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A NEW OPTIONAL TABLE AND UPDATED MS WORD© TEMPLATES FOR MPB PAPERS

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A new, optional table is suggested, but not required, for use in *Minor Planet Bulletin* papers to present general information about asteroids, including the number, name, family or group, absolute magnitude (H), diameter (D) in km, the three primary orbital elements (*a, e, i*), the orbital period, the primary (only or lead in a group) discoverer, and year and month of discovery. The table can be used in lieu of adding the information to the narrative for each object. This can save space, improve the presentation, and, more important, consolidate the information into one place for easier reference by the reader. Updated MS Word© templates (DOT and DOTX) with two paragraph styles have been put on the MPB web site (*https://mpbulletin.org*) along with a revised Authors Guide than includes details about layout and an example.

As is usually the case for the more technical journals, such as *Icarus*, the reader wants to jump right in: the facts and only the facts are what they want. They don't want an appetizer before the main course. Some people, however, do want something to whet the appetite and so, as a reader of a science paper, they want a little something more to lead them into the heart of subject. This probably fits most *Minor Planet Bulletin* readers. There's good science on every page of the *MPB*, but the less formal tone makes it an excellent outlet that can serve the beginning and professional researcher alike.

In some cases, the "appetizer" is background information on the asteroid before the meat and potatoes of rotation periods and spin states are placed on the table. One of the favorites is to include orbital elements, family or group measurement, a size estimate, and who found the asteroid and when. As one who has published hundreds of *MPB* papers, I appreciate how hard it is to be inventive when repeating the same basic facts for each asteroid, all 25 of them. The reader can find it equally challenging to read such a paper.

A solution that presents itself is a table for all asteroid that displays those repeated facts. This puts them all in one place and lets both author and reader concentrate more on research results. To this end, the editorial staff has created such a text box table with structured formatting that gives a consistent look and contents for the asteroid "extras."

This table is not required for any MPB paper. We encourage including it since filling it in extends the knowledge of author and reader alike. If nothing else, it helps gives a little more context to an asteroid's place in the Solar System and in history.

A sample of the table is shown here. It is very similar to the required Observations and Results table in that it is the same width (7 inches), uses the same font and font size, and it is a text box with tab-separated columns, not an actual table. There are two new paragraph styles in the updated DOT and DOTX word templates: AsteroidDataHead and AsteroidData. These should be used as starting points for creating the table.

The "Fam" column is the assigned family or group number using the LCDB approach (Warner et al., 2009). A number without an asterisk is a family defined by Nesvorny et al. (2015; see also Nesvorny, 2015). Those numbers with an asterisk are groups defined by their (*a, e, i*) orbital space. The "9104" group, for example, is the original LCDB MB-I (inner main-belt) designation.

Number	Name	Fam	H	Dkm	*a (au)*	*e*	*i (deg)*	P(yrs)	Discovered by	yyyy/mm
914	Palisana	9104*	7.74	205.0	2.46	0.214	25.21	3.85	J.C. Watson	1867/09
2286	Fesenkov	9104*	13.12	6.7	2.19	0.094	1.35	3.25	N.S. Chernykh	1977/07
23552	1994NB	701	13.68	4.7	2.36	0.278	23.77	3.67	E.F. Helin	1994/07
134340	Pluto	9109*	-0.45	2733.7	139.59	0.252	17.15	249.09	C. Tombaugh	1930/01

Table I. Orbital and discovery information. Fam is the group or family using the LCDB values. An asterisk indicates a generic group, otherwise, the numbers are from Nesvorny et al. (2015).
Web Sources: JPL: *https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/* MPInfo: *https://minorplanet.info/php/oneasteroidinfo.php*

Authors, and readers, should use the two URLs in the caption under the table to find all the needed information. The JPL site will be the primary source. The MPInfo site gives the LCDB family/group number. If the diameter if missing on the JPL site, use the LCDB value, if listed. Warner et al. (2009) and, in particular, the README.pdf in the public distribution of the LCDB have default albedos for the orbital groups and some families along with the formula for computing a diameter if it is not available elsewhere.

In order to make as much room as possible, those columns with decimal values should limit to the precision to what's seen in the table. For $D < 0.005$ km, use 0.01, for 0.005-0.999 km, round to the nearest 0.01 km. For $D \geq 1.0$ km, round to the nearest 0.1 km. The semi-major axis is rounded to the nearest 0.01 au, the eccentric round to the near 0.001, the inclination to the nearest 0.01 deg, and the orbital period is to the nearest 0.01 years.

For the discoverer, use only the sole name or the first name if two or more. Use only initials, with no space between them and the last name. The year and month of discovery are given as 4-digit year/two-digit month. There just isn't room for the date or the discovery location. If those are important for some reason, include them in the narrative text.

We hope that this provides a clean and easier way to spice up your presentations while providing those little extras that make them all the more interesting. Again, *it is optional*, use it when/if you want.

References

Nesvorny, D.; Broz, M.; Carruba, V. (2015). "Identification and Dynamical Properties of Asteroid Families." In *Asteroids IV* (P. Michel, F. DeMeo, W.F. Bottke, R. Binzel, Eds.). Univ. of Arizona Press, Tucson, also available on astro-ph.

Nesvorny, D. (2015). "Nesvorny HCM Asteroids Families V3.0." NASA Planetary Data Systems, id. EAR-A-VARGBET-5-NESVORNYFAM-V3.0.

Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2023 Oct. *https://www.minorplanet.info/php/lcdb.php*

GENERAL REPORT OF POSITION OBSERVATIONS BY THE ALPO MINOR PLANETS SECTION FOR THE YEAR 2023

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Observations of positions of minor planets by members of the Minor Planets Section in calendar year 2023 are summarized.

During the year 2023 a total of 586 visual and 105 CCD observations of 134 different minor planets were reported by members of the Minor Planets Section.

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 interval. When a significant departure from the predicted magnitude was noted, it is stated in the next line below the number of positions. The year is 2023 in each case.

Positional observations were contributed by the following observers:

Observer, Instrument	Location	Planets	Positions
Faure, Gérard		12	77(40 CCD)
5 cm binoculars	Oléron Island (France)		
20 cm Celestron	Vaison la Romaine (France)		
35 cm Meade LX200	Col de L'Arzelier (France)		
35 cm Meade LX200 + Sony A6000 CCD	Col de L'Arzelier (France)		
Harvey, G. Roger	Concord, North Carolina, USA	125	549
81 cm Newtonian			
Rayon, Jean-Michel		1	65 CCD
45 cm Dobsonian 450 + Sony A6004 CCD	Meylan (France)		

MINOR PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2023)	NO. OBS.
1 Ceres	Faure, 5	May 9-11	3
19 Fortuna	Harvey, 81	Jun 28	3
481 Emita	Harvey, 81	Dec 5	3
820 Adriana	Harvey, 81	Jul 31	3
1227 Geranium	Faure, 20	Sep 10	2
1270 Datura	Faure, 20	Sep 9	2
1370 Hella	Harvey, 81	Oct 23-24	5
1400 Tirela	Faure, 20	Jul 17-18	2
2090 Mizuho	Faure, 20	Sep 9	2
2157 Ashbrook	Harvey, 81	Sep 16	3
2309 Mr. Spock	Faure, 35	Jul 9-10	21 CCD
2966 Korsunia	Harvey, 81	Apr 11	3
3203 Huth	Harvey, 81	Oct 20	3
3370 Kohsai	Harvey, 81	Jan 16	6 0.5f@16.0
3530 Hammel	Harvey, 81	Aug 18	6
3739 Rem	Harvey, 81	Aug 15	3 0.8f@15.6
3972 Richard	Harvey, 81	Oct 10	3
4033 Yatsugatake	Harvey, 81	Apr 23	3
4278 Harvey	Harvey, 81	Sep 9-Oct 10	5
4770 Lane	Faure, 20	Jul 17-18	2
5218 Kutsak	Harvey, 81	Sep 4	3
5404 Uemura	Harvey, 81	Dec 5	3
5730 Yonosuke	Harvey, 81	Nov 5	3
5860 Deankoontz	Harvey, 81	Dec 5	3
6065 Chesneau	Harvey, 81	Sep 4	6
6108 Glebov	Harvey, 81	Aug 18	3
6205 Menottigalli	Harvey, 81	Aug 15-18	3

MINOR PLANET	OBSERVER & APERTURE (cm)	OBSERVING PERIOD (2023)	NO. OBS.
6423 Harunasan	Harvey, 81	Oct 9	3
6427 1995 FY	Harvey, 81	Sep 12	3
6581 Sobers	Harvey, 81	Nov 20	3
6646 Churanta	Harvey, 81	Feb 14	3
			0.4b@15.9
6879 Pauldavies	Harvey, 81	Mar 1	3
6888 1971 BD3	Harvey, 81	Dec 20	3
7020 Yourcenar	Harvey, 81	Sep 5	3
7102 Neilbone	Harvey, 81	Aug 15	3
7170 Livesey	Harvey, 81	Nov 19	3
7268 Chigorin	Harvey, 81	Sep 12	3
7422 1992 LP	Harvey, 81	Aug 18	3
7921 Huebner	Harvey, 81	Aug 18	3
8155 Battaglini	Harvey, 81	Sep 5	3
8265 1986 RB5	Harvey, 81	Aug 18	3
8638 1986 QY	Harvey, 81	Dec 16	3
9145 Shustov	Harvey, 81	Apr 11	3
9909 Eschenbach	Harvey, 81	Nov 20	3
9945 Karinaxavier	Harvey, 81	Jul 12	3
10039 Keet Seel	Harvey, 81	Jul 12	3
10756 1990 SJ2	Harvey, 81	Oct 19	3
10824 1993 SW3	Harvey, 81	Sep 12	3
10988 Feinstein	Harvey, 81	Jul 12	3
11303 1993 CA1	Harvey, 81	Jan 28	3
11386 1998 TA18	Harvey, 81	Jul 25	3
12332 1992 UJ6	Harvey, 81	Oct 19	3
12374 Rakhat	Harvey, 81	Aug 21	3
12867 Joëloïc	Faure, 35	Aug 11-14	25 (19 CCD)
	Rayon, 45	Aug 17-Sep 24	65 CCD
15676 Almoisheev	Harvey, 81	Oct 23	3
			0.5f@16.0
15700 1987 QD	Harvey, 81	Aug 21	6
15796 1993 TZ38	Harvey, 81	Aug 20	3
16591 1992 SY17	Harvey, 81	Jul 25	3
16735 1996 JJ	Harvey, 81	Apr 11	3
17112 1999 JM52	Harvey, 81	Sep 4	6
17252 2000 GJ127	Harvey, 81	Sep 16	3
17518 Redqueen	Harvey, 81	Jan 15	3
17846 1998 HB115	Harvey, 81	Feb 14	3
18910 Nolanreis	Harvey, 81	Sep 16	3
19239 1994 AM2	Harvey, 81	Feb 14	3
19373 1997 YC14	Harvey, 81	Aug 21	3
20062 1993 QB3	Harvey, 81	Aug 21	3
21101 1992 OJ1	Harvey, 81	Aug 17	3
21261 1996 FF	Harvey, 81	Apr 18	6
23552 1994 NB	Harvey, 81	Mar 15	3
23587 Abukamado	Harvey, 81	Sep 5	3
24428 2000 CZ26	Harvey, 81	Aug 19	3
24643 MacCready	Harvey, 81	Oct 9	3
25283 1998 WU	Harvey, 81	Aug 15	3
25739 2000 AJ202	Harvey, 81	Nov 19	3
25891 2000 WK9	Harvey, 81	Dec 7	3
26853 1992 UQ2	Harvey, 81	Oct 9	3
28761 2000 HU12	Harvey, 81	Nov 5	3
31485 1999 CM5	Harvey, 81	Oct 19	3
32153 2000 LM34	Faure, 35	Aug 14	3
32772 1986 JL	Harvey, 81	Dec 20	3
32773 1986 TD	Harvey, 81	Nov 4	3
37586 1991 BP2	Harvey, 81	Jan 24	6
37638 1993 VB	Harvey, 81	Feb 18	6
39510 1982 DU	Harvey, 81	Mar 1	3
44530 Horakova	Harvey, 81	Dec 20	3
48469 1991 TQ1	Harvey, 81	Oct 10	3
50403 2000 CB114	Harvey, 81	Nov 20	3
57356 2001 QG293	Harvey, 81	Aug 17	6
59225 1999 CC	Harvey, 81	Dec 7	3
63630 2001 QE83	Harvey, 81	Dec 8-12	4
65190 2001 CV247	Harvey, 81	Sep 12	3
76864 2000 XR13	Harvey, 81	Jul 11	3
77799 2001 QV88	Harvey, 81	Dec 20	3
82256 2001 KM8	Harvey, 81	Nov 5	3
88161 2000 XK18	Harvey, 81	Aug 21	3
88264 2001 KN20	Harvey, 81	Jun 14	6
94891 2001 YC5	Harvey, 81	Oct 19	3
97514 2000 DL1	Harvey, 81	Mar 14	6
98943 2001 CC21	Harvey, 81	Jan 24	6
			0.5b@15.9
100119 1993 OB	Harvey, 81	Aug 21	6
138978 2001 CD32	Harvey, 81	Feb 13	6
139622 2001 QQ142	Harvey, 81	Dec 12	6
154244 2002 KL6	Faure, 35	Jun 24	5
199145 2005 YY128	Harvey, 81	Feb 13	6
218863 2006 WO127	Harvey, 81	Mar 14	6
302169 2001 TD45	Harvey, 81	Oct 29	6
326683 2002 WP	Harvey, 81	Dec 12	6
349507 2008 QY	Harvey, 81	Oct 5	6
367789 2011 AG5	Harvey, 81	Jan 27-28	12
415752 2000 OB22	Harvey, 81	Aug 28	6
458732 2011 MD5	Faure, 35	Sep 10	5
	Harvey, 81	Sep 1	6
467336 2002 LT38	Faure, 35	Jun 25	5
	Harvey, 81	Jun 14	6
488453 1994 XD	Harvey, 81	Jun 10	6
503871 2000 SL	Harvey, 81	Apr 18	6
518635 2008 HO3	Harvey, 81	Oct 1	6
525229 2004 UU1	Harvey, 81	Oct 30	6
			0.5f@15.3
620082 2014 QL433	Harvey, 81	Aug 9	6
620102 2017 QM18	Harvey, 81	Jun 10	6
1998 HH49	Harvey, 81	Oct 19	6
1998 QK28	Harvey, 81	Aug 24	6
2004 GA	Harvey, 81	Mar 30	6
2004 UV1	Harvey, 81	Nov 23-29	12
2006 HV5	Harvey, 81	Apr 23	6
2009 UG	Harvey, 81	Oct 3	6
2011 GA	Harvey, 81	Oct 15-17	12
2019 LH5	Harvey, 81	Jul 7	6
2020 DB5	Harvey, 81	Jun 10	6
2021 SZ4	Harvey, 81	Oct 23-24	12
2023 DQ	Harvey, 81	Mar 8	6
2023 DZ2	Harvey, 81	Mar 24	6
			0.5f@16.1
2023 FM	Harvey, 81	Apr 2	6
			0.5f@15.9
2023 GG	Harvey, 81	Apr 10	6
			0.6f@16.3
2023 HO6	Harvey, 81	Jun 28-29	12
2023 QC	Harvey, 81	Aug 19	6

CALL FOR OBSERVATIONS OF THE PATROCLUS AND MENOETIUS MUTUAL EVENTS: SUPPORT FOR THE NASA LUCY MISSION TO THE TROJAN ASTEROIDS

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Trojan asteroid 617 Patroclus is a large binary pair orbiting in the region of Jupiter's L5 Lagrangian point. The Patroclus-Menoetius binary is a flyby target for NASA's Lucy mission, to be reached in 2033 March. The binary orbit plane crosses the line-of-sight to Earth during the upcoming 2024 September opposition. Photometric measurements can record "mutual event lightcurves" as each body alternately transits and occults the other over the pair's 4.28-day orbital period. Extensive lightcurve measurements are needed to refine the binary orbit and the sizes and shapes of the two components. These refined estimates will allow the most precise instrument targeting by the Lucy spacecraft, supporting the maximum possible science return from the mission.

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The binary nature of L5 Trojan asteroid 617 Patroclus was discovered in 2001 through adaptive optics imaging (Merline et al., 2001). Patroclus and its companion Menoetius, are nearly equal-sized and estimated to be 113 and 104 km, respectively, in their average dimensions. As a large asteroid binary, Patroclus-Menoetius are a target of great interest for spacecraft exploration. Indeed, they are a 2033 March flyby target for NASA's Lucy mission, launched in 2021, which will first explore targets in the L4 Trojan cloud before being re-targeted to the L5 Trojan cloud (Levison et al., 2021).

Spacecraft flyby measurements of Solar System bodies require detailed advanced planning since all pointing parameters, imaging sequences, integration times, etc. must be pre-planned well in advance because the spacecraft *must* perform autonomously during the precious time of closest approach. There are no second chances. The challenge is exacerbated for a binary system, where two bodies are to be studied. Precious time cannot be lost by instrument pointing that is off the edge of the desired target. Therefore, maximum precision knowledge of the target's mutual orbit, separation, sizes, and shapes are of critical value in order to optimize mission planning.

Fortuitously, the orbit plane of the Patroclus-Menoetius binary system crosses through the Earth's line-of-sight twice during their 11.89-year heliocentric orbital period, with the next opportunity coming during their 2024 September opposition at a bright visual magnitude of 14.6. During this time, a series of mutual transits and occultations between the two bodies is readily observable, alternatively during the pair's 4.282753 ± 0.000023-day orbital period (Brozovic et al., 2024). Collectively, these are referred to as "mutual events." Lightcurves of these mutual events impose powerful constraints on the system's orbital parameters and on the shapes and relative sizes of the components.

The author serves as the coordinator of Earth-based telescopic observations in support of the NASA Lucy Mission. Herewith, the asteroid lightcurve community is called upon and encouraged to obtain measurements of Patroclus-Menoetius mutual events. Brozovic et. al. (2024; see their Tables 3 and 4) present detailed predictions, with dates and times reproduced here for convenience. More detailed information on the nature of each predicted event is presented within Brozovic et al., and observers should consult this primary reference directly.

A mutual event can vary in length from a few minutes up to ~7 hours, depending on whether the objects are nearly tangent to one another or are passing directly across the observer's line-of-sight. Similarly, the depth of the event may be a few hundredths of a magnitude to several tenths of a magnitude, where "eclipse" shadows can be a factor in the photometric depth. The predicted times, as tabulated, are imprecise estimates: observers should devote one or more hours before or after the listed times if local observability allows. Photometric precision of 0.01 magnitude or better is desired for individual lightcurve points, a measurement goal that should be taken into account when choosing integration times and/or co-adding individual measures. Partial lightcurves providing timing of individual ingress or egress and event depth are valuable products. Such are the likely products that can be obtained from a single location.

The Minor Planet Bulletin will welcome publication of mutual event lightcurves. The author will facilitate archival of the measurements and their incorporation for updated solutions of the physical parameters of the Patroclus-Menoetius system for use in NASA Lucy Mission planning.

Start Date	UT Start	UT Max	UT End	Type	V mag
2024 09 21	16:04	18:45	21:48	Inferior	14.7
2024 09 23	19:17	21:51	00:51	Superior	14.6
2024 09 25	23:02	01:41	04:26	Inferior	14.6
2024 09 28	02:15	04:50	07:30	Superior	14.6
2024 09 30	06:00	08:38	11:09	Inferior	14.6
2024 10 02	09:14	11:50	14:22	Superior	14.6
2024 10 04	12:58	15:30	18:07	Inferior	14.7
2024 10 06	16:12	18:48	21:20	Superior	14.7
2024 10 08	19:57	22:26	01:05	Inferior	14.7
2024 10 10	23:08	01:45	04:18	Superior	14.7
2024 10 13	02:45	05:24	08:03	Inferior	14.7
2024 10 15	05:52	08:42	11:16	Superior	14.7
2024 10 17	09:29	12:22	15:01	Inferior	14.8
2024 10 19	12:37	15:40	18:14	Superior	14.8
2024 10 21	16:14	19:20	21:58	Inferior	14.8
2024 10 23	19:22	23:37	01:11	Superior	14.8

Table I. Predictions are from Brozovic et al. (2024). Inferior events are Menoetius on the near-side to the observer; Superior events are Menoetius on the far-side to the observer.

References

Brozovic, M.; Jacobson, R.A.; Park, R.S.; Descamps, P.; Berthier, J.; Pinilla-Alonso, N.; Popescu, M.; Licandro, J. (2024). "Orbit of the Patroclus-Menoetius Binary System and Predictions for the 2024/2025 Mutual Events Season." *Astron. J.* **167**, 104, 12 pp. DOI 10.3847/1538-3881/ad1f6e.

Levison, H. and 24 colleagues (2021). "Lucy Mission to the Trojan Asteroids: Science Goals." *Planetary Science Journal* **2**, id.171, 13 pp. DOI 10.3847/PSJ/abf840.

Merline, W.J.; Close, L.M.; Siegler, N.; Potter, D.; Chapman, C.R.; Dumas, C.; Menard, F.; Slater, D.C.; Baker, A.C.; Edmunds, M.G.; Mathlin, G.; Guyon, O.; Roth, K. (2001). "S/2001 (617) 1." *IAU Circ*. **7741**, #2.

300 GERALDINA: POSSIBLY A BINARY WITH A TILTED ROTATIONAL AXIS

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The best of seven published lightcurves of the outer main belt asteroid 300 Geraldina show sharp V-shaped dips characteristic of some binary asteroids. These lightcurves show a range of amplitudes, from 0.04 to 0.3 mag. These lightcurves, plus one new one reported here, suggest the asteroid has a rotational axis near the ecliptic plane. In February 2025, this object will be near opposition and well placed for northern hemisphere observers.

300 Geraldina has an orbital period of 5.75 y, a semimajor axis of 3.210 AU, an eccentricity of 0.059, and an orbital inclination of 0.°7. Seven lightcurves have been published for this object, with the best rotational period being 6.8423 h (Roy and Antonini, 2008).

In December 2023, the author obtained photometry of Geraldina on three nights using the 0.43-m T19 iTelescope at the Utah Desert Remote Observatory (IAU code U94). Two-minute exposures through a luminance filter were obtained spanning 11.3 hours in total. Observations of standard stars in the Landolt system (Clem and Landolt, 2013) provided an excellent transformation between the luminance and V system. The lightcurve below presents absolute V mags, H(V), derived assuming G=0.15 (Bowell et al., 1989). The final data set of 309 points was fit with a smooth spline. The standard deviation scatter around the fit is 0.011 mag. Due to the low amplitude and lack of any sharp features no attempt was made to determine a period from this data, so the data was phased with a period of 6.8423 h.

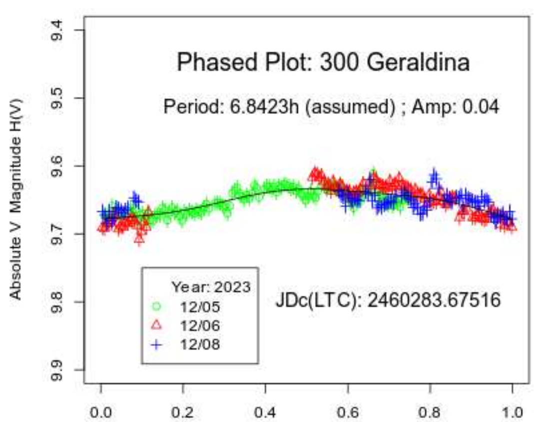

Figure 1. Phased absolute magnitude plot. The observed V mags average around 14.1.

The new lightcurve shows an amplitude of 0.04 mag. This lightcurve is very similar to two published lightcurves, both of which show amplitudes of 0.04 mag (Polakis, 2018; Klinglesmith and Hendrickx, 2018). Three other published lightcurves show amplitudes around 0.15 mag (Licchelli, 2006; Waszczak et al., 2015; Chang et al., 2014). Another two lightcurves give larger amplitudes around 0.3 mag (Ivanova et al., 2002; Roy and Antonini, 2008). One curious aspect of the three lightcurves with low amplitude is that they appear to be single- peaked for the assumed 6.8423 h period, while the other lightcurves show 2 distinct minima for this period.

The Roy and Antonini (2008) lightcurve is the only published one with the highest quality rating (Q=3) in the asteroid lightcurve database (Warner et al., 2009). This curve shows two sharp V shaped minima. At the midpoints in magnitude between maximum and minima these minima have widths of 0.10 and 0.12 of the rotational period. Such narrow minima dips are sometimes seen in binary asteroids, suggesting the possibility that Geraldina is a binary.

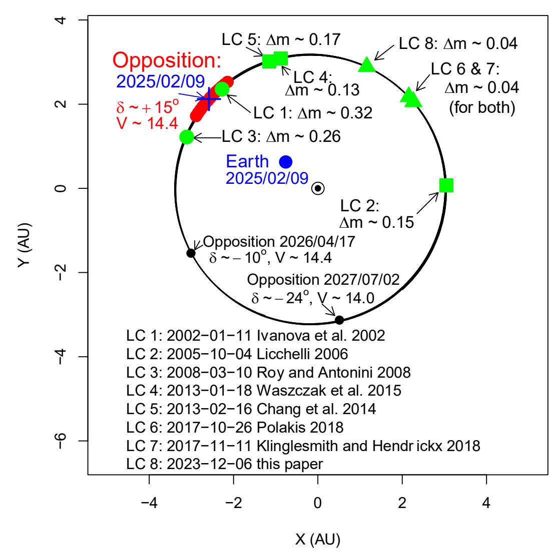

Figure 2. The black ellipse traces the path of Geraldina projected onto the ecliptic plane for the years 2000 to 2025. The green symbols mark the positions of the lightcurves which are labeled with amplitude and number corresponding to the references listed. The blue plus sign marks the position at the 2025 opposition and the heavy red line segment marks the position for the 4 months centered on opposition, during which time the object will be more than 120° from the Sun as seen from Earth, and thus easily observed.

Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
300	Geraldina	2023 12/05-12/08	2.3-3.4	66	0	6.8423(P assumed)		0.04	0.01	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 an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

The orbital positions of Geraldina at the times when each lightcurve was observed are shown in Figure 2. The positions of low, intermediate and high amplitude lightcurves suggest that the rotational axis of the Geraldina system lies near the ecliptic plane, so that the low amplitude lightcurves were obtained looking along a line of sight near the rotational axis and the high amplitude lightcurves were obtained approximately 90° around the orbit from the low amplitudes ones.

At its next opposition in February 2025, Geraldina will be near the position where it was when the high amplitude lightcurves were found. In February 2025 Geraldina should have a V mag as bright as 14.3 at a declination of +15°, providing an excellent observing opportunity for northern hemisphere observers with small telescopes.

If Geraldina is a true binary, with separated components, it would have a small separation between components given the short rotational period. This object, like others with similar lightcurves, could simply be an elongated single object, a contact binary, or a true detached, but close, binary.

Acknowledgements

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LIGHTCURVE AND ROTATION PERIOD OF 703 NOEMI

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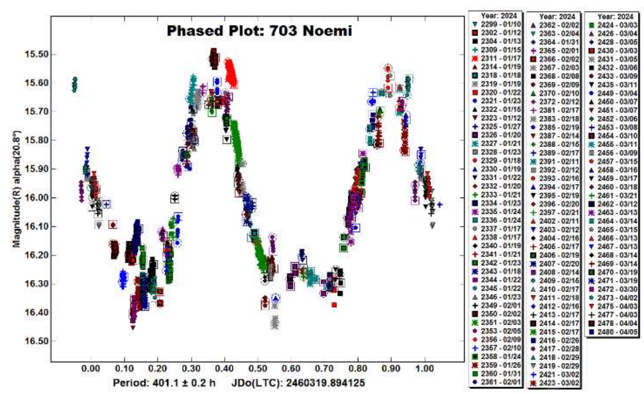
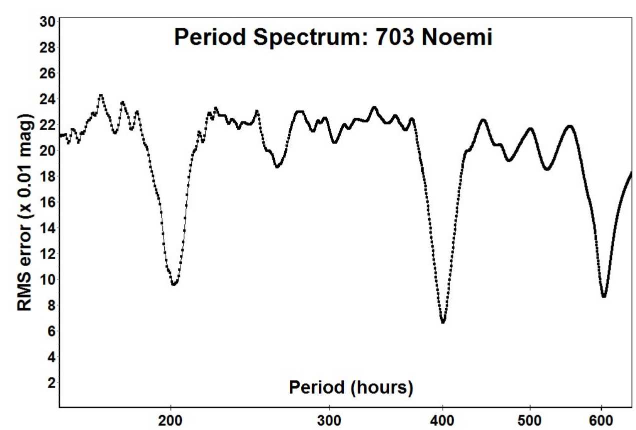
At its early 2024 opposition, a worldwide collaboration of observers have found for 703 Noemi a synodic rotation period of 401.1 ± 0.2 hours, amplitude 0.70 ± 0.05 magnitudes.

The Lightcurve data base (Warner et al., 2009; updated 2023 Oct.) provides three published values of 703 Noemi's rotation period: Franco et al. (2017), 200 hours; Noschese et al. (2017), 201.7 hours, and Sada et al. (2017), 115.108 hours. All three investigations were made near the 2016 November favorable opposition.

A total of 123 sessions 2024 Jan. 10 - April 5 were obtained by the several observers, ranging from four tightly spaced data points to as long as nine hours. Table II provides their complete equipment list. The data provide a good fit to a phased lightcurve with period 401.1 ± 0.2 hours, amplitude 0.70 ± 0.05 magnitudes, with two maxima and minima per rotational cycle. A period spectrum between 150 hours and 650 hours shows deep minima near 200 hours, 400 hours, and 600 hours, with the corresponding lightcurves showing one, two, and three maxima, respectively, per rotational cycle. Harris et al. (2014) shows that for amplitudes exceeding 0.4 magnitudes the only possible lightcurve for an object of uniform albedo has two maxima and minima per rotational cycle. Hence, we choose 401.1 hours as the only period allowed by our data set, with an amplitude of 0.70 magnitudes.





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Number	Name	yyyy/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E	Amp	A.E.
703	Noemi	2024/01/10-04/05	*20.9,18.0	156	-3	401.1	0.3	0.70	0.05

Table I. Observing circumstances and results. The phase angle is given for the first and last date, where the * indicates a minimum was reached between these dates. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984).

Observer	Telescope	Camera
F. Pilcher	SCT 0.35m	SBIG STL-1001E CCD
W. Hawley	SCT 0.35m	SX694 Trius Pro CCD
P. Wiggins	SCT 0.35m	SBIG ST-10 XME CCD
J. D. Armstrong	L09 Sutherland-LCO Aqawan A #1, 0.4m Q58 Siding Spring-LCO Clamshell #1, 0.4m Q59 Siding Spring-LCO Clamshell #1, 0.4m T04 Haleakala-LCO Clamshell #1, 0.4m Z17 Tenerife-LCO Aqawan A #2, 0.4m Z21 Tenerife-LCO Aqawan A #1, 0.4m	QHY 600 CMOS QHY 600 CMOS QHY 600 CMOS QHY 600 CMOS QHY 600 CMOS QHY 600 CMOS
P. Leyland	Dilworth 0.4m	SX 814 Trius Pro CCD
J. McCormick	SCT 0.35m	SBIG St-8 XME CCD
J. Genebriera	RC 0.41m	Moravian G4-16000 CCD
E. Kardasis	SCT 0.28m	ASI 183 Pro CCD
T. Haymes	SCT 0.28m	QHY 174 CCD
G. J. Privett	0.3m Newtonian	SX 694 Trius Pro CCD
A. Noschese et al.	Osservatorio Salvatori Giacomo MPC L07, RC 0.5m, f/8 iTelescope 30, Siding Spring Observatory, Australia, MPC Q62, CDK 0.5m, f/6.8 iTelescope 21, Utah Desert Remote Observatory at Great Basin Desert, Beryl Junction, Utah, USA, MPC U94, CDK 0.43m, f/4.5	FLI-PL4240E CCD FLI-PL6303E FLI-PL6303E CCD

Table II. Equipment List.

Harris, A.W.; Pravec, P.; Galad, A.; Skiff, B.A.; Warner, B.D.; Vilagi, J.; Gajdos, S.; Carbognani, A.; Hornoch, K.; Kusnirak, P.; Cooney, W.R.; Gross, J.; Terrell, D.; Higgins, D.; Bowell, E.; Koehn, B.W. (2014). "On the maximum amplitude of harmonics on an asteroid lightcurve." *Icarus* **235**, 55-59.

Noschese, A.; Vecchione, A.; D'Avino, L.; Izzo, L. (2017). "Lightcurve Analysis for Minot Planet 703 Noemi." *Minor Planet Bull.* **44**, 177-178.

Sada, P.V.; Olguín, L.; Saucedo, J.C.; Loera-González, P.; Garza, J.R.; Ayala-Gómez, S.A.; Avilés, A.; Pérez-Tijerina, E.; Navarro-Meza, S.; Silva, J.S.; Reyes-Ruiz, M.; Segura-Sosa, J.; López-Valdivia, R.; Álvarez-Santana, F. (2017). "Results of the 2016 Mexican Asteroid Photometry Campaign." *Minor Planet Bulletin* **44**, 239-242.

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THE ROTATION PERIOD OF 740 CANTABIA IS RE-EXAMINED

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Rotation periods close to both 64.45 and 32.14 hours have been published for 740 Cantabia. We have re-examined the data and explain why we prefer the 32.14-hour period, with solution 32.141 ± 0.007 hours.

The Lightcurve Database (Warner et al., 2009; updated 2023 Oct.) provides three published values of 740 Cantabia's rotation period: Stephens et al. (2010), 64.453 hours; Behrend (2020), 14.798 hours based on a very sparse lightcurve; and Pál et al. (2020), 32.1535 hours.

Like many asteroids, 740 Cantabia's period is difficult to resolve because the range of observed amplitudes has always been low, ranging from 0.04 to 0.16 mag. With such a low amplitude, it is possible that a lightcurve could have a single minimum/maximum pair, or three or more pairs (Harris et al., 2014).

To resolve the discrepancy in periods, we started by adjusting the zero points of our own sessions (Stephens et al., 2010) by several x0.01 magnitudes to best fit to a period near 32 hours. Figure 1 shows the resultant lightcurve with one maximum and minimum per rotational cycle, rotation period 32.200 ± 0.002 hours, amplitude 0.11 ± 0.02 magnitudes. A period spectrum (Fig. 2) shows the fit to 32.200 hours is as good as the fit to 64.453 hours in the original publication. We note that many asteroids have unambiguous lightcurves with one maximum and minimum per rotational cycle when fairly near polar aspect. Therefore, we must consider the data from the year 2010 to yield a rotation period ambiguous between 32.2 and 64.4 hours.

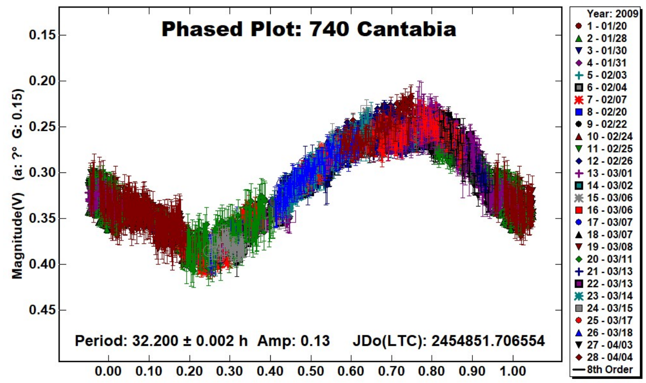

Figure 1. Lightcurve of 740 Cantabia from the year 2009 data (Stephens et al., 2010) phased to 32.200 hours.

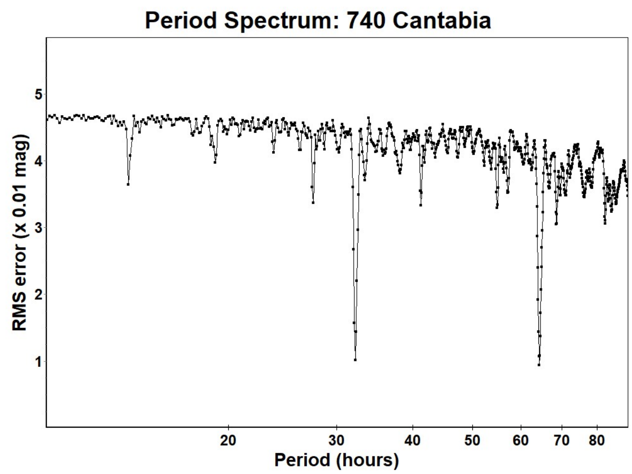

Figure 2. Period spectrum of 740 Cantabia from the year 2009 data (Stephens et al., 2010) phased to 32.200 hours.

We then downloaded the data from Pál et al. (2020) as presented on www.ALCDEF.org, plotted a lightcurve phased to near 32.15 hours, and deleted several outlying data points. Adjustment of the zero points of individual sessions by as much as 0.05 magnitudes was made until the rms error of all data points was minimized. These operations produced a slightly asymmetric bimodal lightcurve (Fig. 3) with period 32.141 ± 0.007 hours, amplitude 0.13 ± 0.02 magnitudes. A split halves plot to the double period of 64.287 hours (Fig. 4) shows that the two halves are nearly identical, and strongly supports a period near 32.14 hours.

Number	Name	yyyy/mm/dd	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.
740	Cantabia	2009/01/20-04/03	*12.9,16.0	152	8	32.200	0.002	0.13	0.02
740	Cantabia	2018/12/16-2019/01/06	* 3.0,7.3	87	-6	32.141	0.007	0.16	0.02

Table I. Observing circumstances and results. The phase angle is given for the first and last date, where the * indicates a minimum was reached between these dates. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984).

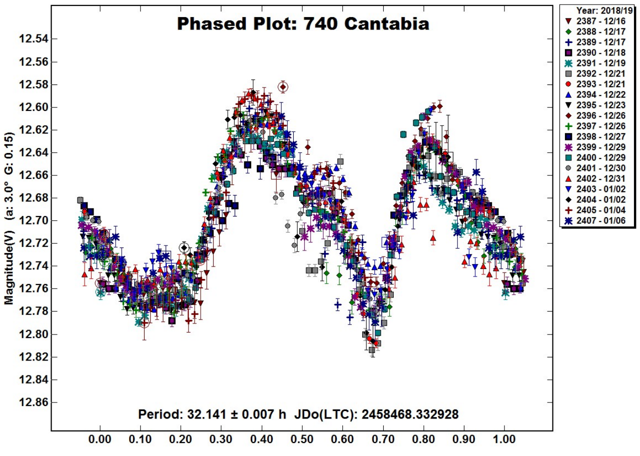

Figure 3. Lightcurve of 740 Cantabia from the year 2018-2019 data (Pál et al., 2020) phased to 32.141 hours.

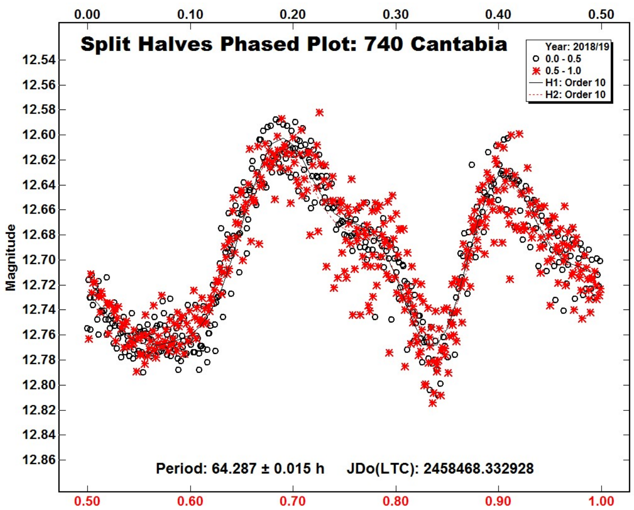

Figure 4. Split halves lightcurve of 740 Cantabia from the year 2018-2019 data (Pal et al., 2020) phased to 64.287 hours.

We conclude that all available data considered together favor the 32-hour period over the 64-hour period. The data from both Stephens et al. (2010) and Pál et al. (2020) are on file in the web source *www.ALCDEF.org* with sharing allowed. We invite any interested reader to make an independent investigation.

The next opposition of 740 Cantabia occurs 2025 Feb. 19 at celestial longitude 151°, declination +20°, very close to the circumstances of our year 2009 investigation. The following opposition is 2026 June 4, at celestial longitude 253°, declination -11°, less favorable from the northern hemisphere. We encourage observers to put both of these events on their schedules.

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Pál, A.; Szakáts, R.; Kiss, C.; Bódi, A.; Bognár, Z.; Kalup, C.; Kiss, L.L.; Marton, G.; Molnár, L.; Plachy, E.; Sárneczky, K.; Szabó, G.M.; Szabó, R. (2020). "Solar System Objects Observed with TESS - First Data Release: Bright Main-belt and Trojan Asteroids from the Southern Survey." *Ap. J. Suppl Ser*. **247**, id. 26.

