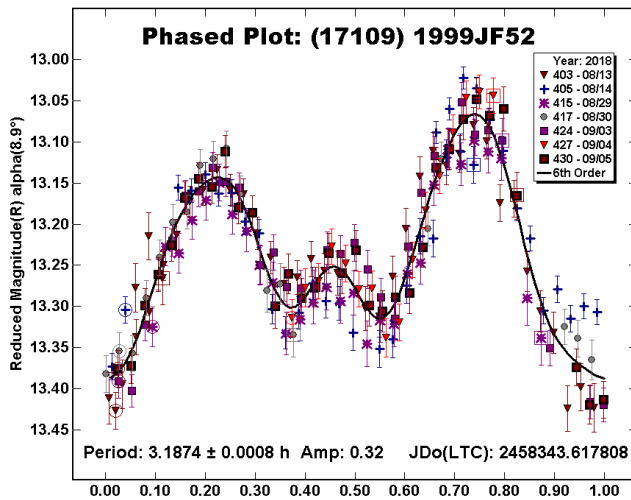
A search of the LCDB shows no previous work. The period spectrum indicates a strong solution near 3.2 h, and gives a trimodal solution.



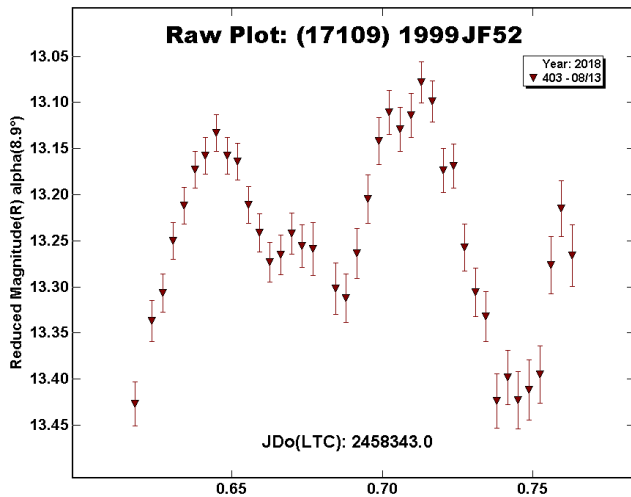
16198 Buzios This Eunomia family member was at a favorable opposition in 2018. A search of the LCDB gave no prior work.

Observations over 1.5 months indicate a slow rotation of 103.6 h with a large amplitude of about 1 mag.

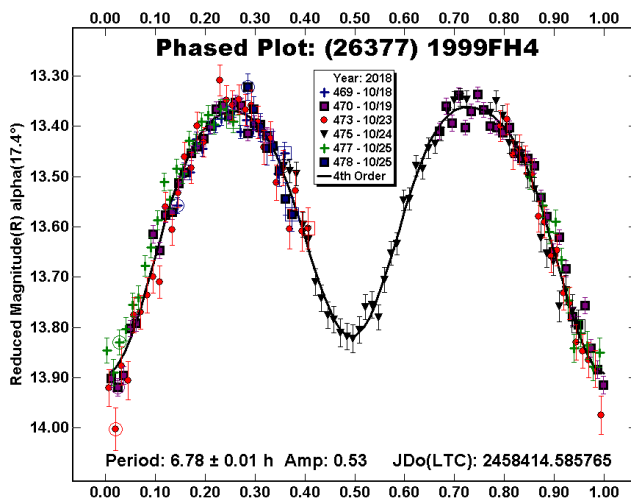




The trimodal lightcurve is seen in several of the nightly raw plots that cover a complete cycle.



(26377) 1999FH4 This main belt asteroid showed no previous work in the LCDB. A 4th order phased plot shows an asymmetric bimodal lightcurve with a period of 6.78 h. and amplitude of 0.53 mag.



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ROTATION PERIOD DETERMINATION FOR 3157 NOVIKOV - ADDENDUM

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(Received: 2019 April 15)

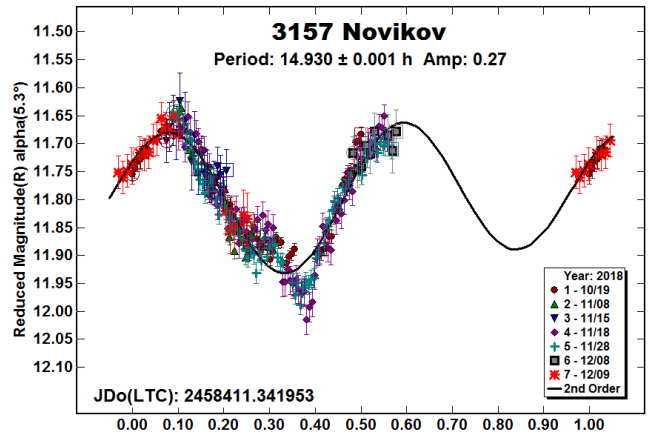
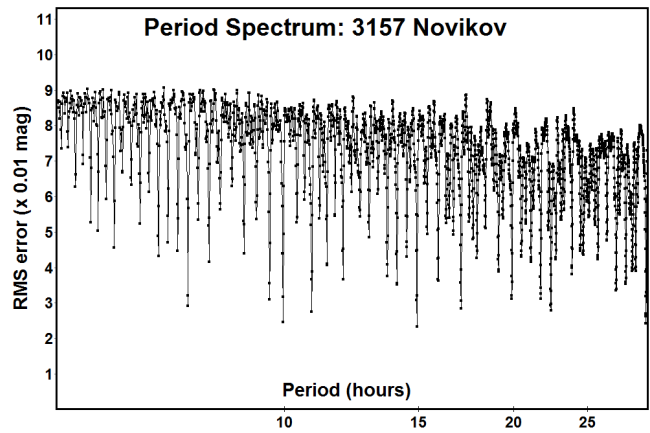
New analysis of data we obtained for 3157 Novikov leads to a revised synodic period of 14.930 ± 0.001 h and lightcurve amplitude of 0.27 ± 0.03 mag.

In a previous paper (Marchini et al., 2019), we presented our work on the asteroid 3157 Novikov. From the analysis of our data, we concluded the most likely synodic period was $P = 9.952 \pm 0.001$ h.

After the publication of the paper, Brian Warner (private communication) noted that the large gaps in days between sessions and overall range of almost seven weeks allowed for a large number of alias periods, i.e., those differing by an integral number of half or full rotations over the total period. Furthermore, the data were obtained at a relatively small phase angle and the amplitude was 0.31 mag. This combination should likely result in a somewhat symmetrical bimodal lightcurve (Harris et al., 2014) whereas the shape of our result was an asymmetrical lightcurve with the two maxima at 0.8 rotation phase apart.

We analyzed our data set again with a result of finding a more symmetric bimodal lightcurve with $P = 14.930 \pm 0.001$ and peak-to-peak amplitude of 0.27 ± 0.03 mag. It's worth noting that the new period is almost exactly 1.5x our original result. This adds to the possibility that a *rotational alias* (miscalculation of the number of rotations) affected our previous analysis. Observing circumstances and the new result for 3157 Novikov are shown in Table I.

Unfortunately, we did not have enough observations to cover the entire lightcurve, which leaves a clearly visible gap. Observations in the future will be gladly welcomed to help better define the lightcurve and refine the synodic period.



Acknowledgments

We thank Brian Warner for his suggestions and help that allowed us to get closer to what we believe to be the actual period.

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Number	Name	2018/mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.
3157	Novikov	10/20-12/09	308	4.9, 14.5	39	0	14.930	0.001	0.27	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. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984).

NEW PHOTOMETRY OF THE HUNGARIA ASTEROID 1600 VYSSOTSKY IN THE 2019 APPARITION

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A systematic photometric monitoring of the Hungaria asteroid 1600 Vyssotsky was carried out from the three observatories in Europe and North America in 2019 February - April. Although early data hinted at the possibility of the existence of a satellite, further systematic observations ruled out such a possibility.

The minor planet 1600 Vyssotsky was discovered on 1947 October 22 by C. A. Wirtanen at Lick Observatory. By its orbital characteristics, 1600 Vyssotsky belongs to the Hungaria orbital group. More interestingly, as a rare A-type asteroid it is also a suspected interloper among Hungaria asteroids with their typical E-type spectra (Warner et al., 2009a).

Numerous synodic rotation period determinations from several different apparitions with rather consistent results were known prior to this work (e. g. Warner 1999, 3.2 h; Behrend 2005, 3.20144; Warner 2006, 3.2011 h; Higgins 2008, 3.20116 h; Warner 2008, 3.201264 h (sidereal period); Warner 2014, 3.205 h; Stephens 2016, 3.206 h, Stephens 2019, 3.199 h. For more period determinations search for 1600 Vyssotsky at <http://www.minorplanet.info/PHP/OneAsteroidInfo.php> (Warner, 2019)). Due to its favorable brightness ($V \sim 15.0$) Benishek nevertheless decided to follow it up over the rare clear nights around the full Moon in 2019 February. The first photometric observations were started on 2019 February 19 at Sopot Astronomical Observatory (SAO) using a 0.35-m Schmidt-Cassegrain telescope (SCT) and a SBIG ST-10XME CCD. Comparing the rotational lightcurves obtained on the first two consecutive observing nights, phased to a period of 3.2 hours (February 19-20 and February 20-21 UT) an apparent misfit of their profiles was noticed. A tentative decomposition of that early data using the Dual Period Search (DPS) procedure in MPO Canopus software (Warner, 2017) indicated a possible presence of a mutual event attenuation (~ 0.05 mag. deep) characteristic for the existence of a satellite. Confidence in such a possibility was additionally strengthened through the fact that the longitude of the phase angle bisector (L_{PAB}) at the very beginning of observations was 172 degrees, or 25 degrees away from the closest value in previous apparitions when other photometric observations were carried out and no mutual events were detected. Such a difference in L_{PAB} allowed for the possibility that a binary asteroid system could get into eclipse geometry (Brian Warner, private communication).

Given these facts, it was decided to extend an invitation for collaboration to observers from significantly different geographic longitudes in order to make data gathering as effective as possible. Frederick Pilcher of Organ Mesa Observatory, New Mexico, USA and Donald Pray of Sugarloaf Mountain Observatory, Massachusetts, USA kindly agreed to participate in the observing campaign. Frederick Pilcher employed a 0.35-m SCT with a SBIG STL-1001E CCD camera and Donald Pray used a 0.5-m Newtonian reflector equipped with a SBIG ST-10XME CCD camera. The first series of observations from the three observatories were conducted up to 2019 March 8. By that time, a total of 10 independent data sets (*sessions*) were collected, of which 2 were contributed by Pray, 2 by Pilcher and 6 by Benishek.

Photometric reductions by all the authors, as well as data sharing and period analysis, were done using MPO Canopus software (Warner, 2017). In all cases up to five field comparison stars of near-solar color ($0.5 \leq B-V \leq 0.9$) were used and calibrated with the R-band magnitudes (R) derived from the Carlsberg Meridian Catalog 15 (VizieR, 2019) Sloan r' magnitudes (r') applying the formula: $R=r'-0.22$.