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THE AMBIGUOUS ROTATION PERIOD OF 805 HORMUTHIA IS SOLVED BY A GLOBAL COLLABORATION OF OBSERVERS

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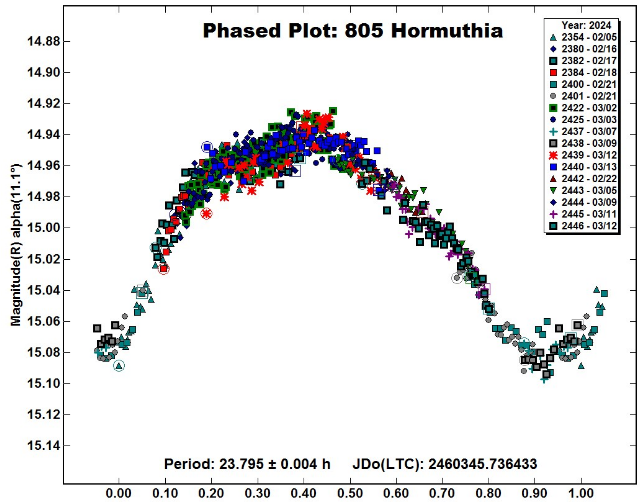
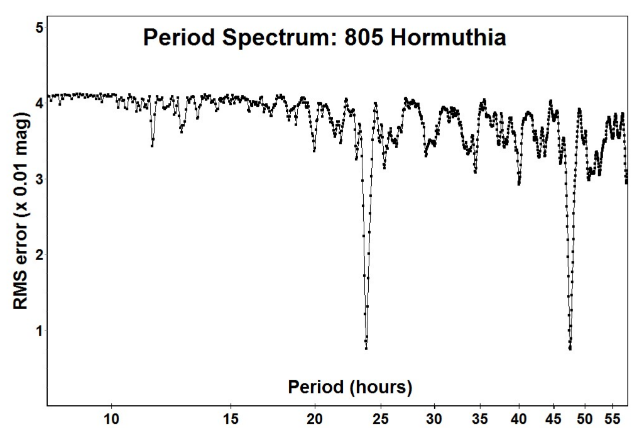
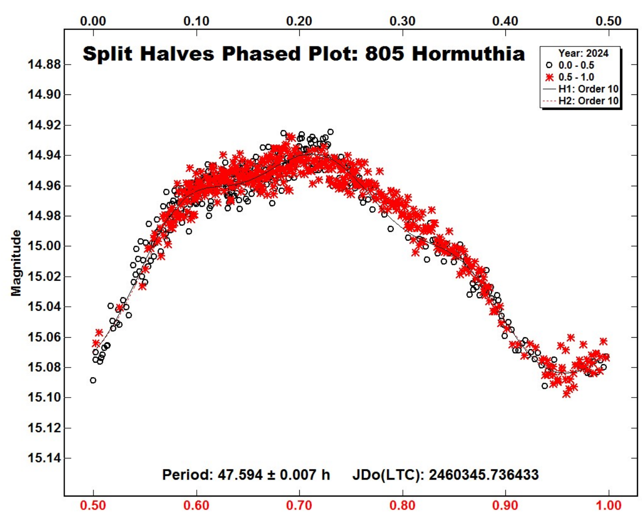
Observers from North America, Australia, and Europe collaborated to find for 805 Hormuthia at its 2024 opposition an unambiguous synodic rotation period of 23.795 ± 0.004 hours and an amplitude of 0.13 ± 0.01 magnitudes with one maximum and minimum per rotational cycle.

Four previous reports provide four different rotation periods for 805 Hormuthia: Behrend (2019web), 23.76 hours; Dose (2021), 11.89 hours; Pilcher and Benishek (2009), 9.51 hours; Polakis (2021), 35.64 hours. It is noteworthy that these periods are, respectively, 1/1, 1/2, 2/5, and 3/2 of the nearly Earth commensurate period of 23.76 hours. The several authors of this paper, from Australia, Europe, and North America collaborated to determine which, if any, of these periods is the correct one. An equipment list for all of the observers is provided in Table II.

A total of seventeen sessions were obtained by the several observers in the interval 2024 Feb. 5 - March 13. They provide an excellent fit to a lightcurve with period 23.795 ± 0.004 hours, an amplitude of 0.13 ± 0.01 magnitudes, and one maximum and minimum per rotational cycle. The period spectrum shows that all periods except this one and the double period of 47.594 hours can be definitively ruled out. A split halves plot shows that both halves of the double period are identical within instrumental error and that the double period is also ruled out. Hence a synodic rotation period of 23.795 ± 0.004 hours can now be considered secure.







Number	Name	yyyy/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E	Amp	A.E.
805	Hormuthia	2024/02/05-2024/03/13	11.1, -0.7	173	1	23.795	0.004	0.13	0.01

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

Observatory (MPC code)	Telescope	CCD	Filter
Organ Mesa Observatory (G50)	0.35-m SCT f/10	SBIG STL-1001E	C
Sopot Astronomical Observatory (K90)	0.35-m SCT f/6.3	SBIG ST-10 XME	C
Blue Mountains Observatory (Q68)	0.35-m SCT f/5.9	SBIG STT1603	C
Osservatorio Astronomico Nastro Verde (C82)	0.35-m SCT f/6.3	SBIG ST10XME (bin 2x2)	C
Astronomical Observatory, University of Siena (K54)	0.30-m MCT f/5.6	SBIG STL-6303e(bin 2x2)	C

Table II. Observing Instrumentations. MCT: Maksutov-Cassegrain, SCT: Schmidt-Cassegrain.

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Behrend, R. (2019web). Observatoire de Geneve web site. *http://obswww.unige.ch/~behrend/page_cou.html*

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Pilcher, F.; Benishek., V. (2009). "Period determinations for 634 Ute and 805 Hormuthia." *Minor Planet Bull*. **36**, 29-30.

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LIGHTCURVES FOR L5 TROJAN ASTEROID (884) PRIAMUS AND KORONIS FAMILY MEMBER (1443) RUPPINA

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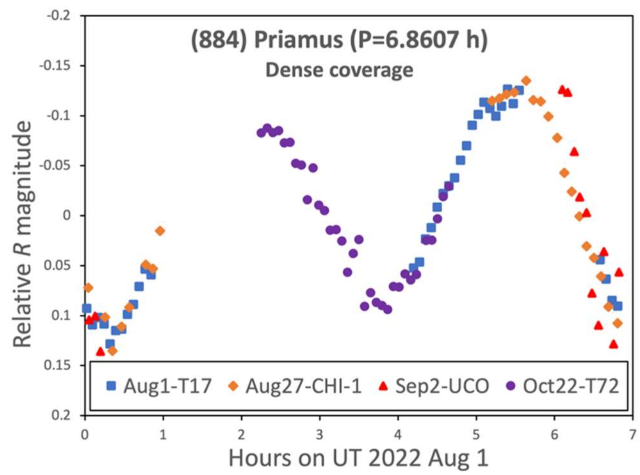
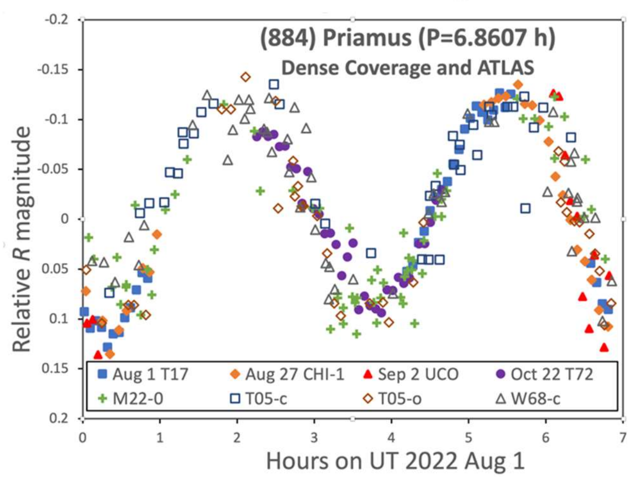
We present lightcurves for (884) Priamus during 2022 and (1443) Ruppina during 2024. Priamus was observed on four nights at four observatories with derived synodic period 6.8607 ± 0.0004 h and amplitude of 0.23 ± 0.03 mag. Ruppina was observed on a single night with period consistent with previously published values, and amplitude 0.32 ± 0.05 mag. Both lightcurves were doubly-periodic at these periods.

In this paper, we have expanded our studies of Koronis family members to also include a Jupiter Trojan in honor of the Lucy Mission. Observation planning was performed using the *Koronisfamily.com* webtool (Slivan, 2003), which accepts numbered asteroids from a predefined list, one of which includes Priamus. Telescope and camera properties are given in Table I. Bias, dark, and flat field corrections for images from the Union College Observatory (UCO) and subsequent photometry were performed in *AstroImageJ* (Collins et al., 2017). Corrections for light-travel time were applied based upon ephemerides from JPL Horizons (JPL, 2024).

<u>(884) Priamus</u>. From prior studies, the period for Priamus was given as 6.8605 ± 0.0005 h (French et al., 2011), 6.854 ± 0.002 h (Stephens et al., 2015) and 6.863 ± 0.001 h (Stephens et al., 2016). Multi-apparition analyses have yielded a sidereal period of 6.86137 ± 0.00001 h (Stephens, 2017) using dense and sparse data. Hanuš et al. (2023) provide sidereal period 6.861330 h and a shape/spin solution using sparse data.

We performed imaging observations on four nights in 2022 from Aug 1 to Oct 22 at four observatories (see Table I). The observation dates are indicated in the legend to the dense coverage lightcurve. We also examined ATLAS sparse survey data (Tonry et al., 2018) for 2022 at telescopes M22, T05 and W68 in the *o* and *c* filters (orange, 560-820 nm; cyan, 420-650 nm) constrained in time between the two stationary points in 2022. ATLAS photometry was corrected for light travel time, unit distance and solar phase angle using a slope parameter $G = 0.15$. Brightness values from individual nights were shifted to produce a self-consistent composite using the ATLAS data as a template across our dense coverage gap. The ATLAS data illustrate that the first maximum falls in our coverage gap. From our final lightcurve of the dense coverage, we derived a synodic period value of 6.8607 ± 0.0004 h and amplitude of 0.23 ± 0.03 mag.





<u>(1443) Ruppina</u>. This asteroid has been studied multiple times, with published synodic period values ranging from 5.87941 to 5.905 h (Neugent and Slivan, 2008; Arredondo et al., 2014; Stephens, 2018; Stephens and Warner, 2020). More recently, Slivan (2021) conducted a multi-apparition analysis, obtaining sidereal period 5.8796 ± 0.0002 h, as well as a pole solution and convex shape

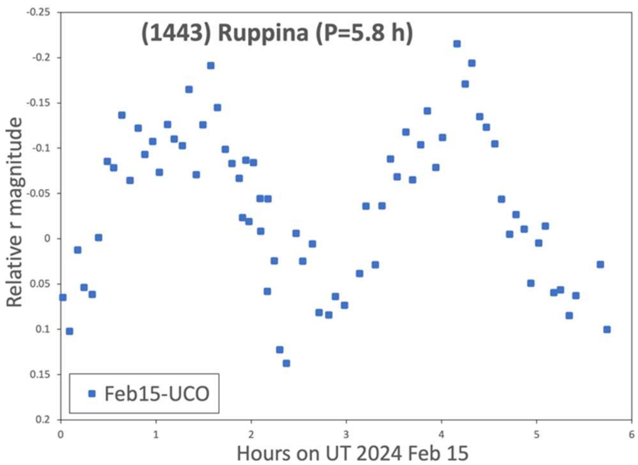
Name	Site	Telescope	Camera	Array	Filter	FOV(')	Scale ("/pix)
UCO	Schenectady, NY	0.50-m RC f/8.1	SBIG STXL-11002	2004×1336×9µm	R_c	30×20	0.93
CHI-1	Rio Hurtado, Chile	0.61-m RC f/6.5	FLI PL9000	3056×3056×12µm	*r'*	32×32	1.24
T17	Siding Spring, Aus	0.43-m CDK f/6.8	FLI PL4710	1024×1024×13µm	*r2*	16×16	0.92
T72	Rio Hurtado, Chile	0.51-m CDK f/6.8	FLI ML16200	4500×3600×6µm	*R*	27×22	0.717

Table I. Telescopes and Cameras. UCO = Union College Observatory; RC = Ritchey-Chrétien; CDK = Planewave Corrected Dall-Kirkham.

Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
884	Priamus	2022 08/1-10/22	*2.1,11.8	317	3	6.8607	0.0004	0.23	0.03	L5
1443	Ruppina	2024 02/15	1.8	141	-1	5.8	0.2	0.32	0.05	Kor

Table II. Observing circumstances and results. The phase angle is given for the first and last dates. If preceded by an asterisk, the phase angle reached an extremum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range. Grp is the asteroid family/group.

model. We observed (1443) Ruppina at the UCO for 6.14 h on a single night. Our brightness measurements, when folded to the previously-published period of Slivan (2021), yield a self-consistent, doubly-periodic curve.



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PHOTOMETRIC ANALYSIS FOR KORONIS FAMILY ASTEROID (993) MOULTONA

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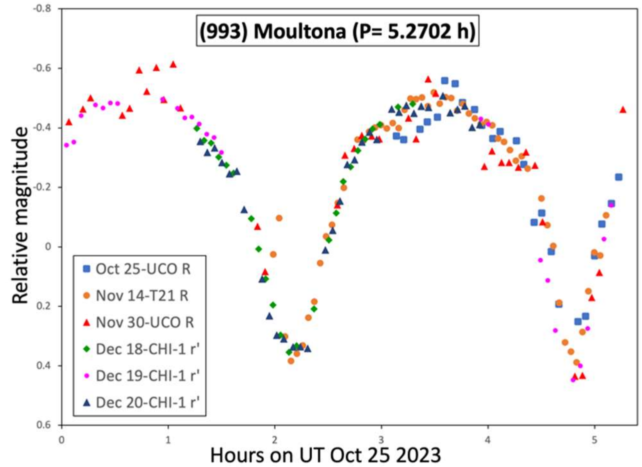
We present a composite lightcurve of the Koronis family asteroid (993) Moultona based on six nights of data. We found the period of (993) Moultona to be 5.2702 ± 0.0003 hours with an amplitude of 0.9 ± 0.1 mag. Our results are consistent with previously published observations of (993) Moultona, at a period of 5.2702 ± 0.0004 hours and amplitude of 0.8 ± 0.06 mag (Crowley and Wilkin, 2023).

These observations were made as a research project in our course Observational Astronomy at Union College, which in previous years involved studies of asteroid and nova lightcurves (Wilkin et al., 2022; Patterson et al. 2022, respectively). We chose to observe the Koronis family asteroid (993) Moultona to follow up the observations made during the 2022 apparition by Crowley and Wilkin (2023) at the Union College Observatory (UCO).

Observations were made using three telescopes, UCO in Schenectady NY, iTelescope T21 in Beryl Junction UT, and TelescopeLive CHI-1 telescope in Rio Hurtado, Chile. Two nights of observations were performed at UCO with 240 s exposure time and 2×2 binning. One night of observations was performed using iTelescope T21 with 180 s exposure times and 1×1 binning. Three nights of observations were performed using TelescopeLive CHI-1, each with 240 s exposure time and 2×2 binning. Filters and telescope information can be found in Table I.

We used *AstroImageJ* (Collins et al., 2017) to process the UCO images for bias, dark, and flat field corrections, as well as perform photometry on all images. Corrections for light travel time were performed using ephemerides from the JPL Horizons web app (JPL, 2024). Additionally, this web app was used for phase and phase angle bisectors in Table II. We folded the lightcurves to account for the time difference in observations, as well as the different relative brightnesses of comparison stars used in photometry. Single-night lightcurves were shifted in brightness to form a self-consistent composite. Our lightcurve yielded a period of 5.2702 ± 0.0003 h.



Acknowledgments

We thank Devin Ramos for his help in observing at the UCO, and also Dimitris Vasileilos Zora for observing and processing the images of Nov 30, and for the use of his lightcurve formatting template. Remote observations were made possible by the Union College IEF Grant to F. Wilkin. We thank Dr. Stephen Slivan for suggesting several improvements to the manuscript.

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Name	Site	Telescope	Camera	Array	Filter	FOV (′)	Scale (″/pix)
UCO	Schenectady, NY	0.50-m RC f/8.1	SBIG STXL-11002	2004×1336×9µm	*R*	30×20	0.93
T21	Beryl Junction, UT	0.42-m CDK f/4.5	FLI-PL6303E	3072×2048×9µm	*R*	32.8×29.2	0.96
CHI-1	Rio Hurtado, Chile	0.61-m RC f/6.8	QHY 600M Pro	9576×6382×3.8µm	*r′*	31×20.7	0.39

Table I. Telescopes and Cameras. RC=Ritchey-Chretien; CDK=Corrected Dall Kirkham. Filters: *R*: Cousins *R*; *r'*: Sloan *r'*.

Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
993	Moultona	2023 10/25-12/20	*4.6,16.7	41	-1	5.2702	0.0003	0.9	0.1	Kor

Table II. Observing circumstances and results. The phase angle is given for the first and last dates. If preceded by an asterisk, the phase angle reached an extremum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range. Grp is the asteroid family/group.

V-BAND MONITORING OF 1083 SALVIA

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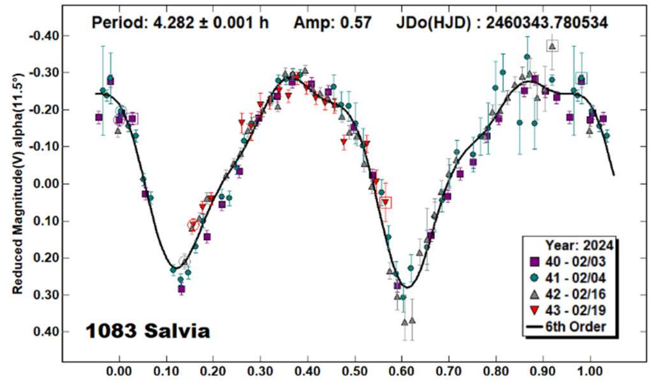
V-band images of 1083 Salvia were collected over the course of four nights in February 2024. We find a best-fit rotation period of 4.282 ± 0.002 h and a V-band variability amplitude of 0.57 ± 0.03 mag. Our results agree well with previously published measurements of the rotation period and variability amplitude for this asteroid.

1083 Salvia was discovered in January 1928 by Karl Wilhelm Reinmuth at Heidelberg Observatory (JPL, 2024). It is an inner main-belt asteroid and is assumed to be stony in type based on its orbit and albedo, though this assumption also seems to be supported by the asteroid colors reported by Wisniewski et al. (1997).

Observations of 1083 Salvia were collected over the course of four nights between UT dates 2024 February 03 and February 19 by students enrolled in the *Observational Techniques and Instrumentation* class at Georgia State University. The Miller Telescope at GSU's Hard Labor Creek Observatory, a 24-inch Planewave f/6.5 Corrected Dall-Kirkham Astrograph, was equipped with an FLI ProLine CCD and images were acquired through a Johnson *V* filter. Each image covered a field of view of 26.3 arcmin × 26.3 arcmin, with a pixel scale of 0.77 arcsec. Exposure times were generally 240-300 s. The weather conditions were mixed across the four nights, varying from clear skies to partly cloudy, and the Moon phase ranged from 3rd quarter to 1st quarter. A total of 138 frames contributed to the measurements of 1083 Salvia.

Images were reduced in *IRAF* following standard procedures, which included bias and overscan subtraction, dark subtraction, and flat fielding. Aperture photometry was also carried out in *IRAF*, with measurements of the asteroid and 4-6 field stars acquired from each reduced image. *V*-band measurements of field stars from the AAVSO Photometric All-Sky Survey (Henden et al., 2009) were adopted to convert instrumental magnitudes to calibrated magnitudes in the Vega system.



The rotation period and amplitude of variability for 1083 Salvia were determined using *MPO Canopus*, which implements the Fourier Analysis of Light Curves (FALC) algorithm of Harris et al. (1989). We explored fitting orders between 4 and 8 for the period search, with a 6th order fitting solution displayed in the folded light curve in this manuscript. We find that the reported period is quite stable despite the choice of orders, while the amplitude of variability is somewhat sensitive to this choice. From this analysis, we adopt a final rotation period of 4.282 ± 0.002 h and a *V*-band variability amplitude of 0.57 ± 0.03 mag.

Our results agree with previous determinations of the rotation period: 4.23 ± 0.02 h (Wisniewski et al., 1997) derived from a single night of observations with a photomultiplier tube in 1992, and 4.281429 ± 0.000001 h (Ďurech et al., 2016) derived from lightcurve inversion modeling of sparse photometry and assuming the period reported by Wisniewski et al. (1997) as an a priori constraint. The only previously reported measurement of the variability amplitude is 0.61 mag from Wisniewski et al. (1997), and our results also agree well with this constraint.

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Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1083	Salvia	2024 02/03-02/19	11.5,4.9	150	7	4.282	0.002	0.57	0.03	MB-I

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 an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

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LIGHTCURVES AND SOLAR PHASE COEFFICIENTS FOR KORONIS FAMILY MEMBER (1725) CRAO FROM UNION COLLEGE OBSERVATORY

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Lightcurves of (1725) CrAO recorded during its 2019 apparition are presented, with derived results for R-band solar phase coefficients $H_R = 11.031 \pm 0.012$ and $G_R = 0.26 \pm 0.03$, and for absolute magnitude $H = 11.49 \pm 0.03$, all for the 2019 viewing geometry.

Koronis family member (1725) CrAO has been studied for spin vector determination with a sample of larger members of the family by Slivan et al. (2023). They reported lightcurves recorded during the 2019 apparition that are calibrated to standard R magnitudes, but those data span only about 2 degrees of solar phase angle, which is insufficient to also determine solar phase coefficients. The present work reports additional standard-calibrated lightcurves of CrAO from 2019 which increase the phase angle coverage, an analysis of the lightcurves combined with the previously published data to derive R-band solar phase coefficients, and a calculation of the absolute magnitude H at the 2019 aspect.

Lightcurves of CrAO were recorded on six nights during 2019 summer and autumn by F. Wilkin and J. Sindoni at the Union College Observatory in Schenectady, NY, using the 0.51-m OGS RC telescope with an SBIG STXL-11002 CCD camera, imaging a 29′×20′ field and binned 2×2 for an image scale of 0.88 arcsec/pix. Image integrations were 240 s using a Cousins R filter. After the first night, observations of Landolt (1983) standard stars having approximately solar colors also were included in the program to calibrate the individual lightcurves to standard R magnitudes. Image processing and measurement procedures were as previously described by Slivan et al. (2008) using synthetic aperture sizes informed by Howell (1989). The lightcurves were reduced for light time, and standard-calibrated brightnesses were reduced to unit distances.

Folding the lightcurves shows that the data are consistent with the known synodic rotation period 21.475 h (Slivan et al., 2023), and comprise about 65% of a rotation including both minima and one maximum (Fig. 1). Although a period determination based on these data is presented in Table II for completeness, the previously published period is significantly more precise and is used for the analysis presented here. The five nights of standard-calibrated coverage are sufficiently spread out in solar phase angle from 2° to 17° to fit for solar phase coefficients; the July 13 lightcurve is relative photometry only and thus does not contribute a brightness to the fit.

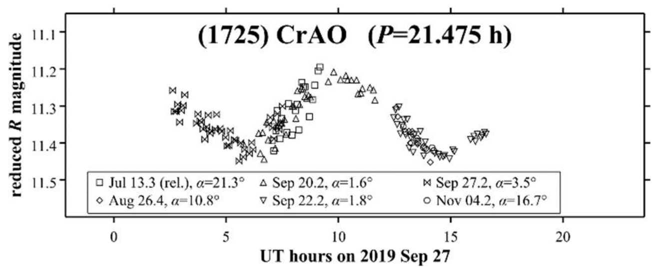

Figure 1. Folded composite lightcurve with the earliest and latest 10% of rotation repeated. The legend gives UT date and solar phase angle α at each lightcurve's mid-time. The brightness zero-point to standard R magnitude is set by the Sep. 27 lightcurve with an estimated error of 0.013 mag. For presentation the other nights' lightcurves have been shifted in brightness for best fit to the composite, so that the assembled shape is insensitive to measurement errors in the calibrated zero-point determinations.

Determining the mean brightness of each night's lightcurve to use for a meaningful solar phase analysis involves removing the rotational variation, nontrivial in this case because each individual night of data records only a short segment of the complete lightcurve. The adopted approach involves modeling the shape of the lightcurve over an entire rotation as a Fourier series; however, the composite lightcurve reported here is missing too much rotation phase for such Fourier series filtering to give accurate results without additional coverage. To proceed, a sufficiently-sampled composite was assembled by combining these data with the CrAO lightcurves that also were recorded during the same 2019 apparition by Slivan et al. (2023).

The lightcurve shape was modeled by fitting a fourth-order Fourier series model to the combined 2019 data set, using the known rotation period for the fundamental. Dropping the constant term of the best-fit model then creates a template of the lightcurve shape information by itself by shifting the model in brightness to a mean magnitude level of zero (Fig. 2). The mean standard-calibrated

Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
1725	CrAO	2019 07/13-11/04	*21.3,16.7	357	-3	21.47	0.06	0.25	0.04

Table II. Observing circumstances and results. Solar phase angles are given for the first and last dates; the asterisk indicates that the phase angle reached a minimum during the interval. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range.

brightness of the asteroid on each night is then obtained by subtracting from each observed lightcurve point the template model value at the corresponding rotation phase, and then averaging the resulting set of differences for the entire lightcurve.

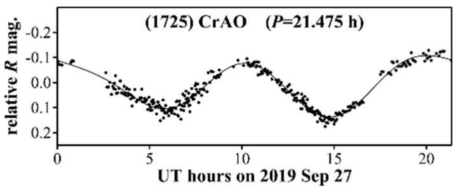

Figure 2. Fourier series model template of lightcurve shape (solid line) determined from the combined observations during the 2019 apparition (dot symbols), excluding data that were not calibrated to standard magnitudes. The RMS fit residual is 0.018 mag.

A weighted fit to the mean brightnesses (Fig. 3 and Table I) determines single-apparition *R*-band solar phase coefficients H_R = 11.031 ± 0.012 and G_R = 0.26 ± 0.03. Finally, offsetting from H_R using the $V-R$ color index 0.46 ± 0.03 (Slivan et al., 2023) yields the corresponding absolute magnitude H = 11.49 ± 0.03 at the 2019 viewing geometry.

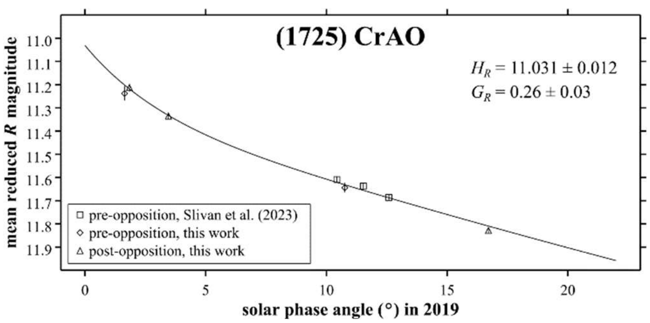

Figure 3. Lumme-Bowell solar phase model result based on analysis of the combined data set of mean brightnesses, as described by Bowell et al. (1989, Appendix). Eqn. A15 of the linear error analysis described there was used to calculate $\Delta H_R(0°)$, which is adopted here as the estimated error in H_R.

```
-----------------------------------------------
  Reduced mean R mag. at 0°        H_R: 11.031 mag
    Slope parameter, R-band        G_R: 0.255
  Weighted mean phase angle         α0: 9.75°
Error in reduced mag. at α0  ΔH_R(α0): ±0.006 mag
Error in reduced mag. at 0°       ΔH_R: ±0.012 mag
               Error in G_R       ΔG_R: ±0.027
-----------------------------------------------
```

Table I: Solar phase results, including the quantities needed to compute the magnitude error as a function of phase angle.

Acknowledgments

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LIGHTCURVE AND ROTATION PERIOD ANALYSIS OF 1429 PEMBA AND 14835 HOLDRIDGE

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Photometric observations of two main-belt asteroids were obtained between 2023 July 22 and 2024 January 10. The following rotational periods were determined: 1429 Pemba, 828.7 ± 0.4 h; 14835 Holdridge, 109.6 ± 0.1 h.

Images were obtained from observatories around the globe. Several of the co-authors used their own equipment and some used the iTelescope or Las Cumbres Observatory facilities.

Photometry and period determination were carried out with *TychoTracker Pro* Version 11.0. (TT), easily performing both functions. Photometric analysis was done using standard differential techniques on images. The TT software has the facility to allow the user to choose comparison stars, for which the default color range of +0.50 < (B-V) < +0.90 was employed. The ATLAS catalog (Kostov and Boney, 2017; Tonry et al., 2018) was used as the source of reference stars for both asteroids. TT's period determination operates by finding model lightcurves - comprising a user-defined number of Fourier components which best fit the asteroid photometric data. The program lists the candidate periods found within a user-defined period range and sampling frequency, based on minimizing Root Mean Square Errors (RMSE), i.e. using the difference between modelled and photometric magnitudes. The candidate periods are listed in increasing RMSE value and the entire suite of RMSE values is plotted as a "periodogram" for quality control. In these periodograms both objects yielded clear 'best-fit' period solutions having well defined 'stalactites' as shown in the following figures. 1429 Pemba has a period of > 20 h, with a quality value of 1, 14835 Holdridge has a period of > 10, with a quality value of 1. 14835 Holdridge has a period of > 10 h, with a quality value of 2-, for their rotational periods listed in the current issue of the LCDB (Warner et al., 2009).

Periodograms often exhibit several possible candidate periods, in which case an examination of the rotational phase plot for each of these is then conducted looking for a credible lightcurve. Where the object shape is the dominant factor in producing the observed magnitude changes, (typically having lightcurve amplitudes of > 0.2 mag), the rotational phase plot often has two peaks and two troughs (bimodal) and this is usually chosen as the most likely for such asteroids. Eric Dose has published a trimodal period for 14835 Holdridge (Dose, 2024), however both Dose and our observations show a high amplitude (> 0.6 mag) and Harris et al. (2014), shows that a tetrahedron shaped object could produce a trimodal curve but that it would be unlikely to have such a high amplitude. Our periodogram does indicate a possible period at the 164.400 h indicated by Dose but the RMSE shown in this paper at the 109.646 h period is significantly lower. We therefore believe the 109.646 h period to be correct.

In this paper there is no attempt to find an absolute magnitude for any of the asteroids and a value of G = 0.15 has been used throughout the calculations. Time-series from different nights and observing locations using a variety of imaging equipment were offset in magnitude to bring them into alignment when producing the raw and rotational-phase plots. The same offset was used for each instance of an individual imaging setup. When this paper is accepted for publication all the observations will be loaded into the ALCDEF database. Some individual datapoints have been combined by stacking during period analysis to improve the signal-to-noise ratio.

The results are summarized in Table I. Column 3 gives the span of dates over which the observations were made. Column 4 is the range of phase angles for each date range, if this is preceded by an asterisk this means the asteroid passed through minimum phase angle during the observing period. Columns 5 and 6 give the range of values for the phase angle bisector (PAB) longitude and latitude respectively, for the mid date of the observation set. Column 7 gives the period and Column 8 the minimum possible formal error in hours given by *TychoTracker Pro*. Columns 9 and 10 give the

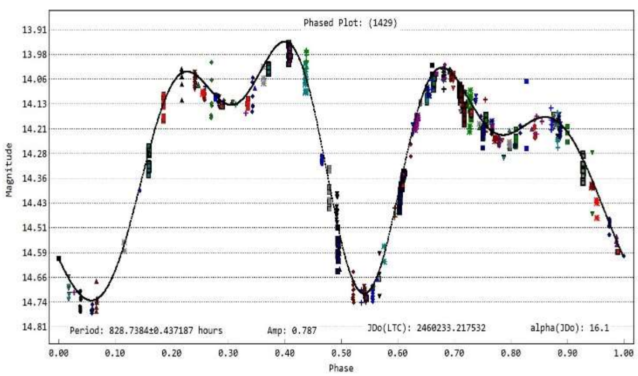
Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
1429	Pemba	2023/09/05-11/11	*0.1,24.2	51	2	828.7	0.4	0.79	0.03	9104
14835	Holdridge	2023/07/22-2024/01/10	*11.2,35.8	35	6	109.6	0.1	0.66	0.03	701

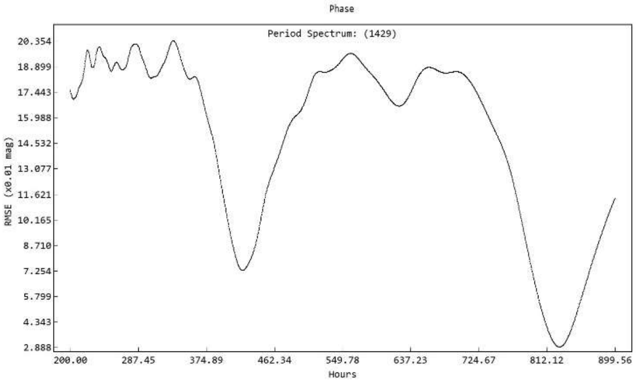
Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached a minimum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009; Nesvorny, 2015).

amplitude and its associated uncertainty in magnitude. Column 11 gives the group number reported in the LCDB. Group with numbers < 9000 are taken from Nesvorny (2015). Those with numbers > 9000 are based on *a, e, i* and define an orbital space, not a specific collisional family.

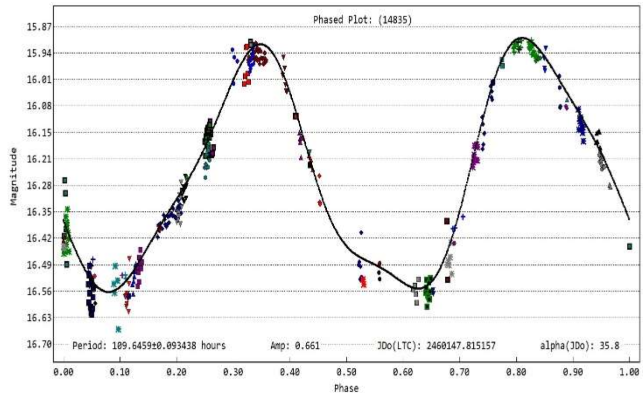
Dips in the results from the period analysis have been checked to see if they are monomodal or bimodal and bimodal periods have been chosen for the best-fit period for each asteroid. Information given below for each of the objects is taken from the JPL Small-Body Database Lookup webpage (JPL, 2023).

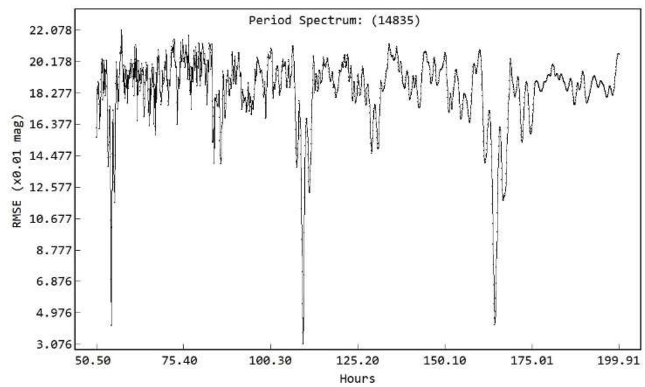
1429 Pemba (1937 NH) is a main belt-inner asteroid that was discovered on 1937 July 2 by Cyril Jackson observing from Johannesburg (Union Observatory), South Africa. It has an approximate diameter of 10 km. The LCDB does list a value of > 20 hours with a quality figure of 1 and 0.3 mag max for the amplitude of its lightcurve, i.e., smaller than the value reported here. The lightcurve period and amplitude results reported here are based on 124 observing sessions (a total of 3099 exposures) during 2023 October-2024 January (828.7 ± 0.4 h, 0.79 ± 0.03 mag).





14835 Holdridge (1987 WF1) is a main-belt asteroid and a member of the Phocaea family. It was discovered on 1987 November 26 by Carolyn and Gene Shoemaker at Palomar Observatory. It is a relatively small object having an approximate diameter of 7 km. A previously published rotation period of > 10 hours with a quality value of 2- and 0.08 mag max (Pravec, 2005web). Lightcurve period and amplitude results from 67 sessions (1997 exposures) are reported for 2023 July-2024 January (109.6 ± 0.1 h, 0.66 ± 0.03 mag).





Acknowledgements

Our thanks are extended to Daniel Parrott, author of *TychoTracker Pro*.

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Observatory	Telescope	CCD/CMOS	F	Asteroid (Sessions)
Old Orchard (Z09, Hawley)	0.25-m SCT f/10	SX694 Trius Pro (2×2)	SR	1429 (14); 14835 (14)
Univ. Utah, Tooele (718, Wiggins)	0.35-m SCT f/5.5	ST-10XME (3×3)	C	1429 (26); 14835 (27)
Farm Cove (E85, McCormick)	0.35-m SCT f/10	ST-8XME (2×2)	C	1429 (2); 14835 (2)
Cerro Tololo LCO-A (W85, Miles)	1.0-m f/8	Sinistro (1×1)	SR V	1429 (1) 1429 (2)
Cerro Tololo LCO-B (W86, Armstrong, Moss)	1.0-m f/8	Sinistro (1×1)	SR	14835 (1)
Siding Spring LCO-A (Q63, Miles)	1.0-m f/8	Sinistro (1×1)	SR V	1429 (1) 1429 (2)
T32 iTelescope, Siding Spring (Q62, Watkins)	0.43-m f/6.8	Moravian G4 16000	V	1429 (1)
Siding Pring LCO-B (Q64, Miles)	1.0-m f/8	Sinistro (1×1)	SR V	1429 (1) 1429 (2)
Siding Spring LCO-Clamshell #1 (Q58, Armstrong, Moss)	0.4-m f/8	SBIG STL-6303 (1×1)	SR	1429 (2)
Siding Spring LCO-Clamshell #2 (Q59, Armstrong, Moss)	0.4-m f/8	SBIG STL-6303 (1×1)	SR	1429 (2)
Sutherland LCO-Aqawan A (L09, Armstrong, Moss)	0.4-m f/8	SBIG STL-6303 (1×1)	SR	1429 (1)
Haleakala-Faulkes Telescope North (F65, Armstrong, Moss)	2.0-m f/8	SBIG STL-6303 (1×1)	SR SI	14835 (11) 14835 (2)
Sutherland LCO-A (K91, Miles)	1.0 f/8	Sinistro (1×1)	SR	1429 (1)
Sutherland LCO-C (K93, Miles)	1.0 f/8	Sinistro (1×1)	SR	1429 (2)
Haleakala LCO-Clamshell #2 (T03, Amrstrong, Moss)	0.4 f/8	SBG STL-6303 (1×1)	SR	1429 (1)
McDonald LCO Aqawan A #1 (V38, Armstrong, Moss)	0.4-m f/8	SBIG STL-6303 (1×1)	SR	1429 (10)
Southside Obs. (Y98, Haynes)	0.28-m f/10	QHY174M	C	1429 (2); 14835 (1)
West View, Knighton Rd., Broad Chalke, Wiltshire, UK (247, Privett)	0.3-m f/4	SX694 Trius Pro	C	1429 (4); 14835 (1)
Pelagia-Eleni Obs. Glyfada-Athens, GREECE. (247, Kardasis)	0.28-m SCT f/10	ASI183M M PRO (4×4)	V	1429 (24) 14835 (5)
T21 iTelescope Obs. Beryl Junction (Sato) (U94, Watkins)	0.43-m f/6.8	FLI PL-16803	V C	1429 (4) 14835 (1)
Organ Mesa, Las Cruces (G50, Pilcher)	0.35-m SCT f/10	SBIG STL-1001E (1×1)	C	1429 (3)
Tenerife Obs. Aqawan A#2 (Z17, Miles)	0.4-m f/8	SBIG STL-6303 (1×1)	SR V	1429 (8)
Tenerife Obs. Aqawan A#1 (Z21, Miles)	0.4-m f/8	SBIG STL-6303 (1×1)	SR V	1429 (4)
Tenerife Obs. LCO A (Z31, Miles)	1.0-m f/8	Sinistro (1×1)	V	1429 (1)
NNHS Obs. (Z34, Arnold)	0.3-m Refl. f/3.8	SX694 (1×1)	C	1429 (2); 14835 (2)

Table II. List of observers, equipment, and filters (F). The last column gives the number of sessions for a given asteroid. When two filters were used for the same asteroid, each line gives the number of sessions for each filter.

DETERMINING THE ROTATIONAL PERIOD OF MAIN-BELT ASTEROID 19633 RUSJAN

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(Received: 2024 April 15 Revised: 2024 May 6)

We present findings from analyzing the lightcurve of the main-belt asteroid 19633 Rusjan using CCD photometric observations: P = 3.326 ± 0.002 h, A = 0.21 mag.

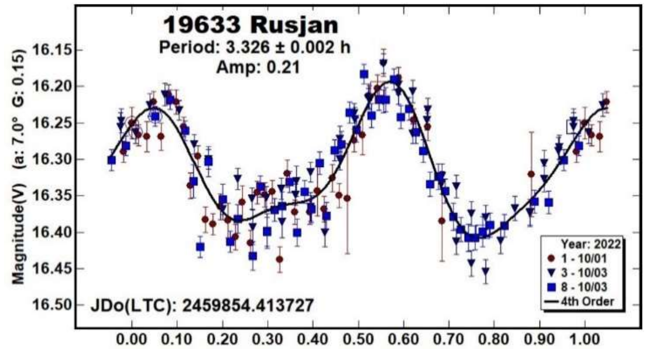
In the framework of the scientific project "Investigating the most ancient asteroids" (*http://users.uoa.gr/~kgaze/research_asteroids_en.html*) time resolved photometry of the asteroid 19633 Rusjan (belonging to the "Zita" family) was measured.

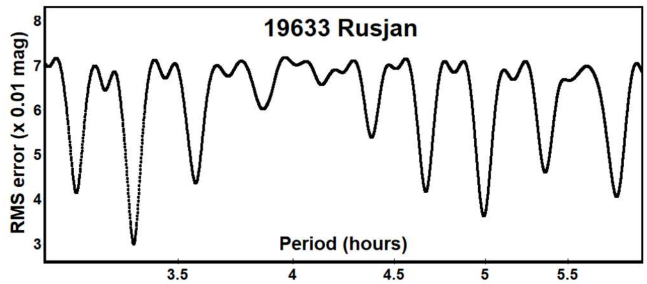
This article is the result of an extra-curricular course promoted by the classical-scientific high school "Peano-Pellico" of Cuneo (Piedmont, Italy). The project focused on the development of technological skills and methods that were used to extrapolate a lightcurve from a series of images provided by the private observatory K76 of Roberto Bonamico who supervised the project.

We started with some theoretical lessons and then, using *MPO Canopus* and the MPOSC3 catalog, we analyzed the images collected in three nights of observations, a time frame long enough to generate an adequate amount of data to produce a complete and precise lightcurve thanks to the short rotation period of the asteroid.

We have been assigned the astronomical target 19633, the asteroid Rusjan discovered in 1999 in Slovenia from the observatory "Observatorij Črni Vrh" and named in honor of the Austro-Hungarian aviator Eduardo Rusjan.

The final result of our work is a lightcurve with an amplitude $A = 0.21$ that determines a rotational period $P = 3.326$ h ± 0.002 h, which, within the error, does not differ from the 3.324 value documented on the Minor Planet Center site.





Observatory MPC Code	Telescope	CCD	Filter
K76	0.30-m RCT F/8	SBIG ST9	C

Table 1 Observing Equipment. RCT: Ritchey-Chretien

References

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Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
19633	Rusjan	2022/10/01-2022/10/03	7.5,6.5	17.3	-5.1	3.326	0.002	0.21	0.01	

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 an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

PHOTOMETRY OF PHA (349507) 2008 QY

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Potentially Hazardous Asteroid (PHA) (349507) 2008 QY was observed for six nights during 2023 October using the University of North Dakota Space Studies Observatory. The rotational period is 11.801 ± 0.003 hours, and the lightcurve amplitude is 0.62 ± 0.04 magnitudes. A search of the Asteroid Lightcurve Database provided no previously published results.

Potentially hazardous asteroid (PHA) (349507) 2008 QY was initially discovered by Spacewatch at Kitt Peak on 2008 August 21. We obtained CCD photometric observations during the close approach of (349507) 2008 QY on 2023 October 8-11, 16, 17, and 20. No previously published rotational period was found in the Asteroid Lightcurve Database (Warner et al., 2009).

Observations were collected from Telescope 3 at the UND Space Studies Observatory (code 730) located at 47.9189° N, -97.3651° E. Telescope 3 is a 16-inch Meade LX 200R SCT with an Alta Apogee U9000 CCD camera. Images were taken using the broadband L-filter and binned 3×3. The exposure times were 120 seconds and the observing cadence was separated by the read-out time of the CCD. In total, 906 science images were obtained and 761 were included in the analysis. Discarded images were omitted due to star contamination, trails due to wind, and intermittent clouds. Flat, bias, and dark frames were obtained each night at the same operating conditions the CCD obtained the science frames. The dark frames were 120 seconds and taken in a set of ten using the L filter. Bias frames were 0.0 second exposures and taken in a set of ten. Dawn flats were obtained in the L-filter and in a set of ten. The total time imaging was ~5.5 hours.

The science frames were bias-, dark-, and flat-field calibrated using *AstroImageJ* software according to the standard CCD calibration equation (Howell, 2006). Following data calibration, the images were imported to *MPO Canopus* and a photometric analysis of the data was performed. Each night contains multiple sessions due to the asteroid's velocity with the telescope's field of view rapidly changing. The *MPO Canopus* Lightcurve wizard combined each night's segments consisting of 23 sessions across seven nights.

In general, each image's analysis involved the selection of five stars (non-variable) for magnitude standards. *MPO Canopus* performs a least squares analysis to determine the relationship between the magnitude and the log of the total counts. For the background correction, a 9×9-pixel circular aperture was utilized to determine counts of the comp stars vs. background. For the PHA vs. background, a variety of aperture sizes, ranging from oblong (21×9 pixels) to circular (7×7 pixels) were used because the PHA's velocity ranged from 16.8-2.2 arcseconds/minute (first night to last night, respectively). The data were light-time corrected using the JD at the start of each exposure.

We plotted each segment of usable data for each night as lightcurves; however, because the sky rapidly changed, so did our background stars used for comparison stars. As such, this introduced a bit of uncertainty in the magnitudes of the comparison stars. We used the delta comp function to adjust the magnitudes and bring them into agreement with the magnitudes of first data set.

(349507) 2008 QY. We produced a composite lightcurve (Fig. 1), and least squares fit of the lightcurve with a Fourier series including seven harmonics. A rotational period of 11.801 ± 0.003 hours was calculated with an amplitude of 0.61 ± 0.04 magnitudes. There are two maxima per rotation, and we have fully captured the first maxima and significantly captured the second maxima. However, we are missing a small section of the lightcurve, which indicates the need for additional observations to further refine the lightcurve, as well as hone in on the period.

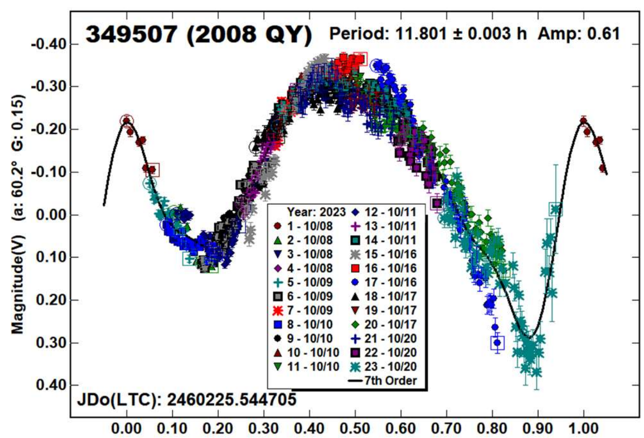

Fig. 1: PHA 349507 (2008 QY) rotational period of 11.801 ± 0.003 hours with an amplitude of 0.61 ± 0.04 magnitude.

Acknowledgements

This study was facilitated by the University of North Dakota Space Studies Observatory. Additionally, LH appreciates Tyler Linder's guidance during the data collection phase.

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Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
349507	2008 QY	2023 10/08-10/20	61.7-37.8	359	18	11.801	0.003	0.61	0.04	PHA

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 an extrema during the period. LPAB and BPAB are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

BINARY SYSTEM 6086 VRCHLICKY

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Photometric observations of main-belt asteroid 6086 Vrchlicky show its binary nature with an orbital period of 22.61 ± 0.01 h. The rotational lightcurve of the primary has a period of 2.7674 ± 0.0001 h with an amplitude of 0.07 mag at solar phases 1-12 degrees. A lower limit on the secondary-to-primary mean-diameter ratio is 0.22 ± 0.02. The measured absolute visual magnitude in R band is 12.03 ± 0.03 mag and the slope parameter is 0.20 ± 0.05.

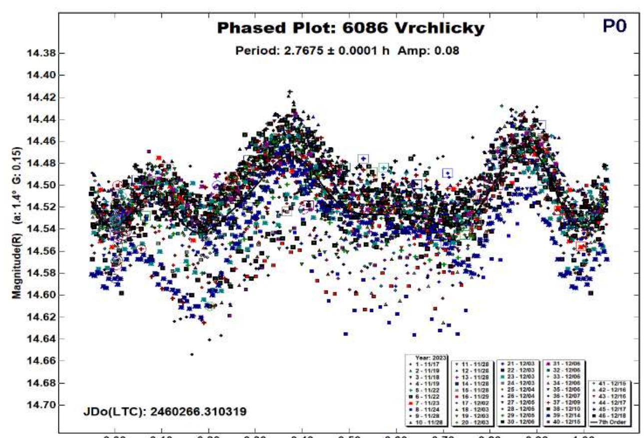
6086 Vrchlicky is a Sl-type (Bus and Binzel, 2002) middle main-belt asteroid, selected as target of the photometric campaign of the Italian Amateur Astronomers Union (UAI, 2023) for the period 2023, October-December.

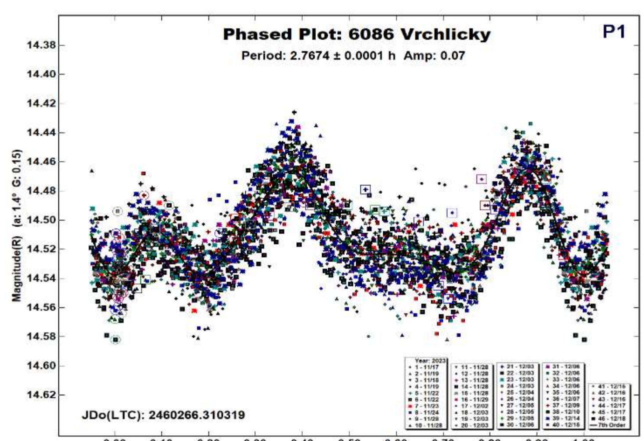
Collaborative CCD observations were carried out over the period spanning from 2023, November 17 to 2023, December 18, using the instrumentation described in the Table II. The first two sessions, acquired by A. Marchini, R. Papini (K54) and by N. Montigiani, M. Mannucci (A57) on 2023, November 17-18 showed some anomalous attenuations which let us to hypothesize its binary nature. The photometric data by A. Pál et al. (2020), downloaded from the lightcurve database (LCDB; Warner et al., 2009), confirmed that hypothesis, when analyzed with the dual-period search function. Due to the cloudy weather in Italy, it was decided to also extend the collaboration to the BinAst observer group led by P. Pravec.

Lightcurves analysis was done with *MPO Canopus* (Warner, 2023). All the images were calibrated with dark and flat frames and converted to standard magnitudes using solar colored field stars from CMC15 catalogue.

The analysis was done using the dual-period search function implemented in MPO Canopus. We found a primary synodic rotational period of P1 = 2.7674 ± 0.0001 h with an amplitude A1 = 0.07 ± 0.01 mag at solar phases 1-12 degrees and an orbital period P2 = 22.61 ± 0.01 h. The deep drop of the secondary eclipse, 0.05 ± 0.01, gives a lower limit on the secondary-to-primary mean-diameter ratio Ds/Dp of 0.22 ± 0.02. The binary nature of this asteroid was announced by the authors through the CBET 5366 (Franco et al., 2024), published on Mar 11, 2024.

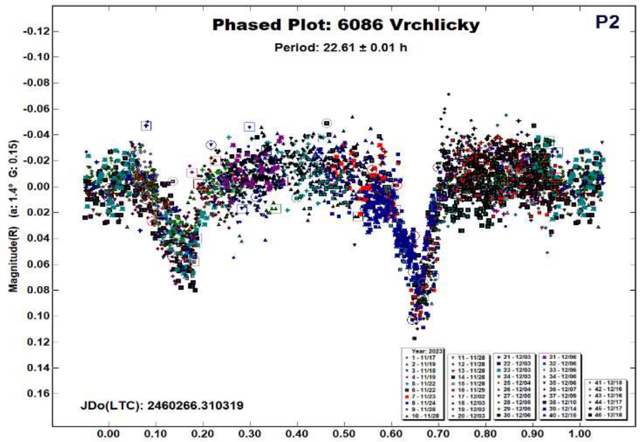
The H-G parameters were found with the function implemented in *MPO Canopus*, using the average R mag of each session, considering the small amplitude of the lightcurves. We found H_R = 12.03 ± 0.03 mag and G = 0.20 ± 0.05.

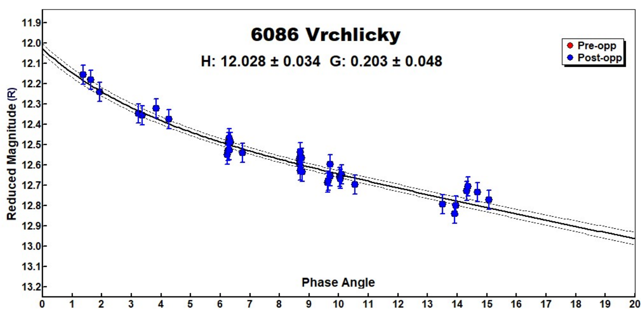




Number	Name	2023 mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
6086	Vrchlicky	11/17-12/18	1.3,15.1	55	-1	2.7674	0.0001	0.07	0.01	MB-M
						22.61	0.01	0.08	0.01	

Table I. Observing circumstances and results. The first line gives the results for the primary of a binary system. The second line gives the orbital period of the satellite and the maximum attenuation. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).





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Observatory (MPC code)	Telescope	CCD	Filter	#Sessions
Sopot Observatory (K90)	0.35-m SCT f/6.3	SBIG ST-8 XME	C	7
Shed of Science South Observatory (V61)	0.50-m CDK f/4.4	FLI ML4710	C	7
Schiaparelli Observatory (204)	0.84-m NRT f/3.8 0.36-m SCT f/7.5	STT-3200 (3×3) Atik 16200 (bin 3×3)	C	6
GiaGa Observatory (203)	0.36-m SCT f/5.8	MORAVIAN G2-3200	C	6
San Marcello Pistoiese Observatory (104)	0.60-m NRT f/4.0	Apogee Alta	Rc	5
Osservatorio Astronomico Margherita Hack (A57)	0.35-m SCT f/8.3	SBIG ST10XME (bin 2×2)	Rc	4
Astronomical Observatory, University of Siena (K54)	0.30-m MCT f/5.6	SBIG STL-6303e(bin 2×2)	C	3
Osservatorio Astronomico Nastro Verde (C82)	0.35-m SCT f/6.3	SBIG ST10XME (bin 2×2)	C	3
Beppe Forti Observatory (K83)	0.40-m RCT f/8.0	SBIG ALUMA 4040	C	2
Iota Scorpii(K78)	0.40-m RCT f/8.0	SBIG STXL-6303e (bin 2×2)	Rc	2
M57 Observatory (K38)	0.35-m RCT f/5.5	SBIG STT1603ME	C	1

Table II. Observing Instrumentations. CDK: Corrected Dall-Kirkham, MCT: Maksutov-Cassegrain, NRT: Newtonian Reflector, RCT: Ritchey-Chretien, SCT: Schmidt-Cassegrain.

DETERMINING THE ROTATIONAL PERIOD OF MAIN-BELT ASTEROIDS 3704 GAOSHIQI AND (16905) 1998 DT21

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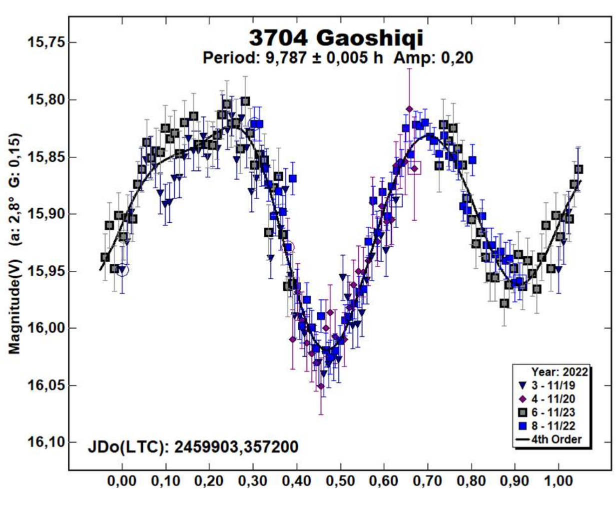
Based on CCD photometric observations of the main-belt asteroids 3704 Gaoshiqi and (16905) 1998 DT21, we report the results of the lightcurves analysis, respectively, P = 9,787 ± 0.005 h, A = 0.20 mag and P = 4,534 ± 0,021 h, A=0,28 mag.

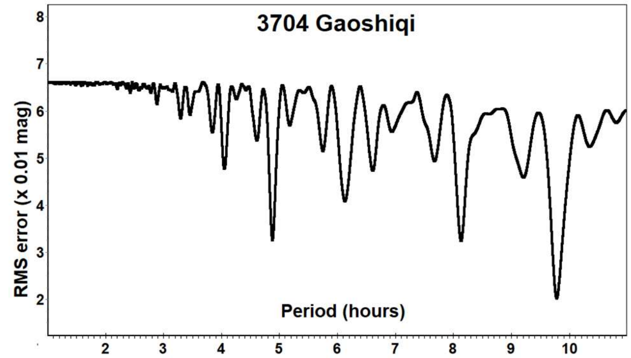
As a result of a scholastic project undertaken by the "Liceo Classico-Scientifico Peano Pellico" (*https://liceocuneo.it/*) we obtained time resolved photometry of two main-belt asteroids. Our scientific focus is in the framework of "Investigating the most ancient asteroids" (*http://users.uoa.gr/~kgaze/research_asteroids_en.html*). In this effort, we obtained time resolved photometry of the asteroid 3704 Gaoshiqi (belonging to the "Athor" family) was measured.

For our project, we used already calibrated data from observations obtained at the Astronomical Observatory BSA (K76) from November 19, 2022, until November 23, 2022. The equipment used was a MARCON RC300 f/8 with a CCD camera SBIG ST9.

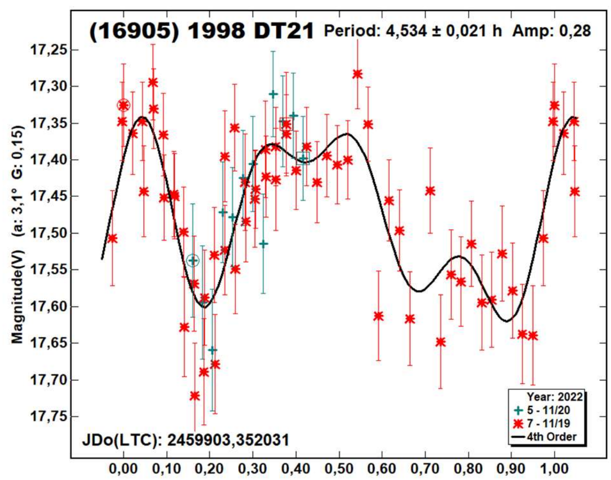
3704 Gaoshiqi was discovered at Nanking on 1998 December 20 by Purple Mountain Observatory and was named in honor of Gao Shiqi, a Chinese famous bacteriologist who contributed to improving the scientific and cultural quality of the whole nation.

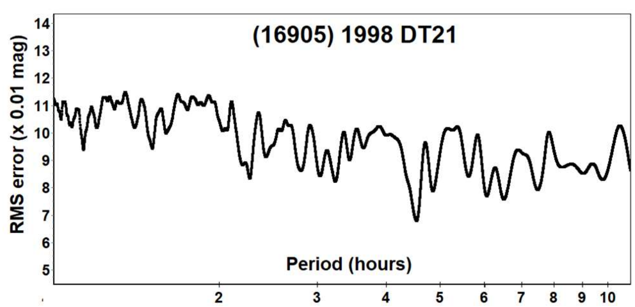
Observing sessions from several individual observers were adjusted vertically for best fit in constructing our results. The resulting period obtained is P= 9.787 h and the lightcurve amplitude A=0.20. These results substantially agree with all the previous published ones: Oey et al. (2013; P=9.7727h) and Stephens and Warner (2019; P= 9.699h.





During the analysis of the data of 3704 Gaoshiqi, DT21 1998 was also discovered within the images, where we note its original discovery on 1998 February 22 by the Spacewatch program at Kitt Peak. A search of the Asteroid Lightcurve Database did not find any previously reported results for this asteroid. Therefore, we analyzed the available images in attempt to establish the period with just two evenings of data, one of which had adverse weather. We have found for (16905) 1998 DT21 a resulting period of P= 4.534 h and the lightcurve amplitude A= 0.28.





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Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
3704	Gaoshiqi	2022/11/19-2022/11/23	2.3, 4.2	51.7	- 0.0	9.787	0.005	0.20	0.01	
16905	1998 DT21	2022/11/19-2022/11/20	2.2, 2.7	51.5	- 0.1	4.534	0.021	0.28	0.01	

Table II. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

Stephens, R.D.; Warner, B.D. (2019). "Main-belt Asteroids Observed from CS3: 2018 October - December." *Minor Planet Bulletin* **46**, 180-187.

Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2016 Sep. *http://www.minorplanet.info/lightcurvedatabase.html*

LIGHTCURVES AND ROTATION PERIODS OF 57 MNEMOSYNE, 58 CONCORDIA, AND 78 DIANA

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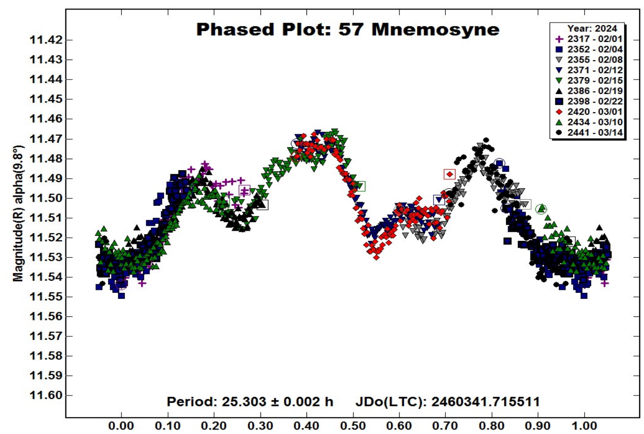
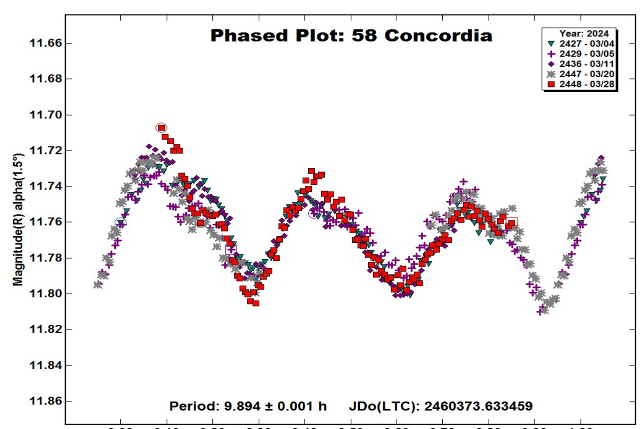
Synodic rotation periods and amplitudes are found for 57 Mnemosyne 25.303 ± 0.002 hours, 0.06 ± 0.01 magnitudes; 58 Concordia 9.894 ± 0.001 hours, 0.08 ± 0.01 magnitudes with three maxima and minima per rotational cycle; and 78 Diana 7.2932 ± 0.0001 hours, 0.28 ± 0.02 magnitudes.

The new observations to produce the results reported in this paper were made at the Organ Mesa Observatory with a Meade 35cm LX200 GPS Schmidt-Cassegrain, SBIG STL-1001E CCD, 60 to 120 second exposures, unguided, red filter for 57 Mnemosyne and 78 Diana and clear filter for 58 Concordia. Image measurement and lightcurve construction were with *MPO Canopus* software with calibration star magnitudes for solar colored stars from the CMC15 catalog reduced to the Cousins R band. Zero-point adjustments of a few ×0.01 magnitude were made for best fit. To reduce the number of data points on the lightcurves and make them easier to read, data points have been binned in sets of 3 with maximum time difference 5 minutes.

57 Mnemosyne. Earlier published periods are by Harris et al. (1992), 12.463 hours; Ditteon and Hawkins (2007), 12.66 hours; Behrend (2016web), 12.64 hours; Behrend (2020web), 12.648 hours. This author (Pilcher, 2019) was unable to fit a lightcurve to a period near 12.5 hours and found a synodic period 25.324 hours with one maximum and minimum per cycle near celestial longitude 197º. This author obtained additional sets of observations (Pilcher, 2020) near celestial longitude 258º, synodic period 25.281 hours; (Pilcher, 2022) near celestial longitude 331º, synodic period 25.308 hours; (Pilcher, 2023), 25.316 hours near celestial longitude 66º. New observations on 10 nights 2024 Feb. 1 - Mar. 14 near celestial longitude 157º provide a fit to an irregular lightcurve with period 25.303 ± 0.002 hours, amplitude 0.06 ± 0.01 magnitudes. The observations in years 2019, 2020, 2021, 2022, and 2024, respectively, show a range of synodic rotation periods which, although qualitatively consistent, differ from each other by amounts greater than their formal errors and have very different lightcurve shapes. The differing synodic periods and shapes indicate that the observations were made at different asterocentric latitudes and should be helpful toward future LI modeling.



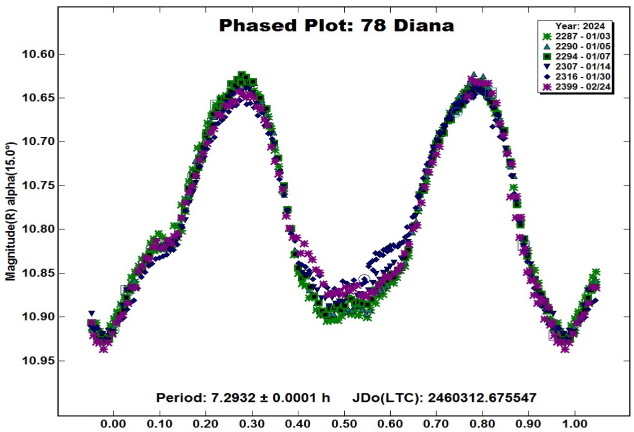
58 Concordia. The Asteroid Lightcurve Database (Warner et al., 2009; updated 2023 October) lists 14 previously published rotation periods, all very close to the preferred value 9.895 hours. New observations on five nights 2024 March 4 - March 28 provide a good fit to a lightcurve with period 9.894 ± 0.001 hours, amplitude 0.08 ± 0.01 magnitudes with three maxima and minima per rotational cycle. This result is consistent with all previously published periods.



Number	Name	yyyy/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E	Amp	A.E.
57	Mnemosyne	2024/02/01-2024/03/14	* 9.8 - 7.3	157	-13	25.303	0.002	0.06	0.01
58	Concordia	2024/03/04-2024/03/28	1.5 - 12.0	161	0	9.894	0.001	0.08	0.01
78	Diana	2024/01/03-2024/02/24	*15.0 - 13.8	129	5	7.2932	0.0001	0.28	0.02

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

78 Diana. Previously published periods are by Taylor et al. (1976), 8 h; Harris and Young (1989), 7.225 h; Licchelli (2006), 7.300 h; Fleenor (2007), 7.346 h; Benishek and Protitch-Benishek (2008), 7.2991 h; and Pilcher (2020), 7.2929 h. New observations on six nights from 2024 Jan. 3 to Feb. 24 provide a good fit to a lightcurve with period 7.2932 ± 0.0001 h, amplitude 0.28 ± 0.02 magnitudes. A period of 7.2932 h is consistent with all of the previously published periods of 78 Diana.



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LIGHTCURVES OF 3 SMALL MAIN-BELT ASTEROIDS FROM FEBRUARY TO APRIL 2023

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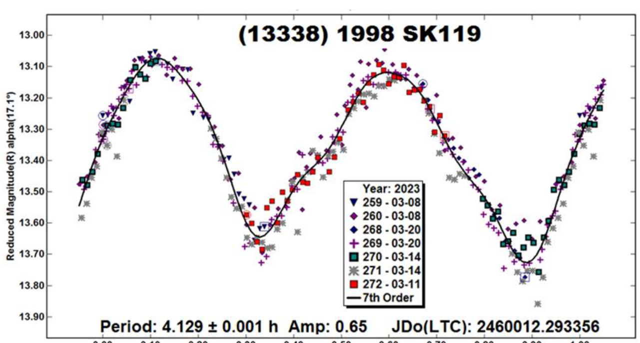
(Received: 2024 April 15)

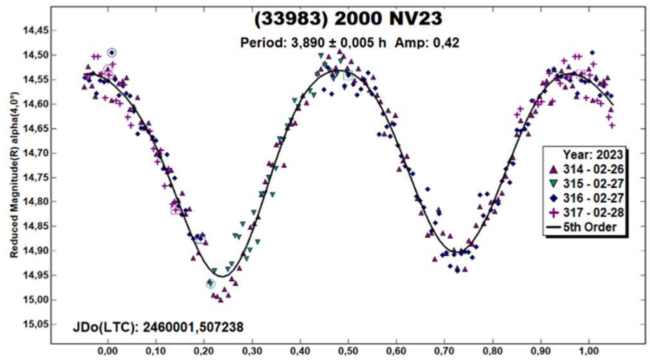
Lightcurves of 3 asteroids were obtained from February 2023 through April 2023. Synodic periods and amplitudes are found for (13338) 1998 SK119 (4.129 ± 0.001 h and 0.65 mag), (33983) 2000 NV23 (3.890 ± 0.002 h and 0.45 mag) and (101283) 1998 SJ118 with no indication of period and very low amplitude.

Observations reported here are made though Johnson R-filter and unbinned. Exposure times between 60 and 240 s, depending on the brightness of the target asteroids. A 0.35-m Newtonian telescope f/4.5 was used with a Moravian G2-3200 camera and Wynne-Riccardi coma corrector. The mount was a friction drive model Mesu-200, a German equatorial type. The camera was thermoelectrical cooled to -30°C and all images were calibrated with a master flat and master darks of same exposure length as the science frames, using *Astro Art 7.0*. During calibration the timeseries was not aligned to avoid interpolation of pixel intensities prior to analysis which was done with *MPO Canopus* v10.8.1.1 (Warner, 2019). 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 the ATLAS catalog (Tonry et al., 2018). Period analysis is done with *MPO Canopus*, which implements the FALC algorithm by Harris (Harris et al., 1989).

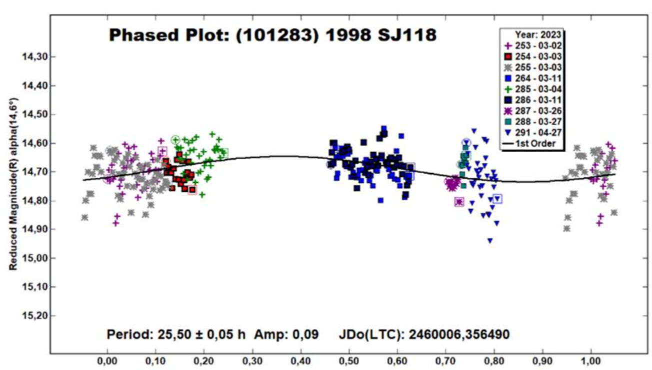
<u>(13338) 1998 SK119</u> is a small asteroid in the mid main belt with a diameter of 7.54 km. A search in the LCDB updated on Oct. 1st, 2023, reports a siderial period of 4.129105 h derived from sparse data by Durech (Durech et al., 2016). The present work confirms the period (but synodic) of 4.129 ± 0.001 h and amplitude of 0.65 magnitudes. 355 data points were used for the analysis and the best fit has an RMS = 0.039 magnitudes. The D.C. adjustments where between -0.03 and +0.05 magnitudes.



<u>(33983) 2000 NV23</u> is a small 3.3 km asteroid in the inner main belt. It had a favorable opposition on February 21st, 2023. (33983) was observed for 3.87 h the first night of 2023 Feb 26. That lightcurve displayed two distinctly different minima and suggested three maxima. It was possible to determine a preliminary period of P = 3.7 h on the first night. The following three consecutive nights observations of this asteroid continued. The durations of these sections were 1.7 h, 3.0 h and 1.1 h. Those short sessions lead to several alias solutions for the period almost as deep as the one reported here of P = 3.890 h. The lightcurve has an amplitude of 0.45 magnitude so it is highly unlikely that the correct lightcurve is more than bimodal, according to the work of Harris et al. (2014). A search in the LCDB (Warner et al., 2009) of October 2023 revealed no entries for this asteroid.

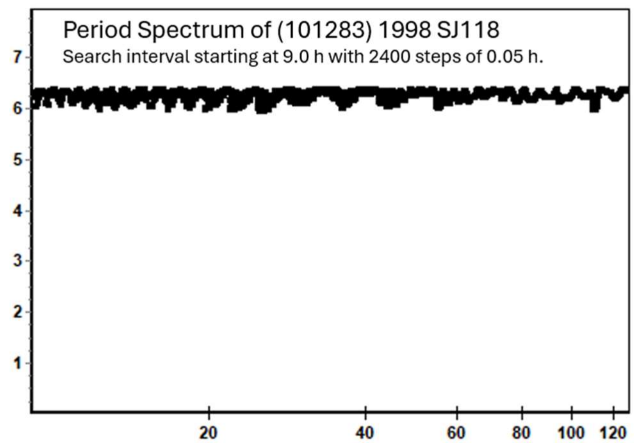


<u>(101283) 1998 SJ118</u> is a small main-belt asteroid with a diameter of 6 km. It is situated in the outer main belt at a = 2.77 and e = 0.27. Data were collected on 4 different dates. Most observations were in Johnson R-filter. Two short sessions in Clear filter have been left out of this analysis. The longest single night lightcurve was of 7.5 h length (S255 and 285) with a flip at the meridian. This lightcurve showed no signs of variation. Using the ATLAS catalog (Tonry et al. (2018) in the analysis it is easy to link lightcurves from different nights with a high level of accuracy. Because of this, it was decided only to observe for a few hours each night. In case of a definite change in reduced magnitude, should show up, this asteroid would receive a higher priority. But, in the period from March 2nd to April 27th, the reduced R-magnitude was constant within the measuring accuracy of +/- 0.1 magnitude. A period search was conducted from 9.0 h to 129 h in 2400 steps of 0.05 h, but no significant signal was found. In the lightcurve of (101283) the "best fit" is shown with a period of P = 25.5 h. However, as can be seen from the period spectrum of (101283), there are no plausible solutions found for this object. One explanation could be that (101283) was observed pole on, another that it is a very nearly spherical object.



Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
(13338)	1998 SK119	2023 03/08-03/20	14.8,19.9	130	10	4.129	0.001	0.65	0.05	MB-M
(33983)	2000 NV23	2023 02/25-02-28	3.6, 5.1	153	-4	3.890	0.005	0.42	0.03	MB-I
101283)	1998 SJ118	2023 03/02-04/27	179.0,180.8	180	12	-	0.06	0.09	0.06	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 an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).



Acknowledgements

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 SpaceTelescope Science Institute, and the South African Astronomical Observatory.

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PHOTOMETRY OF 18 ASTEROIDS FROM SOPOT ASTRONOMICAL OBSERVATORY: 2023 DECEMBER – 2024 APRIL

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The results of lightcurve and synodic rotation period determinations for 18 asteroids obtained from CCD photometric observations carried out at the Sopot Astronomical Observatory in the time span 2023 December - 2024 April are summarized.

Photometric observations of 18 asteroids were conducted at Sopot Astronomical Observatory (SAO) from 2023 December through 2024 April 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 2×2 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 was conducted using *MPO Canopus* (Warner, 2018). Differential photometry with up to five comparison stars of near solar color ($0.5 \leq$ B-V ≤ 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, 2024) 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 achieving the most favorable statistical indicators of Fourier fit goodness.

Lightcurve construction and period analysis was performed using *Perfindia* custom-made software developed in the R statistical programming language (R Core Team, 2020) by the author of this paper. The essence of its algorithm is reflected in finding the most favorable solution for rotational period by minimizing the residual standard error of the lightcurve Fourier fit.

The lightcurve plots presented in this paper show so-called 2% error for rotational periods, i.e. an error that would cause the last data point in a combined data set by date order to be shifted by 2% (Warner, 2012) and represented by the following formula:

$$\Delta P = (0.02 \cdot P^2) / T$$

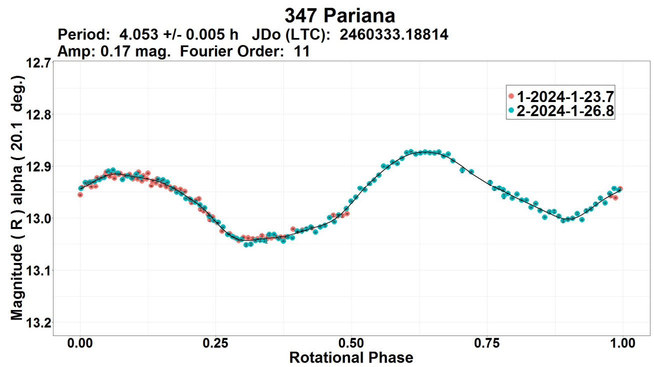
where P and T are the rotational period and the total time span of observations, respectively. Both of these quantities must be expressed in the same units.

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.

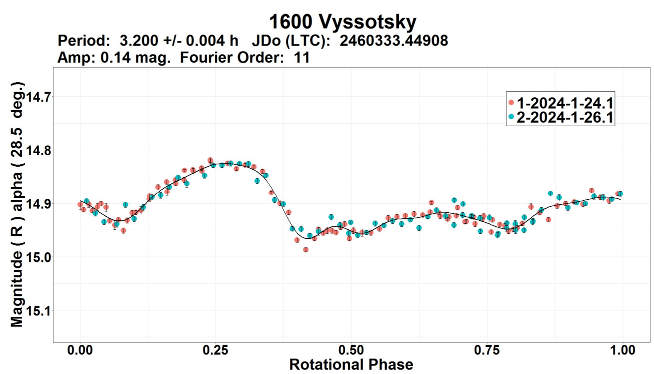
Table I gives the observing circumstances and results.

Observations and results

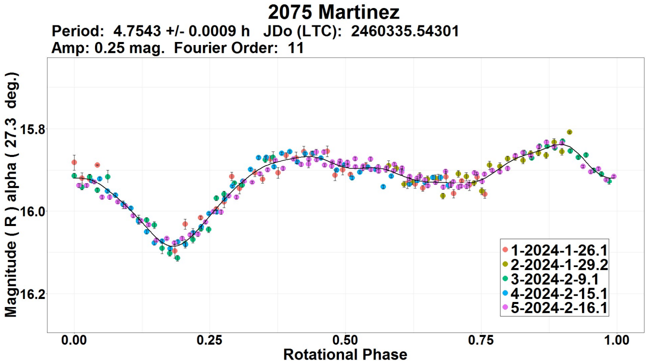
347 Pariana. Period of P = 4.053 ± 0.005 h found from data obtained in late 2024 January shows very good agreement with almost all previously determined rotation periods, some of which are as follows: 4.05 h (Lagerkvist et al., 1992), 4.052 h (Denchev, 2000), 4.052 h (Caspari, 2010), 4.0524 h (Behrend, 2012web), 4.05249 h (Behrend, 2016web), 4.05289 h (Pal et al., 2020).



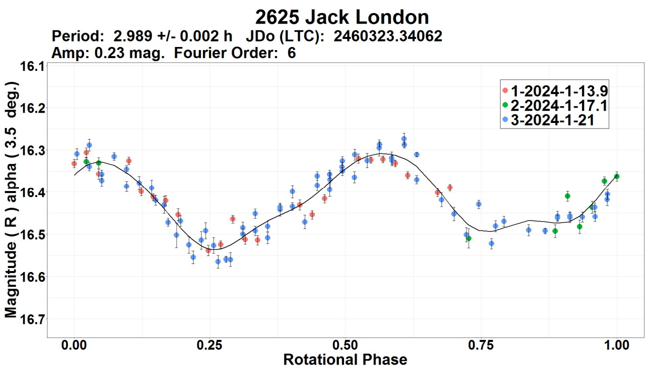
1600 Vyssotsky. A particularly good match of the entire series of previously found values for rotation period recorded in the Asteroid Lightcurve Database (LCDB; Warner et al., 2009) with the period result of P = 3.200 ± 0.004 h, determined from the 2024 January SAO data is evident in this case as well. Some of the earlier determinations for rotation period are: 3.2 h (Warner, 1999), 3.20144 h (Behrend, 2005web), 3.20116 (Higgins, 2008), 3.205 h (Warner, 2014), 3.20145 h and 3.2014 h (Benishek et al., 2019), 3.20141 h (Pravec, 2019web).



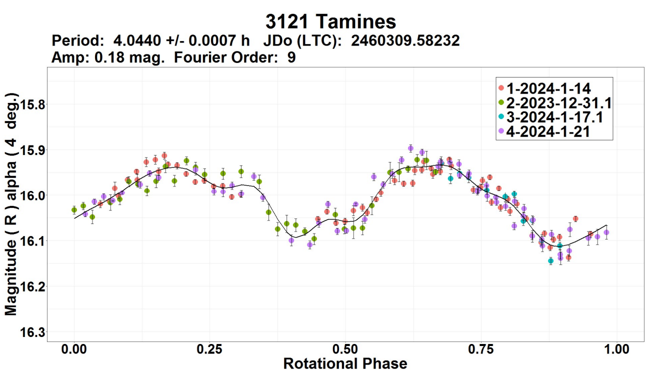
2075 Martinez. A dense photometric dataset acquired over 5 nights in 2024 January - February indicates a synodic rotation period of P = 4.7543 ± 0.0009 h, which is undoubtedly in good agreement with previously established period results found in the LCDB: 4.755 h (Menke et al., 2008), 4.7531 h (Benishek, 2020), 4.75539 h (Pal et al., 2020), 4.749 h (Polakis, 2020).



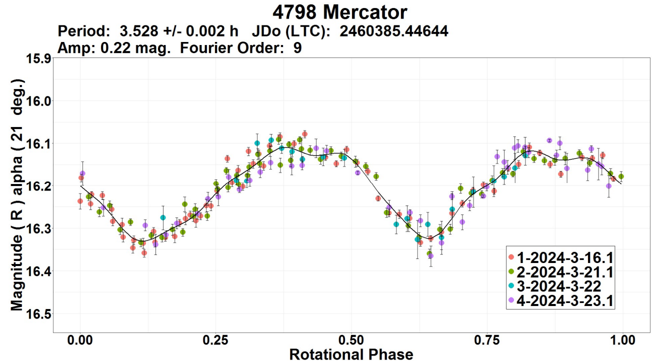
2625 Jack London. The only previously published period result by Polishook (2010, 2.988 h) is statistically identical to the rotation period (P = 2.989 ± 0.002 h) found from the SAO data collected over 3 nights in 2024 January.



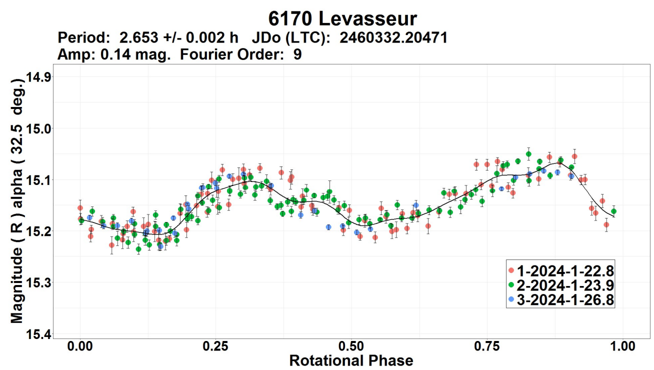
3121 Tamines. Data obtained over four nights in 2023 December - 2024 January show a bimodal solution for a period of P = 4.0440 ± 0.0007 h. Some of the previous results are as follows: 4.045 h (Pravec, 2011web), 4.05 h (Chang et al., 2015), 4.047 h (Waszczak et al., 2015), and a sidereal result of 4.04364 h (Durech et al., 2020).



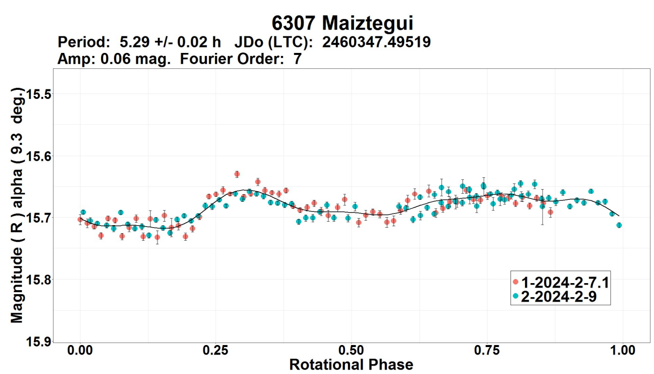
4798 Mercator. A BinAstPhot Survey target with no previously known rotation period. Dense photometric observations carried out on 4 nights in 2024 March reveal a bimodal solution for a period of P = 3.528 ± 0.002 h as the most plausible value resulting from the period analysis.