With the exception of the data obtained on the first night (2019 February 19-20), the rest of the data do not show any deviations that could indicate a possible presence of a secondary rotational period and/or an orbital periodic component. The assumption of the observed attenuation as a result of the possible existence of a satellite has become very likely implausible as no evidence of similar deviations was found from the additional data covering a fairly long time span.

Furthermore, the second series of lightcurves obtained at SAO by Benishek from 2019 April 18 through April 22 over additional four nights has not yielded any sign of attenuation dips. This series of observations was undertaken in the conditions of the changed viewing geometry in relation to the first series obtained by 2019 March 08, so that the resulting rotational lightcurve shows a rather altered shape. Consequently, this group of data was treated separately in the period analysis.

Excluding completely the 2019 February 19-20 data set from the period analysis, two completely identical values of the synodic rotation period (P) were derived from the two independent data groups: $P = 3.20145 \pm 0.00007$ h (2019 February 19 - 2019 March 08 data) and $P = 3.2014 \pm 0.0006$ h (2019 April 18 - 2019 April 22 data).

Accordingly, it can be concluded that our photometric data on 1600 Vyssotsky obtained during 2019 apparition strictly point to a unique rotation period of 3.2014 h without clear indication of secondary periodic component.

The fact that the observations were started just at the time of the full Moon when the asteroid was at a rather small angular distance from the Moon of about 45 degrees, could explain a deviation seen in the data set of 2019 February 19-20, although a possibility of some other causes of instrumental nature should not be rejected.

Acknowledgements

Observational work at Sopot Astronomical Observatory is supported by a 2018 Gene Shoemaker NEO Grant from The Planetary Society. Operations at Sugarloaf Mt. Observatory are supported by Gene Shoemaker NEO Grants from The Planetary Society.

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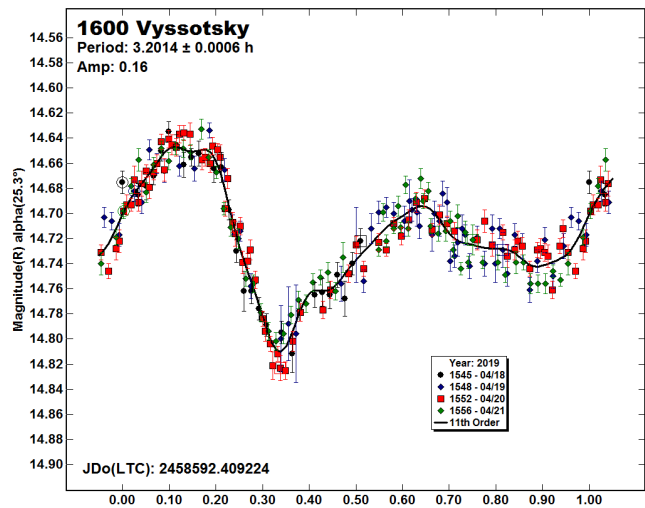
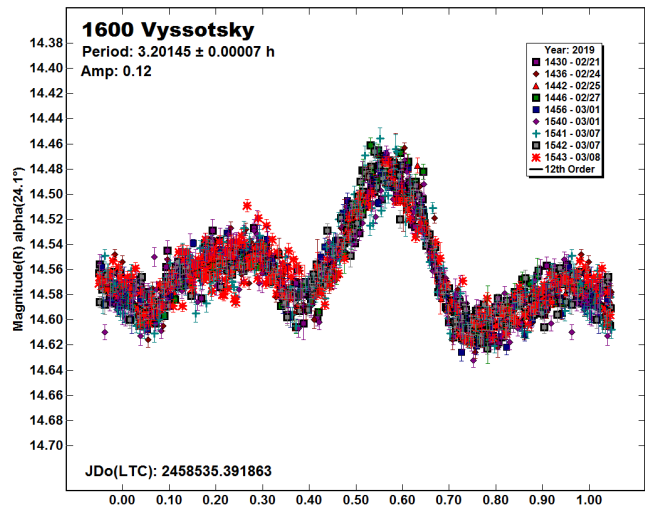
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Number	Name	2019/mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
1600	Vyssotsky	02/20-03/08	1340	24.1,21.4	173	31	3.20145	0.00007	0.12	0.02	HUN
1600	Vyssotsky	04/18-04/22	225	25.2,26.0	178	24	3.2014	0.0006	0.16	0.02	HUN

Table I. 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. L_{PAB} and B_{PAB} are the average phase angle bisector longitude and latitude. Grp is the asteroid family/group (Warner et al., 2009b): HUN = Hungaria

**ROTATION PERIOD DETERMINATIONS FOR
58 CONCORDIA, 384 BURDIGALA, 464 MEGAIRA,
488 KREUSA, AND 491 CARINA**

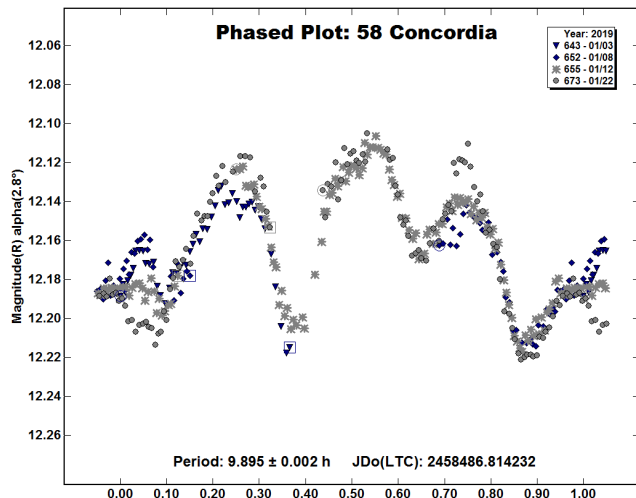
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Synodic rotation periods and amplitudes are found for 58 Concordia 9.895 ± 0.002 hours, 0.10 ± 0.01 magnitudes with an irregular lightcurve; 384 Burdigala 404.9 ± 0.1 hours, 0.40 ± 0.05 magnitudes with no detected tumbling; 464 Megaira 12.879 ± 0.001 hours, 0.12 ± 0.01 magnitudes; 488 Kreusa 32.645 ± 0.001 hours, 0.12 ± 0.01 magnitudes; 491 Carina 14.836 ± 0.001 hours, 0.13 ± 0.01 magnitudes. For 384 Burdigala the color index is $V-R=0.48$, at mid-light in the V photometric system $H=9.53 \pm 0.05$, $G=0.22 \pm 0.05$.

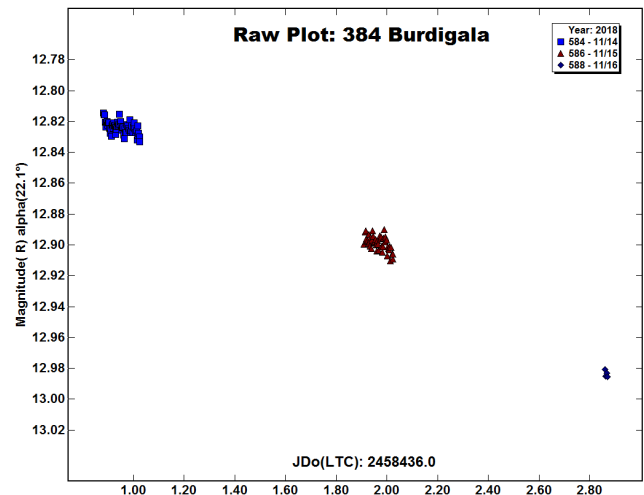
Observations to obtain the data used in this paper were made at the Organ Mesa Observatory with a 0.35-meter Meade LX200 GPS Schmidt-Cassegrain (SCT) and SBIG STL-1001E CCD. Exposures were 60 seconds, unguided, with a clear filter except for 384 Burdigala and 488 Kreusa near opposition where the exposure was limited to 30 seconds. 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.

58 Concordia. Previously published period determinations are by Gil-Hutton (1993), >16 . hours; Wang (2002), 9.89 hours; Behrend (2006), 9.9 hours; Behrend (2010), 9.905 hours; Behrend (2011), 9.904 hours; Stephens (2006), 9.895 hours; and Pilcher (2016), 9.895 hours. New observations on 4 nights 2019 Jan. 3-22 provide a good fit to an irregular lightcurve with period 9.895 ± 0.002 hours, amplitude 0.10 ± 0.01 magnitudes. Two small bumps on the phased lightcurve near phases 0.08 and 0.75, respectively, show progressive changes through the interval of observation. The 9.895 hour period is consistent with most of the previously published values.



384 Burdigala. Two previously published period determinations are both based on sparse lightcurves with very small amplitudes: Behrend (2009), 21.1 hours; and Robinson (2011), 17 hours. In the author's experience it is a fairly common occurrence that a low reliability period with low amplitude results from an effort to adjust the instrumental magnitudes of different sessions to a good fit without considering or being able to look for a much larger amplitude variation of very long period. Before starting an observation campaign that lasted nearly 5 months, the author suspected that 384 Burdigala might be a very slow rotator. Calibration solar colored stars with magnitudes from the Carlsberg Meridian Catalog 15 (CMC15) were used for all sessions. Magnitudes from this catalog are internally consistent usually within 0.05 magnitudes. The author therefore made no adjustments in instrumental magnitudes. A raw plot of non-adjusted magnitudes over the first 3 nights of observation revealed a consistent dimming by 0.07 magnitudes per night. These data were sufficient to confirm very slow rotation, but several weeks of observations every clear night were required before even an approximate period and amplitude could be found.