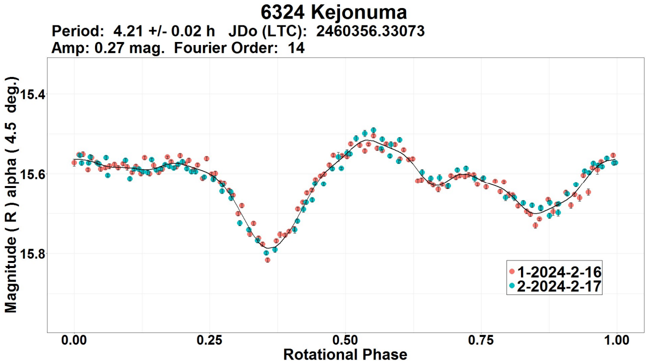
6170 Levasseur. Another BinAstPhot Survey program target followed up by various observers in earlier apparitions. Fully consistent synodic rotation periods were found by Pray et al. (2006, 2.6529 h), Pravec (2010web, 2.6531 h), and Higgins (2011, 2.6528 h). This sequence is well complemented by the period result of P = 2.653 ± 0.002 h, found from the 2024 late January SAO data obtained over 3 nights.



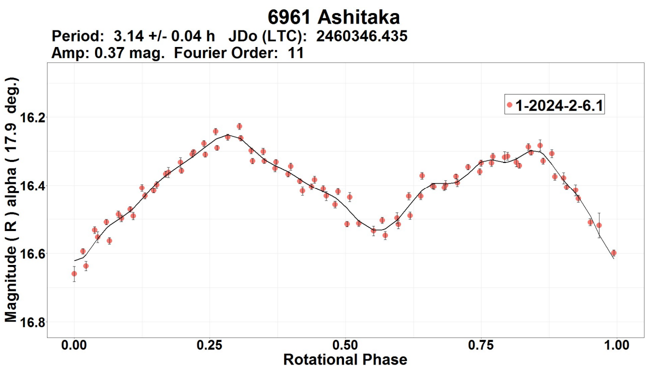
6307 Maiztegui. Period analysis conducted on new observations over 2 nights at SAO found a rotation period of P = 5.29 ± 0.02 h, which fully confirms the previous period result determined by Benishek (2022, 5.290 h) from the 2021 June - July data.



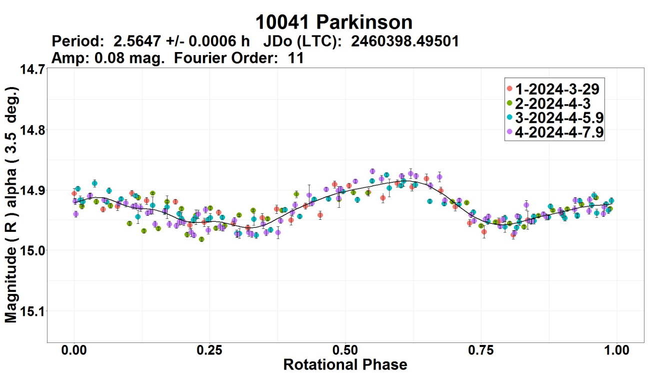
6324 Kejonuma. According to the LCDB records, this is the first rotation period determination for this asteroid. Period analysis performed on a dense combined dataset from 2 consecutive nights in 2024 February yielded a bimodal period solution of P = 4.21 ± 0.02 h.



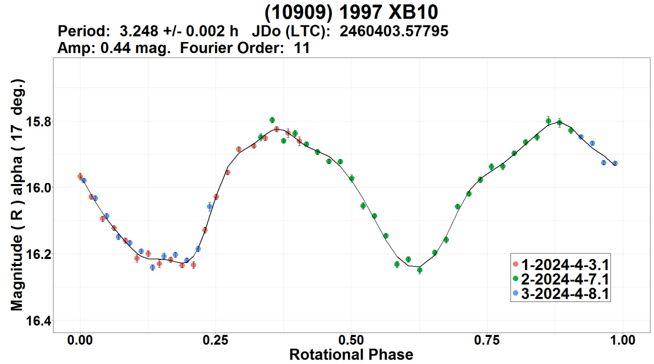
6961 Ashitaka. Period found from the 2024 February 05 - 06 SAO data (P = 3.14 ± 0.04 h) confirms the two previously reported period determination results by Albers et al. (2010, 3.1457 h) and by Oey (2011, 3.1461 h).



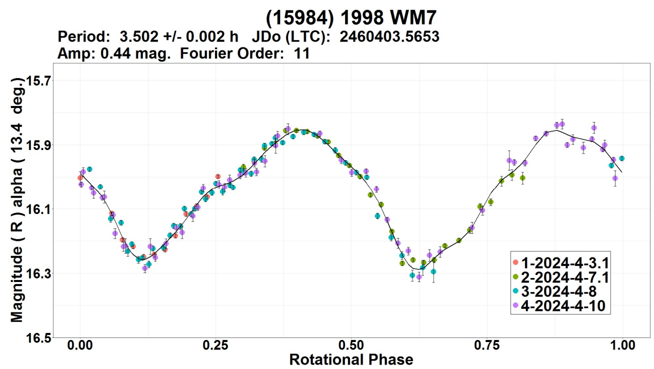
10041 Parkinson. The newly established rotation period of P = 2.5647 ± 0.0006 h using the data collected on 4 nights at SAO in 2024 late March - early April is in good agreement with the majority of previously reported period results, such as by Behrend (2017web, 2.5647 h), Pravec (2017web, 2.56428 h), and quite well with that of Mas et al. (2018, 2.592 h).



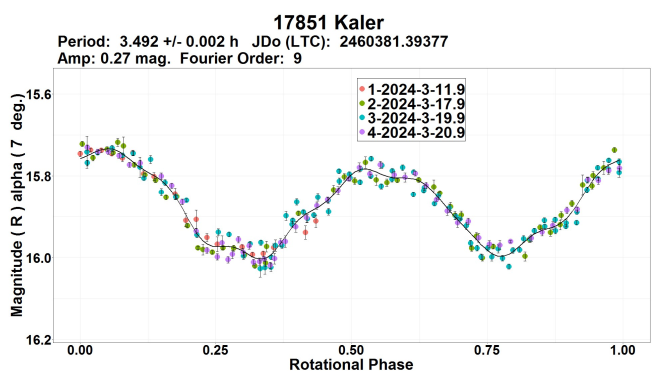
(10909) 1997 XB10. Higgins et al. (2006) and Pal et al. (2020) found very close rotation period values of 3.2483 h and 3.24853 h, respectively. A bimodal lightcurve of rather high amplitude (0.44 mag.) phased to a period of P = 3.248 ± 0.002 h results as the most favorable solution from the SAO observations during 3 nights at the beginning of 2024 April.



(15984) 1998 WM7. Pal et al. (2020) finds a period of 1.75121 h, which is actually exactly half of the 3.502-hour period associated with the high-amplitude (0.44 mag.) bimodal lightcurve obtained from SAO data collected at relatively low solar phase angles in early 2024 April. Such a high amplitude (> 0.4 mag.) at low solar phase angles gives an unequivocal advantage to a longer period of 3.502 h over the previously reported shorter one (Harris et al., 2014).



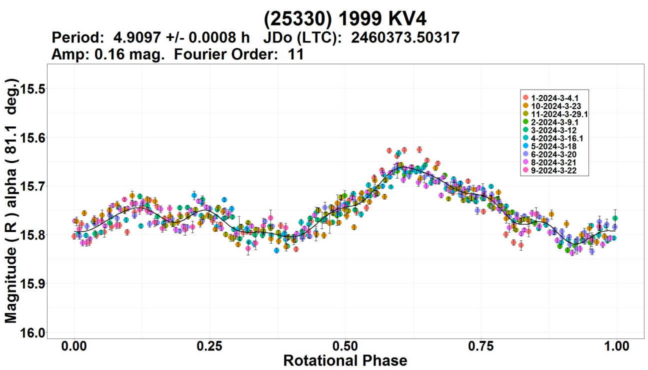
17851 Kaler. No records on the previous rotation period determinations exist in the LCDB. Data obtained over 4 nights in 2024 March revealed a bimodal period of P = 3.492 ± 0.002 h as an unequivocal solution for the rotation period.

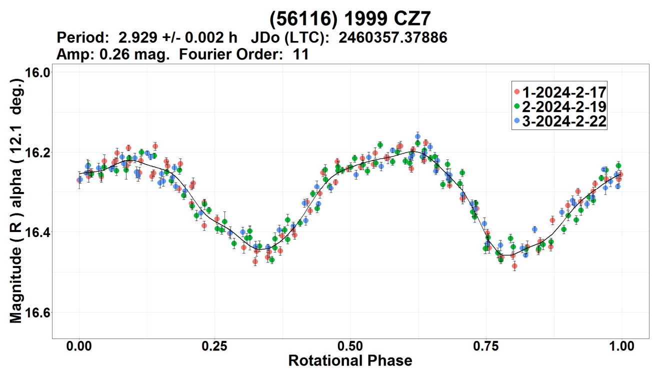


(25330) 1999 KV4. Pravec (2002web) states 4.919 ± 0.004 h for a rotation period of this near-Earth asteroid (NEA). Period analysis performed on extensive photometric observations carried on over almost one month at SAO indicate a period value of P = 4.9097 ± 0.0008, statistically identical to the only previous period determination result by Pravec.

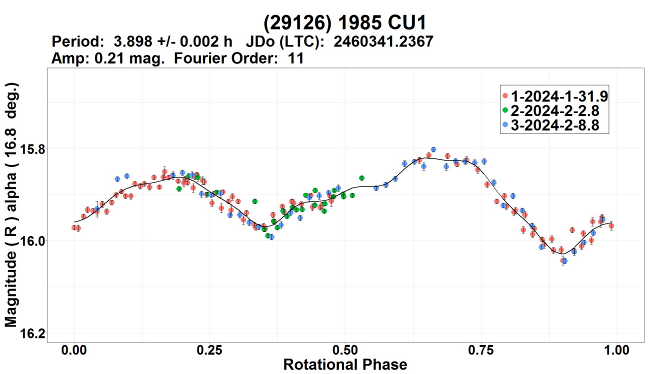
Number	Name	20yy/mm/dd	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
347	Pariana	24/01/23-24/01/26	20.1,20.7	69	-1	4.053	0.005	0.17	0.01	MB-M
1600	Vyssotsky	24/01/23-24/01/26	28.5,28.1	160	30	3.200	0.004	0.14	0.01	HUN
2075	Martinez	24/01/26-24/02/16	21.9,14.6	19	-8	2.9815	0.0006	0.20	0.02	MB-I
2625	Jack London	24/01/13-24/01/21	*3.5, 0.5	120	-1	2.989	0.002	0.23	0.03	MB-I
3121	Tamines	23/12/31-24/01/21	*11.2, 0.5	120	-1	4.0440	0.0007	0.18	0.03	MB-I
4798	Mercator	24/03/15-24/03/23	21.0,18.4	213	5	3.528	0.002	0.22	0.03	MB-I
6170	Levasseur	24/01/22-24/01/26	32.5,33.2	90	34	2.653	0.002	0.14	0.02	PHO
6307	Maiztegui	24/02/06-24/02/09	9.3, 8.6	156	12	5.29	0.02	0.06	0.02	MAR
6324	Kejonuma	24/02/15-24/02/17	4.5, 3.8	153	3	4.21	0.02	0.27	0.02	MB-I
6961	Ashitaka	24/02/05-24/02/06	17.9,17.8	167	-6	3.14	0.04	0.37	0.03	MB-I
10041	Parkinson	24/03/28-24/04/08	3.5,10.2	185	4	2.5647	0.0006	0.08	0.02	PHO
10909	1997 XB10	24/04/03-24/04/08	17,14.8	221	10	3.248	0.002	0.44	0.02	MB-I
15984	1998 WM7	24/04/03-24/04/10	13.4,10.5	213	12	3.502	0.002	0.44	0.02	MB-I
17851	Kaler	24/03/11-24/03/20	7.0, 3.0	182	4	3.492	0.002	0.27	0.02	HER
25330	1999 KV4	24/03/04-24/03/29	81.1,57.2	191	46	4.9097	0.0008	0.16	0.02	NEA
29126	1985 CU1	24/01/31-24/02/08	16.8,19.4	113	15	3.898	0.002	0.21	0.03	PHO
56116	1999 CZ7	24/02/16-24/02/22	12.1, 9.3	168	2	2.929	0.002	0.26	0.03	PHO
187026	2005 EK70	24/01/28-24/02/01	57.2,53.2	154	30	3.464	0.003	0.13	0.02	NEA

Table I. Observing circumstances and results. Phase is the solar phase angle given at the start and end of the date range. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the average phase angle bisector longitude and latitude (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009): MB-I/M = main-belt inner/middle, NEA = near-Earth asteroid, MAR = Maria, V = Vestoid, HUN = Hungaria, PHO = Phocaea, HER = Hertha.



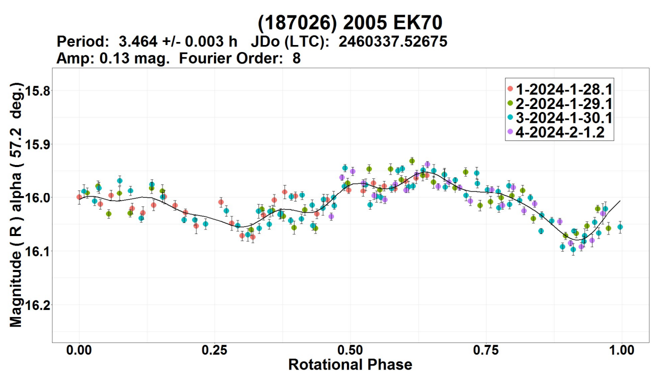


<u>(29126) 1985 CU1</u>. No previous reports on rotation period determinations found for this asteroid. Data taken on 3 nights in 2024 January - February indicate a bimodal solution for a period of P = 3.898 ± 0.002 h.



<u>(56116) 1999 CZ7</u>. Tomassini et al. (2018) found the only previous rotation period of 3.12 h associated with a bimodal lightcurve showing a fairly high data scatter. New dense photometric observations at SAO over 3 nights in 2024 February indicate a slightly shorter bimodal rotation period of P = 2.929 ± 0.002 h.

<u>(187026) 2005 EK70</u>. No previous rotation period determinations were reported for this NEA. Photometric observations conducted at SAO on 4 nights in 2024 January - February led to the statistically most favorable period solution of P = 3.464 ± 0.003 h.



Acknowledgements

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LIGHTCURVE ANALYSIS FOR THREE MAIN-BELT, THREE NEAR-EARTH, AND TWO MARS-CROSSER ASTEROIDS

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(Received: 2024 April 15)

We present photometric observations for three main-belt, three near-Earth and two Mars-crosser asteroids. We derived the following rotational synodic periods: 1864 Daedalus, 8.5726 ± 0.0001 h; 2240 Tsai, 4.4153 ± 0.0002 h; 6460 Bassano, 2.91258 ± 0.00006 h; (12582) 1999 RY34, 3.7831 ± 0.0001 h; (41074) 1999 VL40, 11.6339 ± 0.0002 h; (56116) 1999 CZ7, 2.9292 ± 0.001 h; (187026) 2005 EK70, 6.95555 ± 0.00026 h. Our one night of measurements for (26499) 2003 DX10 did not reveal a solution. We further report one rotational sidereal period: 1864 Daedalus, 8.57192 ± 0.00001 h.

We report on the photometric analysis results for three near-Earth and two Mars-crosser asteroids by Asociación Valenciana de Astronomía (AVA). The data were obtained during the first months of 2024. We present plotted results of data analysis, mainly lightcurves, with each plot phased to a given period. We managed to obtain several accurate and complete lightcurves and calculating as accurately as possible their rotation periods.

Observatory	Telescope (meters)	CCD
C.A.A.T. J57	43 cm DK	QHY- 600
C.A.A.T. J57	200 mm NW	ZWO ASI 1600
Z93	SC 8”	SBIG ST8300
J67	SC 10”	SBIG ST7

Table I. List of instruments used for the observations.

We focused on asteroids with no reported period and those where the reported period was poorly established and needed confirmation. The targets were selected from the Collaborative Asteroid Lightcurve (CALL) website (*http://www.minorplanet.info/call.html),* the Minor Planet Center (*http://www.minorplanet.net*) and Brian D. Warner et al. (2024). The Asteroid Lightcurve Database (LCDB; Warner et al., 2009) was consulted to locate previously published results.

Work Methods

Images were measured using *MPO Canopus* (Bdw Publishing) with a differential photometry technique. The comparison stars were restricted to near solar-color to minimize color dependencies, especially at larger air masses. The lightcurves show the synodic rotation period. The amplitude (peak-to-peak) that is shown is that for the Fourier model curve and not necessarily the true amplitude.

If we have enough data in ALCDEF in addition to our own data, we can try a second step with the software *LC INVERT (*Bdw Publishing), which uses the inversion method described by M. Kaasalainen (2001). This software uses the code written by J. Durech based on the original FORTRAN code written by Kaasalainen: “Period Scan”. The advantage of this method is that it allows the use of “dense” data such as the ones we have obtained in our measurements together with “sparse” data type, available in databases from Catalina, USNO, Atlas, Palomar, etc.

This is an iterative method that, based on an initial estimate of the period given by the lightcurve, finds the local minimum of χ^2 and gives the corresponding solution. The procedure starts with six initial poles for each trial period and selects the period that gives the lowest χ^2. If there is a clear minimum in χ^2 when plotted as a function of the period, we can assume it as a correct solution. Not always we get a clear solution. We have referenced only those asteroids with an unambiguous calculation.

When calculating we use weighting coefficients to take into account the density of the data. We assign to “dense” data a value of 1 and to “sparse” data a value of 0.3 as an empiric rule.

Error estimates for inversion method are no obvious. The smallest separation ΔP of local minima (Kaasalainen and Torppa, 2001; Kaasalainen et al., 2001), in the period parameter space is roughly given by

$$\Delta P \approx 0.5 * P^2/\Delta t$$

where Δt is the full epoch range of the data set. This derives from the fact that the maxima and minima of a double sinusoidal lightcurve for periods P and P ± ΔP are at the same epochs after Δt time.

As we can read at M. Kaasalainen and Torppa (2001), “The period error is mostly governed by the epochs of the lightcurves. If the best local χ^2minimum of the period spectrum is clearly lower than the others, one can obtain an error estimate of, say, a hundredth part of the smallest minimum width ΔP since the edge of a local minimum ravine always lies much higher than its bottom”.

Durech et al. (2020) proposes an estimate of error of

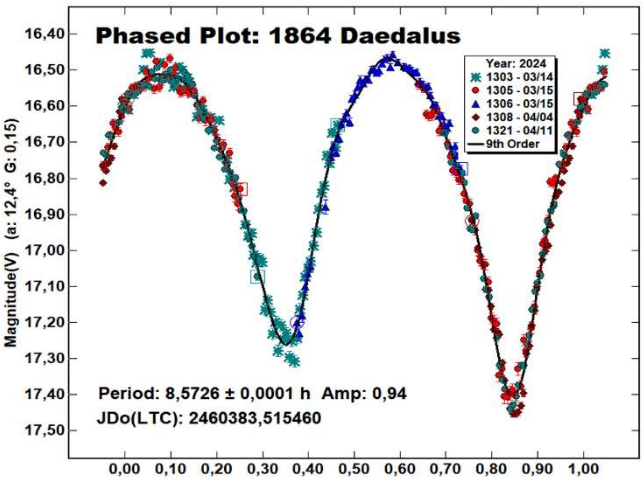
$$\Delta P \approx (1/10 * 0.5) * P^2/\Delta t$$

The factor 1/10 means that the period accuracy is 1/10 of the difference between local minima in the periodogram.

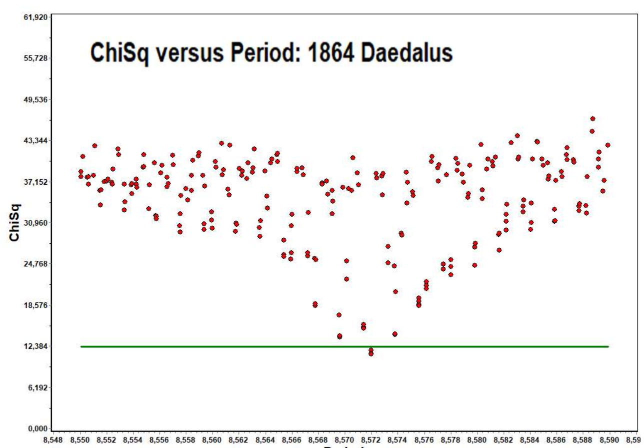
In case we get an unambiguous result with the inversion Method, we can check our result with the calculation method given by Slivan (2012, 2013); (Eqs. 3-5, implemented in *http://www.koronisfamily.com*). With this method, from the maximum lux of different apparitions, we try to delimit the error intervals to know an exact number of rotations of the asteroid, which univocally leads us to know its sidereal period. This is a valid method for data of the “dense” type, obtained continuously during an entire observation session.

Results

1864 Daedalus. This Apollo-class near-Earth object was discovered on 1971 March 24 at Palomar by T. Gehrels. We made observations from 2024 March 14 to April 3. From our data we derive a rotation period of 8.5726 ± 0.0001 h and an amplitude of 0.94 mag. Pravec et al. (2001web) got a period of 8.572 h. Gehrels et al. (1971) got 8.57 h. Pravec et al. (1995) got 8.572 h, Warner (2015) got 8.575 h. The same Warner (2018) got 8.570 h and Warner and Stephens (2020) got 8.570 h. All of them are consistent with our calculation.



We use data from LCDB, Brian Warner 2015, 2017 and 2020 in conjunction with our own dense data and sparse data from ATLAS (370 points 2017/9/29 - 2024/1/23), Catalina (529 points 2004/1/27 - 2023/2/8) and Palomar (57 points 2018/2/7 - 2021/10/13). With the inversion method we calculate a sidereal rotation period of 8.57197 ± 0.00002 h. For the error estimation we have used the interval 2004-2024. In the lower graph we show the χ^2 value as a function of the period, which shows the convergence of the iterative method used.



We use the calculation method given by Slivan (2012, 2013). The times of the maximum values in the lightcurves are:

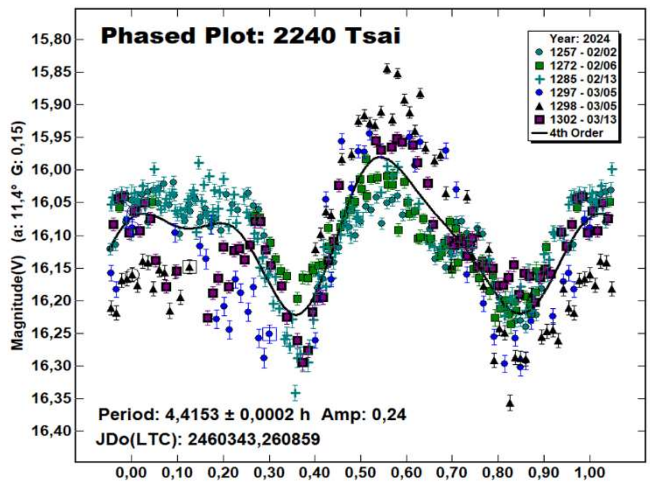
1. 2024/4/8: JD 2460385,49540 lPAB: 191.3
2. 2020/2/1: JD 2458880,87360 lPAB: 151.9
3. 2017/12/22: JD 2458110.06290 lPAB: 133.3

Unfortunately, we do not get an unambiguous solution with the three data sets:

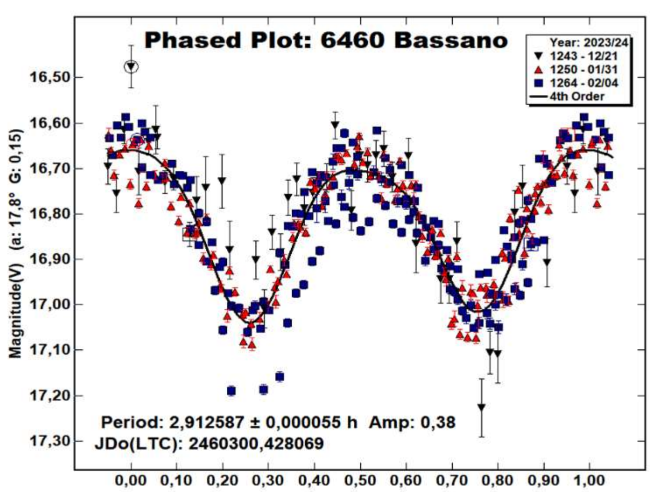
- 1 & 2: P = 8.571931
- 1 & 3: P = 8.571924
- 2 & 3: P = 8.571910

With the quality of our data we can only affirm a period of 8.57192 ± $1*10^{-5}$ h with an amplitude of 0.85 mag. Warner (2018) found a period of 8.571974 h with the inversion method as we did.

2240 Tsai. This outer main-belt asteroid was discovered on 1978 Dec 30 at the Harvard Observatory. We made observations from 2024 Feb 2 to March 13. From our data we derive a rotation period of 4.4153 ± 0.0002 h and an amplitude of 0.24 mag. Durech et al. (2020) got a period of 4.41563 h.



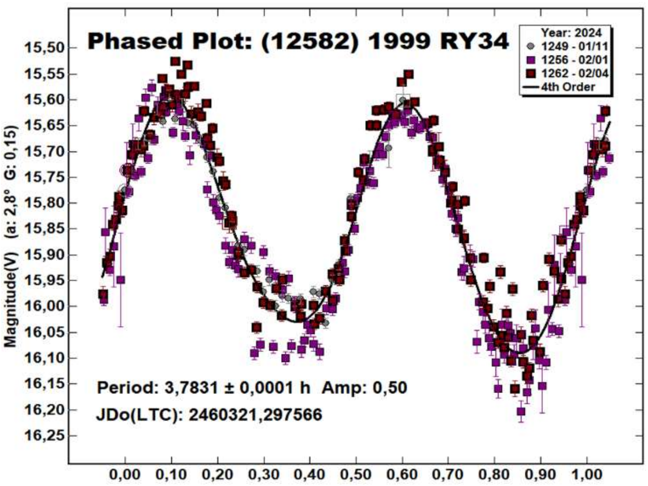
6460 Bassano. This inner main-belt asteroid was discovered on 1992 Oct 28 by U. Quadri at Bassano Bresciano. We made observations from 2023 Dec 21 to 2024 Feb 4. From our data we derive a rotation period of 2.91258 ± 0.00006 h and an amplitude of 0.38 mag. Waszczak found 2.913 h and 2.914 h at Waszczak et al. (2015).



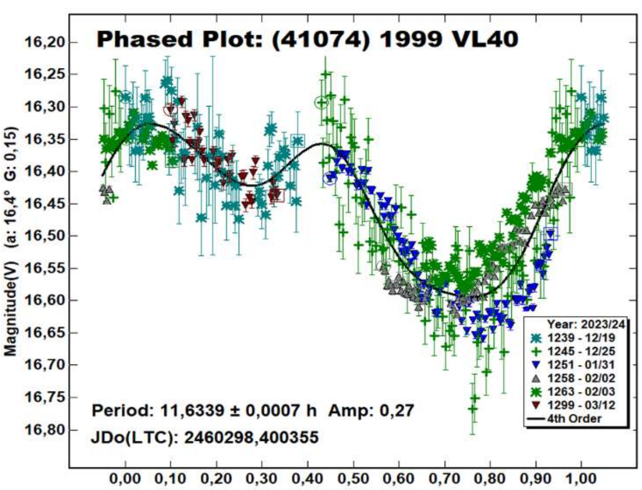
Number	Name	mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1864	Daedalus	2024/3/14-4/3	12.4, 5.3	191.3	0.75	8.5721	0.0001	0.85	0.05	NEA
2240	Tsai	2024/2/12-3/13	12.2,19.1	113.95	0.8	4.4153	0.0002	0.24	0.05	MB-O
6460	Bassano	2023/12/21-2024/2/4	17.7, 7.9	120.15	0.1	2.91258	0.00006	0.38	0.02	MB-I
12582	1999 RY34	2024/1/11-2/4	6.0,25.4	188.15	3.25	3.7831	0.0001	0.5	0.05	MB-I
41074	1999 VL40	2023/12/19-2024/3/12	16.3,35.9	115.8	-16.1	11.6339	0.0002	0.27	0.05	MC
56116	1999 CZ7	2024/2/14-3/14	13.4, 3.8	167.8	0.0	2.9292	0.0001	0.27	0.05	MC
187026	2005 EK70	2024/1/22-2/18	61.0, 6.8	150.3	19.2	6.95555	0.00026	0.17	0.05	NEA
264993	2003 DX10	2024/3/13	38.14	187.5	17.6	-	-	-	-	NEA

Table II. Synodic Periods. Observing circumstances and results. The phase angle values are for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009). MB-I/O: Main-belt inner/outer; NEA: Near Earth Asteroid; MC: Mars-Crosser.

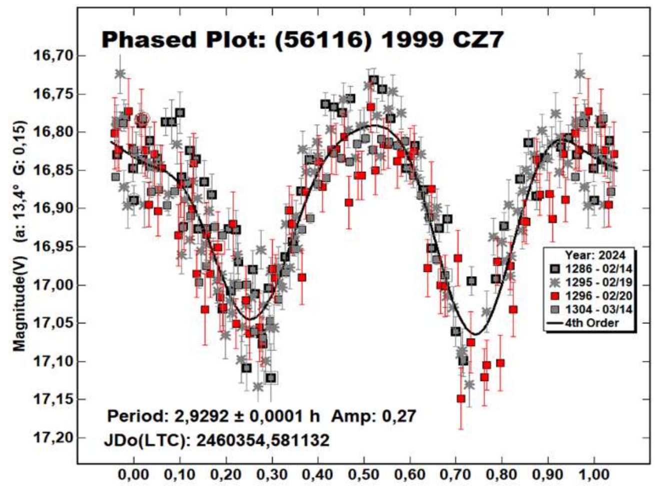
(12582) 1999 RY34. This inner main-belt asteroid was discovered on 1999 Sep 11 at Višnjan Observatory. We made observations from 2024 Jan 11 to Feb 4. From our data we derive a rotation period of 3.7831 ± 0.0001 h and an amplitude of 0.5 mag. We have not previous information about its rotation period.



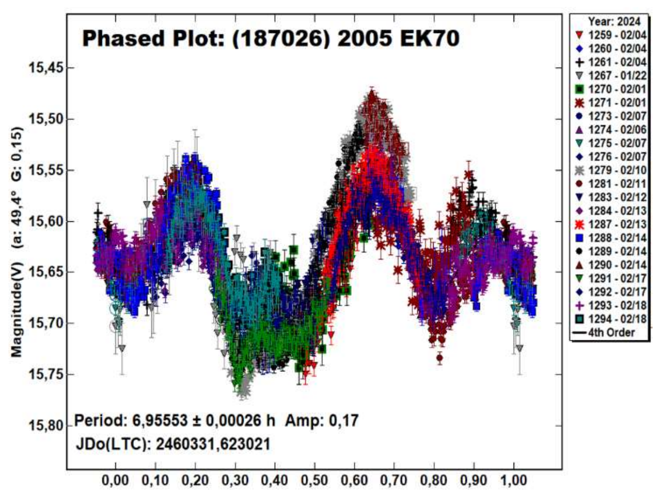
(41074) 1999 VL40. This Mars-crosser asteroid was discovered on 1999 Nov 13 by LONEOS at Anderson Mesa observatory. We made observations from 2023 Dic 19 to 2024 March 12. From our data, we derive a rotation period of 11.6339 ± 0.0002 h and an amplitude of 0.27 mag. There are no previous reports about its rotation period.



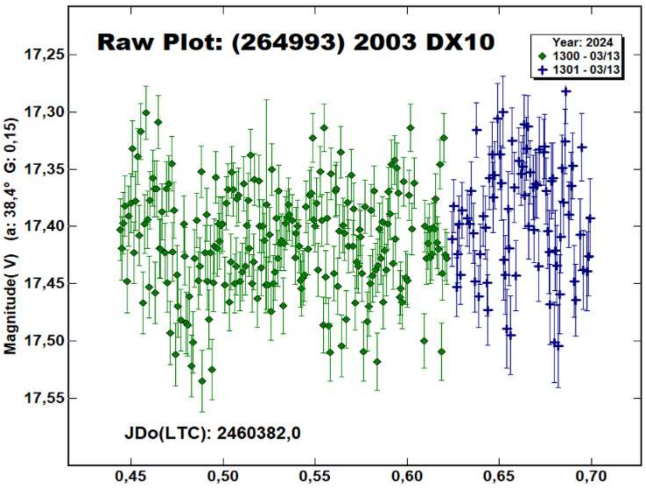
(56116) 1999 CZ7. This Mars-crosser asteroid of the PHO family was discovered on 1999 Feb 11 by LINEAR. We made observations from 2024 Feb 14 to March 14. From our data, we derive a rotation period of 2.9292 ± 0.0001 h and an amplitude of 0.27 mag. Tomassini et al. (2018) found a period of 3.12 h.



(187026) 2005 EK70. This near-Earth asteroid of the Aten family was discovered on 2005 March by LINEAR at Socorro. We made observations on 2024 Jan 22 to Feb 18. From our data we derive a rotation period of 6.95555 ± 0.00026 h and an amplitude of 0.17 mag. We found no previous information about its rotation period.



(264993) 2003 DX10. This Apollo class PHA asteroid was discovered on 2003 Feb 26 by LINEAR. We made observations on 2024 March 13 spanning about six hours. From our data we are not able to derive any rotation period.



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We would like to express our gratitude to Brian Warner for supporting the CALL web site and his suggestions.

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LIGHTCURVES AND ROTATION PERIODS OF ASTEROIDS 1033 SIMONA, 3100 ZIMMERMAN, 4026 BEET, 10707 PRUNARIU, 13039 AWASHIMA, 15817 LUCIANOTESI, 17855 GEFFERT, AND (29826) 1999 DW6

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We present lightcurves and synodic rotation periods for 1033 Simona, 3100 Zimmerman, 4026 Beet, 10707 Prunariu, 13093 Awashima, 15817 Lucianotesi, 17855 Geffert, and (29826) 1999 DW6 observed from 2023 September through 2024 April at Dimension Point Observatory.

Photometric observation of eight minor planets was conducted from 2023 September through 2024 April at Dimension Point Observatory (MPC V42) near Mayhill, NM.

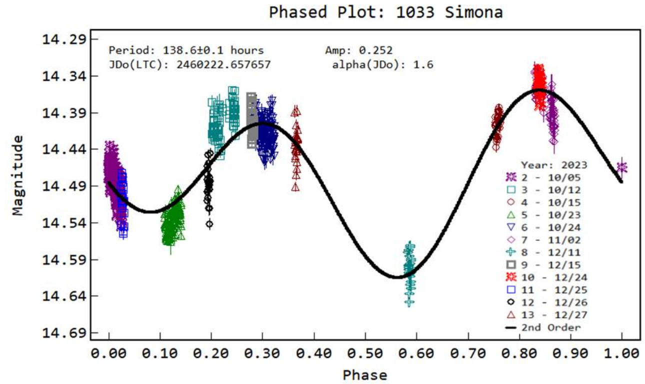
Images were acquired using PlaneWave Instruments 0.43-m *f*/6.8 and 0.61-m *f*/6.5 Corrected Dall-Kirkham telescopes on PlaneWave Instruments L-500 and L-600 direct-drive mounts. Image acquisition was with a Finger Lakes Instrumentation Kepler KL400 back-illuminated CMOS camera. The equipment was operated remotely using *ACP Expert* (Denny, 2023) and *MaximDL* (George et al., 2021). Orbital elements, ephemeris and other information were obtained from the Minor Planet Center (*http://www.minorplanet.net*), the JPL Solar System Dynamics (*http://ssd.jpl.nasa.gov*) and the Lowell Observatory Minor Planet Services (*http://asteroid.lowell.edu*) websites. Target selection and planning was performed using the authors own Python scripts.

Images were made unfiltered in HDR mode, utilizing camera internal stacking every 30 seconds. Exposure duration varied based on the target brightness and apparent motion but was typically 120 seconds.

Image calibration, plate solving, measurement, and period analysis were performed using *Tycho-Tracker* V11.5 (Parrott, 2024). Comparison stars of near solar color were chosen from the ATLAS refcat2 star catalog (Tonry et al., 2018) using the comparison star selection feature of *Tycho-Tracker*.

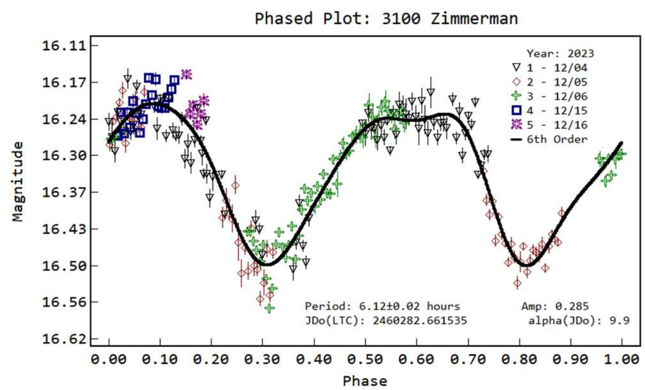
<ins>1033 Simona</ins> is a member of the Eos family discovered in 1924 by Van Beisbroeck at Williams Bay. We found one period report in the LCDB by Shipley at al. (2008) of 10.07 ± 0.06 h. Polakis and Wiles (2024) recently reported 136.7 ± 0.9 h. We observed Simona on thirteen nights in 2023 October through December resulting in a total of 801 observations.

Analysis of the data using the published G value of 0.24 resulted in a best fit of 138.6 ± 0.16 hours with an amplitude of 0.25 ± 0.02 mag, disagreeing with Shipley and in close agreement with Polakis.



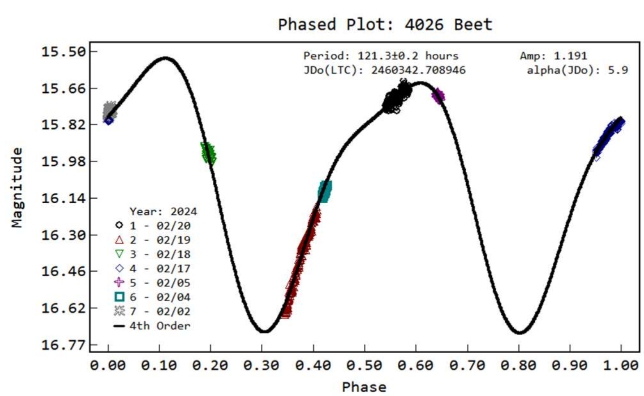
<ins>3100 Zimmerman</ins> is an inner main-belt asteroid discovered in 1977 by N. Chernykh at Nauchny. We observed is on five nights in 2023 December resulting in a total of 228 observations.

A search of the LCDB found one report from Ďurech et. al. (2020) of 6.12607 ± 0.00002 hours. Analysis of our data resulted in a best fit period of 6.12 ± 0.02 hours with an amplitude of 0.28 ± 0.03 mag, in close agreement with Ďurech.



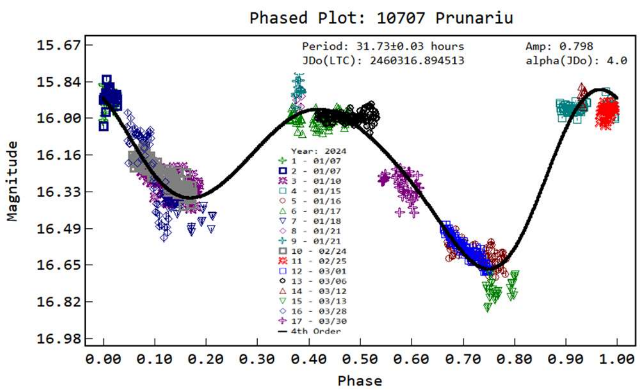
<ins>4026 Beet</ins> is an inner main-belt asteroid discovered in 1982 by E. Bowell at Flagstaff. We observed it on five nights in 2024 February resulting in a total of 638 observations.

A search of the LCDB showed one report by Ďurech et al. (2020) of 121.309 ± 0.008 hours. Analysis of our data resulted in a best fit of 121.3 ± 0.2 hours with an amplitude of > 1.1 ± 0.2 mag, close to the report by Ďurech. Coverage is relatively sparse and missing extrema so the calculated error estimates may be optimistic.



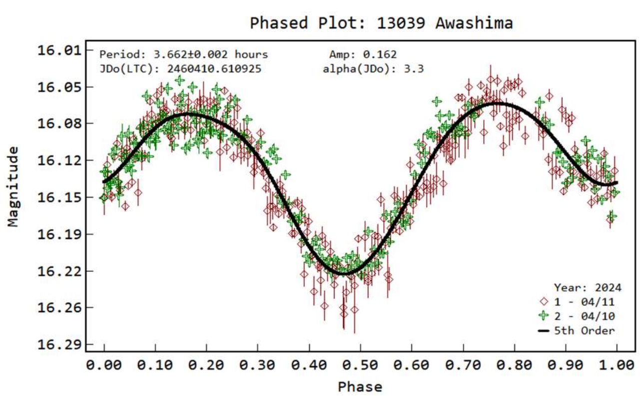
<u>10707 Prunariu</u> is an inner main-belt asteroid discovered in 1981 by S. J. Bus at Palomar. It is named for Dumitru-Dorin Prunariu, the first Romanian cosmonaut flying aboard Soyuz 40 to the Salyut 6 space laboratory. We observed 10707 Prunariu on seventeen nights in 2024 January through March resulting in a total of 856 observations.

No prior rotation periods were found in a search of the LCDB. Analysis of the data resulted in a best fit period of 31.73 ± 0.03 hours with an amplitude of 0.79 ± 0.07 mag. Coverage is incomplete so while this appears to be close to the correct period it could be wrong.



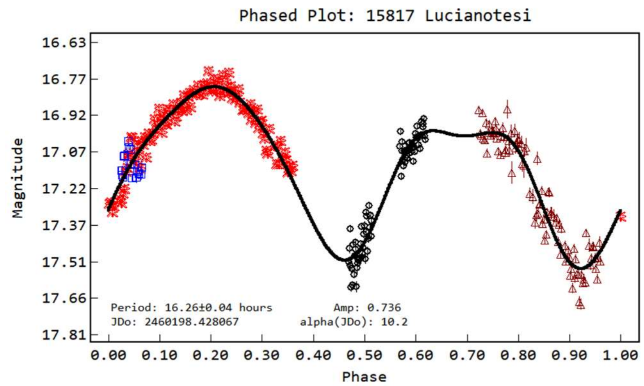
<u>13039 Awashima</u> is an outer main-belt asteroid discovered in 1990 by K. Endate and K. Watanabe at Kitami. It is named for a small island, 20km in circumference, in the Sea of Japan. We observed it on two nights in 2024 April resulting in a total of 466 observations.

A search of the LCDB showed no prior rotation period reports. Analysis of our data resulted in a best fit period of 3.661 ± 0.002 hours with an amplitude of 0.16 ± 0.02 mag.



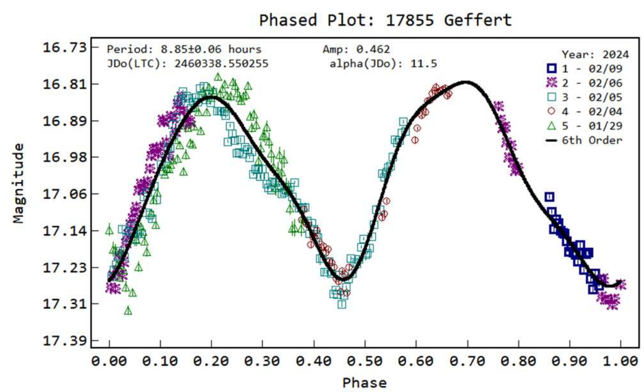
<u>15817 Lucianotesi</u> is a NEO and member of the Amor family discovered in 1994 by A. Boattini and M. Tombelli at San Marcello Pistoiese. It is named for Luciano Tesi who founded the Amateur Group of the Pistoiese Mountain in 1980. This later led to the construction of the Pian dei Termini Observatory.

A search of the LCDB found a report from Pravec (2000) with a period lower limit of 11 hours. This was referenced as '2000web,' which we were unable to find. There were two nights of data found in the LCDB from G. Fornas. We observed 15817 Lucianotesi on two nights in 2023 September with a total of 94 observations. Combining the Fornas data with our own resulted in a best fit period of 16.26 ± 0.04 hours with an amplitude of 0.74 ± 0.05 mag. Coverage is not complete so, while this result seems close to the correct value, it could be wrong.



<u>17855 Geffert</u> is an outer main-belt asteroid discovered in 1998 by Heppenheim at the Starkenburg Observatory. We observed it on five nights in 2024 January and February, resulting in 346 total observations.

A search of the LCDB found one report from Pál et al. in 2020 of 7.46763 ± 0.00005 hours. Analysis of our data resulted in a period of 8.85 ± 0.06 hours and an amplitude of 0.46 ± 0.04 mag, longer than the report from Pál.

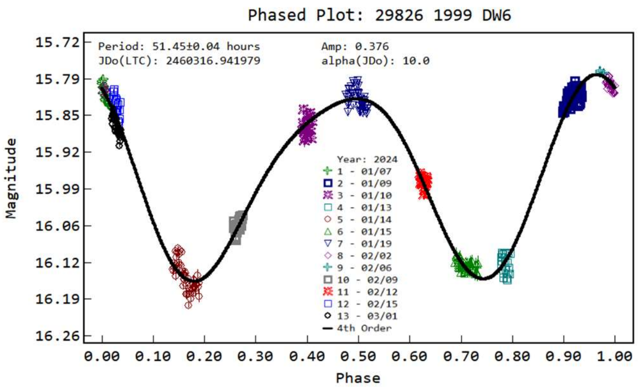


<u>(29826) 1999 DW6</u> is an inner main-belt asteroid discovered in 1999 by LINEAR at Socorro. We observed it on thirteen nights in 2024 January through march resulting in a total of 356 observations.

No prior rotation period reports were found in the LCDB. Analysis of our data resulted in a best fit period of 51.45 ± 0.04 hours with an amplitude of 0.38 ± 0.02 mag.

Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1033	Simona	2023 10/04-12/27	1.2,21,7	9	0	138.6	0.16	0.25	0.02	EOS
3100	Zimmerman	2023 12/04-12/16	3.4,9.8	88	3	6.12	0.02	0.28	0.03	MB-I
4026	Beet	2024 02/02-02/20	*5.86,4.4	143	1	121.3	0.2	>1.2	0.2	MB-I
10707	Prunariu	2024 01/10-03/30	4.1,23.3	110	8	31.73	0.03	0.79	0.07	MB-I
13039	Awashima	2024 04/10-04/11	3.36,3.7	195	5	3.661	0.002	0.16	0.02	MB-O
15817	Lucianotesi	2023 09/11-09/23	*11.99,10.25	355	-6	16.26	0.04	0.74	0.05	AMOR
17855	Geffert	2024 01/29-02/09	11.6,15.1	102	-3	8.85	0.06	0.46	0.04	MB-O
29826	1999 DW6	2024 01/07-03/01	*10.03,21.26	119	10	51.44	0.04	0.38	0.02	MB-I

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 an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).



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LIGHTCURVES OF TEN ASTEROIDS

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We present lightcurves and synodic rotation periods for ten asteroids.

We present asteroid lightcurves obtained via the workflow process described by Dose (2020) and later improved (Dose, 2021a). This workflow applies to each image an ensemble of typically 25-100 nearby comparison ("comp") stars selected from the ATLAS refcat2 catalog (Tonry et al., 2018). This abundance of comp stars and our custom diagnostic plots allow for rapid identification and removal of outlier, variable, and poorly measured comp stars.

The product of this custom workflow is one night's time series of absolute Sloan r' (SR) magnitudes for one target asteroid. These absolute magnitudes are corrected for instrument transforms, sky extinction, and image-to-image ("cirrus") fluctuations, and thus they represent absolute magnitudes at the top of earth's atmosphere. These magnitudes are imported directly into *MPO Canopus* software (Warner, 2021) where they are adjusted for distance and phase-angle dependence, then fit by Fourier analysis including identifying and ruling out of aliases, and plotted.

Phase-angle corrections are made by applying a *H-G* model to the night's phase angle, using the *G* value minimizing best-fit RMS error across all nights' data. For campaigns in which we cannot estimate an asteroid's *G* value, usually due to a narrow range of phase angles, we apply the Minor Planet Center's default value of 0.15. No nightly zero-point adjustments (Delta Comps in *MPO Canopus*) were made to any session, other than by estimating *G*.

Lightcurve Results

Ten asteroids were observed from New Mexico Skies observatory at 2310 meters elevation in southern New Mexico. Images were acquired with: a 0.50-m PlaneWave OTA on a PlaneWave L-500 mount and equatorial wedge, and a SBIG AC4040M CMOS camera cooled to -22°C (or to -15°C before December 14) and fitted with a Schott GG495 yellow filter.

This equipment was operated remotely via *ACP software* (DC-3 Dreams), running one-night plan files generated by python scripts (Dose, 2020). Exposure times targeted 2.5-5.0 millimagnitudes uncertainty in asteroid instrumental magnitude, subject to a minimum exposure of 90 seconds to ensure suitable comp-star photometry, and to a maximum of 480 seconds.

FITS images were calibrated using temperature-matched, exposure-matched, median-averaged dark images and recent flat images of a flux-adjustable light panel. Calibrated images were plate-solved by *TheSkyX* (Software Bisque), and target asteroids were identified in *Astrometrica* (Herbert Raab). All photometric images were visually inspected; the author excluded images with inadequate tracking or seeing quality, excessive interference by cloud or moon, or having stars, satellite tracks, cosmic ray artifacts, residual image artifacts, or other apparent light sources within 12 arcseconds of the target asteroid's signal centroid. Images passing these screens were submitted to the workflow.

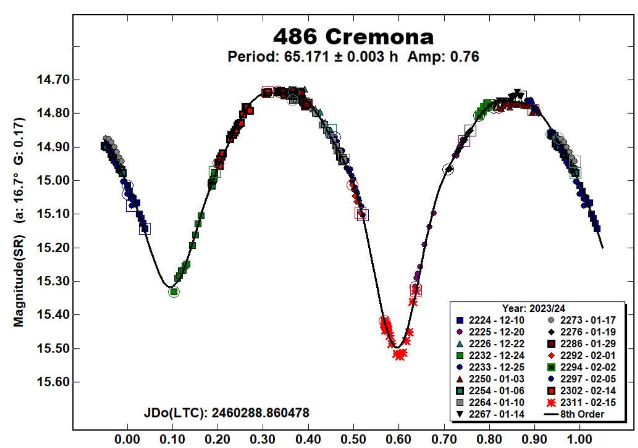
The GG495 yellow filter used here requires only modest first-order transforms to yield magnitudes in the standard Sloan r' (SR) passband. In our hands, using a light yellow filter (rather than a clear filter or no filter) improves night-to-night reproducibility to a degree outweighing loss of signal-to-noise ratio caused by ~15% loss of measured flux.

Our workflow selects as comp stars all ATLAS refcat2 catalog stars that have: distance of at least 15 arcseconds from image boundaries and from other catalogued flux sources, no catalog VARIABLE flag, SR magnitude within [-2, +1] of the target asteroid's SR magnitude on that night (except that very faint asteroids used comp stars with magnitudes in the range 14 to 16), Sloan r'-i' color value within [0.10, 0.34], and absence of variability as seen in session plots of each comp star's instrumental magnitude vs time.

In this report, "period" refers to an asteroid's synodic rotation period, "SR" denotes the Sloan r' passband, and "mmag" denotes millimagnitudes (0.001 magnitude). In these lightcurves, *MPO Canopus* v10 shows "SR" for both Pan-STARRS and Sloan r' values.

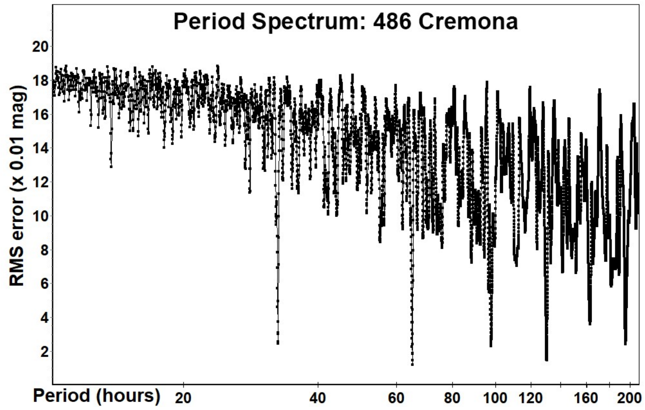
486 Cremona. No lightcurve for this low-numbered inner main-belt asteroid has yet been assigned the best uncertainty score U of 3 by the Minor Planet Lightcurve Database (LCDB; Warner et al., 2009). Published lightcurves show frequent phase gaps despite the relative accessibility of the consensus rotation period (65.90 h, Warner, 2006; 65.15 h, Cooney et al., 2007; 65.151 h, Hanuš et al., 2011; 65.178 h, McNeill et al., 2019; 65.0918 h, Pál et al., 2020; 64.941 h, Colazo et al., 2021; 65.203 h, Dose, 2021b) and one differing early estimate (77.5 h, Behrend, 2006web).

Our new observations were made with equipment approximately 3 times as sensitive as was used in the author's 2021 campaign on this asteroid. These new observations over 17 nights result in a new lightcurve with only a few minor gaps, as well as a fortuitiously high amplitude. An eighth-order Fourier fit yields RMS error of 12 mmag (amplitude/error ~ 60) and a best period estimate of 65.171 ± 0.003 h. The best *H-G* phase-angle correction gives *G* of 0.17, close to the author's 2021 estimate of 0.18.

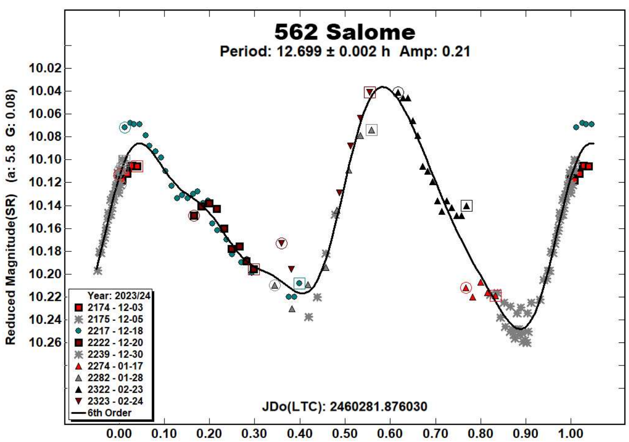


The period spectrum is dominated by our period estimate, followed by other signals at multiples of ½ period as is expected when the two lightcurve halves are similar. From this period spectrum and from the large amplitude, we adopt a bimodal interpretation as previous investigators have done.

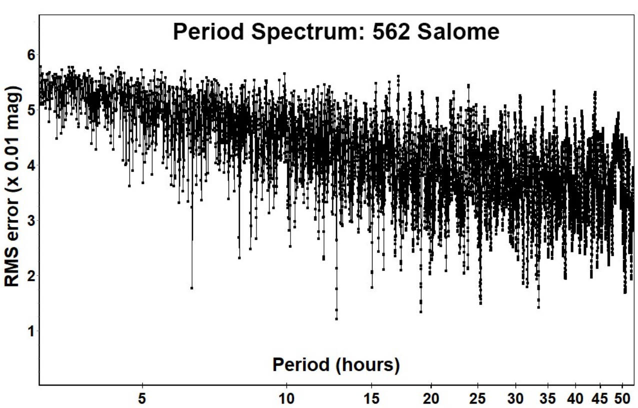
Several published lightcurves differ in shape and amplitude, so that 486 Cremona may make an attractive target for shape analysis.



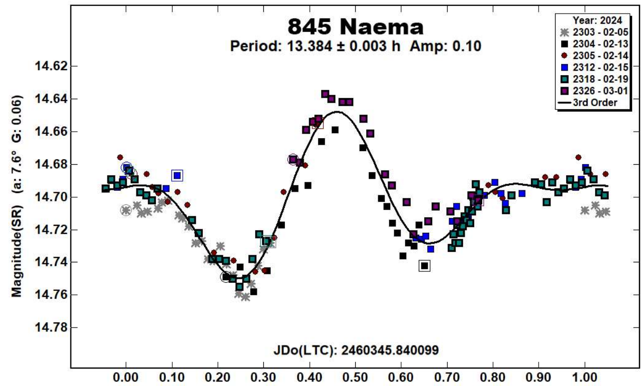
562 Salome. Ten previously published rotation period estimates have not produced a consensus period for this bright Eos-family asteroid (10.4 h, Binzel, 1987; 12.7 h, Behrend, 2005web; 12.705 h, Bembrick and Allen, 2007; 12.7050 h, Hamanowa and Hamanowa, 2011web; 6.3501 h, Higgins, 2011web; 6.351 h, Alkema, 2013; 6.35031, Hanuš et al., 2016a; 6.350305 h, Hanuš et al., 2016b; 6.35030 h, Hanuš et al., 2018a; 20.5726 h, Hanuš et al., 2018b). Based on 9 nights' observations, we offer a new period estimate of 12.699 ± 0.002 h, agreeing with three of the earlier reports. Our lightcurve is clearly bimodal; our Fourier fit RMS error is 12 mmag.



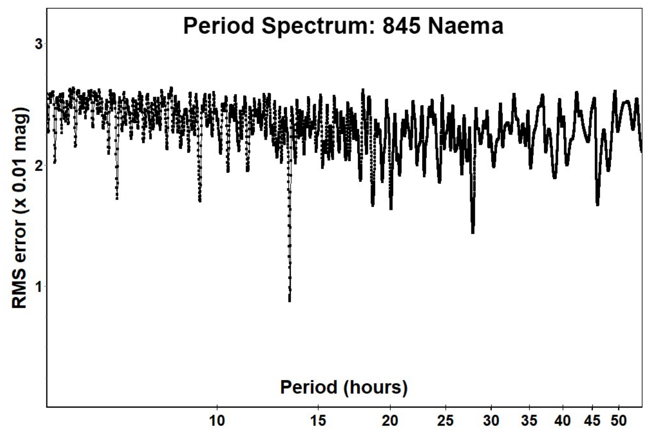
The period spectrum shows a secondary signal near 6.35 h, corresponding to a monomodal interpretation, but no major signals appear near published period estimates of 10.4 and 20.6 h.



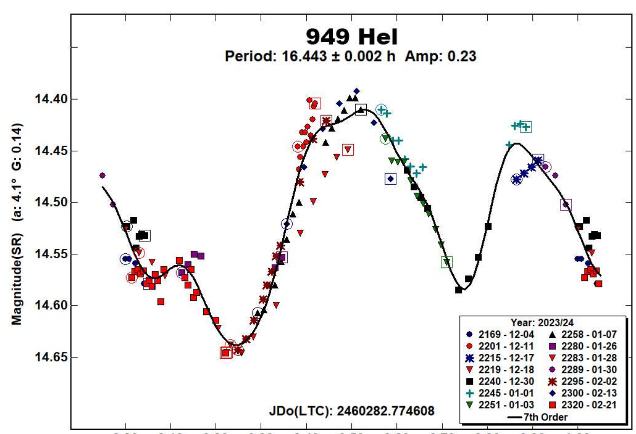
845 Naema. For this principal asteroid of the Naema family, all three known period estimates differ (20.892 h, Bembrick et al., 2008; 12.1 h, Behrend, 2017web; 13.378 h, Dose, 2023b). Our new observations yield a period estimate of 13.384 ± 0.003 h, confirming the author's 2023 result. Our Fourier fit RMS error is 9 mmag, and our best *G* value is 0.06.



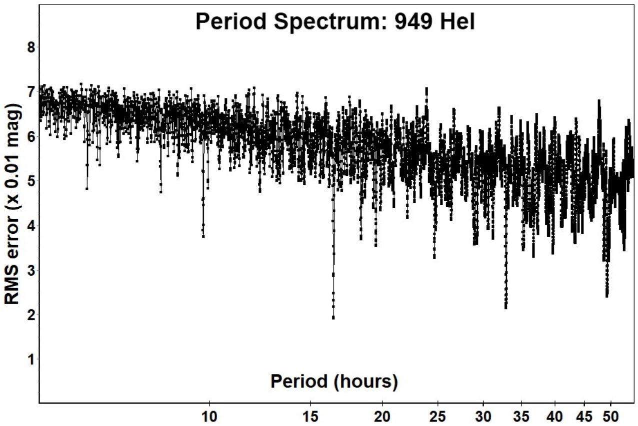
The period spectrum strongly supports the present estimate over alternatives, including published estimates near 21 h or 12 h.



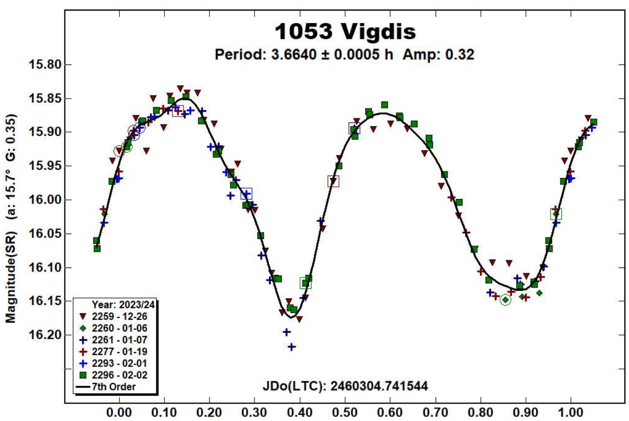
949 Hel. For this outer main-belt asteroid, our new rotation period estimate of 16.443 ± 0.002 h differs from the three known published estimates (10.862 h, Behrend, 2001web; 10.85 h, Behrend, 2004web; 8.215 h, Brines et al., 2017), though it is close to twice that of Brines. Our lightcurve shape changed noticeably during our observational campaign of 14 nights over 11 weeks, but the shape remained clearly bimodal with its halves differing in shape.



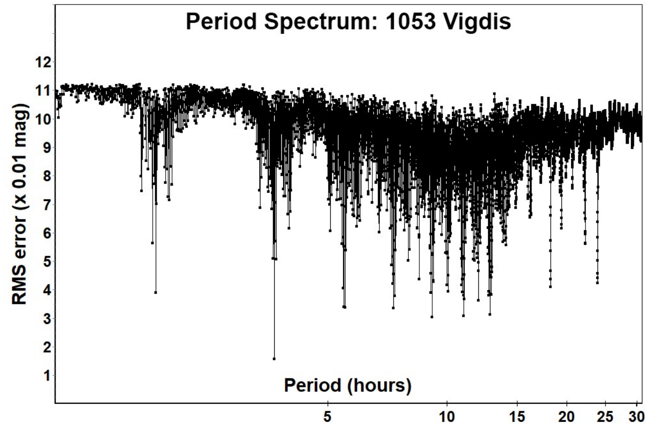
The period spectrum favors our new estimate and lacks appreciable signal near 10.86 h.



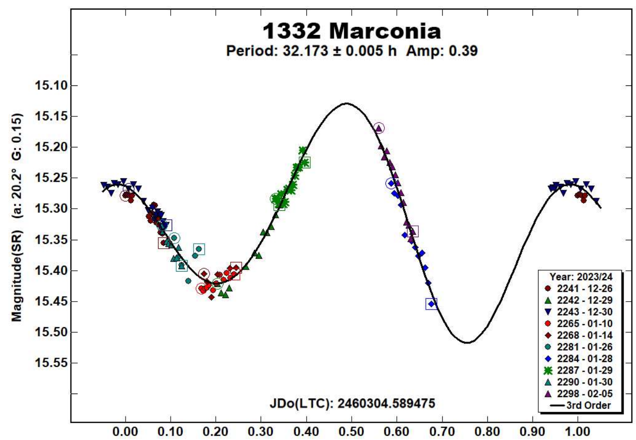
1053 Vigdis. We estimate the period for this middle main-belt asteroid to be 3.6640 ± 0.0005 h. No previously published period estimates are known to us. The halves of this bimodal lightcurve are similar in maximum and minimum brightness but differ in shape, requiring an order-7 Fourier fit whose RMS error is 16 mmag. Our best *G* value was 0.35; indeed, it was challenging to get the Fourier fit to converge properly when applying MPC's default *G* value of 0.15.



Our period estimate dominates the period spectrum.



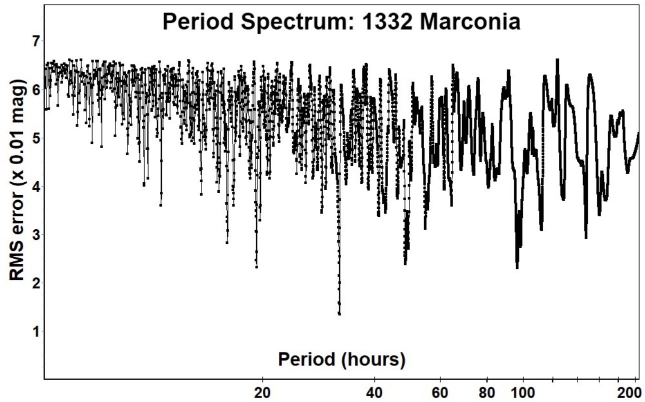
1332 Marconia. For this principal asteroid of the Marconia family, five published rotation period estimates (19.16 h, Stephens, 2013; 19.2264 h, Ďurech et al., 2016; 32.1201 h, Devogèle et al., 2017; 31.34 h, Polakis and Wiles, 2024; 32.029 h, Colazo et al., 2024) form two groups mutually aliased by ½ rotation period per 24 h. Our new period estimate of 32.173 ± 0.005 h agrees with the more recent reports. Our RMS error is 13 mmag.



Despite unfortunate phase-coverage gaps, largely caused by our campaign's starting 10 weeks after maximum brightness, our lightcurve shape shows two reproducibly differing regions of dimming (phases 0-0.2 vs 0.5-0.7 in the lightcurve above), and our period spectrum strongly favors our estimate over those near 19 hours.

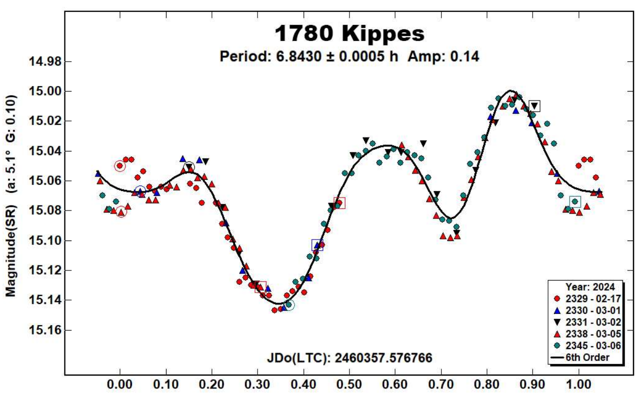
Number	Name	yyyy mm/dd		Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
486	Cremona	2023-4	12/10-02/15	*16.8,15.0	116	5	65.171	0.003	0.76	0.04	MB-I
562	Salome	2023-4	12/03-02/24	*6.0,17.5	86	5	12.699	0.002	0.21	0.04	EOS
845	Naema	2024	02/05-03/01	*7.7,6.4	151	15	13.384	0.003	0.10	0.02	NAE
949	Hel	2023-4	12/04-02/21	*4.2,17.5	74	11	16.443	0.002	0.23	0.03	MB-O
1053	Vigdis	2023-4	12/26-02/02	*15.8,5.2	129	10	3.664	0.001	0.32	0.04	MB-M
1332	Marconia	2023-4	12/26-02/05	20.2,20.2	35	1	32.173	0.005	0.39	0.06	MRC
1780	Kippes	2024	02/17-03/06	5.0,10.9	135	-5	6.843	0.001	0.14	0.02	EOS
3643	Tienchanglin	2023-4	12/10-01/17	*17.7,10.1	108	15	2.867	0.001	0.11	0.05	MB-I
18651	1998 FP11	2024	04/03-04/11	6.4,10.6	184	3	4.572	0.001	0.82	0.05	MB-I
29515	1997 YL7	2023-4	12/24-02/05	*9.9,16.1	108	5	12.224	0.001	0.84	0.04	MB-M

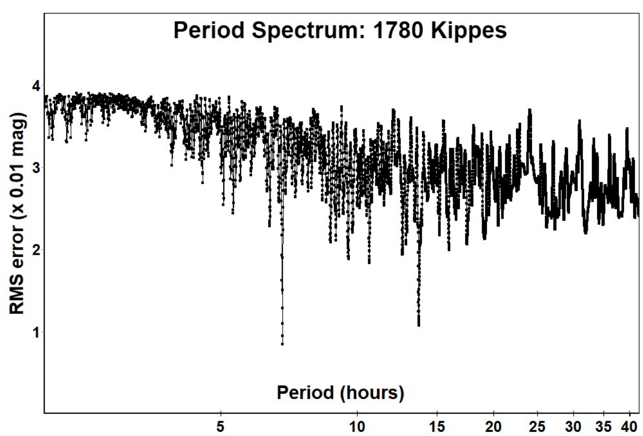
Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984).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



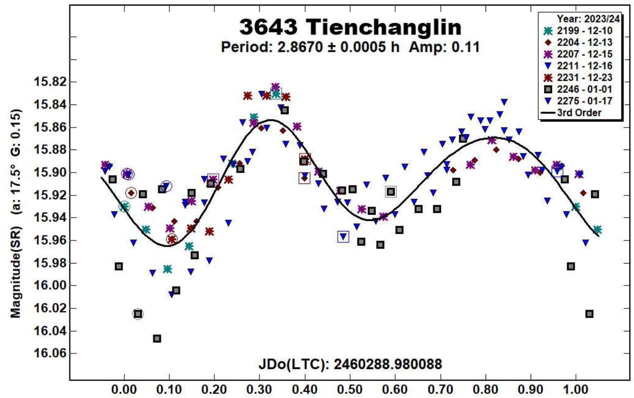
1780 Kippes. Three published period estimates for this Eos-family asteroid all differ (18.0 h, Binzel, 1987; 6.83899 h, Pál et al., 2020; 13.684 h, Dose, 2023a). Our recent observations yield a new period estimate of 6.8430 ± 0.0005 h, agreeing with Pál's estimate.

This new estimate is half of that of the author's 2023 report, which already mentioned the plausibility of monomodal (ca. 6.84 h) interpretation. The current data benefit from a higher lightcurve amplitude relative to that measured by the author in 2023 (0.14 mag vs 0.09) and has lower Fourier fit RMS error (8 mmag vs 15) as well.

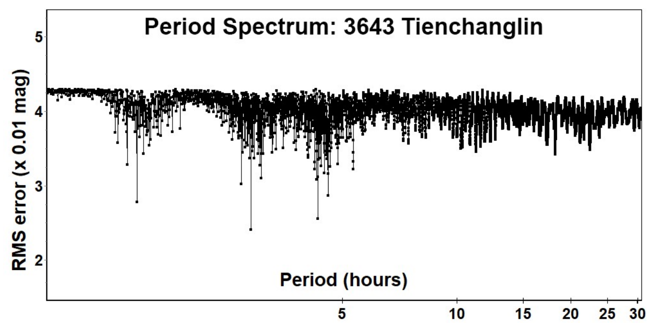




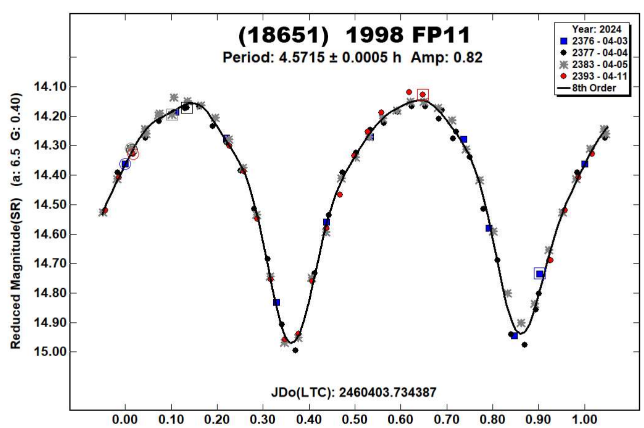
3643 Tienchanglin. Our rotation period estimate for this relatively faint inner main-belt asteroid is 2.8670 ± 0.0005 h; no published estimates are known to us. The lightcurve shape appeared to change rapidly during our observation campaign. Our RMS error is 24 mmag.



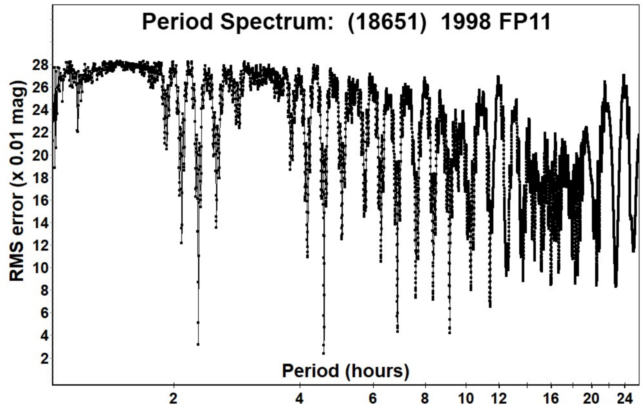
Despite the noisy data, modest amplitude, and probable changes in lightcurve shape during the observation campaign, the resulting period spectrum supports our period estimate.



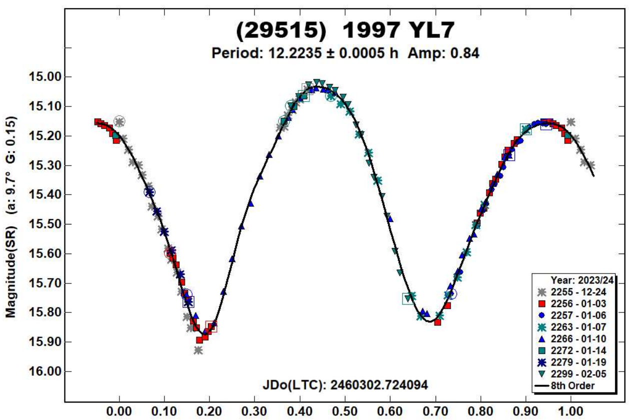
(18651) 1998 FP11. This inner main-belt asteroid was found in recent images targeting asteroid 1965 van de Kamp (whose observing campaign is in progress). The short rotation period and exceptionally large amplitude allowed for rapid convergence to our proposed period of 4.5715 ± 0.0005 h. We know of no previously published period estimates. Even with only 4 nights' data, Fourier fitting required order 8 and yielded RMS error of 22 mmag.



The period spectrum is dominated by our proposed rotation period, followed by secondary signals at multiples of ½ that period.



(29515) 1997 YL7. Our period estimate of 12.2235 ± 0.0005 h for this middle main-belt asteroid matches two previously published estimates (12.231 h, Warner, 2007; 12.2249 h, Pál et al., 2020). The amplitude is a remarkably large 0.84 mag, and our Fourier fit of order 8 has RMS error of 16 mmag. The lightcurve shape is clearly bimodal with the two halves differing in shape and amplitude.



Acknowledgements

The author thanks all contributors to the ATLAS paper (Tonry et al., 2018) for providing openly and without cost the ATLAS refcat2 catalog release. This current work also makes extensive use of the python language interpreter and of several supporting packages (notably: astropy, ccdproc, ephem, matplotlib, pandas, photutils, requests, skyfield, and statsmodels), all made available openly and without cost.

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PHOTOMETRIC OBSERVATIONS OF ASTEROIDS 347 PARIANA, 632 PYRRHA, 3067 AKHMATOVA AND 8602 OEDICNEMUS

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Photometric observations of four main-belt asteroids were conducted to determine their synodic rotation periods. We found: for 347 Pariana, $P = 4.053 \pm 0.001$ h with $A = 0.15 \pm 0.02$ mag; for 632 Pyrrha, $P = 4.119 \pm 0.003$ h with $A = 0.30 \pm 0.02$ mag; for 3067 Akhmatova, $P = 3.686 \pm 0.001$ h with $A = 0.35 \pm 0.03$ mag, for 8062 Oedicnemus, $P = 10.502 \pm 0.003$ h with $A = 0.44 \pm 0.02$ mag.

CCD photometric observations of four main-belt asteroids were carried out in January-March 2024 at the Astronomical Observatory of the University of Siena (K54). We used a 0.30-m *f*/5.6 Maksutov-Cassegrain telescope, SBIG STL-6303E NABG CCD camera; the pixel scale was 2.30 arcsec when binned at 2×2 pixels. For 347 Pariana we used a Rc filter and 180 seconds of exposure time, for the other asteroids we used a Clear filter and 300 seconds of exposure time.

Data processing and analysis were done with *MPO Canopus* (Warner, 2018). All images were calibrated with dark and flat-field frames and the instrumental magnitudes 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.

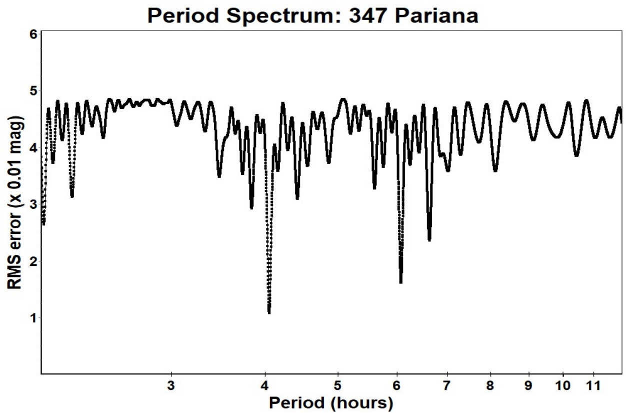
A search through the asteroid lightcurve database (LCDB; Warner et al., 2009) indicates that our result may be the first reported lightcurve observations and results for 8062 Oedicnemus.

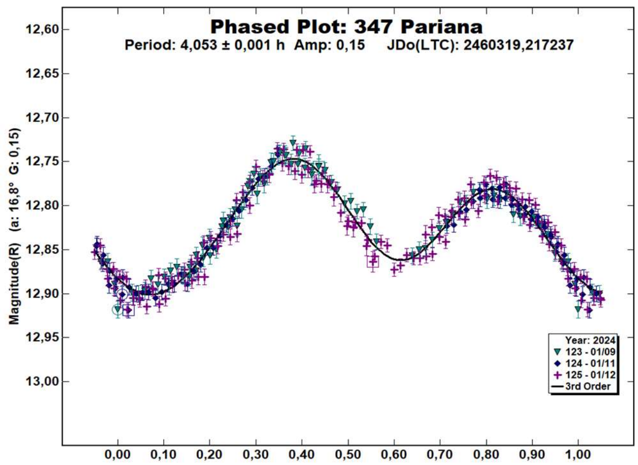
347 Pariana (1892 WD) was discovered by Auguste Honoré Charlois at Nice on 1892 November 28. It is a middle main-belt asteroid with a semi-major axis of 2.615 AU, eccentricity 0.167, inclination 11.686°, and an orbital period of 4.23 years. Its absolute magnitude is $H = 9.04$ (JPL, 2024). The NEOWISE satellite infrared radiometry survey (Mainzer et al., 2019) found a diameter $D = 48.615 \pm 0.118$ km using an absolute magnitude $H = 8.96$.

Observations were conducted over three nights and collected 271 data points. The period analysis shows a rotational period of $P = 4.053 \pm 0.001$ h with an amplitude $A = 0.15 \pm 0.02$ mag, in perfect agreement with the previously results published in the LCDB (Pál et al., 2020).

Number	Name	2024/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
347	Pariana	01/09-01/12	16.8,17.7	67	-2	4.053	0.001	0.15	0.02	MB-M
632	Pyrrha	03/13-03/15	*0.4,0.4	174	0	4.119	0.003	0.30	0.01	MB-M
3067	Akhmatova	03/13-03/20	*0.3,3.5	174	0	3.686	0.001	0.35	0.03	MB-I
8602	Oedicnemus	03/13-03/20	*0.3,3.4	174	0	10.502	0.003	0.44	0.02	MB-I

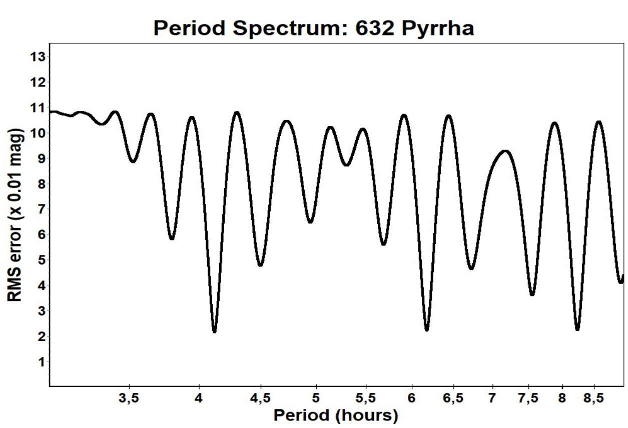
Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extremum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al.,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

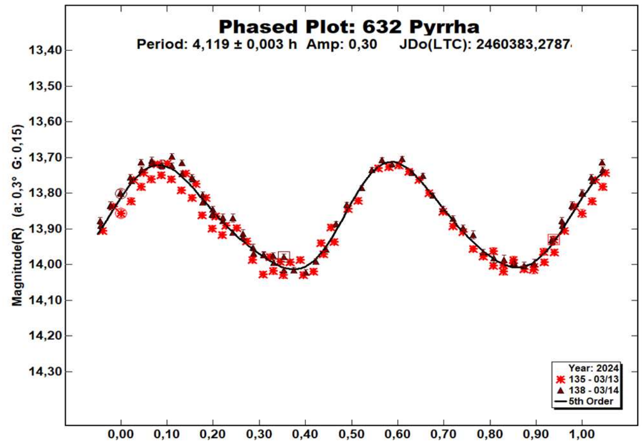




632 Pyrrha (1907 GY) was discovered on 1907 April 5 by August Kopff at Heidelberg. It is a middle main-belt asteroid with a semi-major axis of 2.662 AU, eccentricity 0.191, inclination 2.216°, and an orbital period of 4.34 years. Its absolute magnitude is $H = 11.45$ (JPL, 2024). The NEOWISE satellite infrared radiometry survey (Mainzer et al., 2019) found a diameter $D = 14.419 \pm 0.219$ km using an absolute magnitude $H = 11.6$.

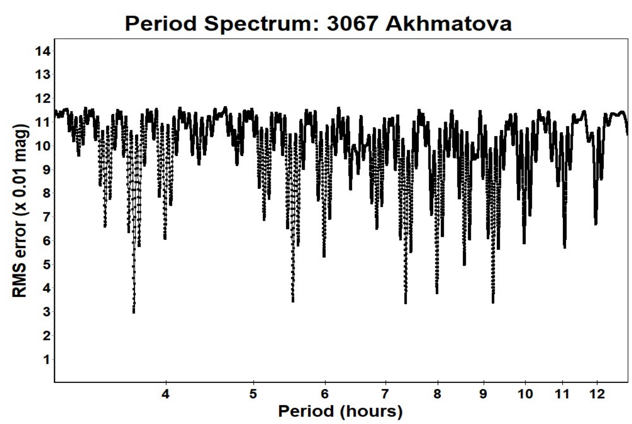
Observations were conducted over two nights and collected 128 data points. The period analysis shows a rotational period of $P = 4.119 \pm 0.003$ h with an amplitude $A = 0.30 \pm 0.02$ mag, in good agreement with the previously results published in the LCDB (Martikainen et al., 2021). Because of a slight possible attenuation of light observed in the first session, further observations are strongly encouraged to investigate the possibility of a satellite.

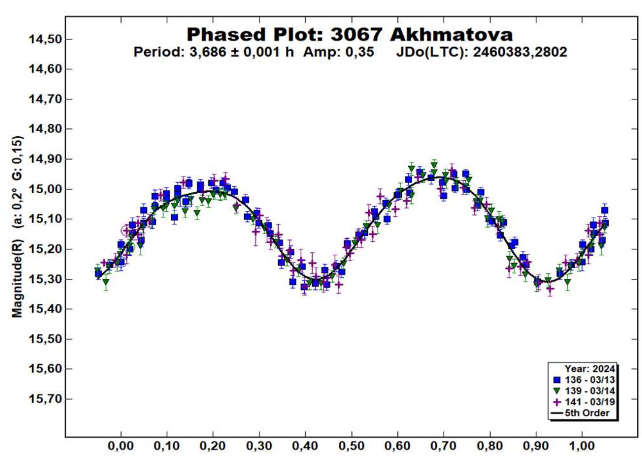




3067 Akhmatova (1982 TE2) was discovered on 1982 October 14 by L.V. Zhuravleva and L.G. Karachkina at Nauchnyj and named in honor of the Russian poetess Anna Andreevna Akhmatova (1889-1966). It is an inner main-belt asteroid with a semi-major axis of 2.245 AU, eccentricity 0.137, inclination 4.520°, and an orbital period of 3.36 years. Its absolute magnitude is $H = 13.30$ (JPL, 2024). The NEOWISE satellite infrared radiometry survey (Mainzer et al., 2019) found a diameter $D = 6.253 \pm 0.160$ km using an absolute magnitude $H = 13.0$.