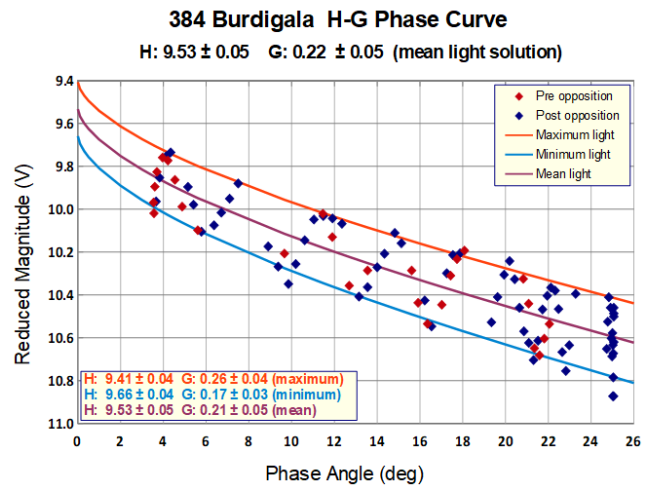
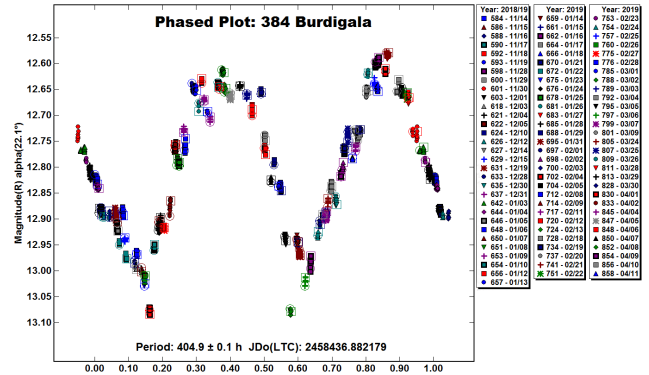
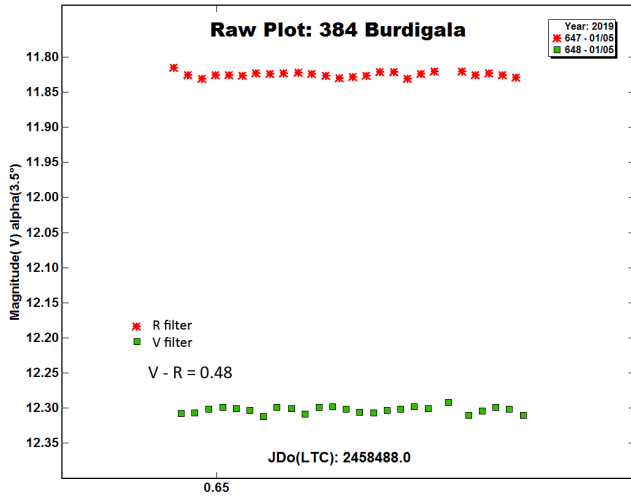
An effective means for observing a very slow rotator on the large number of nights required to obtain a reliable and moderately accurate rotation period, as well as look for the tumbling behavior commonly found in such objects, is to obtain a small number of individual data points every clear night except when the Moon is close in the sky. This can be done at the end of the night before opposition, or at the start of the night after opposition, with a more rapidly rotating target observed for the rest of the night. A total of 91 sessions were obtained in the interval 2018 Nov. 14 – 2019 Apr. 11, nearly nine rotational cycles.



On 2019 Jan. 5 twenty images of exposure time 60 seconds each were obtained alternately in R and V filters and measured with the same comparison stars with their respective R and V magnitudes as derived from CMC15 catalog r^* , J, Ks magnitudes. The R magnitude session in the raw lightcurve plot of these two sessions must be adjusted downward by 0.48 magnitudes for best overlap; this value is the color index $V-R=0.48$.

Number	Name	yyyy/mm/dd	Pts	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.		
58	Concordia	2019/01/03-2019/01/22	1111	2.8,	9.6	100	-5	9.895	0.001	0.10	0.01	
384	Burdigala	2018/11/14-2019/04/11	4320	22.0,	3.5,	25.1	106	7	404.9	0.1	0.40	0.05
464	Megaira	2019/02/28-2019/03/30	2493	4.4,	3.9,	8.7	165	11	12.879	0.001	0.12	0.01
488	Kreusa	2019/01/17-2019/03/26	3671	16.1,	6.7,	12.6	158	14	32.645	0.001	0.12	0.01
491	Carina	2019/02/04-2019/02/26	1759	8.4,	2.6	158	-8	14.836	0.001	0.13	0.01	

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

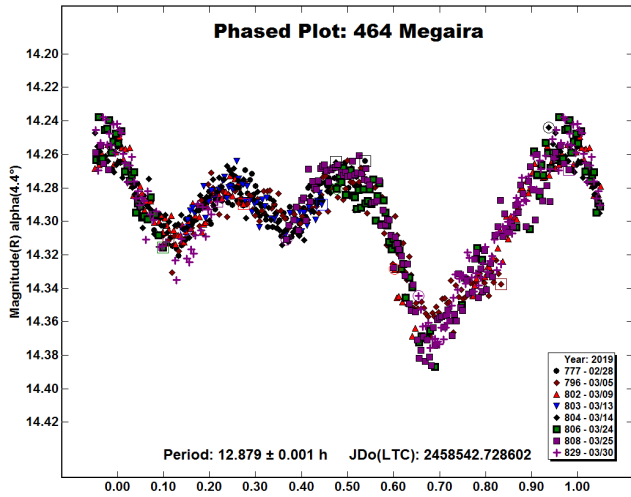


The R magnitudes of the sessions were converted to V by $V-R=0.48$ to construct an H-G plot. The author thanks Lorenzo Franco for preparing an H-G plot for maximum light, minimum light, and mean light. The values of H and G are, respectively, at maximum light 9.41 ± 0.04 , 0.26 ± 0.04 ; at minimum light 9.66 ± 0.04 , 0.17 ± 0.03 ; at mean light 9.53 ± 0.05 , 0.22 ± 0.05 .

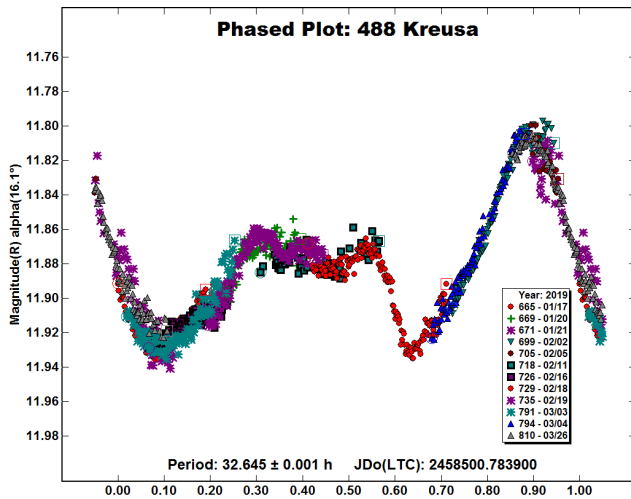
MPO Canopus software adjusts the instrumental magnitudes of each session in accordance with changes in the Sun and Earth distances and the phase angle. Brightness changes vary with Sun and Earth distances as inverse square laws and may be precisely and reliably computed. Brightness changes with varying phase angles are different for different asteroids and computed numerically with the phase factor G. For every phased lightcurve an rms error of the difference of magnitude of individual data points from a numerical Fourier series that best fits all points is stated as a multiple of 0.01 magnitude. For 384 Burdigala the value of G had not been measured previously and the default $G=0.150$ was assumed. A phased lightcurve constructed for all 91 sessions assuming $G=0.150$ stated an rms error 4.1923. *MPO Canopus* software version 10.7 enables the user to change the value of G used to adjust the changes of magnitude with phase angle. When the lightcurve was replotted with mean light $G=0.22$, a smaller rms error of 3.3716 was stated. The lightcurve published here is drawn for $G=0.22$. It shows a good fit to a period of 404.9 ± 0.1 hours, amplitude 0.40 ± 0.05 magnitudes. The reader should understand that the real error in the period is larger than the formal error of fitting a period to a Fourier series approximation. For very slow rotators the common procedure of adjusting corresponding phases of different sessions to best fit cannot be used. The scatter in the data points for separate sessions is no greater than can be explained by errors in CMC15 magnitudes up to about 0.05 magnitudes and changes in the form of the lightcurve with the large changes in phase angle encountered in this study.

The author thanks Petr Pravec (private communication) for an independent analysis of the photometric data. He finds “no significant deviation from the main period of 405 h (realistic error 2 h). This slow rotator is in or very close to a principal axis rotation.”

464 Megaira. Two previously published determinations are by Behrend (2005), 12.726 hours; and by Waszczak et al. (2015) in the Palomar Transient Factory Survey, 12.871 hours. New observations on 8 nights 2019 Feb. 28 – Mar. 30 provide a good fit to a lightcurve with period 12.879 ± 0.001 hours, amplitude 0.12 ± 0.01 magnitudes, and 3 unequal maxima and minima per cycle. This is compatible with Waszczak et al. (2015) and differs slightly from Behrend (2005).

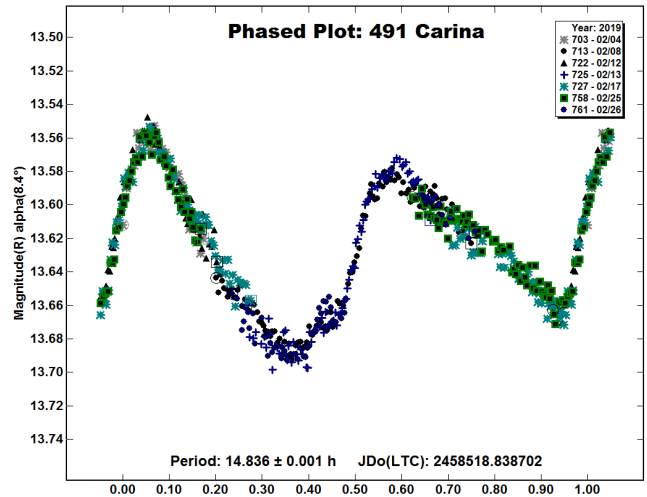


488 Kreusa. Several previous authors have published rotation periods for 488 Kreusa, none of them fully reliable. Harris and Young (1989) found a monotonic 0.2 magnitude increase in a single 7 hour session and inferred a period >28 hours. Other authors have published a wide range of periods: Blanco et al., 6.457 hours; Behrend (2007), 65.3 hours; Robinson (2011), 19.26 hours; and Stephens (2014), 32.666 hours. New observations on 12 nights 2019 Jan. 17 – March 26 provide a good fit to an irregular lightcurve with period 32.645 ± 0.001 hours, amplitude 0.12 ± 0.01 magnitudes. This period is consistent with Stephens (2014) and shows that Behrend (2007) obtained the double period. All other previously published rotation periods are now ruled out.



491 Carina. Previously published rotation periods are by Florczak et al. (1997), 14.87 hours; Behrend (2005), 15 hours based on a single 7 hour session that seemed to cover about 1/2 cycle; and Stephens (2014), 15.153 hours. New observations on 7 nights 2019 Feb. 4 – 26 provide a good fit to a lightcurve with period 14.836 ± 0.001 hours, amplitude 0.13 ± 0.01 magnitudes. This period is consistent with Florczak et al. (1997) and, considering his very meager data, Behrend (2005). The inconsistency with Stephens (2014) may be reconciled by explaining how Stephens found a very remarkable alias. Stephens obtained several sessions 2014 April 10 - 14, no more until several additional sessions were obtained 2014 May 6 - 10. The short interval observation sets of April and May, respectively, did not provide sufficiently accurate periods for the number of rotational cycles during the long interval

between the two sets to be counted accurately. For a 15.153 hour period there are 47.51 cycles in 30 days. For a 14.836 hour period there are 48.53 cycles in 30 days. The spacing of Stephens's observations permitted a fairly good fit to both periods. In the current study, the observations were more evenly distributed in time, and can fit only a 14.836 hour period.