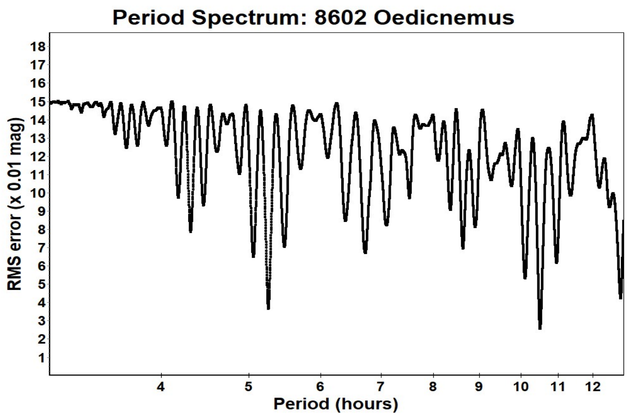
Observations were conducted over three nights and collected 185 data points. The period analysis shows a rotational period of $P = 3.686 \pm 0.001$ h with an amplitude $A = 0.35 \pm 0.03$ mag, in good agreement with the previously results published in the LCDB (Benishek, 2017).

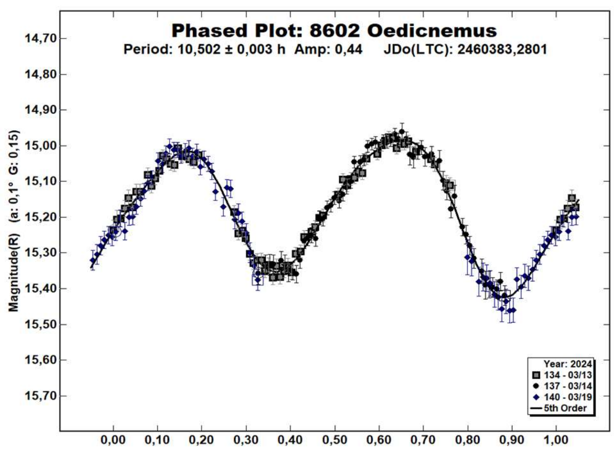




8602 Oedicnemus (2480 T-3) was discovered on 1977 October 16 by C.J. van Houten, I. van Houten-Groeneveld and T. Gehrels at Palomar; it is named for Burhinus Oedicnemus, a northern species of the Burhinidae (stone-curlew) bird family. It is an inner main-belt asteroid with a semi-major axis of 2.400 AU, eccentricity 0.133, inclination 8.074°, and an orbital period of 3.72 years. Its absolute magnitude is H = 13.35 (JPL, 2024). The NEOWISE satellite infrared radiometry survey (Mainzer et al., 2019) found a diameter D = 5.677 ± 0.113 km using an absolute magnitude H = 13.0.

Observations were conducted over three nights and collected 185 data points. The period analysis shows a rotational period of P = 10.502 ± 0.003 h with an amplitude A = 0.44 ± 0.02 mag.





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ANALYSIS AND LIGHTCURVES OF 22 ASTEROIDS

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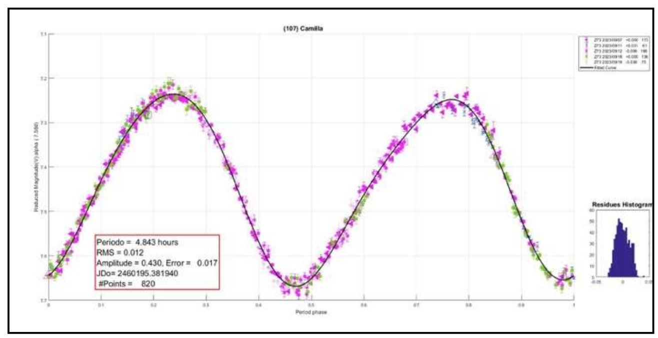
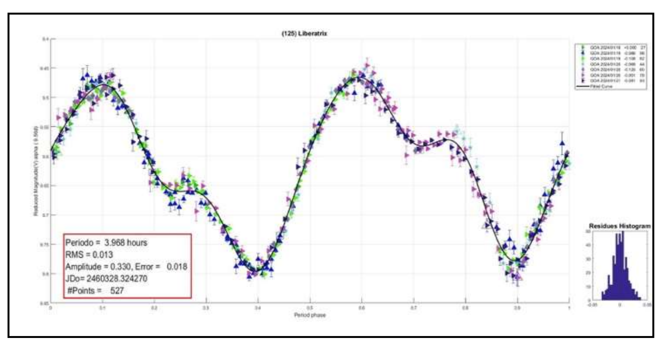
The analysis and lightcurves of the 22 asteroids presented here were carried out from 2022 September 2022 to 2024 January, although most of the cases were in late 2023 and early 2024. For several asteroids, we found no previously published light curves or 3D models. In other cases, we believed that the lightcurves and rotation periods needed revision, as they corresponded to data from many years ago. The 22 asteroids studied were:107 Camilla (4.843 h), 125 Liberatrix (3.968 h), 283 Emma (6.894 h), 347 Pariana (4.052 h), 353 Ruperto-Carola (2.738 h), 378 Holmia (4.440 h), 694 Ekard (5.924 h), 765 Mattiaca (3.229 h), 822 Lalage (3.346 h), 1011 Laodamia (5.171 h), 1111 Reinmuthia (4.007 h), 1408 Trusanda (29.378 h), 1610 Mirnaya (4.745 h), 1806 Derice (3.225 h), 2244 Tesla (15.247 h), 2343 Siding Spring (2.106 h), 2724 Orlov (13.788 h), 3505 Byrd (9.162 h), 4084 Hollis (4.454 h), 4222 Nancita (3.872 h), 4442 Garcia (6.398 h), and 6100 Kunitomoikkansai (18.450 h).

All observations reported here were unfiltered. The images were calibrated in the standard way (bias, darks and flats). Images were measured, and periods analysis were done using *FotoDif* (2021) *Tycho Tracker* (2023) and *Periodos* (2020) packages. All data were light-time corrected. The results are summarized below. Individual lightcurve plots along additional comments as required are also presented.

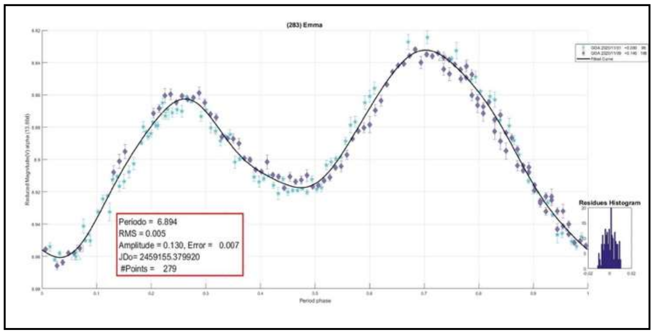
107 Camilla. This is one of the larger asteroids from the outermost edge of the asteroid belt, approximately 250 kilometers in diameter. It is a member of the Sylvia family and located within the Cybele group. Although there are data on its rotation period since 2004, our observations (carried out from 2023 September to November) confirmed the value of this known data, detecting no significant variation since then. Our values were P = 4.843 ± 0.012 hours and an amplitude of 0.43 ± 0.02 mag.



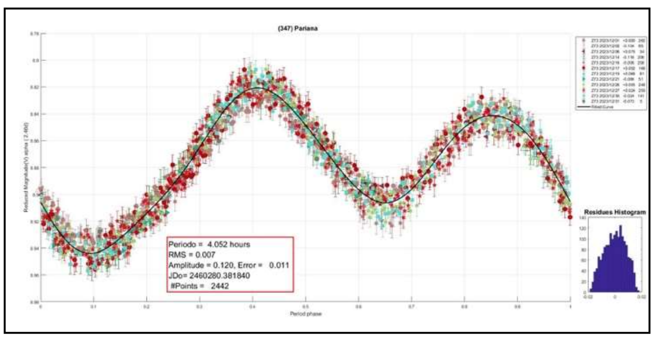
125 Liberatrix. Belonging to the main asteroid belt, Liberatrix has an M-type spectrum and it seems possible that it is the remains of an asteroid that underwent differentiation, with traces of orthopyroxene minerals on its surface. Our observations were carried out during the month of 2024 January, and we were able to determine a rotation period very much in line with that previously recorded: P = 3.968 ± 0.013 hours and an amplitude of 0.33 ± 0.02 mag.



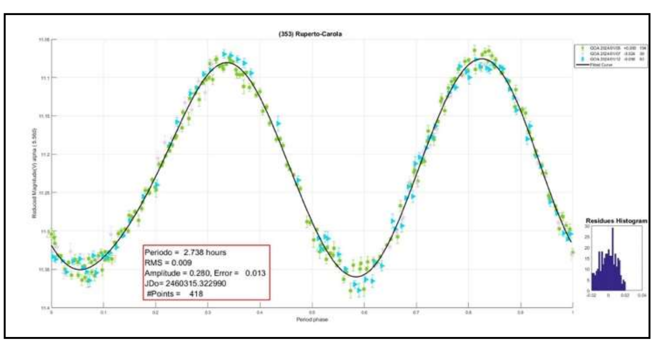
283 Emma. Discovered in 1889 February from Nice, Emma is an asteroid of about 145 km in diameter belonging to the main belt. Our observations on it date from 2020 November and we were able to determine a rotation period very much in line with those previously recorded in the literature: P = 6.894 ± 0.005 hours and an amplitude of 0.13 ± 0.01 mag.



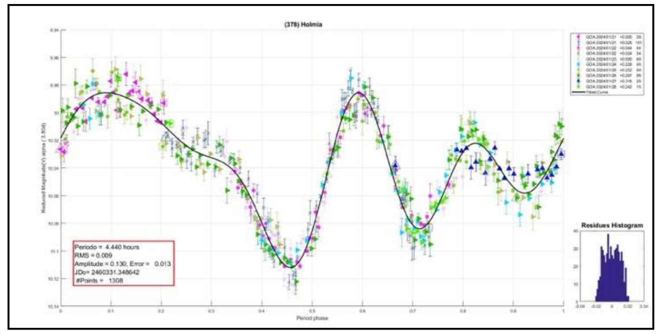
347 Pariana. This is a metallic background asteroid from the central region of the asteroid belt. It was discovered by French astronomer Auguste Charlois at the Nice Observatory on 1892 November 28. The M-type asteroid has a short rotation period of 4.053 hours and measures approximately 49 kilometers in diameter. Our measurements were carried out in 2023 December, arriving at a rotation period coinciding with that published above: P = 4.052 ± 0.007 hours and A = 0.12 ± 0.01 mag.



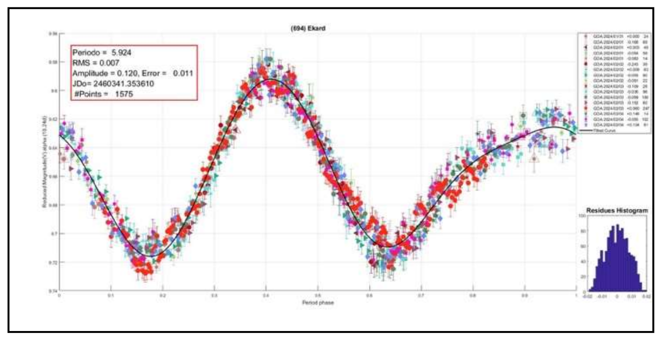
353 Ruperto-Carola. It is a background asteroid from the central region of the asteroid belt. It was discovered by German astronomer Max Wolf at the Heidelberg Observatory on 1893 January 16. It is named after the Ruprecht Karls University (University of Heidelberg), whose Latin name is Ruperto Carola Heidelbergensis. Our observations, carried out during the month of 2024 January, found no significant differences in the rotation period from that previously published: P = 2.738 ± 0.009 hours and A = 0.28 ± 0.01mag.



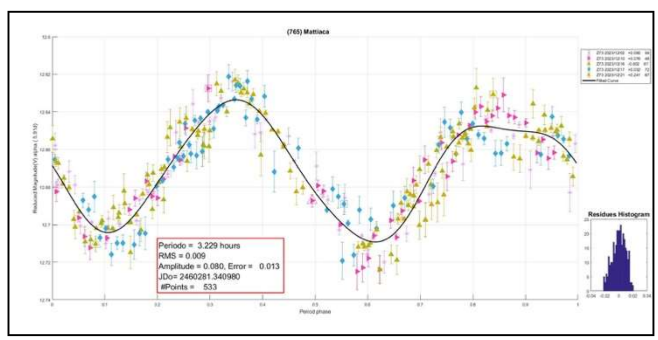
378 Holmia. Named after the ancient name of the capital of Sweden, this asteroid was discovered in 1893 December from Nice. It belongs to the main asteroid belt and has a diameter of almost 28 km. The observations recorded by our team, which took place in 2024 January, found a slightly different value for the rotation period than the previously published one: P = 4.440 ± 0.009 hours and A = 0.13 ± 0.01 mag.



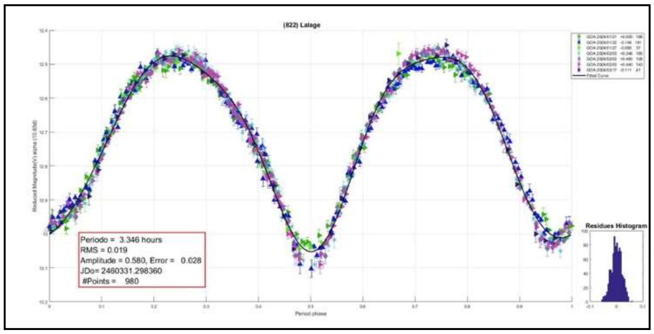
694 Ekard. Our observations of this asteroid, discovered in 1909 November, took place in 2024 January. The result found for its rotation period does not vary significantly from those previously published: P = 5.924 ± 0.007 hours and A = 0.12 ± 0.01 mag.



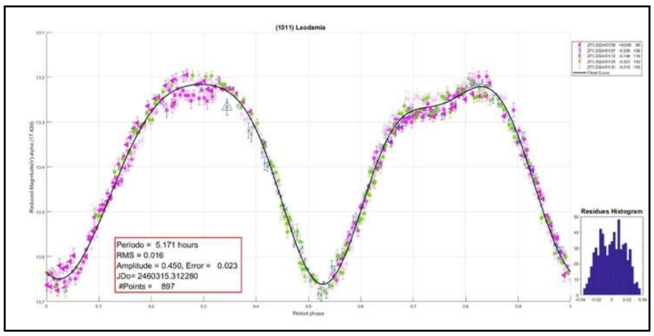
765 Mattiaca, belonging to the main asteroid belt, was discovered in 1913 September. The records for its rotation period, for the years 2011-2012, give a slightly higher result than those obtained by our team, which were P = 3.229 ± 0.009 hours and A = 0.08 ± 0.01 mag.



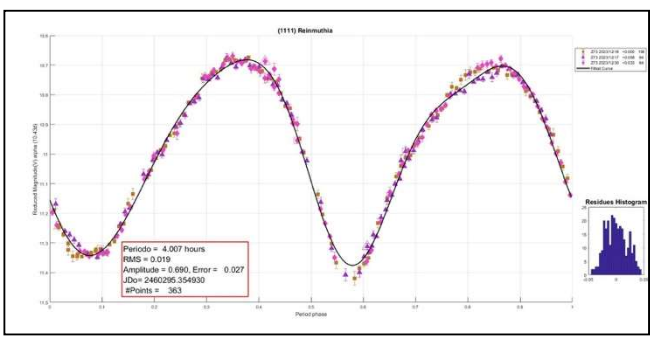
822 Lalage. This is a background asteroid from the inner regions of the asteroid belt. It was discovered on 1916 March 31 by astronomer Max Wolf at the Heidelberg-Königstuhl State Observatory in southwest Germany. The likely highly-elongated asteroid with an unclear spectral type has a short rotation period of 3.345 hours and measures approximately 9 kilometers in diameter. Our data collected between the end of 2024 January and the beginning of February show a result very much in line with the published one: P = 3.346 ± 0.019 hours and A = 0.58 ± 0.03 mag.



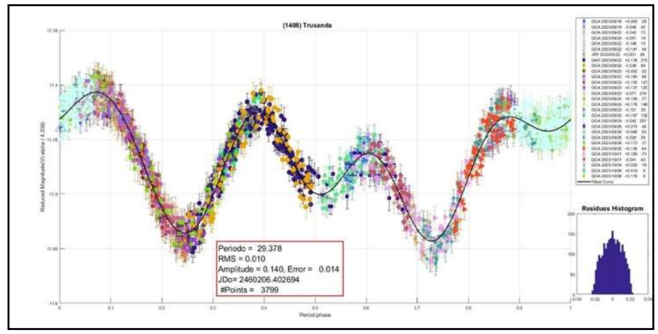
1011 Laodamia. Almost 8 km in diameter, this asteroid, discovered in 1924 January from Germany, has a rotation period recorded in the literature very similar to the one our team has determined, which was P = 5.171 ± 0.016 hours and A = 0.45 ± 0.02 mag. Our measurements were carried out in 2024 January.



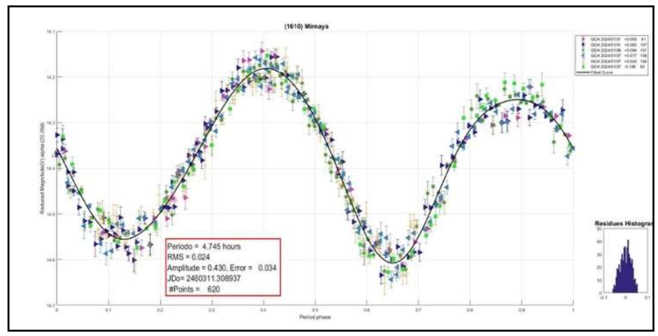
1111 Reinmuthia is an F-type asteroid (FX) of about 40 km in diameter. Discovered in 1927 February and located in the outer zone of the main asteroid belt, it has a short rotation period that our team determined to be very similar to the published one: P = 4.007 ± 0.019 hours and A = 0.69 ± 0.03 mag.



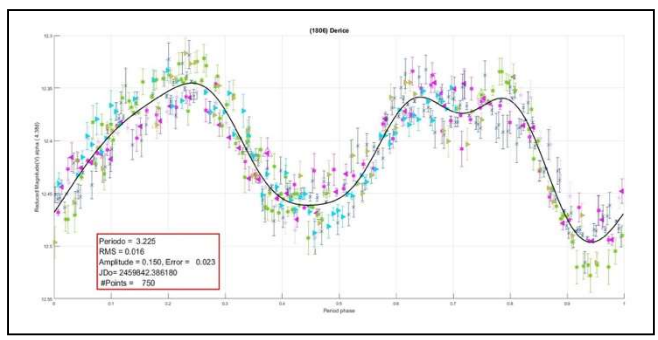
1408 Trusanda (1936 WF). Located in the main belt and discovered in 1936 November, this asteroid has a diameter of just over 35 km. We found no published rotation period or lightcurve. Our observations were made during the month of 2023 September, and allowed us to determine a value of 29.378 ± 0.010 hours for its rotation period, with an amplitude of A = 0.14 ± 0.01 mag.



1610 Mirnaya was discovered in 1928; our observations on Mirnaya took place in 2024 January and lead to a rotation period in close agreement with the previously published one: P = 4.745 ± 0.024 hours and A = 0.43 ± 0.03 mag.



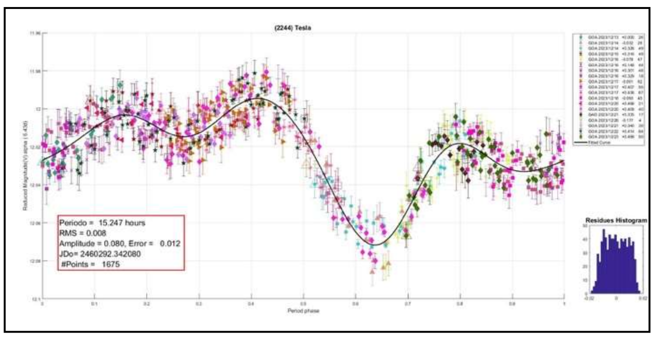
1806 Derice. About 10 km in diameter, and discovered in 1971 June from Australia, this main-belt asteroid was observed by our team in 2022 September. We found a rotation period of P = 3.225 ± 0.016 hours and A = 0.15 ± 0.02 mag.



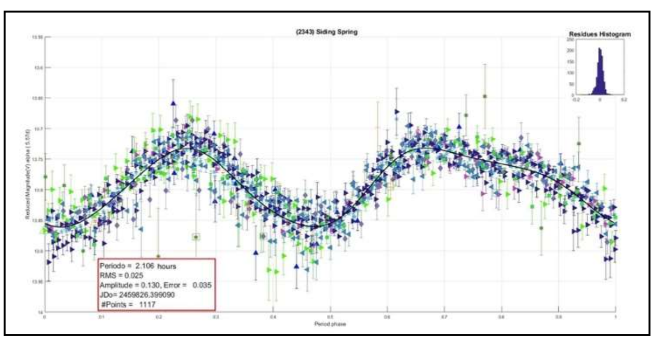
2244 Tesla. This is carbonaceous asteroid from the central region of the asteroid belt is approximately 25 kilometers in diameter. It was discovered on 1952 October 22, by Serbian astronomer Milorad Protić at the Belgrade Observatory, in the then Federal People's Republic of Yugoslavia, now known as Serbia. We did not find in the literature any rotation period or lightcurve published to date. Our observations were carried out during 2023 December. We obtained a rotation period of P = 15.247 ± 0.008 hours and an amplitude A = 0.08 ± 0.01 mag.

Number	Asteroid	20yy mm/dd	Phase	Period(h)	P.E.	Amp	A.E.
107	Camilla	23/09/19-23/11/18	10.4-15.5	4.843	0.012	0.43	0.02
125	Liberatrix	24/01/18-24/01/21	9.6-10.6	3.968	0.013	0.33	0.02
283	Emma	20/11/01-20/11/09	13.7-11.2	6.894	0.005	0.13	0.01
347	Pariana	23/12/01-23/12/30	2.5-13.6	4.052	0.007	0.12	0.01
353	Ruperto-Carola	24/01/05-24/01/12	5.6-9.6	2.738	0.009	0.28	0.01
378	Holmia	24/01/21-24/01/27	3.8-5.3	4.440	0.009	0.13	0.01
694	Ekard	24/01/31-24/02/04	10.2-11.2	5.924	0.007	0.12	0.01
765	Mattiaca	23/12/02-23/12/21	5.9-11.7	3.229	0.009	0.08	0.01
822	Lalage	24/01/12-24/02/16	10.7-22.9	3.346	0.019	0.58	0.03
1011	Laodamia	24/01/05-24/01/31	17.5-30.4	5.171	0.016	0.45	0.02
1111	Reinmuthia	23/12/16-23/12/30	10.4-14.7	4.007	0.019	0.69	0.03
1408	Trusanda	23/09/19-23/11/23	15.1-4.6	29.378	0.010	0.14	0.01
1610	Mirnaya	24/01/01-24/01/07	20.3-22.4	4.745	0.024	0.43	0.03
1806	Derice	22/09/16-22/09/21	4.4-6.6	3.225	0.016	0.15	0.02
2244	Tesla	23/12/13-23/12/26	6.4-12.0	15.247	0.008	0.08	0.01
2343	Siding Spring	22/09/03-22/09/18	5.6-5.0	2.106	0.025	0.13	0.04
2724	Orlov	23/10/09-23/11/07	2.1-10.1	13.788	0.014	0.27	0.02
3505	Byrd	23/11/12-23/11/16	9.9-11.2	9.162	0.028	0.56	0.04
4084	Hollis	24/02/18-24/03/13	2.0-10.6	4.454	0.034	0.46	0.05
4222	Nancita	23/11/24-23/12/20	4.4-15.1	3.872	0.011	0.53	0.02
4442	Garcia	24/01/29-24/02/06	7.9-11.2	6.398	0.038	0.40	0.05
6100	Kunitomoikkansai	23/11/21-23/12/19	4.9-11.8	18.450	0.023	0.17	0.03

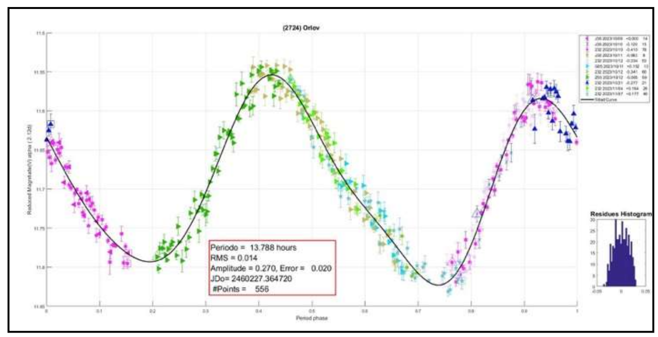
Table I. Observing circumstances and results. Phase is the solar phase angle given at the start and end of the date range. If preceded by an asterisk, the phase angle reached an extrema during the period.



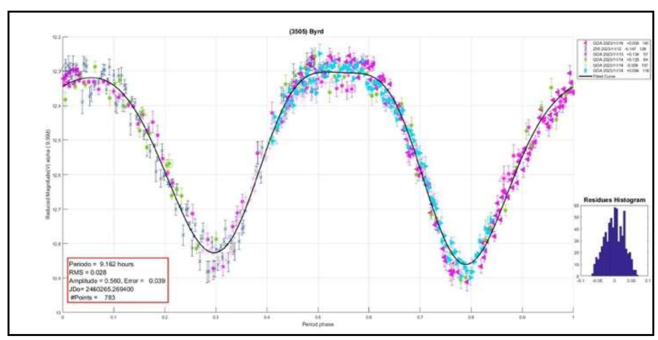
2343 Siding Spring. Our work on this asteroid, carried out in 2022 September, allowed us to deduce a rotation period very similar to the one previously published: P = 2.106 ± 0.025 hours and an amplitude of A = 0.13 ± 0.04 mag.



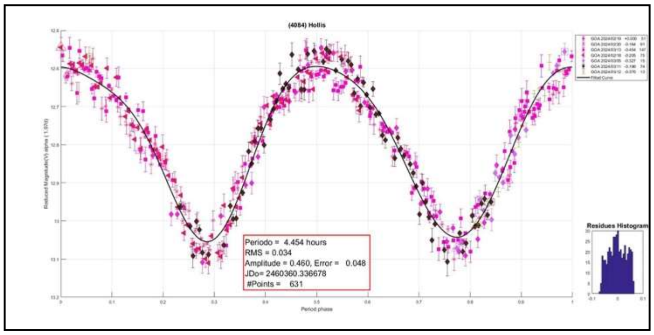
2724 Orlov. Our study and follow-up of this main-belt asteroid took place between 2023 October and November. Until that date, we found no published rotation period or lightcurve. Based on our measurements, we were able to conclude a rotation period P = 13.788 ± 0.014 hours, and an amplitude A = 0.27 ± 0.02 mag.



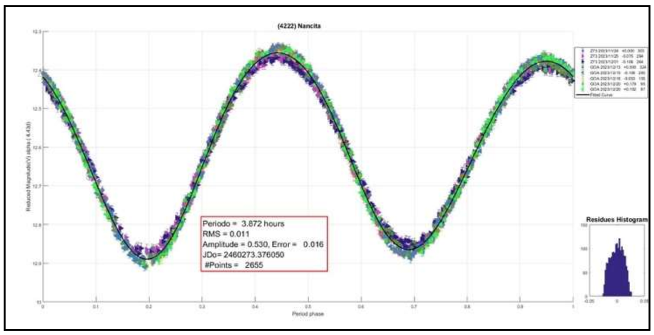
3505 Byrd was discovered on 1983 January 9; our team found no rotation period or lightcurve published in the literature. Measurements of images obtained in 2023 November lead to P = 9.162 ± 0.028 hours and A = 0.56 ± 0.04 mag.



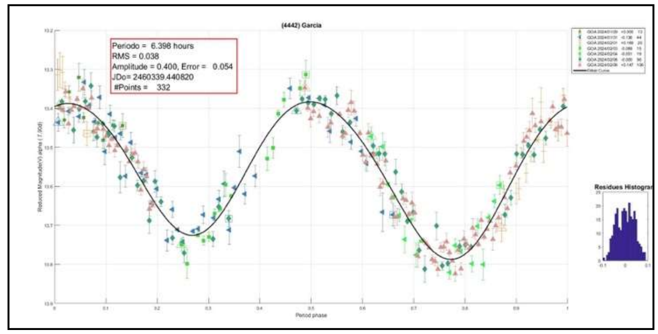
4084 Hollis was discovered on 1985 April 14. Our observations of this asteroid took place between 2024 February and March. We were able to measure P = 4.454 ± 0.034 hours and an amplitude of A = 0.46 ± 0.05 mag. These results do not differ substantially from those previously recorded in the literature.



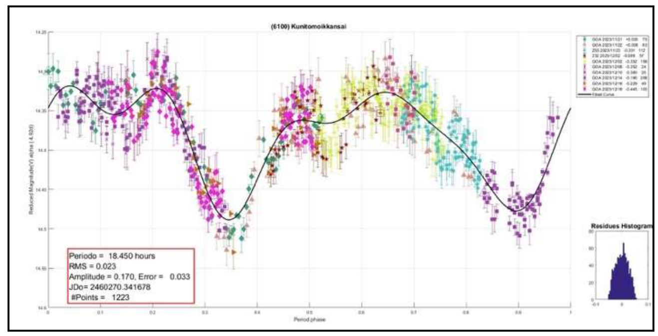
4222 Nancita. We also found no significant differences in the result for the rotation period of this asteroid, discovered in 1988. The observations were carried out in 2023 November. We obtained $P = 3.872 \pm 0.011$ hours and $A = 0.53 \pm 0.02$ mag.



4442 Garcia. It was between 2024 January and February that our team observed this main-belt asteroid, obtaining values for its rotation period very similar to those previously reported in the literature: $P = 6.398 \pm 0.038$ hours and an amplitude $A = 0.40 \pm 0.05$ mag.



6100 Kunitomoikkansai. There is a published rotation period in the literature for this asteroid of 30.2 hours. However, the observations we carried out during the months of 2023 November and December allowed us to deduce a significantly lower figure: $P = 18.450 \pm 0.023$ hours and an amplitude $A = 0.17 \pm 0.03$ mag.



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Períodos (2020) software. *http://www.astrosurf.com/salvador/Programas.html*

Tycho Tracker (2023) software. *https://www.tycho-tracker.com*

PHOTOMETRIC OBSERVATIONS OF THIRTEEN MINOR PLANETS

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Photometric measurements were made for 13 main-belt asteroids, based on CCD observations made from 2024 January through 2024 March. Phased lightcurves were created for 12 of the 13 asteroids. All of the data have been submitted to the ALCDEF database.

CCD photometric observations of 13 main-belt asteroids were performed at Command Module Observatory (MPC V02) in Tempe, AZ.

Images were taken at V02 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 the images was 2 minutes. The image scale after 2×2 binning was 1.76 arcsec/pixel.

Table I shows the observing circumstances and results. All of the images for these asteroids were obtained between 2024 January and 2024 March.

Images taken at V02 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, 2023). 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. *MPO Canopus* plots instrumental vs catalog magnitudes for solar-colored stars, which is useful for selecting comp stars of suitable color and brightness.

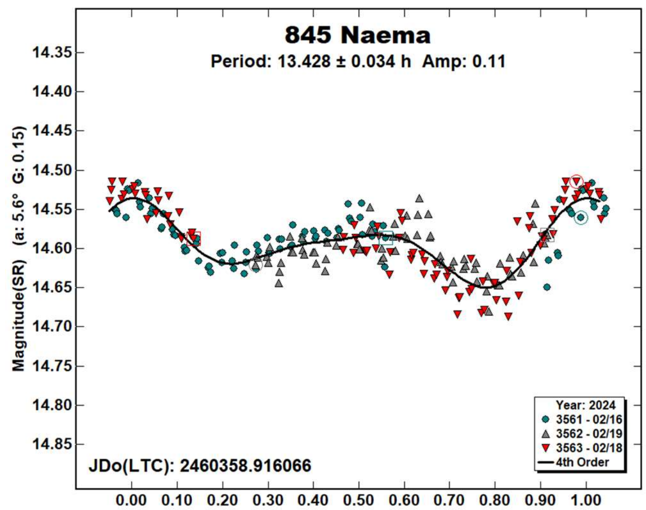
The clear-filtered images were reduced to Sloan r′ to minimize error with respect to a color term. Comparison star magnitudes were obtained from the ATLAS catalog (Tonry et al., 2018), which is incorporated directly into *MPO Canopus*. The ATLAS catalog derives Sloan griz magnitudes using a number of available catalogs. The consistency of the ATLAS 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.

Data reduction for V02 images used a 9-pixel (16 arcsec) diameter measuring aperture for asteroids and comp stars. It was typically necessary to employ star subtraction to remove contamination by field stars.

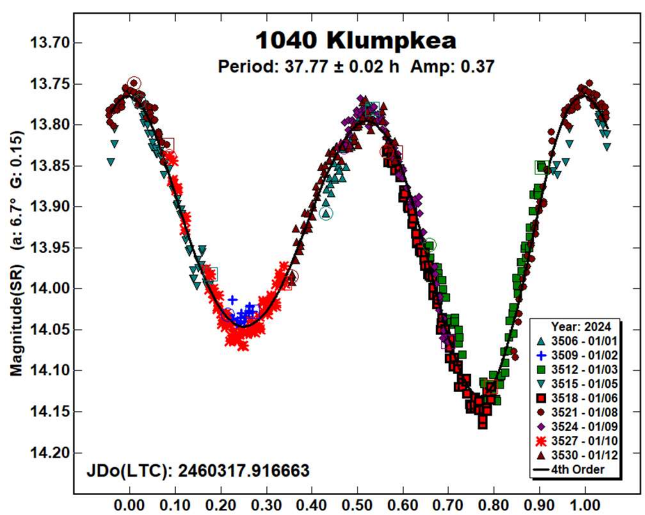
For the asteroids described here, the RMS scatter on the phased lightcurves is noted, which gives an indication of the overall data quality including errors from the calibration of the frames, measurement of the comp stars, the asteroid itself, and the period-fit. Period determination was done using 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), either for having uncertain periods or for needing more lightcurves for shape modeling. In this set of observations, ten of the 13 asteroids had U=2, and one was rated as U=1. The Asteroid Lightcurve Database (LCDB; Warner et al., 2009) was consulted to locate previously published results. All the new data for these asteroids can be found in the ALCDEF database.

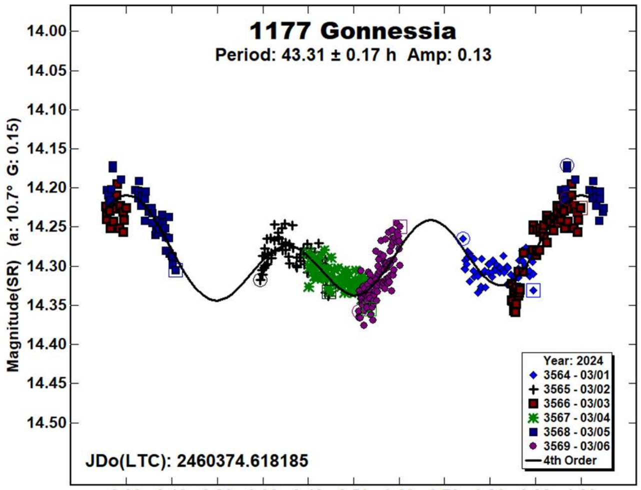
<u>845 Naema</u> was discovered in 1916 at Heidelberg by Max Wolf. Bembrick et al. (2008) computed a period of 20.892 ± 0.019 h. More recently, Dose (2023) published a value of 13.378 ± 0.002 h. During three nights, 231 images were gathered, resulting in a period solution of 13.428 ± 0.034 h, agreeing with Dose's result. The amplitude of the lightcurve is 0.11 ± 0.02 mag.



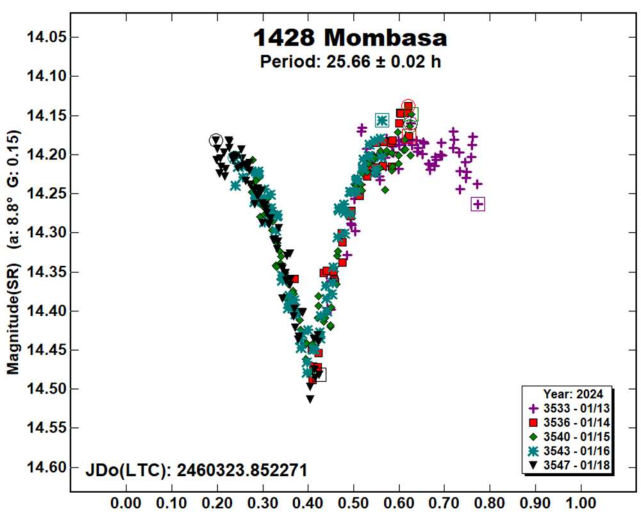
<u>1040 Klumpkea</u> is the largest member of the asteroid family bearing its name. It was discovered by Benjamin Jekhovsky at Algiers in 1925. Hanus et al. (2013) published a rotation period of 56.588 ± 0.003 h, while Pál et al. (2020) computed 37.687 ± 0.005 h. After nine nights of observation, 540 data points were used to compute a period of 37.77 ± 0.02 h, in agreement with Pál. The amplitude of the lightcurve is 0.37 mag, with an RMS error of 0.02 mag.



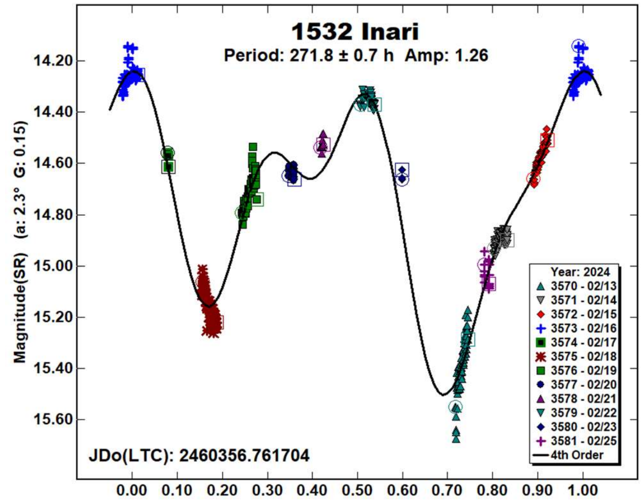
<u>1177 Gonnessia</u> was discovered at Algiers in 1930 by Louis Boyer. Stephens (2011) calculated a period of 30.51 ± 0.02 h. Ďurech et al. (2020) and Pál et al. (2020) show similar period solutions: 42.903 ± 0.003 h and 43.0215 ± 0.0005 h, respectively. A total of 385 images were gathered over the course of six nights. The period spectrum shows bimodal and trimodal solutions of 29.22 ± 0.05 h and 43.31 ± 0.17 h. The trimodal solution is favored, agreeing with Ďurech and Pál. The lightcurve has an amplitude of 0.13 ± 0.02 mag.



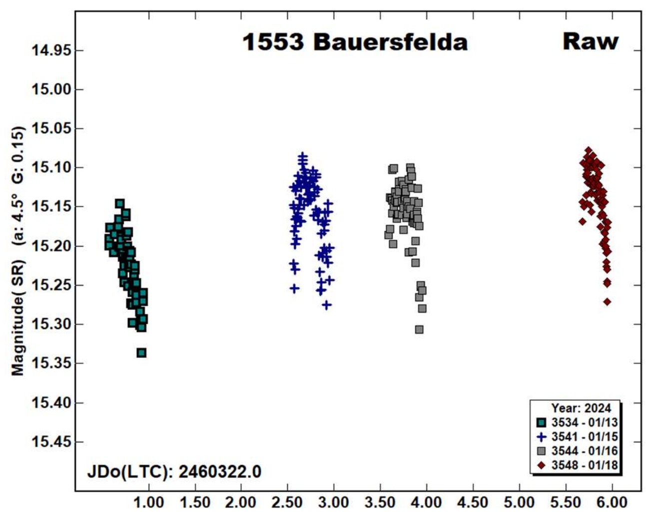
<u>1428 Mombasa</u> is an outer main-belt asteroid, discovered by Cyril Jackson at Johannesburg in 1937. Pál et al. (2020) published a period of 25.646 ± 0.005 h, and Dose (2021) computed 25.621 ± 0.004h. After five nights of observations, 335 images were taken, and a period solution of 25.66 ± 0.02 h was obtained. Poor observing conditions prevented the completion of the lightcurve, so only a half cycle is shown. The lightcurve has an amplitude of 0.31 ± 0.02 mag.



<u>1532 Inari</u>. This Eos-family asteroid was discovered in 1938 at Turku by Yrjö Väisälä. The only period solution in the LCDB is Behrend (2008web), who shows 25 h. Over the course of 12 nights, 568 images were taken, and a period solution of 271.8 ± 0.7 h was obtained. The lightcurve has a large amplitude of 1.26 ± 0.5 mag. Some tumbling is likely present.



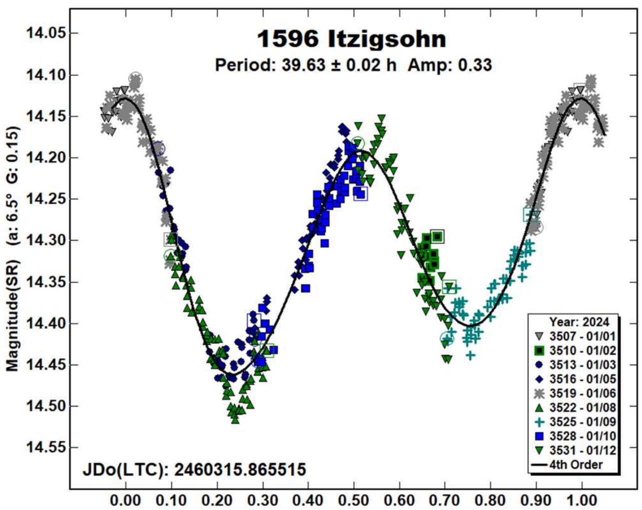
<u>1553 Bauersfelda</u>. Karl Reinmuth discovered this minor planet in 1940 at Heidelberg. The only period solution in the LCDB belongs to Waszczak et al. (2015): 51.191 ± 0.135 h. A total of 292 images were taken during four nights. No period solution was found. The raw lightcurve is provided.



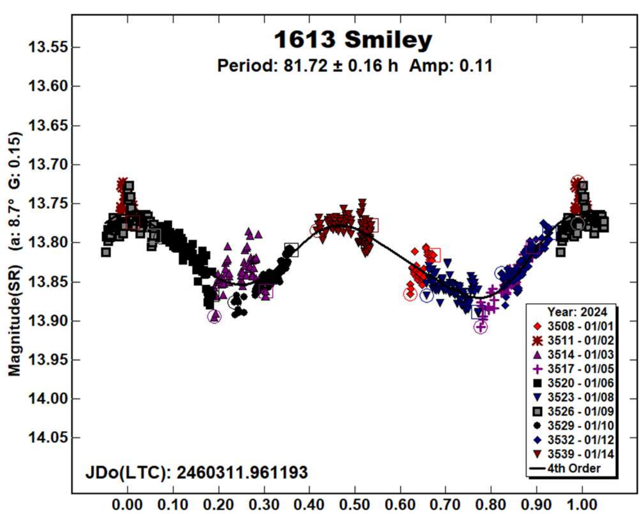
<u>1596 Itzigsohn</u> is an outer main-belt asteroid, which Miguel Itzigsohn discovered at La Plata in 1951. Ďurech et al. (2020) and Pál et al. (2020) computed similar periods of 39.697 ± 0.001 h and 39.6658 ± 0.0005 h, respectively. In nine nights, 476 data points were obtained, and the resulting rotation period is 39.63 ± 0.02 h, in agreement with published values. The lightcurve's amplitude is 0.33 ± 0.02 mag.

Number	Name	yy/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
845	Naema	24/02/16-02/18	5.6, 5.4	151	15	13.428	0.034	0.11	0.02	NAE
1040	Klumpkea	24/01/01-01/12	7.0, 2.8	114	-5	37.77	0.02	0.37	0.02	KLU
1177	Gonnessia	24/03/01-03/06	10.7,11.9	133	-16	43.31	0.17	0.13	0.02	MB-O
1428	Mombasa	24/01/13-01/18	8.8,10.5	93	-7	25.66	0.02	0.31	0.02	MB-O
1532	Inari	24/02/13-02/25	*2.3, 2.6	149	0	271.8	0.7	1.26	0.05	EOS
1553	Bauersfelda	24/01/13-01/18	4.5, 6.7	102	0	--	--	--	--	MB-O
1596	Itzigsohn	24/01/01-01/12	6.5, 5.0	109	-11	39.63	0.02	0.33	0.02	MB-O
1613	Smiley	24/02/01-01/14	8.7, 3.3	113	6	81.72	0.16	0.11	0.02	CHL
1614	Goldschmidt	24/03/13-02/15	3.0, 3.4	141	-6	16.573	0.031	0.18	0.03	MB-O
2091	Sampo	24/03/01-03/05	4.7, 4.4	166	11	71.08	0.11	0.27	0.02	EOS
2879	Shimizu	24/02/16-02/21	2.0, 4.4	143	-1	27.95	0.06	0.25	0.03	MB-O
4931	Tomsk	24/01/13-01/16	17.6,15.1	113	-24	9.910	0.008	0.41	0.04	MB-I
5765	Izett	24/01/17-01/17	17.1,17.2	91	14	7.840	0.033	0.33	0.03	BAR

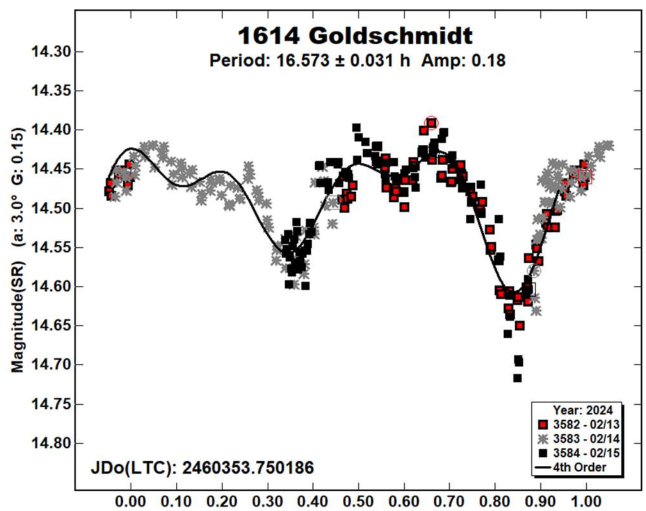
Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984).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



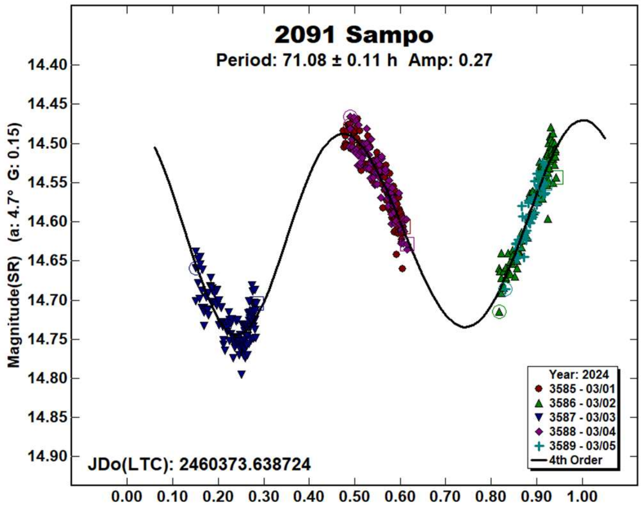
1613 Smiley. This Chloris-family asteroid was discovered in 1950 by Sylvain Arend in 1950 at Uccle. Warner (2006) found a period of 81.9 ± 0.1 h, and Molnar et al. (2008) computed 80.61 ± 0.05 h. A total of 654 images were taken in 10 nights to produce a rotation period solution of 81.72 ± 0.16 h, in agreement with previous determinations. The lightcurve amplitude is 0.11 ± 0.02 mag.

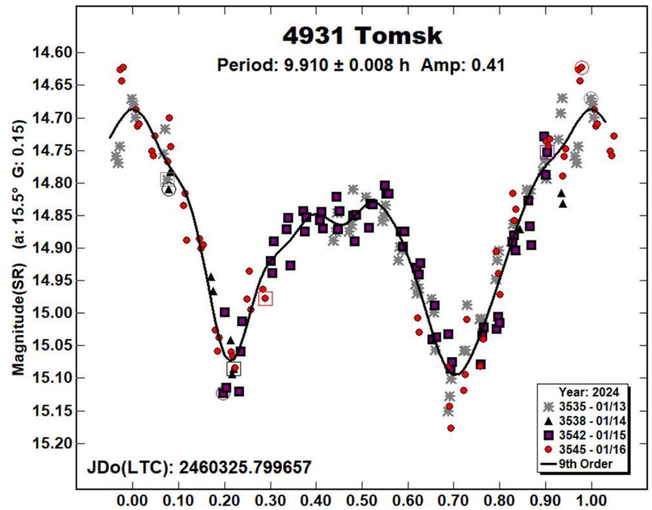


1614 Goldschmidt was discovered by Alfred Schmitt at Uccle in 1952. Kozden et al. (2016) published a period solution of 8.873 ± 0.002 h, but Polakis (2019) found nearly twice this value, 16.540 ± 0.013 h. During three nights, 265 images were acquired, resulting in a period of 16.573 ± 0.031 h, in agreement with the longer period. The amplitude is 0.18 mag., and the RMS error is 0.03 mag.

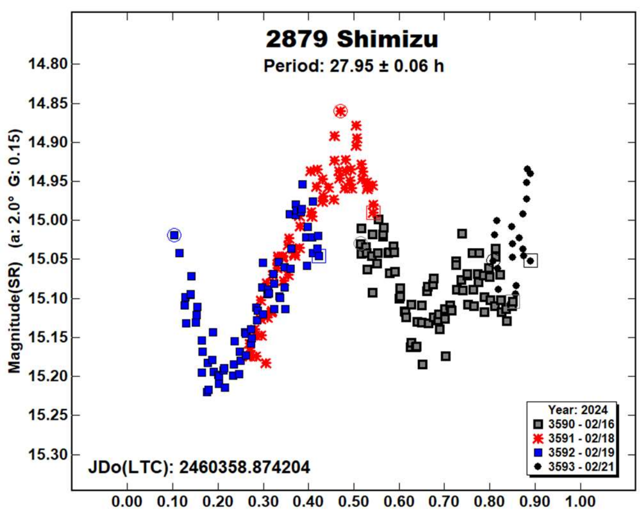


2091 Sampo is an Eos family minor planet, discovered in 1941 at Turku by Yrjö Väisälä. Two similar periods appear in the LCDB; Behrend (2003web), 71.34 ± 0.05 h, and Ďurech et al. (2020), 71.136 ± 0.003 h. The target was observed on five nights, during which 480 images were acquired. The period was determined to be 71.08 ± 0.11 h, with a lightcurve amplitude of 0.27 ± 0.02 mag. Note the incomplete coverage, due to the body's rotation period being roughly three times that of the earth.



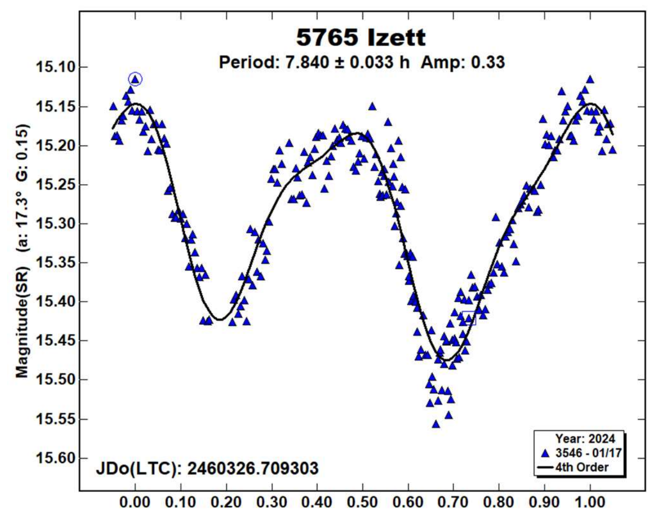


2879 Shimizu was discovered by Karl Reinmuth at Heidelberg in 1932. Pál et al. (2020) published a period of 55.3718 ± 0.0005 h. After four nights, 239 data points were used to determine a period of 27.95 ± 0.06 h, or roughly half that of Pál. The lightcurve has an amplitude of 0.25 mag, with an RMS error of 0.03 mag. Coverage is incomplete due to unfavorable observing conditions.



4931 Tomsk lies in a greatly inclined and eccentric orbit, and came to a relatively favorable opposition in 2024. Henri Debehogne discovered the minor planet at La Silla in 1983. Period solutions include Behrend (2020web), 9.2701 ± 0.0003 h and Polakis (2020), 9.935 ± 0.008 h. In four nights, 172 images were obtained, and the period solution is 9.910 ± 0.008 h, agreeing with Polakis' result. The lightcurve has an amplitude of 0.41 ± 0.04 mag.

5765 Izett also orbits with a high inclination and eccentricity. Carolyn Shoemaker discovered the asteroid at Palomar in 1986. The only period in the LCDB belongs to Behrend (2020web), who computed 8.9553 ± 0.0002 h. In a single night, 240 images were acquired, resulting in a synodic period of 7.840 ± 0.033 h, disagreeing with Behrend. The amplitude is 0.33 ± 0.03 mag.



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PHOTOMETRIC OBSERVATIONS AND ANALYSIS OF EIGHT ASTEROIDS

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In this paper, we report the results of our photometric observations of eight main-belt asteroids from six observatories in Malta, and Slovakia. We obtained lightcurves for the following asteroids, which can facilitate future analysis of these objects at different oppositions: (2173) Maresjev; (2300) Stebbins; (3819) Robinson; (4569) Baerbel; (6147) Straub; (6336) Dodo; (13042) 1990 QE; and (20725) 1999 XP120.

We conducted photometric observations of eight main-belt asteroids from four observatories located in Malta, and one at Važec, Slovakia. Through these observatories listed in Table 1, we have observed the following asteroids: (2173) Maresjev; (2300) Stebbins; (3819) Robinson; (4569) Baerbel; (6147) Straub; (6336) Dodo; (13042) 1990 QE; (20725); and 1999 XP120. We employed a clear filter (unfiltered) with SR (Sloan R) zero point for all other images and calibrated all of our images using dark and flat-field subtraction frames.

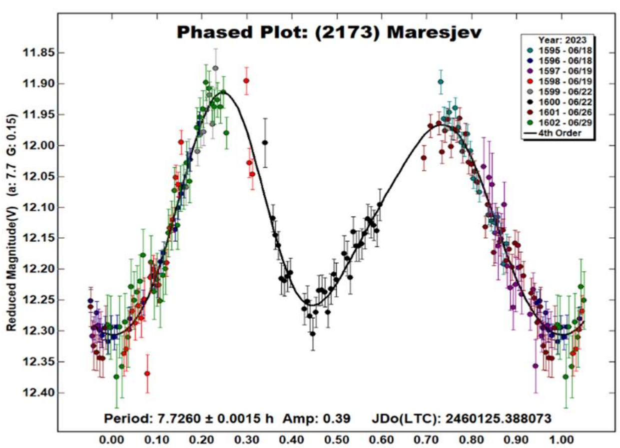
We remotely controlled all our equipment over the internet or from a nearby location for each telescope. We used *Sequence Generator Pro* (Binary Star Software) for image acquisition by all Maltese Observatories. Luckystar Observatory used the *NINA* image acquisition software (Berg, 2023) software. We used *MPO Canopus* software (Warner, 2017) for our image analysis, to obtain differential aperture photometry and to construct light curves. Table 1 displays the details of the instrumentation and Observation Runs for each target. We selected near-solar color comparison stars using the Comparison Star Selector (CSS) feature of *MPO Canopus*. We based all brightness measurements on the Asteroid Terrestrial-impact Last Alert System (ATLAS) catalogue (Tonry et al., 2018).

Observatory/ Country	Scope and Type	Camera	Observed Asteroids (#Nights)
Antares obs./ MALTA	0.28-m SCT	SBIG ST-11	#3819 (4)
Flarestar Obs. (MPC: 171)/ MALTA	0.25-m SCT	Moravian G2-1600	#2300 (1) #4569 (5)
Luckystar Obs. (MPC: M55)/ SLOVAKIA	0.25-m SCT	Atik 460EX	#13042 (2) #2173 (5) #6147 (4) #20725 (3)
Znith Astronomy Obs./ MALTA	0.2-m SCT	Moravian G2-1600	#6336 (4)

Table 1. Instrumentation and Observation Runs. SCT: Schmidt-Cassegrain Telescope.

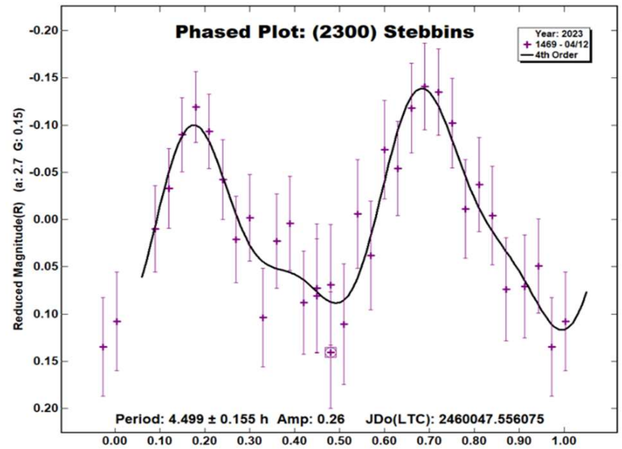
<u>(2173) Maresjev</u> is a main-belt asteroid that was discovered on 1974 Aug 22 by L. V. Zhuravleva at the Crimean Astrophysical Observatory. The asteroid was named in honor of Alexej Petrovich Maresjev, a war veteran whose heroic deed is described in B. Polevoj's novel "Story about a True Man." The estimated diameter of Maresjev is 28.32 ± 0.226 km (Masiero et al., 2014). This asteroid has an absolute magnitude H of 11.68 and orbits the sun at a semi-major axis of 3.138 AU with an eccentricity of 0.115. Maresjev takes 5.56 years to complete an orbit around the sun (JPL, 2024).

This asteroid was observed from Luckystar Observatory on 4 nights, namely on 2023 Jun 18, 19, 26 and 29. Our results yielded a synodic period of 7.7260 ± 0.002 h with an amplitude of 0.39 ± 0.05 mag. This is consistent with the previously published result by Wiles (2023).



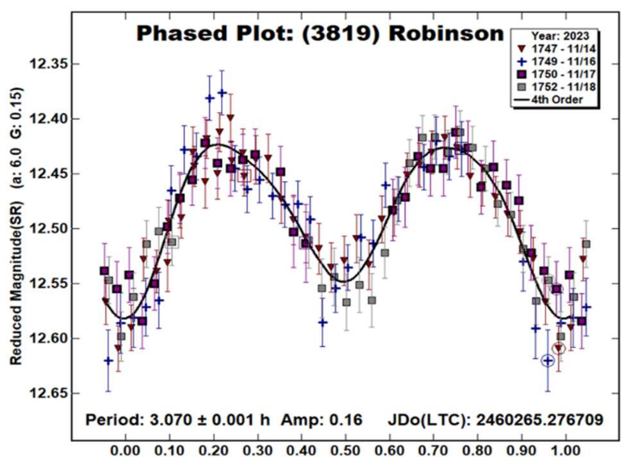
<u>(2300) Stebbins</u> is a main-belt asteroid that was discovered on October 10, 1953 by Goethe Link Observatory at Brooklyn (JPL, 2024). Its estimated diameter is 11.879 ± 0.201 km (Masiero et al., 2014). It orbits the sun with a semi-major axis of 2.839 AU and has an eccentricity of 0.076 and an absolute magnitude H of 12.06. The asteroid completes one orbit around the sun every 4.78 years (JPL, 2024).

We have observed asteroid Stebbins from Flarestar Observatory over a single night due to adverse weather conditions, precisely on 2023 Dec 12. Based on these observations, we determined the synodic period to be 4.499 ± 0.155 hours, with an amplitude of 0.26 ± 0.10 mag. The LCDB database does not show any published period for (2300) Stebbins.



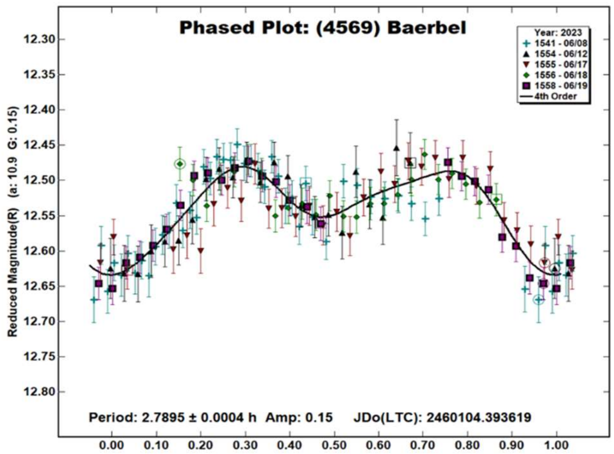
<u>(3819) Robinson (1983 AR)</u> is also a main-belt asteroid. This asteroid was first discovered on 1983 Jan 12 by B.A. Skiff at Flagstaff (AM). The asteroid has a derived absolute magnitude H of 12.15 and orbits the sun at a semi-major axis of 2.773 AU. Its orbit has an eccentricity of 0.140, and orbits the sun every 4.62 years (JPL, 2024).

(3819) Robinson was observed from Antares Observatory over 4 nights on 2023 Nov 14, 16, 17 and 18 from which we derived the synodic period to be 3.070 ± 0.001 h with an amplitude of 0.16 ± 0.02 mag. Our results are consistent with the results obtained by Ferrero and Bonamico (2020).



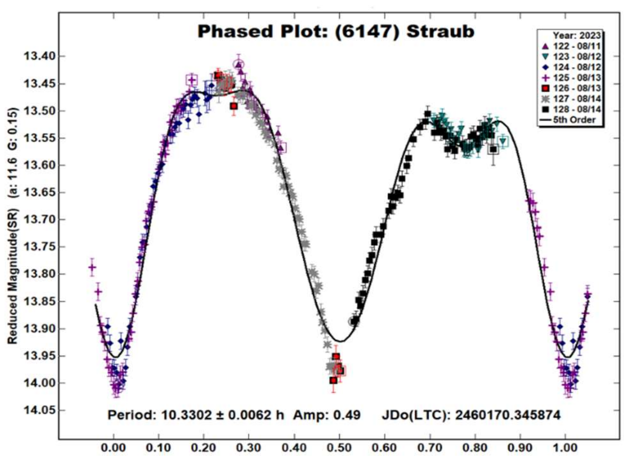
<u>(4569) Baerbel</u> is an outer main-belt asteroid that was discovered on April 15, 1985 by C.S. Shoemaker at Palomar Observatory, USA. It has an estimated diameter of 9.395 ± 0.057 km diameter, based on H of 2.79. It orbits the sun with a semi-major axis of 2.585 AU with an eccentricity of 0.06 and orbital period of 4.16 years (JPL, 2024).

Flarestar Observatory observed this target for a period of 5 nights starting from 2023 Jun 08 to 19. Our results of (4569) Baerbel show a derived synodic period of 2.7895 ± 0.0004 h with an amplitude of 0.15 ± 0.05 mag. The LCDB database shows a published period of 2.790 h which according to JPL (2024) this result was based on partial coverage of the phased plot as published by Brinsfield (2010) and Stephens and Warner (2020). By means of our result, we can therefore confirm the good accuracy of previous results based on the fact that our phased plot is considered to be complete.



(6147) Straub (1081 T-3) is a main-belt asteroid and was discovered on 1977 Oct 17 by C.J. van Houten, I. van Houten-Groeneveld and T. Gehrels at Palomar Observatory at Palomar, USA (JPL, 2024). The asteroid is named in honor of the German sculptor Johann Baptist Straub (1704-1784). The estimated diameter was derived to be 6.997 ± 0.156 km (Masiero et al., 2011), while its absolute magnitude H is 13.04. The semi-major axis of this asteroid is 2.61 AU and its orbit has an eccentricity of 0.216. It orbits the sun every 4.21 years (JPL, 2024).

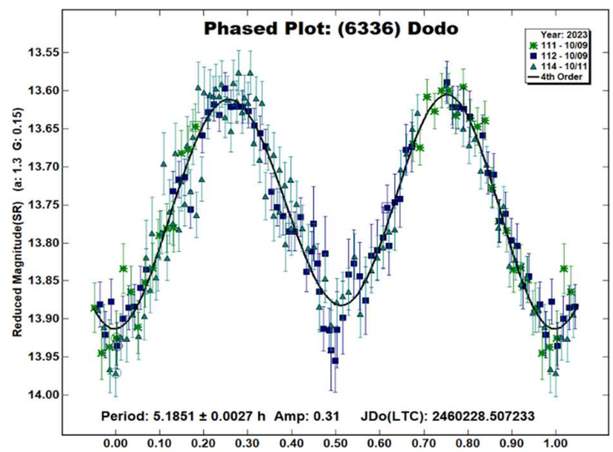
(6147) Straub was observed on 4 nights from Luckystar Observatory from 2023 Aug 11 to 14. Our data shows the rotation period to be 10.327 ± 0.0563 h, with an amplitude of 0.53 ± 0.01 mag. Behrend (2024web) reports a provisional value of 10.9 h based on an incomplete phase plot produced in 2023 by Rene Roy.



(6336) Dodo is another main-belt asteroid that was discovered by S. Otomo at Kiyasato on 1992 Oct 21. The asteroid was named for a large, flightless bird first discovered in 1507 on the island of Mauritius and extinct since the seventeenth century. Scientists plot the de-extinction of this extinct species by incorporating advances in ancient DNA sequencing, gene editing technology and synthetic biology.

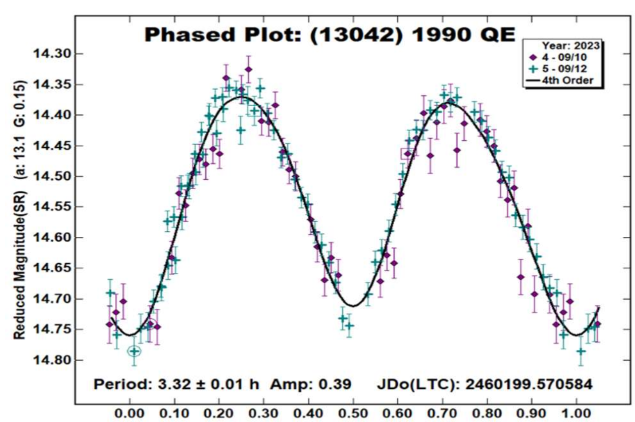
Based on NEOWISE data, the estimated diameter of Dodo was derived to be 8.704 ± 0.215 km (Masiero et al., 2011). This asteroid has an absolute magnitude H of 13.24. This minor planet orbits the sun with a semi-major axis of 2.473 AU and its orbit has an eccentricity of 0.098, and a period of 3.89 years (JPL, 2024).

As no published synodic period has been published, this asteroid was picked up for observation by Znith Astronomy Observatory. Observations of Dodo were acquired over 2 nights from 2023 Oct 09 and 11. We derived a synodic period of 5.185 ± 0.003 h with an amplitude of 0.31 ± 0.05 mag. The LCDB database does not show any published period for (6336) Dodo.



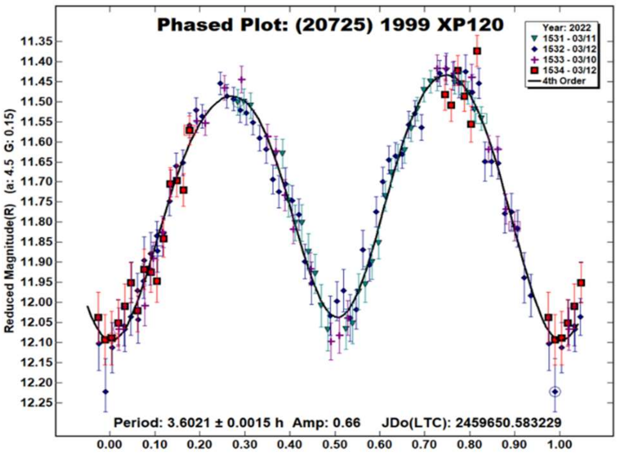
(13042) 1990 QE is a main-belt asteroid that was discovered on 1990 Aug 18, by E.F. Helin at Palomar Observatory in the USA (JPL, 2024). The estimated diameter of it is 7.367 ± 0.276 km (Masiero et al., 2012). The asteroid orbits the sun with a semi-major axis of 2.568 AU and has an eccentricity of 0.240. It has an absolute magnitude H of 13.95 and completes one orbit around the sun every 4.11 years (JPL, 2024).

The asteroid (13042) was observed by Luckystar Observatory on the nights of 2023 Sep 10 and 12. Based on these observations, the synodic period was determined to be 3.32 ± 0.01 hours, with an amplitude of 0.39 ± 0.04 mag. It is worth noting that the LCDB database does not currently show any published period for (13042) 1990 QE.



(20725) 1999 XP120 was discovered on 1999 Dec 5 by Catalina Sky Survey at Catalina, USA. The Small-Body database and JPL (2024), does not list the diameter of this asteroid. It orbits the sun with a semi-major axis of 3.022 AU. Its orbit has an eccentricity of 0.112 and a period of 5.254 years (JPL, 2024).

The main-belt asteroid 1999 XP120 was observed from Luckystar Observatory on 4 nights starting from 2023 Mar 10 to 12. Our results yielded a synodic period of 3.602 ± 0.001 h with an amplitude of 0.66 ± 0.05 mag consistent with the previously published results by Ďurech et al. (2016).



Acknowledgements

We would like to thank Brian Warner for his work in the development of *MPO Canopus* and for his efforts in maintaining the CALL website (Warner, 2016; 2021). This research has made use of the JPL's Small-Body Database (JPL, 2024).

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Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2173	Maresjev	2023 06/18-06/29	7.6,9.8	258.5	17.8	7.7260	0.002	0.39	0.05	MB
2300	Stebbins	2023 04/12	0.5	250.6	-1.3	4.499	0.155	0.26	0.10	Koronis
3819	Robinson	2023 11/14-11/18	5.9,7.8	40.6	-0.6	3.070	0.001	0.16	0.02	MB
4569	Baerbel	2023 06/08-06/19	10.9,9.2	271.2	17.4	2.7895	0.0004	0.15	0.05	Maria
6147	Straub	2023 08/11-08/14	11.6,11.4	321.8	17.8	10.327	0.0563	0.53	0.01	Eunomia
6336	Dodo	2023 10/09-10/11	1.1,1.3	16.3	-1.8	5.185	0.003	0.31	0.05	MB
13042	1990 QE	2023 09/10-09-12	13.1,12.9	355.4	18.1	3.32	0.010	0.39	0.04	Prokne
20725	1999 XP120	2022 03/11-03/12	6.3,6.6	161.0	11.0	3.602	0.0010	0.66	0.05	MB

Table 2. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

ASTEROID PHOTOMETRY AND LIGHTCURVES OF NINE ASTEROIDS

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Synodic rotation periods and amplitudes are reported for: 526 Jena; 667 Denise; 717 Wisibada; 892 Seeligeria; 1429 Pemba; 1504 Lappeenranta; 2052 Tamriko; 2967 Vladisvyat; and 3819 Robinson.

The periods and amplitudes of asteroid lightcurves presented in this paper are the product of collaborative work by the GORA (Grupo de Observadores de Rotaciones de Asteroides) group. In all the studies, we have applied relative photometry assigning V magnitudes to the calibration stars.

The image acquisition was performed without filters and with exposure times of a few minutes. All images used were corrected using dark frames and, in some cases, bias and flat-field corrections were also used. Photometry measurements were performed using *FotoDif* software (Castellano, 2023) and for the analysis, we employed *Periodos* software (Mazzone, 2012).

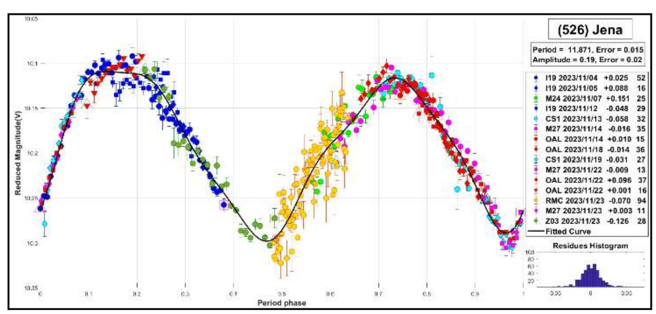
Below, we present the results for each asteroid studied. The lightcurve figures contain the estimated period and period error and the estimated amplitude and amplitude error. In the reference boxes, the columns represent, respectively, the marker, observatory MPC code, or - failing that - the GORA internal code, session date, session offset, and several data points.

Targets were selected based on 1) those asteroids with magnitudes accessible to the equipment of all participants, 2) those with favorable observation conditions from Argentina or Spain or Italy, i.e. with negative or positive declinations δ, respectively, and 3) objects with few periods reported in the literature and/or LCDB (Warner et al., 2009) with quality codes (U) of less than 3.

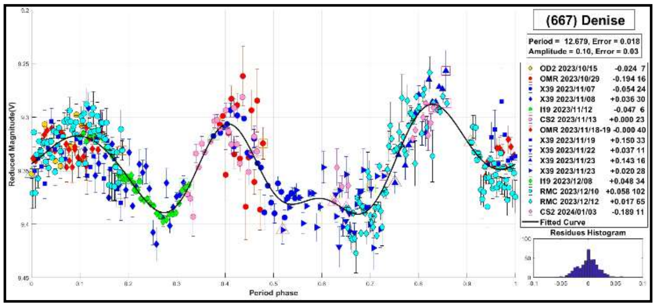
In this work, we present measurements of periods corresponding to asteroids previously analyzed by our team. These lightcurves display improved results and are part of a new long-term project that we are initiating.

For 717 Wisibada and 1429 Pemba, we applied the formula: $DP = 0.027778 * P^2 / T$, where P is the period and T is the total span of the observations, to estimate the period error (Warner, private communication).

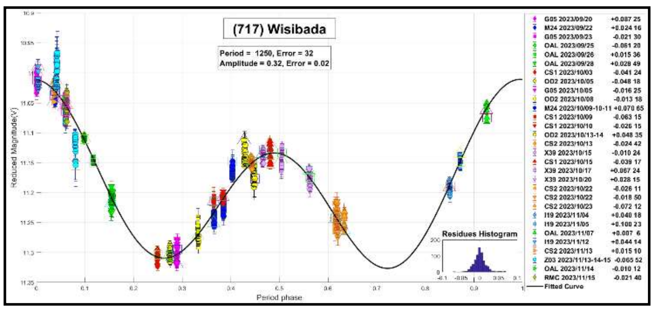
526 Jena is a B-type asteroid discovered in 1904 by M. Wolf. The most recent period from the literature is P = 11.87651 ± 0.00006 h (Martiknainen et al., 2021). We determined a period of 11.871 ± 0.015 h with Δm = 0.19 ± 0.02 mag, which is consistent with the one proposed by Martikainen et al.



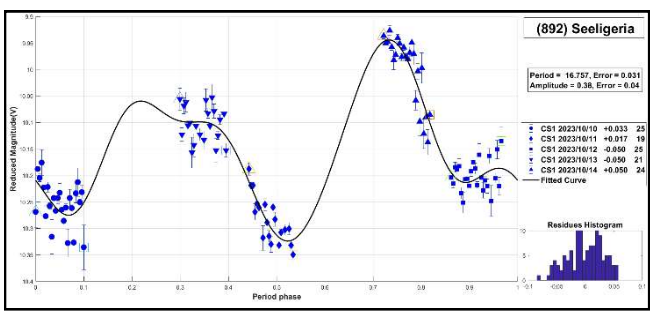
667 Denise was discovered in 1908 by A. Kopff. The most recent period from in the literature is P = 12.684 h (Wilawer et al., 2022). Our period of P = 12.679 ± 0.018 h with Δm = 0.10 ± 0.03 mag agrees with the one measured by Wilawer.



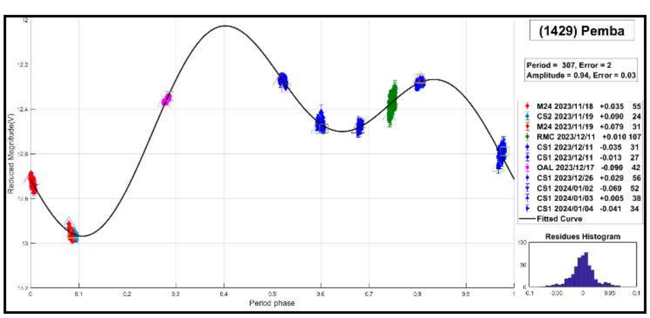
717 Wisibada is a DX-type asteroid discovered in 1911 by F. Kaiser. We couldn't find a reported period for this object. We propose a long-term period of P = 1250 ± 35 h with Δm = 0.32 ± 0.02 mag.



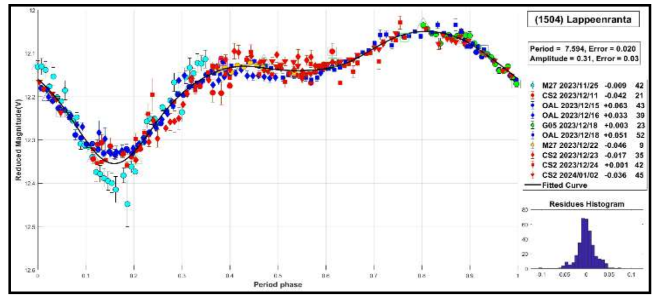
892 Seeligeria was discovered in 1918 by M. Wolf. We previously measured the period of this asteroid, obtaining a result of P = 16.693 ± 0.008 h with Δm = 0.11 ± 0.01 mag (Colazo et al., 2023). In this work, we report P = 16.757 ± 0.031 h with Δm = 0.38 ± 0.04 mag obtained at a different solar phase angle and phase angle bisector.



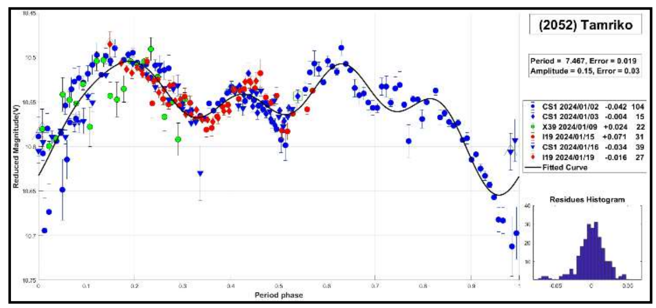
1429 Pemba was discovered in 1918 by C. Harris Jackson. Harris et al. (1999) estimated that the period of this object should be longer than 20 hours. We couldn't find any other period reported in the literature, apart from this estimate. In this work, we propose a long-term period of P = 307 ± 3 h with Δm = 0.94 ± 0.03 mag.



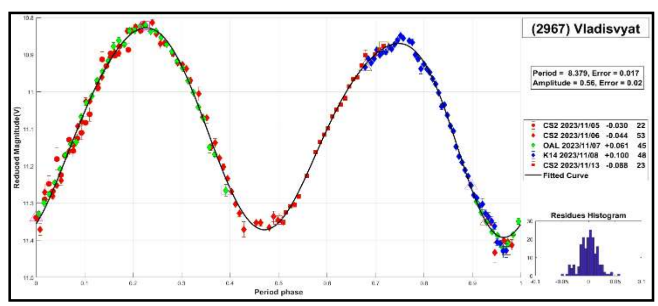
1504 Lappeenranta is an S-type asteroid, discovered in 1939 by L. Oterma. The most recent period in the literature corresponds to P = 15.187 ± 0.002 h (Dose, 2021). In this work, we provide a different result of P = 7.594 ± 0.020 h and Δm = 0.31 ± 0.03 mag.



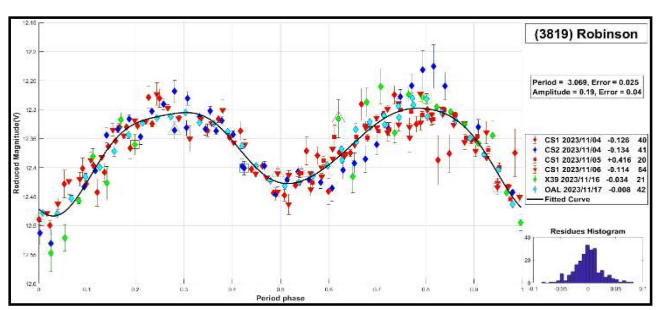
2052 Tamriko is an S-type asteroid discovered in 1976 by R.M. West. The most recent period in the literature corresponds to P = 7.462 h (Pál et al., 2020). We measured a period of P = 7.467 ± 0.019 h with Δm = 0.11 ± 0.04 mag.



2967 Vladisvyat was discovered in 1977 by N. Chernykh. We couldn't find previous published periods in the literature. Based on a well-sampled bimodal curve, we propose a period of P = 8.379 ± 0.017 h with Δm = 0.56 ± 0.02 mag.



3819 Robinson was discovered in 1983 by B.A. Skiff. The period most recently reported is P = 3.070 ± 0.002 h (Ferrero and Bonamico, 2020). The results we obtained are P = 3.069 ± 0.025 h and Δm = 0.19 ± 0.04 mag. Our period agrees well with the one measured by Ferrero.



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We want to thank Julio Castellano as we used his *FotoDif* program for preliminary analyses, Fernando Mazzone for his *Periods* program, which was used in final analyses, and Matías Martini for his *CalculadorMDE_v0.2* used for generating ephemerides used in the planning stage of the observations. This research has made use of the Small Bodies Data Ferret (*http://sbn.psi.edu/ferret/*), supported by the NASA Planetary System. This research has made use of data and/or services provided by the International Astronomical Union's Minor Planet Center.

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Number	Name	20 yy/ mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
526	Jena	23/11/04-23/11/23	*3.8,03.9	50	-3	11.871	0.015	0.19	0.02	THM
667	Denise	23/10/15-24/01/03	9.1,20.5	19	-24	12.679	0.018	0.10	0.03	MB-O
717	Wisibada	23/09/20-23/11/16	*14.2,12.6	26	2	1250	35	0.32	0.02	MB-O
892	Seeligeria	23/10/10-23/10/14	14.8,14.4	268	20	16.757	0.031	0.38	0.04	MB-O
1429	Pemba	23/11/18-24/01/04	4.8,23.1	50	2	307	3	0.94	0.03	MB-I
1504	Lappeenranta	23/11/25-24/01/02	*14.6,06.1	90	-2	7.594	0.020	0.31	0.03	MB-I
2052	Tamriko	24/01/02-24/01/19	11.6,06.5	129	-12	7.467	0.019	0.15	0.03	EOS
2967	Vladisvyat	23/11/05-23/11/14	*3.6,03.1	48	6	8.379	0.017	0.56	0.02	URS
3819	Robinson	23/11/04-23/11/17	0.9,06.9	40	-1	3.069	0.025	0.19	0.04	MB-O

Table I. Observing circumstances and results. The phase angle is given for the first and last date, with an asterisk used if the phase angle reached an extremum. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the family/group (Warner et al., 2009). THM: 24 Themis; MB-O: main-belt outer; MB-I: main-belt inner; EOS: EOS; URS: Ursula.