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LIGHTCURVE ANALYSIS OF ASTEROID 2305 KING

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Photometric observations of outer main-belt asteroid 2305 King were made from the Phillips Academy Observatory from 2018 November 30 to 2019 January 15. The rotational period of the asteroid is determined to be 3.0368 ± 0.0005 h, with amplitude 0.19 ± 0.10 mag.

Photometric observations of asteroid 2305 King were commenced as a part of an astronomy research class taught at Phillips Academy, a high school in Andover, Massachusetts. Students used the CALL website to identify asteroids with previously unmeasured periods and favored candidates with high declinations, apparent visual magnitudes between 15 and 17, and appealing names. This outer main-belt (MB-O) asteroid was discovered on 1980 September 12 at the Harvard College Observatory's Agassiz Station. It has a semi-major axis of 2.786 AU, an eccentricity of 0.0312, and a sidereal orbital period of 1698.745 d. The asteroid was named in honor of Martin Luther King, the revolutionary American civil rights leader (JPL, 2019).

Observations were acquired using an 0.40-m *f*/8 Ritchey-Chrétien telescope manufactured by DFM Engineering. Images were captured with an Andor Tech iKon DW436 camera with a 2048x2048 array of 13.5-micron pixels. The resulting image scale was 0.86 arcsecs per pixel. All images were taken with a 300-sec exposure for a total of 7 nights between 2018 November 30 and 2019 January 29. Observations were attempted on four additional nights after 2019 January 29, but poor weather conditions failed to yield useable data. These data were therefore not included in the final period solution. All photographs were unbinned, and guided. Calibrations were performed with *AstroimageJ* software (Collins *et al.*, 2018), using the appropriate dark, flat, and bias frames.

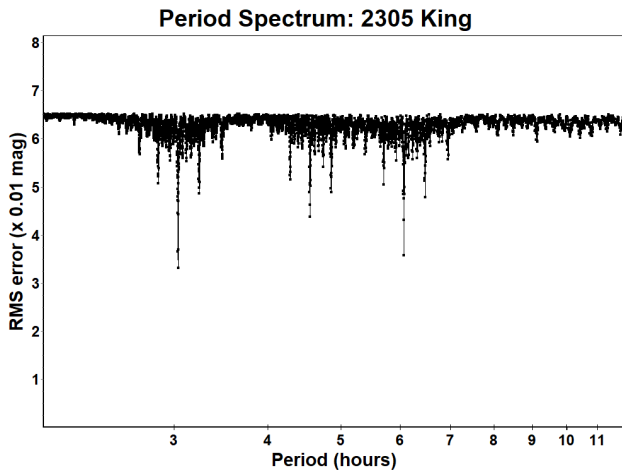
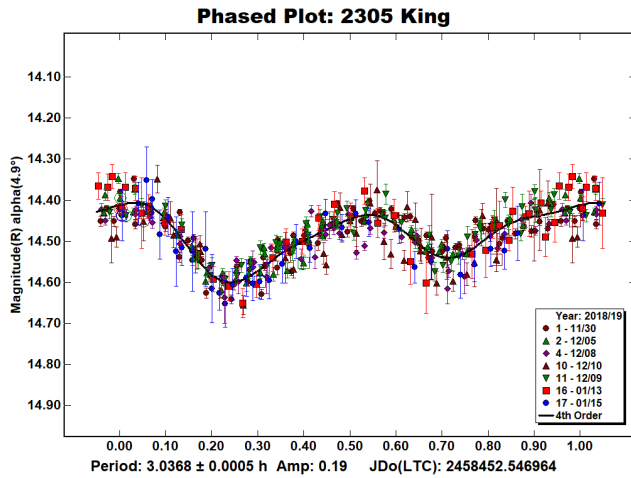
The program *MPO Canopus* (Warner, 2018) was utilized for lightcurve analysis of 2305 King. Comparison stars were chosen to have near solar color, a B-V value close to 0.8, and a V-R value close to 0.45 (Warner, 2012). The composite lightcurve for 2305 King utilized the Fourier Analysis for Lightcurves (FALC) algorithm developed by Alan Harris (Harris *et al.*, 1989) and modified by Petr Pravec (Warner, 2012).

2305 King. Analysis of 360 data points found a rotational period of 3.0368 ± 0.0005 h with amplitude 0.19 ± 0.10 mag. The Asteroid Lightcurve Database (LCDB) did not reveal any previous rotational period results for 2305 King (Warner *et al.*, 2009). The resulting lightcurve is well covered, and the bimodal solution is

Number	Name	2018/2019	mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.		
Amp	A.E.	Grp									
2305	King	11/30-01/15	360	4.9, 14.7	76.2	7.6	3.0368	0.0005	0.19	0.10	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

strongly favored by the period spectrum (included). Each of the authors assembled a lightcurve from the data. The plot included here was generated by R. Beckwith.



Acknowledgements

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LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2019 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 2019 July through 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 $V \leq 18.0$ 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, *do 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).

Number	Name	Brightest		Dec	LCDB Data		U
		Date	Mag		Period	Amp	
4717	Kaneko	07 01.2	15.0	-31			
3882	Johncox	07 01.9	15.1	-14			
3439	Lebofsky	07 03.5	15.1	-31	5.969	0.20	2
1055	Tynka	07 04.0	13.4	-15	11.893	0.06-0.33	2
18571	1997 WQ21	07 04.7	15.1	-20			
10359	1993 TU36	07 04.9	15.4	-26	2.411		0.18 2
21910	1999 VT23	07 05.1	15.1	-13	9.4		0.35 2
6419	Susono	07 07.6	14.9	-19			
9849	1990 RF2	07 08.3	15.5	-20	2.608		0.12 2
18765	1999 JN17	07 10.5	15.0	-13			
3761	Romanskaya	07 12.8	14.4	+6	15.32		0.34 2
3638	Davis	07 13.9	15.1	-22	8.9		0.40 2
2587	Gardner	07 14.8	15.0	-23	11.631		0.48 2
21526	Mirano	07 15.4	14.9	-1			
12069	1998 FC59	07 15.8	15.3	-9			
11927	Mount Kent	07 15.9	15.4	-21			
23120	Paulallen	07 16.4	14.8	-21			
2938	Hopi	07 18.3	14.9	-30			
900	Rosalinde	07 18.7	14.2	-1	16.648	0.28-0.52	2+
12228	1985 TZ3	07 20.7	15.3	-23			
3578	Carestia	07 20.8	13.7	-12	9.93		0.13 2
4420	Alandreev	07 20.8	13.6	-22			
24525	2001 CS4	07 21.0	15.4	-19			0.49
9900	Llull	07 21.4	14.6	-18	183.319		0.88 2
791	Ani	07 21.5	12.6	-15	16.72	0.17-0.38	2
8263	1986 QT	07 21.7	15.4	-20			
13403	Sarahmoussa	07 22.6	15.3	-32			
6649	Yokotatakao	07 22.7	14.5	-27			
6658	Akiraabe	07 22.9	15.3	-21			0.61
2158	Tietjen	07 24.0	14.6	-18			
997	Priska	07 25.0	15.0	-4	16.22		0.61 2
455432	2003 RP8	07 25.5	14.1	-24			
6934	1994 YN2	07 27.0	15.4	-28			
13803	1998 WU10	07 27.9	15.4	-15			
7241	Kuroda	07 31.0	15.3	-22	59.6		0.61 2
5250	Jas	08 01.2	15.2	-16			
24730	1991 VM5	08 02.1	15.3	-30			
23297	2001 AX3	08 02.2	15.0	-7			
32897	Curtharris	08 02.3	14.7	-14			0.36
9065	1993 FN1	08 02.9	15.1	-13	3.064	0.19-0.19	2
1354	Botha	08 03.1	14.3	-27	4.		0.21 1+
2096	Vaino	08 05.5	14.9	-17	3.32	0.06-0.10	2
4342	Freud	08 07.4	15.2	-17			
7217	Dacke	08 07.6	14.8	-20			
19158	1990 SN7	08 08.4	15.4	-26			
6260	Kelsey	08 08.8	14.4	-20	5.11		0.17 2
2519	Annagerman	08 08.9	14.8	-19	12.982		0.14 2
5900	Jensen	08 09.1	15.3	-12			
7820	1990 TU8	08 10.2	15.4	-20			
4139	Ul'yanin	08 12.0	15.3	-15			
8096	Emilezola	08 12.4	15.0	-16			
835	Olivia	08 12.8	15.4	-14			
4864	1988 RA5	08 12.8	15.2	-20			
26851	Sarapul	08 13.3	14.9	-12			
8271	Imai	08 15.4	14.7	-15			

Number	Name	Brightest			LCDB Data		
		Date	Mag	Dec	Period	Amp	U
3150	Tosa	08 15.5	15.4	-30			
7248	Alvsjo	08 15.6	15.3	-18			
15596	2000 GZ95	08 16.7	15.5	-14	2.923	0.25-0.35	2
12518	1998 HM52	08 17.6	15.0	-25			
1066	Lobelia	08 17.9	13.8	-17			
10990	Okunev	08 17.9	15.3	-6			
2918	Salazar	08 19.0	15.3	-14			
99915	1997 TR6	08 19.6	15.2	-14			
6567	Shigemasa	08 19.7	15.1	-4			
3502	Huangpu	08 20.4	15.1	-15			
4643	Cisneros	08 21.6	15.0	-14	5.25	0.32-0.33	2
9053	Hamamelis	08 21.7	15.5	-23	10.386	0.29-0.33	2
3302	Schliemann	08 23.7	14.8	-11			
153842	2001 XT30	08 23.8	15.1	-22			
306381	1993 RR2	08 23.8	14.4	-8			
13050	1990 SY	08 24.0	15.2	-11			
8142	Zolotov	08 25.4	15.2	-17			
9061	1992 WC3	08 25.4	15.3	-22			
5309	MacPherson	08 25.7	15.2	-4			
5437	1990 DU3	08 25.7	15.2	-8			
7752	Otauchunokai	08 25.9	15.1	-5			
1136	Mercedes	08 27.0	13.1	+3	24.64	0.10-0.15	2
3568	ASCI	08 27.0	15.3	-40			
52930	1998 SK127	08 27.3	15.2	-11			
82676	2001 PV23	08 27.5	15.4	-20			
19707	Tokunai	08 28.4	15.1	-19			
1686	De Sitter	08 29.2	14.4	-10			
6100	Kunitomoikkansa	08 29.3	15.3	-6	30.267	0.27	2-
1897	Hind	08 29.6	15.1	-17	2.633	0.09	2
7078	Unojonsson	08 30.6	15.1	-10			
80593	2000 AG144	09 01.0	14.7	+13			
2858	Carlosporter	09 01.2	14.9	-15	3.35	0.15-0.47	2
7365	Sejong	09 01.2	14.1	-8			
11790	Goode	09 01.2	15.4	-12			
4434	Nikulin	09 01.3	15.2	-7			
4961	Timherder	09 01.3	15.3	-3			
15815	1994 PY18	09 02.2	14.9	-4			
7463	Oukawamine	09 03.6	14.7	-10			
7534	1995 UA7	09 04.1	14.8	-17			
24277	Schoch	09 04.1	15.4	-6			
4268	Grebenikov	09 04.2	15.3	-10			
3860	Plovdiv	09 04.8	14.6	+3	6.114	0.34-0.37	2+
2628	Kopal	09 05.2	15.5	-6			
4264	Karljosephine	09 05.9	14.6	-4	30.96	0.09-0.45	2
1043	Beate	09 06.8	13.5	-7	44.3	0.47	2+
3056	INAG	09 07.0	14.7	-11			
2629	Rudra	09 07.4	15.0	-5	123.171	0.58	2
2389	Dibaj	09 08.0	14.3	-3			
2555	Thomas	09 08.3	15.1	-5			
5857	Neglinka	09 08.9	15.5	-5			
848	Inna	09 09.0	14.4	-5			
4445	Jimstratton	09 09.5	15.1	-1	3.74	0.13	2
14441	1992 SJ	09 09.5	15.2	-10			
5421	Ulanova	09 10.7	15.1	+1	9.814	0.60	2+
5890	Carlsberg	09 10.8	14.9	-21			
2580	Smilevskia	09 11.2	13.7	-7			
5391	Emmons	09 12.0	14.1	-3	3.028	0.16	2
8842	1990 KF	09 12.5	15.2	-13			
7052	1988 VQ2	09 14.0	15.3	-34			
4604	Stekarstrom	09 14.1	15.1	-4			
3427	Szentmartoni	09 15.6	15.5	+0		0.75	
467317	2000 QW7	09 15.9	14.0	-37	71.3	1.0	2
1073	Gellivara	09 16.2	15.0	-5	11.32	0.35	2
1366	Piccolo	09 16.4	13.8	-10	16.57	0.24-0.33	2
10090	Sikorsky	09 16.7	15.4	-1			
707	Steina	09 17.5	13.8	+5	414.	1.00-1.00	2+
4300	Marg Edmondson	09 18.6	15.2	+2	9.328	0.12	2
13065	1991 PG11	09 18.9	15.0	-1			
3340	Yinhai	09 19.1	14.7	-9			
3811	Karma	09 19.6	14.5	+3	13.23	0.20-0.33	2+
7759	1990 QD2	09 19.9	15.3	-4			
1725	CrAO	09 20.3	14.7	-5	21.45	0.08-0.28	2
5804	Bambinidipraga	09 20.8	15.4	+9	11.379	0.39	2
12374	Rakhat	09 20.8	15.4	-14	18.17	0.31	2
7527	Marples	09 23.2	15.2	+6			
4021	Dancey	09 24.2	14.9	-5			
354030	2001 RB18	09 25.5	14.6	+20			
10418	1998 WZ23	09 26.2	15.3	-2			
2466	Golson	09 26.3	14.3	-2			
29032	2059 T-1	09 26.7	14.8	+2			
1174	Marmara	09 27.0	14.8	+2	12.	0.2	2
10261	Nikdollezhal'	09 27.5	14.9	+13	16.747	0.06-0.09	2
7868	Barker	09 27.8	15.1	-3			
11026	1986 RE1	09 28.4	15.1	+4			
3346	Gerla	09 28.5	14.8	+3			
4087	Part	09 28.6	15.1	-1	16.47	0.59	2
2226	Cunitza	09 29.4	14.9	+0			
5640	Yoshino	09 30.4	15.1	+1			
10720	Danzl	09 30.4	15.3	+2			

Number	Name	Brightest			LCDB Data		
		Date	Mag	Dec	Period	Amp	U
29763	1999 CH20	09 30.7	15.4	+0			
25632	2000 AO55	09 30.9	15.5	-7			

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-G₁₂, introduced by Muinonen *et al.* (2010; *Icarus* **209**, 542-555). It will be some years before H-G₁₂ 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 $\alpha > 7^\circ$, 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
323	Bruclia	07 01.1	0.51	12.5	-24	9.463	0.19-0.36	3
424	Gratia	07 04.9	0.24	13.5	-24	19.47	0.32	3-
2524	Budovicium	07 10.1	0.09	14.3	-22	10.0819	0.17	3
371	Bohemia	07 10.9	0.40	11.8	-21	10.7391	0.12-0.18	3
351	Yrsa	07 11.0	0.69	13.2	-24	13.29	0.40-0.42	3
158	Koronis	07 12.1	0.12	13.1	-22	14.218	0.28-0.43	3
367	Amicitia	07 12.2	0.95	13.5	-24	5.0554	0.25-0.90	3
1171	Rusthawelia	07 13.5	0.27	14.5	-21	10.98	0.26-0.31	3
379	Huenna	07 15.1	0.83	12.5	-19	14.141	0.07-0.12	3
657	Gunlod	07 18.1	0.29	14.3	-22	15.6652	0.19-0.20	3
149	Medusa	07 20.4	0.55	13.0	-20	26.023	0.33-0.56	3
4420	Alandreev	07 20.8	0.77	13.5	-22			
440	Theodora	07 23.2	0.20	14.3	-20	4.828	0.43-0.72	3
570	Kythera	07 23.4	0.77	13.4	-18	8.120	0.12-0.20	2
1162	Larissa	07 23.8	0.71	14.5	-23	6.516	0.12-0.20	3
1127	Mimi	07 29.3	0.48	14.1	-18	12.749	0.72-0.95	3
142	Polana	07 29.4	0.45	12.8	-18	9.764	0.11-0.21	3
1271	Isergina	07 29.7	0.13	14.4	-19	7.5993	0.25-0.36	3-
383	Janina	07 30.1	0.67	14.3	-21	6.4	0.06-0.17	3
206	Hersilia	08 01.8	0.59	12.3	-16	11.122	0.13-0.20	3
180	Garumna	08 02.9	0.08	14.5	-18	23.866	0.27-0.6	3
1727	Mette	08 06.6	0.35	14.1	-17	2.9811	0.19-0.38	3
16	Psyche	08 07.2	0.51	9.3	-15	4.196	0.03-0.34	3
181	Eucharis	08 09.6	0.89	12.8	-13	52.23	0.04-0.15	3
1641	Tana	08 18.0	0.68	13.9	-15	7.95	0.32-0.33	3-
723	Hammonia	08 20.2	0.74	13.9	-11	5.436	0.08-0.18	3
1467	Mashona	08 20.4	0.17	12.4	-12	9.76	0.24-0.31	3
203	Pompeja	08 22.9	0.61	12.2	-13	24.052	0.10	3
1686	De Sitter	08 29.2	0.21	14.5	-10			
333	Badenia	08 30.6	0.63	12.9	-11	9.862	0.20-0.33	3

Num Name	Date	α	V	Dec	Period	Amp	U
243 Ida	09 01.0	0.15	13.6	-08	4.634	0.45-0.86	3
7365 Sejong	09 01.2	0.48	14.2	-08			
317 Roxane	09 02.6	0.30	11.9	-08	8.169	0.61-0.75	3
1128 Astrid	09 03.1	0.60	14.3	-09	10.228	0.13-0.35	2+
135 Hertha	09 06.2	0.15	9.6	-07	8.403	0.12-0.30	3
190 Ismene	09 06.5	0.44	13.1	-05	6.52	0.10-0.16	3
1043 Beate	09 06.8	0.36	13.5	-07	44.3	0.47	2+
268 Adorea	09 08.6	0.70	13.1	-08	7.80	0.15-0.20	3
848 Inna	09 09.0	0.44	14.4	-05			
232 Russia	09 09.3	0.80	14.0	-07	21.905	0.14-0.31	3
624 Hektor	09 11.0	0.37	14.1	-03	6.924	0.10-1.10	3
5391 Emmons	09 12.1	0.73	14.2	-03	3.028	0.16	2
150 Nuwa	09 15.8	0.76	11.5	-01	8.1347	0.08-0.31	3
1494 Savo	09 16.8	0.99	13.7	-01	5.3501	0.38-0.63	3
748 Simeisa	09 17.1	0.81	14.3	+00	11.919	0.22-0.36	2
2006 Polonskaya	09 22.2	0.26	14.3	-01	3.1183	0.08-0.16	3
711 Marmulla	09 22.9	0.26	13.2	+00	2.721	0.03-0.18	3
247 Eukrate	09 23.1	0.23	10.4	-01	12.093	0.10-0.18	3
422 Berolina	09 24.5	0.96	11.6	-01	25.978	0.06-0.16	3
104 Klymene	09 25.6	0.94	12.2	-02	8.984	0.2 -0.3	3
1645 Waterfield	09 28.8	0.59	14.5	+03	4.861	0.18-0.20	3
611 Valeria	09 30.0	0.40	12.9	+04	6.977	0.08-0.16	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 \geq 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.

Num Name	Brightest			LCDB Data		U
	Date	Mag	Dec	Period	Amp	
323 Brucia	07 01.2	12.5	-24	9.463	0.19-0.36	3
713 Luscinia	07 02.0	13.6	-10	9.9143	0.09-0.40	3
428 Monachia	07 04.5	14.9	-34	3.6338	0.18-0.34	3
4375 Kiyomori	07 07.6	15.5	-17	6.4709	0.15-0.16	3
266 Aline	07 09.7	12.8	-6	13.018	0.05-0.10	3
3682 Welther	07 10.3	14.7	-10	3.5973	0.21-0.37	3
1694 Kaiser	07 12.1	14.2	-43	13.02	0.14-0.32	3
1171 Rusthawelia	07 13.5	14.5	-21	10.98	0.26-0.31	3
869 Mellena	07 14.0	14.1	-12	6.5155	0.20-0.27	3
1675 Simonida	07 14.8	15.0	-33	5.2885	0.16-0.65	3
947 Monterosa	07 16.1	13.3	-31	5.164	0.15-0.23	3-
3879 Machar	07 16.4	14.9	-31	4.131	0.19-0.23	3
657 Gunlod	07 18.0	14.3	-22	15.6652	0.19-0.20	3
214088 2004 JN13	07 21.4	13.9	-59	6.342	0.17-0.40	3
754 Malabar	07 23.8	14.0	+10	11.74	0.19-0.38	3
1777 Gehrels	07 26.2	14.9	-22	2.8355	0.21-0.27	3
1520 Imatra	07 26.6	14.6	-2	18.635	0.27-0.35	3-
618 Elfriede	07 28.3	12.3	-25	14.791	0.11-0.17	3
373 Melusina	07 29.4	13.2	-39	12.97	0.20-0.25	3
206 Hersilia	08 01.8	12.3	-16	11.122	0.13-0.20	3
1115 Sabauda	08 03.8	14.9	-35	6.718	0.16-0.27	3
1727 Mette	08 06.6	14.0	-17	2.9811	0.19-0.38	3

Num Name	Date	Brightest		LCDB Data		U
		Mag	Dec	Period	Amp	
298 Baptistina	08 06.9	14.2	-25	16.23	0.10-0.25	3
654 Zelinda	08 07.5	12.4	+9	31.735	0.08-0.3	3
635 Vundtia	08 07.8	13.5	-5	11.79	0.15-0.27	3
255 Oppavia	08 08.3	14.5	-28	19.499	0.14-0.16	3
252 Clementina	08 11.8	14.0	-3	10.864	0.32-0.44	3
2131 Mayall	08 12.9	14.1	+17	2.5678	0.05-0.09	3
235 Carolina	08 14.9	12.7	-27	17.61	0.25-0.38	3
1342 Brabantia	08 15.0	14.7	-8	4.1754	0.17-0.21	3
971 Alsatia	08 17.3	14.2	-31	9.614	0.17-0.29	3
289 Nenetta	08 19.4	12.5	-7	6.902	0.18-0.19	3
970 Primula	08 19.4	14.6	-11	2.777	0.16-0.30	3
3028 Zhangguoxi	08 20.8	15.0	-3	4.826	0.12-0.25	3
975 Perseverantia	08 22.0	14.3	-16	7.267	0.17-0.23	3
911 Agamemnon	08 24.1	14.8	-15	6.592	0.04-0.29	3
1509 Escalangona	08 25.5	15.0	+25	3.2528	0.11-0.35	3
348 May	08 28.7	13.8	-22	7.3812	0.14-0.16	3
504 Cora	08 28.8	12.6	-27	7.588	0.15-0.4	3-
333 Badenia	08 30.7	12.9	-11	9.862	0.20-0.33	3
66146 1998 TU3	08 31.8	11.9	-85	2.375	0.07-0.15	3
305 Gordonia	08 31.9	13.5	-4	12.893	0.10-0.23	3
472 Roma	09 01.9	12.2	-21	9.8007	0.27-0.46	3
3870 Mayre	09 02.1	15.0	+6	3.9915	0.44-0.45	3
759 Viniifera	09 04.3	13.1	+10	14.229	0.36-0.40	3
380 Fiducia	09 04.9	12.4	-16	13.69	0.04-0.32	3
143 Adria	09 05.2	12.9	-4	22.005	0.07-0.10	3
232 Russia	09 09.2	14.0	-7	21.905	0.14-0.31	3
4224 Susa	09 11.3	14.5	+5	6.178	0.21-0.27	3-
2486 Metsahovi	09 17.5	15.0	-4	4.4518	0.04-0.13	3
3948 Bohr	09 17.9	14.7	-1	24.884	0.2-0.90	3
240 Vanadis	09 19.9	11.6	-5	10.64	0.08-0.34	3
3332 Raksha	09 20.5	14.8	-16	4.8065	0.25-0.36	3
275 Sapientia	09 22.1	13.3	-5	14.931	0.05-0.12	3-
2006 Polonskaya	09 22.2	14.2	-1	3.1183	0.08-0.16	3
592 Bathseba	09 22.6	13.2	-3	7.7465	0.22-0.32	3
888 Parysatis	09 29.1	12.7	-18	5.9314	0.22-0.26	3
483 Seppina	09 29.2	12.9	-3	12.727	0.14-0.29	3
611 Valeria	09 30.1	12.9	+4	6.977	0.08-0.16	3

Radar-Optical Opportunities

Past radar targets:

<http://echo.jpl.nasa.gov/~lance/radar.nea.periods.html>

Arecibo targets:

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

<http://www.naic.edu/~pradar/ephemfuture.txt>

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. “BIN?” 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>

The “A” is for Arecibo; “G” is for Goldstone. The calculator SNRs for Arecibo are based on a reduced power of 600 kW.

Asteroid	Period	Amp	App	Last	R SNR
(418900) 2009 BE2 NEA	-	-	-	-	A 35 G -
(494999) 2010 JU39 NEA PHA	-	-	-	-	A 110 G 35
(441987) 2010 NY65 NEA	5.541	0.16	3	2018	A 2340 G 780
(11500) Tomaiyowit NEA	73	0.5	1	1998	A 10
(90403) 2003 YE45 NEA	500	0.81	1	2019	A 180 G 60
(293054) 2006 WP127 NEA	5.311	0.35	1	2015	A 40
(455432) 2003 RP8 NEA	-	-	-	-	A 13
(66146) 1998 TU3 NEA	2.375	0.07	6	2017	A 25 G 25
(237805) 2002 CF26 NEA	3.776	0.99	1	2017	A 60 G 20
(141593) 2002 HK12 NEA	12.690	1.5	1	2002	A 470 G 160
(1620) Geographos NEA	5.222	0.95	4	2019	G 25 2.03

Asteroid	Period	Amp	App	Last	R SNR
(504800) 2010 CO1 NEA	-	-	-	-	A 15 G 25
(467317) 2000 QW7 NEA	71.3	1.0	1	2000	A 2950 G 990
(2100) Ra-Shalom NEA	19.797	0.30 0.55	4	2016	A 35 G 12
(354030) 2001 RB18 NEA	-	-	-	-	A 40 G 15
(297418) 2000 SP43 NEA	-	-	-	-	G 47
1996 TC1 NEA	-	-	-	-	A 2870 G 960

Table I. Summary of radar-optical opportunities for the current quarter. Period and amplitude data are from the asteroid lightcurve database (Warner *et al.*, 2009; *Icarus* 202, 134-146). SNR values are *estimates* that are affected by power output of the radar along with rotation period, size, and distance. They are given for relative comparisons among the objects in the list.

The SNRs were calculated using the current MPCORB absolute magnitude (H), a period of 4 hours (2 hours if $D \leq 200$ m) 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 when using the SNR calculator mentioned above.

(418900) 2009 BE2 ($H = 19.2$)

The estimated size is 430 m for the asteroid with no reported rotation period. Because of its size, the period is likely $P > 2.2$ h.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
06/20	14 04.0	+31 07	0.12	1.05	17.1	70.9	103	101	-0.93	+74
06/23	14 12.7	+18 47	0.11	1.06	16.8	65.1	109	127	-0.72	+70
06/26	14 21.6	+04 41	0.10	1.07	16.5	58.8	116	156	-0.44	+59
06/29	14 30.9	-09 40	0.11	1.08	16.4	53.6	122	170	-0.17	+46
07/02	14 40.5	-22 35	0.11	1.09	16.5	50.2	125	135	-0.01	+34
07/05	14 50.7	-33 09	0.13	1.10	16.8	48.6	126	98	+0.07	+23
07/08	15 01.4	-41 22	0.15	1.11	17.0	48.0	126	64	+0.34	+15
07/11	15 12.6	-47 39	0.17	1.12	17.3	47.8	125	39	+0.67	+9
07/14	15 24.4	-52 26	0.19	1.13	17.6	47.8	124	38	+0.92	+4
07/17	15 36.8	-56 06	0.21	1.15	17.9	47.8	123	57	-1.00	+0

(494999) 2010 JU39 ($H = 19.6$)

There is no reported period for this 360-m NEA. Note that most of the positions are actually in the previous quarter (June) since the asteroid makes a very brief appearance at acceptable phase angles and solar elongations. The radar team will need photometry and astrometry.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
06/20	18 11.5	+24 24	0.12	1.10	17.0	43.2	132	53	-0.93	+19
06/21	17 58.0	+24 27	0.11	1.10	16.8	43.5	132	62	-0.87	+22
06/22	17 41.6	+24 24	0.10	1.09	16.5	44.0	132	72	-0.80	+26
06/23	17 21.7	+24 10	0.09	1.08	16.3	45.0	131	85	-0.72	+30
06/24	16 57.4	+23 38	0.08	1.07	16.1	46.7	130	99	-0.63	+35
06/25	16 27.9	+22 39	0.08	1.06	16.0	49.4	127	114	-0.54	+41
06/26	15 52.5	+20 57	0.07	1.06	15.9	53.4	123	130	-0.44	+48
06/27	15 11.5	+18 21	0.06	1.05	15.8	59.2	118	147	-0.35	+57
06/28	14 26.8	+14 45	0.06	1.04	15.9	66.4	110	157	-0.25	+65
06/29	13 41.3	+10 23	0.06	1.03	16.2	74.7	102	148	-0.17	+70
06/30	12 58.4	+05 46	0.06	1.02	16.5	83.1	93	130	-0.10	+69

(441987) 2010 NY65 ($H = 21.5$)

This 150-meter NEA is going to “light up” both Arecibo and Goldstone, assuming – as always – that they are operational and at full power. This is a potentially hazardous asteroid (PHA) and also a good candidate for measuring the Yarkovsky effect on the asteroid. This is a thermal force that leads to the size of the orbit decreasing (retrograde rotation) or increasing (prograde rotation).

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
06/27	15 21.1	+45 19	0.03	1.02	16.3	78.4	100	125	-0.35	+55
06/28	15 55.9	+37 17	0.03	1.03	16.4	68.4	110	129	-0.25	+50
06/29	16 15.9	+31 21	0.04	1.03	16.6	61.4	117	133	-0.17	+46
06/30	16 28.7	+26 59	0.04	1.04	16.8	56.5	121	136	-0.10	+42
07/01	16 37.6	+23 42	0.05	1.05	17.0	52.9	125	136	-0.04	+39
07/02	16 44.2	+21 09	0.06	1.05	17.2	50.2	127	134	-0.01	+37
07/03	16 49.2	+19 07	0.06	1.06	17.4	48.2	129	128	+0.00	+35
07/04	16 53.2	+17 28	0.07	1.06	17.6	46.6	131	120	+0.02	+34
07/05	16 56.4	+16 05	0.08	1.07	17.8	45.3	132	110	+0.07	+33
07/06	16 59.2	+14 55	0.08	1.08	18.0	44.3	132	99	+0.14	+31

(11500) Tomaiyowit ($H = 12.6$)

This asteroid will barely be within reach of the Arecibo radar, but it is still worth photometric efforts. Note that the period is almost three Earth days. This calls for a coordinated campaign involving observers at well-separated longitudes.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
06/30	13 17.7	+25 09	0.20	1.04	17.7	79.1	90	122	-0.10	+84
07/03	13 46.7	+23 06	0.21	1.05	17.7	74.4	94	92	+0.00	+77
07/06	14 12.0	+20 58	0.23	1.07	17.7	70.1	98	59	+0.14	+71
07/09	14 33.9	+18 52	0.24	1.09	17.8	66.5	101	32	+0.45	+65
07/12	14 52.9	+16 51	0.26	1.11	17.9	63.4	103	32	+0.77	+60
07/15	15 09.6	+14 57	0.28	1.12	18.0	60.8	105	56	+0.96	+56
07/18	15 24.3	+13 11	0.30	1.14	18.1	58.5	107	85	-0.99	+52
07/21	15 37.5	+11 32	0.32	1.16	18.2	56.6	108	113	-0.85	+48
07/24	15 49.3	+10 00	0.34	1.17	18.3	55.0	109	140	-0.60	+45
07/27	16 00.1	+08 34	0.36	1.19	18.4	53.7	110	156	-0.31	+42

(90403) 2003 YE45 ($H = 17.6$)

By the smallest of margins, this asteroid was actually brighter back in January. However, NEAs can have more than one opposition and close approach in a given year. On this second time around, it offers a prolonged period where it is within reach of many backyard telescopes, if they are well north of the equator.

The period is believed to be on the order of 500 hours (almost three Earth *weeks*). That’s hardly the record, but it this does call for another prolonged, coordinated observing campaign involving several, well-separated observers. It will also require careful calibration of the data so that all observing runs have essentially the same zero point.

The long period also makes this a very likely candidate for tumbling and so makes the needed for tightly-calibrated data even more essential.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/15	00 29.8	+36 39	0.17	1.03	16.6	81.3	89	108	+0.96	-26
07/22	23 48.2	+44 10	0.19	1.06	16.7	72.2	97	51	-0.78	-17
07/29	23 08.1	+48 47	0.22	1.09	16.8	64.9	104	78	-0.13	-11
08/05	22 30.8	+51 06	0.25	1.12	17.0	59.0	109	121	+0.21	-6
08/12	21 58.1	+51 41	0.28	1.15	17.1	54.2	113	85	+0.89	-3
08/19	21 31.6	+50 59	0.31	1.18	17.3	50.3	116	65	-0.89	+0
08/26	21 11.5	+49 24	0.35	1.21	17.5	47.2	118	98	-0.26	+1
09/02	20 57.7	+47 11	0.38	1.25	17.7	44.6	120	110	+0.10	+1
09/09	20 49.5	+44 36	0.42	1.27	17.9	42.6	121	70	+0.78	+0
09/16	20 46.0	+41 51	0.46	1.30	18.1	41.2	121	69	-0.97	-1

(293054) 2006 WP127 ($H = 18.3$)

Mid-July provides the best observing opportunities, if considering only the galactic latitude. The estimated diameter is 650 meters. The period is known to be about 5.3 hours, but that needs confirmation and/or refinement.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/10	13 44.6	+80 49	0.11	0.98	17.3	105.1	69	85	+0.57	+36
07/13	17 53.7	+65 34	0.10	1.02	16.3	83.6	91	85	+0.85	+30
07/16	18 38.6	+45 42	0.11	1.06	15.9	63.0	111	68	+0.99	+21
07/19	18 55.2	+30 03	0.13	1.10	15.9	47.3	127	61	-0.96	+12
07/22	19 03.9	+19 05	0.16	1.14	16.1	36.7	138	75	-0.78	+6
07/25	19 09.3	+11 27	0.19	1.18	16.4	29.8	145	102	-0.51	+1
07/28	19 13.1	+06 00	0.23	1.22	16.7	25.5	149	134	-0.21	-2
07/31	19 16.1	+01 57	0.26	1.25	17.0	23.0	151	156	-0.02	-5
08/03	19 18.7	-01 08	0.30	1.29	17.3	21.6	152	129	+0.05	-7
08/06	19 21.0	-03 35	0.35	1.33	17.6	21.1	152	89	+0.31	-8
08/09	19 23.1	-05 32	0.39	1.37	18.0	21.1	151	50	+0.64	-10
08/12	19 25.2	-07 09	0.43	1.40	18.3	21.4	150	18	+0.89	-11
08/15	19 27.3	-08 29	0.48	1.44	18.5	21.9	148	29	+1.00	-12
08/18	19 29.5	-09 37	0.52	1.47	18.8	22.5	146	61	-0.94	-13

(455432) 2003 RP8 ($H = 18.2$)

There’s no rotation period in the asteroid lightcurve database (LCDB) for this 680-meter NEA. The size virtually assures that the rotation period is going to be $P > 2$ hours. Southern Hemisphere observers are decidedly favored this time around.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/01	22 41.5	-70 29	0.29	1.19	17.6	46.8	121	110	-0.04	-43
07/06	22 13.5	-68 07	0.24	1.17	17.2	44.6	126	127	+0.14	-43
07/11	21 37.8	-63 50	0.20	1.16	16.6	40.4	132	89	+0.67	-42
07/16	20 57.8	-55 59	0.16	1.14	15.8	32.7	143	40	+0.99	-40
07/21	20 18.4	-41 47	0.12	1.13	14.9	19.3	158	48	-0.85	-33
07/26	19 43.8	-19 22	0.11	1.12	14.1	7.5	172	109	-0.41	-20
07/31	19 15.9	+05 42	0.11	1.11	14.9	28.6	148	152	-0.02	-3
08/05	18 54.6	+24 25	0.14	1.11	15.9	45.8	129	94	+0.21	+10
08/10	18 39.1	+35 56	0.17	1.10	16.6	55.7	116	61	+0.74	+18
08/15	18 28.2	+42 58	0.21	1.10	17.2	61.0	108	73	+1.00	+22

(66146) 1998 TU3 ($H = 14.5$)

If looking at Table I, it may seem strange that the estimated SNR is the same for Arecibo and Goldstone. The reason is that the asteroid is significantly farther away during the time it can be observed by Arecibo, which has a more restricted declination range of about -1° to $+38^\circ$.

Closest approach is actually in late August, but the viewing geometry doesn’t allow visual observations until a few days later. Note that the ephemeris goes into the fourth quarter (October) and that the interval is four days.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
09/01	20 27.8	-85 21	0.09	1.03	11.9	72.7	102	97	+0.04	-29
09/05	20 29.2	-71 38	0.11	1.05	12.0	62.8	112	69	+0.38	-33
09/09	20 30.7	-62 13	0.13	1.07	12.3	57.2	116	41	+0.78	-35
09/13	20 32.6	-55 34	0.16	1.09	12.6	54.3	118	50	+0.99	-36
09/17	20 34.9	-50 39	0.18	1.11	13.0	52.9	119	85	-0.93	-37
09/21	20 37.6	-46 52	0.21	1.12	13.3	52.5	118	127	-0.62	-37
09/25	20 40.6	-43 49	0.24	1.13	13.6	52.5	117	156	-0.20	-38
09/29	20 44.1	-41 16	0.27	1.14	13.9	52.8	115	114	+0.00	-38
10/03	20 47.9	-39 06	0.30	1.15	14.1	53.3	113	60	+0.23	-39
10/07	20 52.0	-37 12	0.33	1.16	14.4	53.9	111	19	+0.63	-39

(237805) 2002 CF26 ($H = 17.4$)

The ephemeris interval is 7 days for this 980-meter NEA and so it covers just more than two months. The period is $P \sim 3.77$ h. The phase angle is always relatively large, which could make for some interesting lightcurve shapes due to shadowing; a bimodal lightcurve cannot always be *guaranteed* under such circumstances.

The phase angle bisector longitude swings from 335° to 0° and then up to 35° during the ephemeris interval. The latitude changes by more than 90° over the same time.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
08/01	02 03.3	-45 47	0.42	1.22	17.8	51.5	110	110	+0.00	-67
08/08	02 02.4	-42 59	0.34	1.19	17.4	51.4	113	122	+0.53	-69
08/15	01 55.7	-38 37	0.27	1.16	16.7	50.0	118	63	+1.00	-72
08/22	01 40.1	-30 45	0.20	1.14	15.9	45.6	127	43	-0.66	-79
08/29	01 08.7	-14 14	0.13	1.12	14.7	35.2	140	123	-0.03	-76
09/05	00 08.0	+19 21	0.10	1.10	13.9	29.4	148	128	+0.38	-42
09/12	22 23.8	+51 41	0.13	1.08	15.0	51.6	123	68	+0.96	-5
09/19	20 24.1	+62 58	0.18	1.07	16.2	65.0	105	83	-0.80	+14
09/26	19 01.7	+64 48	0.25	1.06	17.0	69.9	96	93	-0.11	+23
10/03	18 15.7	+64 27	0.32	1.06	17.5	71.1	91	86	+0.23	+28

(141593) 2002 HK12 ($H = 18.1$)

The rotation period for 2002 HK12 is $P \sim 12.7$ hours. A single station can eventually cover the entire lightcurve but two observers at well-separated longitudes could make much quicker work of completing the lightcurve. The estimated diameter is 710 meters. The combination of a closest approach of 0.062 AU, the diameter, and period should make this a bright radar target.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
09/05	04 17.1	+35 45	0.11	1.02	16.2	80.6	93	159	+0.38	-11
09/12	03 41.0	+33 31	0.14	1.06	16.2	65.3	107	96	+0.96	-17
09/19	03 15.3	+31 27	0.17	1.10	16.3	52.6	120	18	-0.80	-22
09/26	02 54.3	+29 26	0.20	1.14	16.5	41.2	131	93	-0.11	-26
10/03	02 36.0	+27 23	0.23	1.19	16.6	30.9	142	154	+0.23	-30
10/10	02 20.0	+25 19	0.26	1.24	16.7	21.5	153	68	+0.87	-33
10/17	02 06.6	+23 18	0.30	1.29	16.8	13.4	163	25	-0.91	-36
10/24	01 55.8	+21 26	0.35	1.34	17.0	7.4	170	117	-0.23	-39
10/31	01 47.9	+19 48	0.41	1.39	17.4	6.7	171	136	+0.11	-41
11/07	01 42.7	+18 26	0.47	1.45	17.9	10.4	165	49	+0.74	-43

(1620) Geographos ($H = 15.6$)

Based on diameter, rotation period, and minimum distance, this NEA would normally be a good target for Arecibo. However, it will move too far away before it gets into the behemoth radar's field of view. The period is well known ($P \sim 5.22204$ h), but data from each new apparition helps refine the amount that YORP is increasing the asteroid's rotation rate (decreasing the period), which has been given as $(1.5 \pm 0.2) \times 10^{-3}$ rad yr⁻² (Rozitis et al., 2014; *AA* 568, A11).

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
09/10	18 29.0	-20 46	0.16	1.07	14.0	62.0	110	25	+0.85	-5
09/13	18 57.1	-16 34	0.17	1.09	14.1	57.7	114	54	+0.99	-9
09/16	19 20.2	-12 53	0.19	1.10	14.2	54.3	117	84	-0.97	-12
09/19	19 39.4	-09 45	0.21	1.12	14.4	51.7	119	114	-0.80	-15
09/22	19 55.5	-07 06	0.23	1.14	14.6	49.7	120	146	-0.51	-17
09/25	20 09.4	-04 52	0.25	1.15	14.7	48.2	121	162	-0.20	-20
09/28	20 21.5	-02 59	0.28	1.17	14.9	47.1	121	129	-0.01	-21
10/01	20 32.3	-01 23	0.30	1.19	15.1	46.2	121	90	+0.08	-23
10/04	20 42.1	-00 01	0.33	1.20	15.3	45.5	121	54	+0.33	-24
10/07	20 51.1	+01 10	0.35	1.22	15.5	44.9	121	26	+0.63	-26

(504800) 2010 CO1 ($H = 21.8$)

The estimated diameter of this NEA is 130 meters. That makes it a good candidate for being a super-fast rotator ($P < 2$ h). If for no other reason that this, use the minimum exposure time that allows a useful SNR, at least until a good estimate of the rotation period has been made. Keep in mind that exposures must be less than $0.187P$ to avoid "rotational smearing" (Pravec et al., 2000; *Icarus* 147, 477-486).

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
09/10	10 39.5	-81 41	0.05	1.01	18.5	90.1	87	76	+0.85	-20
09/12	18 40.3	-78 18	0.04	1.01	17.6	79.3	99	66	+0.96	-26
09/14	19 50.0	-54 29	0.04	1.02	16.9	64.9	113	63	-1.00	-30
09/16	20 06.7	-29 19	0.04	1.03	16.8	53.6	125	74	-0.97	-28
09/18	20 14.3	-10 46	0.05	1.04	17.1	49.6	128	94	-0.87	-23
09/20	20 18.9	+01 05	0.06	1.04	17.6	49.5	128	114	-0.71	-19
09/22	20 22.0	+08 39	0.07	1.05	18.1	50.4	126	131	-0.51	-16
09/24	20 24.6	+13 45	0.09	1.06	18.6	51.3	125	143	-0.30	-14
09/26	20 26.7	+17 20	0.10	1.06	19.0	52.2	123	141	-0.11	-12
09/28	20 28.7	+19 59	0.12	1.07	19.3	52.8	122	125	-0.01	-11

(467317) 2000 QW7 ($H = 19.8$)

Here's another NEA with a known period that is long and, to make things more difficult, is nearly commensurate with an Earth day. This calls for another well-coordinated observing campaign.

On the plus side, the estimated size of 330 meters and minimum distance of about 0.036 AU mean that the SNR for Arecibo could be near 3000 and 1000 for Goldstone.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/01	18 28.2	-07 46	0.31	1.32	18.6	11.9	164	155	-0.04	+2
07/16	18 15.1	-06 29	0.23	1.23	18.1	20.6	155	19	+0.99	+5
07/31	18 03.5	-06 36	0.17	1.15	17.7	34.1	140	153	-0.02	+8
08/15	18 03.7	-09 05	0.12	1.09	17.1	47.2	128	48	+1.00	+6
08/30	18 37.8	-16 49	0.07	1.05	16.1	54.0	123	128	+0.00	-5
09/14	22 15.7	-36 34	0.04	1.04	14.1	35.4	143	32	-1.00	-56
09/29	02 46.6	-19 56	0.06	1.05	15.5	39.9	138	144	+0.00	-63
10/14	03 29.5	-10 05	0.12	1.09	16.7	34.4	142	33	-1.00	-49
10/29	03 33.1	-05 04	0.18	1.16	17.5	23.3	153	160	+0.01	-46
11/13	03 27.5	-01 05	0.26	1.23	18.1	15.4	161	17	-1.00	-44

(2100) Ra-Shalom ($H = 16.1$)

Because of orbital geometries, Ra-Shalom (1.8 km) has reported rotation periods (not counting sidereal periods from modeling) from only four apparitions between 1978 and 2016. The period is about 19.8 h, which makes it a difficult target but it's going to be available for almost three months starting in August. That should be enough time to get a good data set.

The large range of phase angles will likely lead to large changes in lightcurve amplitude and shape. In such circumstances, it's better to do analysis on subsets of data where the synodic period and amplitude are nearly the same. Doing this can be highly instructive for showing the effect of the phase angle on lightcurve amplitude and shape.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
08/01	01 26.1	+27 39	0.41	1.15	16.7	61.5	98	96	+0.00	-35
08/11	01 28.0	+25 38	0.36	1.17	16.3	55.8	107	121	+0.82	-37
08/21	01 23.5	+22 00	0.30	1.19	15.7	48.1	119	17	-0.75	-40
08/31	01 09.2	+15 33	0.25	1.19	14.9	36.9	135	142	+0.01	-47
09/10	00 41.3	+04 32	0.20	1.19	14.0	20.5	155	70	+0.85	-58
09/20	23 58.1	-11 16	0.18	1.18	13.3	8.7	170	66	-0.71	-70
09/30	23 06.0	-26 57	0.19	1.16	14.1	29.5	145	132	+0.03	-67
10/10	22 18.4	-37 21	0.22	1.13	14.9	48.1	122	24	+0.87	-56
10/20	21 44.0	-42 55	0.26	1.09	15.6	61.4	105	136	-0.66	-49
10/30	21 21.9	-45 56	0.31	1.05	16.1	71.5	92	71	+0.05	-45

(354030) 2001 RB18 ($H = 18.5$)

There's no reported period in the LCDB for this 600 meter NEA. The ephemeris stretches into the fourth quarter (October) with a 10-day interval, or nearly three months. It's unusual to have such a prolonged observing opportunity for an NEA. Take advantage if you can.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
07/25	21 28.5	+00 07	0.38	1.37	18.1	19.6	153	69	-0.51	-34
08/04	21 37.0	+02 45	0.31	1.30	17.4	17.5	157	148	+0.12	-34
08/14	21 47.6	+05 38	0.24	1.25	16.8	16.6	159	33	+0.98	-35
08/24	22 03.9	+08 52	0.19	1.19	16.2	17.1	160	90	-0.46	-36
09/03	22 31.5	+12 35	0.15	1.15	15.6	18.1	159	129	+0.18	-38
09/13	23 20.4	+16 41	0.12	1.12	15.0	18.7	159	31	+0.99	-41
09/23	00 39.8	+19 56	0.10	1.09	14.6	20.7	157	84	-0.40	-43
10/03	02 16.1	+19 33	0.09	1.08	14.8	27.1	150	150	+0.23	-39
10/13	03 32.4	+16 00	0.11	1.09	15.2	32.4	144	45	+0.99	-32
10/23	04 16.7	+12 22	0.13	1.11	15.7	32.3	144	75	-0.34	-26

(297418) 2000 SP43 ($H = 18.5$)

Another 600-meter NEA, 2000 SP43 has no reported rotation period. It's in the Sun's glare until the end of September, so the ephemeris carries into mid-October as an incentive to observe early and observe often (weather and moon allowing). Here again, the phase angles are large: look out for unusual lightcurve shapes.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
09/25	18 00.2	-08 37	0.08	1.00	16.1	86.7	89	138	-0.20	+7
09/27	18 38.9	-06 40	0.09	1.02	16.1	78.5	96	119	-0.05	+0
09/29	19 08.8	-05 02	0.10	1.03	16.1	72.3	102	97	+0.00	-6
10/01	19 32.1	-03 42	0.12	1.04	16.3	67.7	106	75	+0.08	-11
10/03	19 50.4	-02 37	0.13	1.05	16.5	64.3	109	53	+0.23	-14
10/05	20 05.3	-01 45	0.15	1.06	16.7	61.8	111	34	+0.43	-17
10/07	20 17.5	-01 01	0.16	1.07	16.8	59.9	112	21	+0.63	-20
10/09	20 27.8	-00 25	0.18	1.08	17.0	58.4	113	25	+0.80	-22
10/11	20 36.7	+00 05	0.19	1.09	17.2	57.3	113	40	+0.93	-23
10/13	20 44.4	+00 32	0.21	1.10	17.4	56.5	113	60	+0.99	-25

1996 TC1 ($H = 23.9$)

1996 TC1 is a PHA and virtual impactor with a diameter of only 50 meters. That makes it very likely that its period is $P < 2$ h and, maybe less so, that it is tumbling. The observing window for backyard telescopes is only 4-6 days.

According to the Minor Planet Center ephemeris, the sky motion (arcsec/min) at 0 h UT will be: Sep 25, 81; Sep 26, 194; Sep 27, 54; Sep 28, 19; Sep 29, 9. To paraphrase a famous movie line, "You're going to need a bigger telescope."

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
09/25	08 40.2	-24 54	0.02	0.99	20.0	124.1	55	45	-0.20	+10
09/26	04 08.9	-18 40	0.01	1.01	16.1	61.4	118	91	-0.11	-44
09/27	01 13.0	+00 31	0.02	1.02	16.1	14.9	165	141	-0.05	-62
09/28	00 25.1	+06 23	0.03	1.03	16.9	5.0	175	163	-0.01	-56
09/29	00 05.1	+08 43	0.04	1.05	17.8	0.4	172	167	+0.00	-52
09/30	23 54.3	+09 57	0.06	1.06	18.5	9.8	170	154	+0.03	-50
10/01	23 47.6	+10 41	0.07	1.07	19.0	11.6	168	140	+0.08	-49
10/02	23 43.0	+11 11	0.09	1.08	19.5	13.0	166	125	+0.15	-48
10/03	23 39.8	+11 32	0.10	1.10	19.9	14.1	164	112	+0.23	-48
10/04	23 37.4	+11 47	0.11	1.11	20.2	15.1	163	98	+0.33	-47

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13063	Purifoy	3	229	68348	2001 LO7	12	238	318411	2005 AH14	78	304
14874	1990 US4	54	280	69971	Tanzi	114	340	381677	2009 BJ81	78	304
15438	Joegotobed	120	346	73308	2002 JJ74	42	268	410088	2007 EJ	78	304
16198	Buzios	127	353	76978	2001 BY60	120	346	414586	2009 UV18	12	238
16529	Dangoldin	115	341	85818	1998 XM4	12	238	445068	2008 SE268	106	332
16724	Ullilotzmann	72	298	88254	2001 FM129	78	304	454177	2013 GJ35	78	304
16880	1998 BW11	54	280	89959	2002 NT7	78	304	464798	2004 JX20	12	238
16908	Groeselenberg	120	346	90403	2003 YE45	78	304		2005 FC3	78	304
16960	1998 QS52	12	238	95260	2002 CS59	120	346		2006 SK134	78	304
17109	1999 JF52	127	353	100088	1993 DC	115	341		2008 US4	12	238
17989	1999 JE64	54	280	101496	1998 XM3	12	238		2010 JV34	12	238
18348	1990 BM1	103	329	110767	2001 UB25	51	277		2014 QR295	78	304
18736	1998 NU1	78	304	136849	1998 CS1	12	238		2016 AZ8	78	304
18736	1998 NU1	61	287	137032	1998 UO1	12	238		2018 WR1	78	304
18895	2000 GJ108	120	346	137052	Tjelvar	12	238		2018 XV	78	304
20446	1999 JB80	12	238	137170	1999 HF1	12	238		2019 AP3	78	304
26355	Grueber	10	236	138852	2000 WN10	12	238		2019 CH	78	304
									2019 EA2	95	321

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