Observatory		Telescope	Camera
G05	Obs. Astr. Giordano Bruno	SCT (D=203mm; f=6.3)	CCD Atik 420 m
I19	Obs. Astr. El Gato Gris	SCT (D=355mm; f=10.6)	CCD SBIG STF-8300M
K14	Obs. Astr. de Sencelles	Newtonian (D=250mm; f=4.0)	CCD SBIG ST-7XME
24	Oss. Astr. La Macchina del Tempo	RCT (D250mm; f=8.0)	CMOS ZWO ASI 1600MM
M27	Elijah Observatory	RCT (D250mm; f=6.0)	CCD QSI 683
X39	Obs. Astr. Antares	Newtonian (D=250mm; f=4.72)	CCD QHY9 Mono
Z03	Obs. Astr. Río Cofio	SCT (D=254mm; f=6.3)	CCD SBIG ST-8XME
CS1	CapoSudObservatory	RCT (D=400mm; f=5.7)	CCD Atik 383L+Mono
CS2	CapoSudObservatory	Newtonian (D=254mm; f=4.7)	CCD Atik 420 Mono
OAL	Osservatorio Astronomico di Orciatico	SCT (D=355mm; f=7.4)	CCD SBIG ST10XME
OD2	Obs. Astr. de Damián Scotta 2	Newtonian (D=250mm; f=4.0)	CCD SBIG STF-8300M
OMR	Obs. Astr. Municipal Reconquista	Newtonian (D=254mm; f=4.0)	Player One Ceres-M
RMC	Obs. Astr. de Raúl Melia Carlos Paz	Newtonian (D=254mm; f=4.7)	CMOS QHY 174M

Table II. List of observatories and equipment.

ASTEROID LIGHTCURVE ANALYSIS AT THE CENTER FOR SOLAR SYSTEM STUDIES PALMER DIVIDE STATION: 2024 JANUARY

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(Received: 2024 March 13)

CCD photometric observations of three Hungaria asteroids were made at the Center for Solar System Studies Palmer Divide Station in 2024 January. The synodic rotation periods found were: 2001 Einstein (5.485 h), (6394) 1990 QM2 (3.681 h), and (9068) 1993 OD (3.470 h).

CCD photometric observations of three Hungaria asteroids were carried out at the Center for Solar System Studies Palmer Divide Station (CS3-PDS) in 2024 January as part of an ongoing general study of asteroid rotation periods with a concentration on near-Earth, Hungaria, and Hilda group/family asteroids.

Telescope	Camera
0.30-m *f*/6.3 SCT	SBIG STL-1001E
0.35-m *f*/9.1 SCT (×3)	FLI Microline 1001E
0.50-m *f*/8.1 Ritchey-Chrétien	FLI Proline 1001E

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

Table I lists the five telescope/CCD camera pairs available at CS3-PDS. All the cameras use CCD chips from the KAF 1001 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 made with no or a clear filter. The exposures varied depending on the asteroid's brightness.

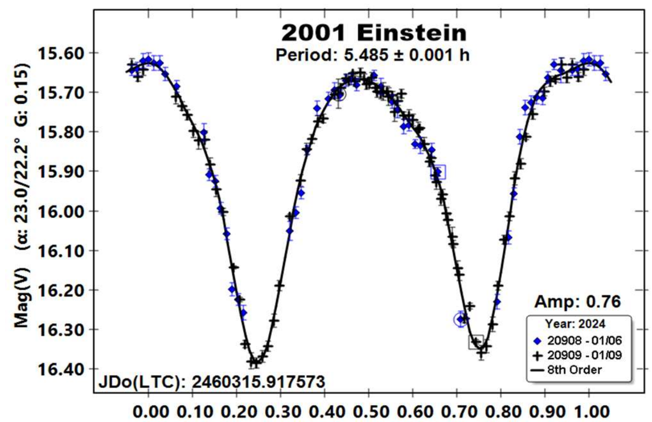
To keep adjustments to nightly zero-points to a minimum, ATLAS catalog r´ (PR) magnitudes on the Pan-STARRS photometric system (Tonry et al., 2018) are usually used. Those adjustments are almost always ≤ ±0.03 mag. In those cases where Johnson V magnitudes are given, those are from the APASS DR9 catalog (Henden et al., 2009). The rare larger corrections using either catalog may be related in part to using unfiltered observations, poor centroiding of the reference stars, and not correcting for second-order extinction. Another cause may be selecting what appears to be a single star but is actually an unresolved pair.

The Y-axis values are "sky" (catalog) magnitudes in the stated photometric band (V = Johnson V; PR = Pan-STARRS r´). The values in the parentheses give the phase angle(s), *a*, along with the value of *G* used to normalize the data to the comparison stars and asteroid phase angle used in the earliest session. This, in effect, adjusts all the observations so that they seem to have been made at a single fixed date/time and phase angle. Presumably, any remaining variations are due only to the asteroid's rotation and/or albedo changes.

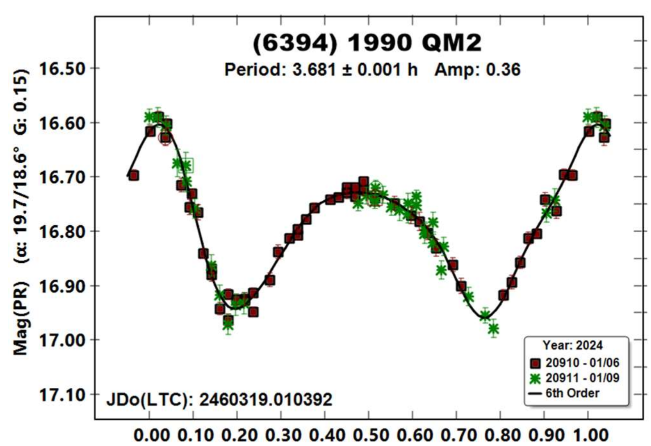
There can be up to three phase angles If two, the values are for the first and last night of observations. If three, the middle value is the extrema (maximum or minimum) reached between the first and last observing runs. The X-axis shows rotational phase from -0.05 to 1.05. If the plot includes the amplitude, e.g., "Amp: 0.65," this is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*.

For brevity, only some of the previous results are referenced. A more complete listing is in the asteroid lightcurve database (Warner et al., 2009; "LCDB" from here on).

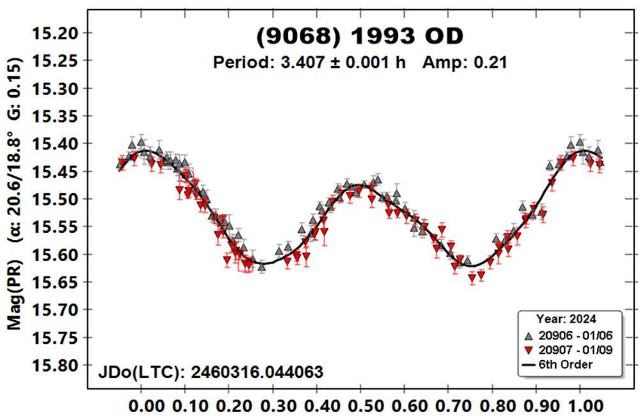
2001 Einstein. This Hungaria is a group member (Nesvorny, 2015; Nesvorny et al., 2015), meaning it is in the same orbital space, but not a member of the Hungaria collisional family. The 2024 apparition was the fifth one observed at Palmer Divide Observatory/Station since 2004 (Warner, 2005; 2008; 2010; 2013a). The period of 5.485 h closely duplicates the results from all four previous apparitions. Using sparse and dense data through 2014, a preliminary pole of $(\lambda, \beta)_{J2000}$ = (116°, -74°) was found (Warner et al., 2014).



(6394) 1990 QM2. Nesvorny (2015; et al., 2015) make this to be a member of the Hungaria collisional family, i.e., a piece of the parent body of the Hungarias. This was the fifth apparition observed by the author and sixth overall from CS3: Warner (2008; 2011; 2013b; 2015) and Stephens (2016). All previous results showed a synodic period of about 3.688 h. The shorter period in 2024, by 0.007 h, could be due to the limited amount of dense data obtained. A preliminary pole of $(\lambda, \beta)_{J2000}$ = (272°, -35°) or (184°, -68°) ± 15° (Warner et al., 2014) is based on data through 2014.



(9068) 1993 OD. This is a 14-km Hungaria *group* member. It was first observed by the author in 2008 (Warner, 2009) and again in 2013 (Warner, 2014). Pravec et al. (2019) made extensive observations in the fourth quarter of 2013 and discovered it to be part of an asteroid pair, the other being (455327) 2002 OP28. Stephens and Warner (2019) last observed the asteroid from CS3 in 2019 February. All previous synodic rotation periods were very close to the 2024 period of 3.407 h.



Acknowledgements

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Number	Name	2024/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2001	Einstein	01/06-01/09	23.0,22.2	135	25	5.485	0.001	0.76	0.03	H
6394	1990 QM2	01/06-01/09	19.7,18.6	135	-19	3.681	0.001	0.36	0.02	**H**
9068	1993 OD	01/06-01/09	20.6,18.7	133	-1	3.47	0.001	0.22	0.02	H

Table II. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extremum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). The Grp column gives the asteroid family or group (Nesvorny 2015; Nesvorny et al., 2015). H = Hungaria (bold = collisional family member).

LIGHTCURVE ANALYSIS FOR 17 NEAR-EARTH ASTEROIDS OBSERVED BETWEEN 2009 AND 2024

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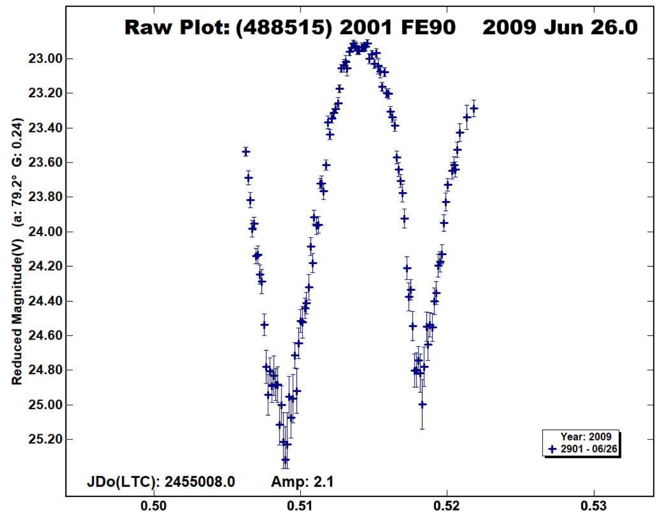
Lightcurves and amplitudes for 17 near-Earth asteroids observed from Great Shefford Observatory during close approaches between 2009 - 2019 and January - March 2024 are reported. All have rotation periods below the 2.2 h spin barrier with all but two having periods shorter than 10 minutes. Five have reliably detected tumbling rotation and another is a possible tumbler.

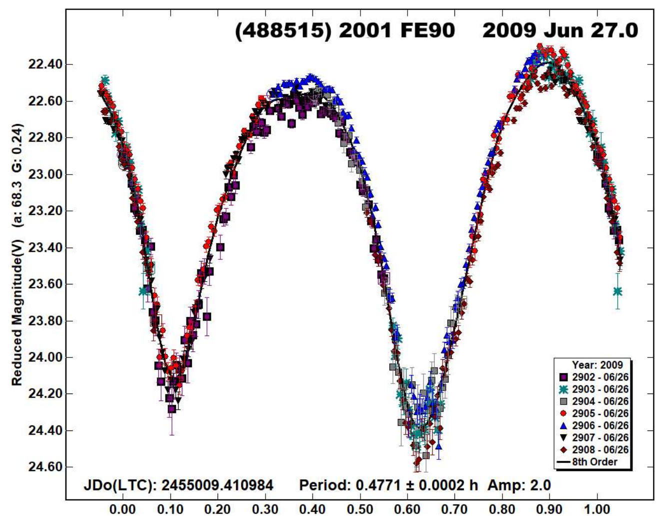
Photometric observations of near-Earth asteroids during close approaches to Earth in 2009 - 2019 and January - March 2024 were made at Great Shefford Observatory using a 0.40-m Schmidt-Cassegrain and Apogee Alta U47+ CCD camera. All observations were made unfiltered and with the telescope operating with a focal reducer at f/6. The 1k×1k, 13-micron CCD was binned 2×2 resulting in an image scale of 2.16 arcseconds/pixel. All the images were calibrated with dark and flat frames and *Astrometrica* (Raab, 2024) was used to measure photometry using APASS Johnson V band data from the UCAC4 catalogue (Zacharias et al., 2013). *MPO Canopus* (Warner, 2023), incorporating the Fourier algorithm developed by Harris (Harris et al., 1989) was used for lightcurve analysis.

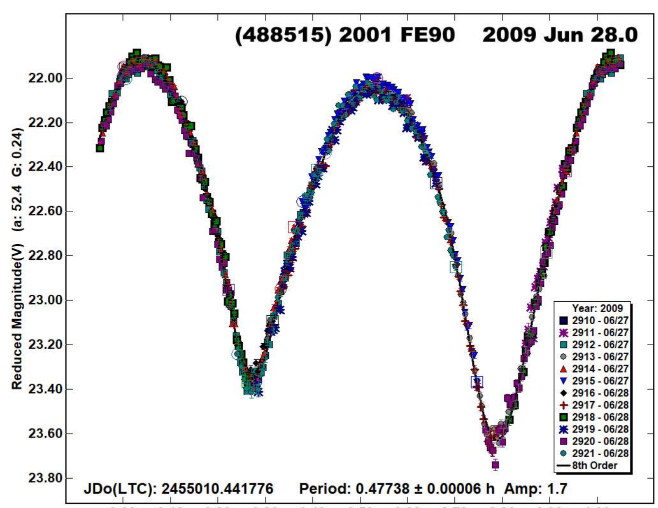
No previously reported results have been found in the Asteroid Lightcurve Database (LCDB) (Warner et al., 2009), from searches via the Astrophysics Data System (ADS, 2024) or from wider searches unless otherwise noted. All size estimates are calculated using H values from the Small-Body Database Lookup (JPL, 2024), using an assumed albedo for NEAs of 0.2 (LCDB readme.pdf file) and are therefore uncertain and offered for relative comparison only.

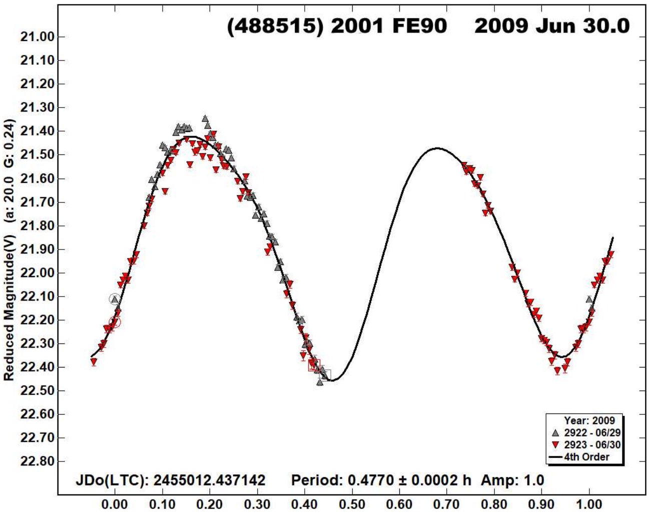
<u>(488515) 2001 FE90</u>. This Apollo (H = 20.7, dia. ~210 m) made an approach to 7 Lunar Distances (LD) on 2009 Jun 28.5 UTC. It was observed on four nights in 2009 June, with the mid-time dates, together with the number of observations and hours spanned being June 26.0, 110 over 0.37 h, June 27.0, 566 over 1.9 h, June 28.0, 822 over 3.1 h and June 30.0, 143 over 2.6 h. With a rotation period of 0.48 h only partial lightcurves resulted from observations on the first and last dates. A raw plot is given for the first date as there are not enough observations to make a good period determination, though the amplitude is well defined, with the assumption that the asymmetric lightcurve is similar to the other dates. The middle two dates were better covered and on June 28.0, with the asteroid reaching 13[th] mag the RMS scatter in the fitted lightcurve was at its lowest, at 0.031 mag.

(488515) 2001 FE90 has also been reported by Hicks et al. (2009), Oey (2011), Koehn et al. (2014) and Skiff et al. (2019), all based on observations from the same 2009 June apparition, with the Skiff paper being a revision of the same data set used in the earlier Koehn work (NEAPS papers 2 and 4). All agree well with the results given here.

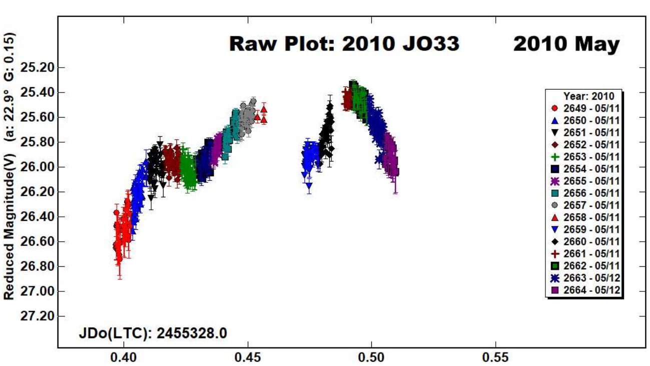


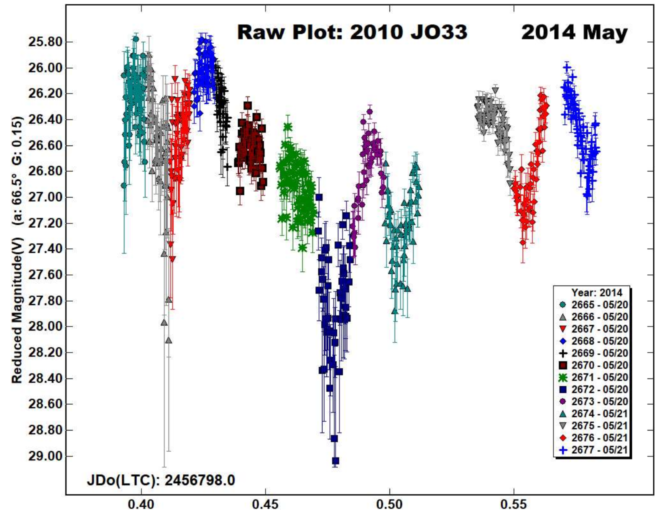


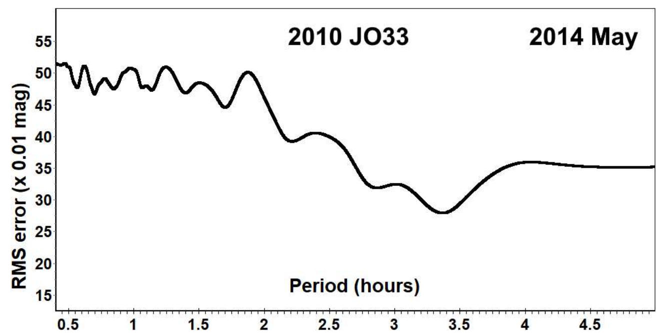


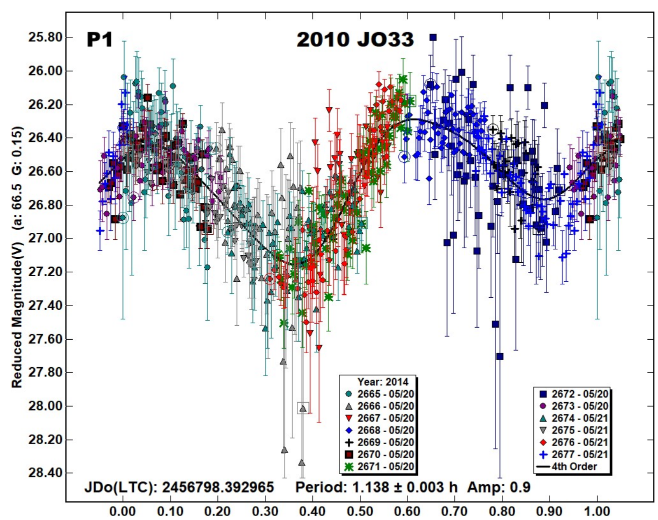


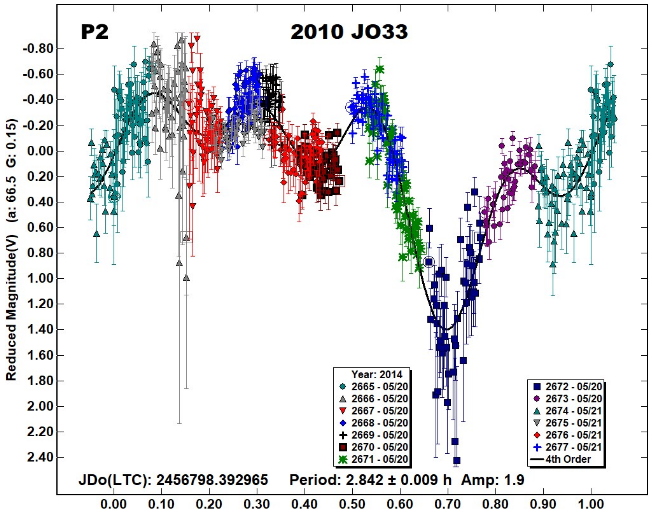
2010 JO33 = 2014 KD2. 2010 JO33 is an Apollo (H = 25.0, dia. ~30 m) and was a Catalina Sky Survey discovery made on 2010 May 8.2 UTC (Buzzi et al., 2010). With an orbital period of almost exactly 4 years it was re-discovered by the Palomar Transient Factory survey on 2014 May 19.3 UTC and received the designation 2014 KD2 a few hours before the two apparitions were linked. It was observed for 2.7 h starting on 2010 May 11.90 UTC and then observed 4 years later for 4.6 h starting on 2014 May 20.89 UTC. Raw plots are given for the two observing sessions, with X and Y axes at the same scale in both. It can be seen that there are large semi-periodic magnitude variations, most evident in the longer run in 2014 but these are not regular, strongly suggesting Non-Principal Axis Rotation (NPAR) or tumbling is present. A period spectrum from the 2014 observations indicates various poorly defined minima extending up to the 4.6 h span of observations. Attempts to determine a reliable NPAR solution are not possible with the relatively short span, with possible periods in the 0.8 - 7 h range. One of a number of solutions is given here as an example, with the two NPAR periods labelled P1 and P2 but neither may be correct as a consequence of the derived periods being not much shorter than the span of observations. It is expected that 2010 JO33 may be rated as PAR = -2 on the scale defined in Pravec et al. (2005) where NPA rotation is detected based on deviations from a single period but the second period is not resolved. (Petr Pravec, personal communication).



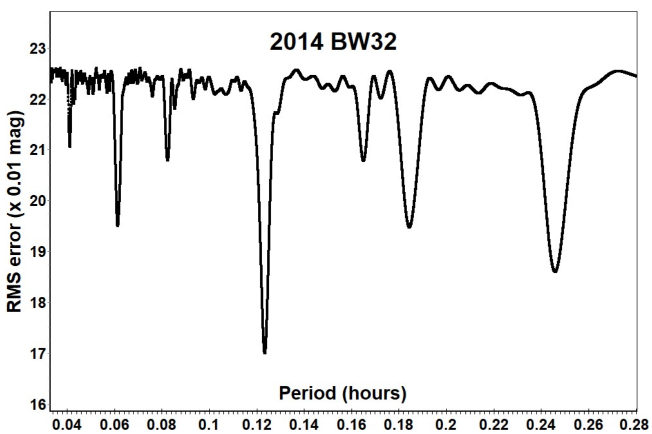


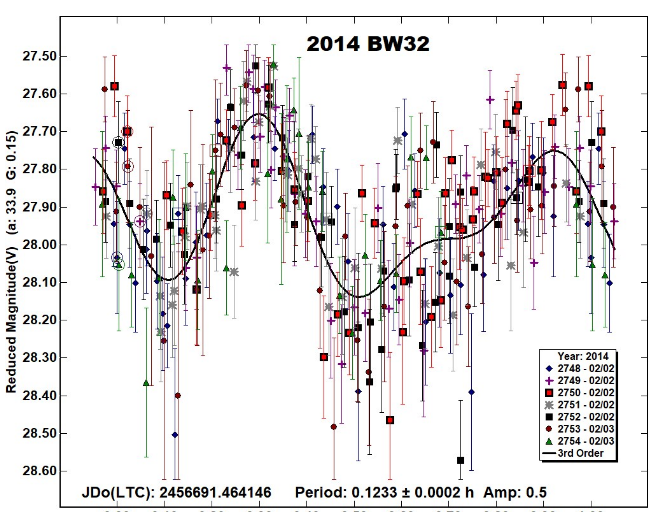




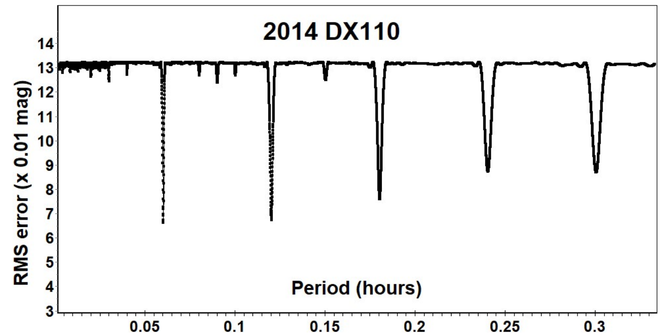


2014 BW32. This is an Aten (H = 26.6, dia. ~14 m) discovered from Mt. Lemmon on 2014 Jan 23 UTC that made an approach to within 2 LD of Earth on 2014 Feb 3.7 UTC (Johnson et al., 2014). It was observed starting at 2014 Feb 2.96 UTC and 272 measurable images were obtained over 1.4 h. The linearly scaled period spectrum shows seven significant minima, with the best-fit at 0.123 h; the other six minima are related, being small integer multiples of 1/3 or 1/2 of that period. The best-fit lightcurve is given and the period of 0.1233 ± 0.0002 h indicates that 11 rotations were completed during the period of observation.

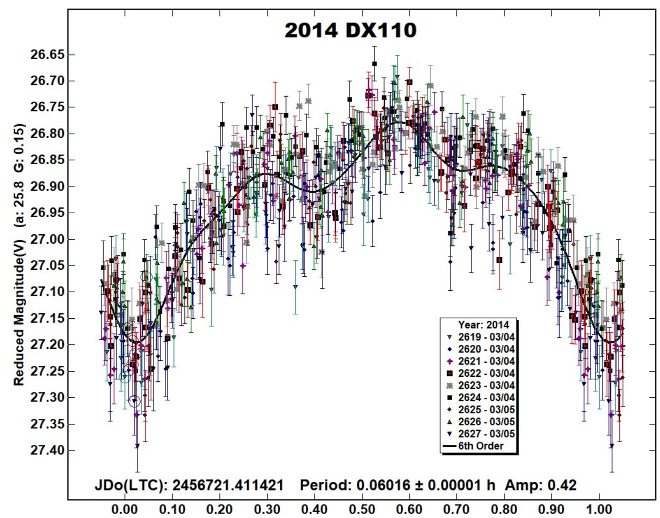


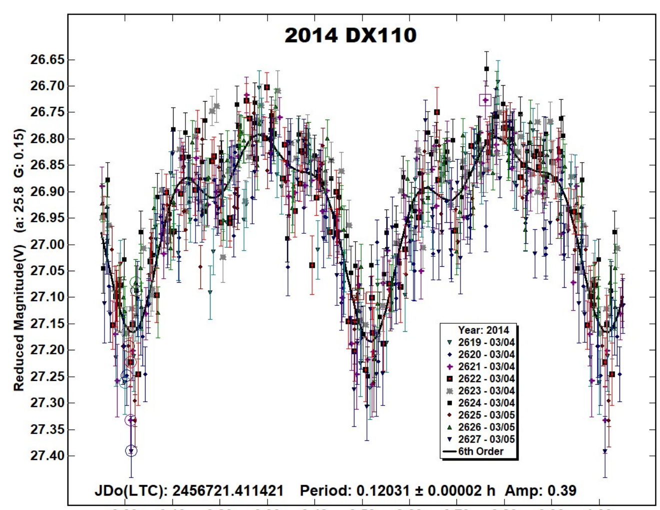


2014 DX110. This Pan-STARRS 1 discovery of an Apollo (H = 25.7, dia. ~22 m) was made on 2014 Feb 28 and it passed Earth at 0.9 LD on 2014 Mar 5.88 UTC (Primak et al., 2014). Observations were made starting on 2014 Mar 4.91 UTC for 3 hours and 628 measurable images were obtained. A linearly scaled period spectrum shows the best-fit solution at 0.060 h but with an only slightly inferior result at double that value at 0.120 h. A series of minor minima from 0.02 - 0.15 h are all related to the best-fit period, being small integer multiples of 1/3 or 1/2 of that period.

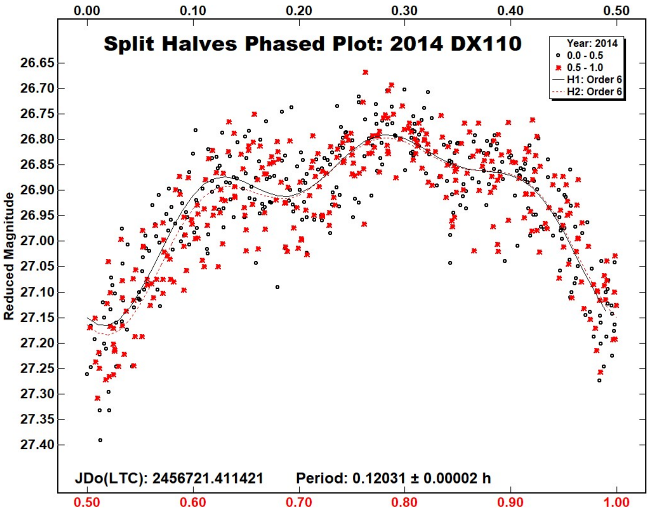


Further analysis of the lightcurve indicates significant improvement of the residuals with a 6th order solution and lightcurves for the two most likely periods are given.





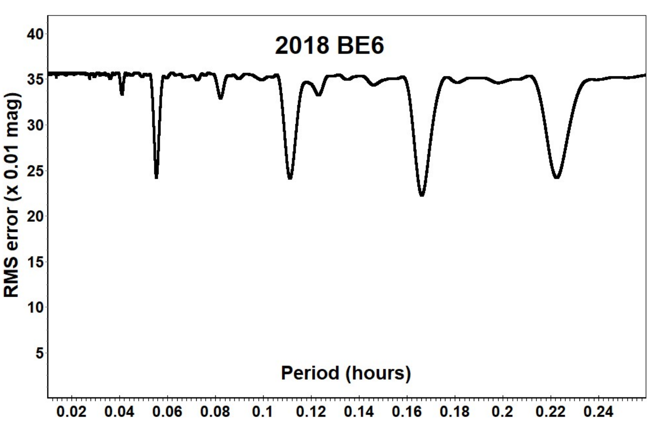
The shape of the two maxima in the bimodal lightcurve of the longer period appear strikingly similar and a Split Halves plot generated in *MPO Canopus* shows the two halves match to better than 0.03 magnitudes, within the overall RMS scatter of 0.07 magnitudes.



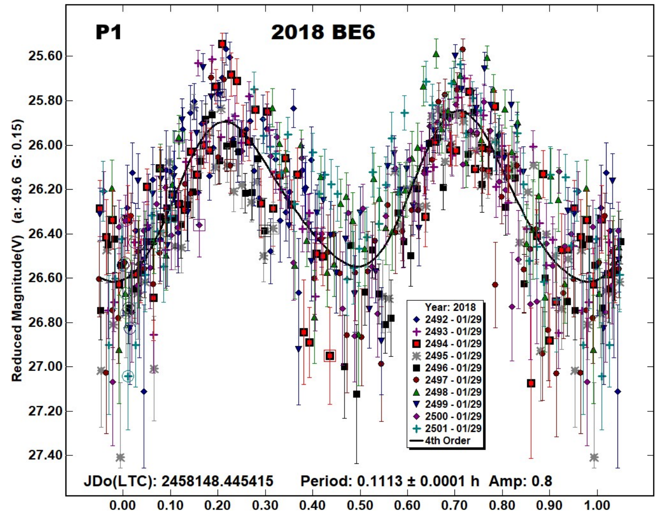
This suggests that the shorter period may be correct and indeed the shorter period gives smaller RMS values in each reduction tested up to the 9th order and is adopted here as the preferred solution.

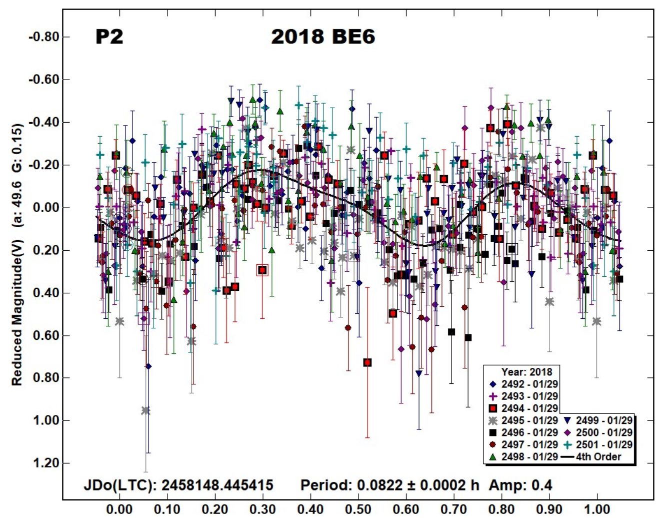
2014 DX110 was previously reported by Warner (2014) where it was observed for 70 minutes starting on 2014 Mar 5.28 UTC, some 6 hours after the final observations in the current paper. Similar results were obtained and it was noted there was uncertainty whether the lightcurve should be monomodal (0.06019 ± 0.00004 h) or bimodal (0.12041 ± 0.00008 h), siding with the longer period due to a slight misalignment in a split halves plot, but noting this is too little to be certain.

2018 BE6. This Apollo (H = 24.5, dia. ~37 m) was discovered by the Catalina Sky Survey on 2018 Jan 25.2 UTC and approached the Earth to within 3.4 LD on 2018 Jan 30.4 UTC (Bacci et al., 2018a). It was observed for 60 minutes starting at 2018 Jan 29.95 UTC when it was moving in excess of 130 arcsec/min and exposures were limited to 4 seconds or less to stop excessive trailing. A period spectrum shows a set of strong signals in multiples of 0.0555 h, with a bimodal solution at 0.1111 h, but the strongest signal is at 3 × 0.0555 h = 0.1665 h. However, a weaker set of minima can be seen at multiples of 0.0413 h, suggesting that non-principal axis rotation (NPAR) or tumbling may be present and it is noted that 4 × 0.0413 h ≈ 3 × 0.0555 h, causing the strength of the signal at 0.166 h to appear amplified.



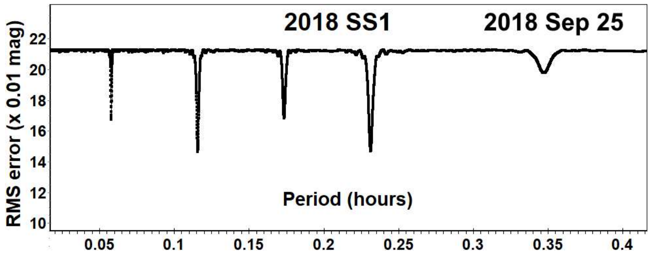
An NPAR solution derived using the Dual Period Search function in *MPO Canopus* isolates bimodal periods of P1 = 0.1113 h and P2 = 0.0822 h, with corresponding lightcurves labelled P1 and P2.

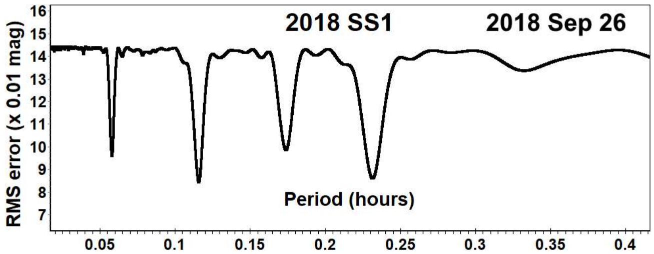




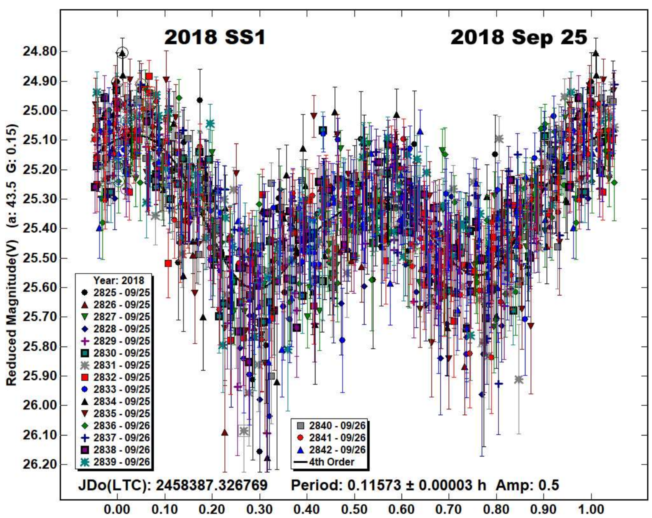
The observations span 9 revolutions of the P1 period and 12 of the P2 period. On the scale defined in Pravec et al. (2005) it is expected to be rated as PAR = -3 with NPA rotation reliably detected with the two periods resolved. (Petr Pravec, personal communication). The NPAR solution indicates the full amplitude of the combined lightcurves is 1.1 magnitudes.

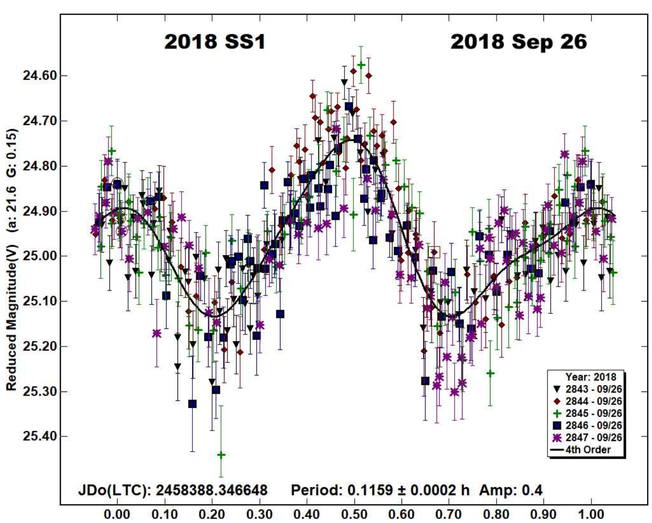
2018 SS1. With a perihelion distance of 1.012 AU the Minor Planet Center lists this as an Amor object, but with a slightly different definition it is classified as an Apollo in the JPL Small Body Database (JPL, 2024), with H = 23.8 (dia. ~52 m). It was discovered from Mt. Lemmon on 2018 Sep 22 and approached the Earth to 6.5 LD on 2018 Sep 27.1 UTC (Bacci et al., 2018b). It was observed for 3.6 h over a 5.6-h span starting on 2018 Sep 25.83 UTC with 1151 usable images being obtained when it was at a distance of 7.5 LD. A further 344 images were collected during 48 minutes starting at 2018 Sep 26.85 UTC when it had approached to 6.5 LD and brightened by 0.6 magnitudes from the night before. Independent analysis of the two dates produced very similar period spectra and both show the best-fit solution to be at 0.116 h.



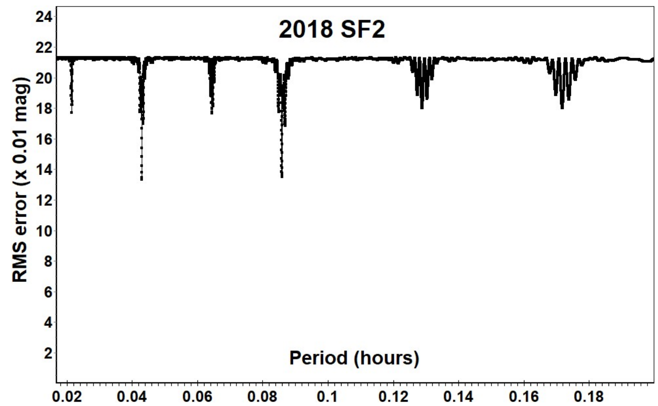


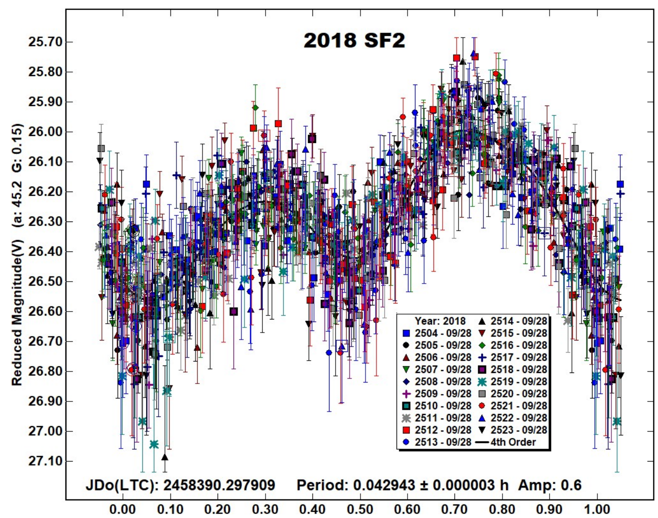
Lightcurves from the two dates show the amplitude decreasing as the phase angle halved. During the time it was actively under observation it completed 31 rotations on the first date and 7 on the second date.



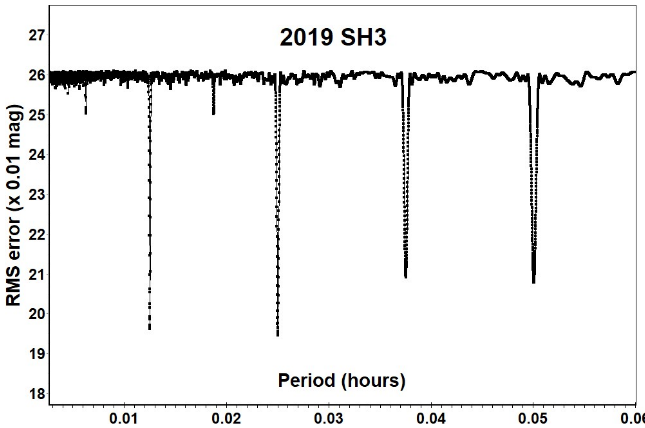


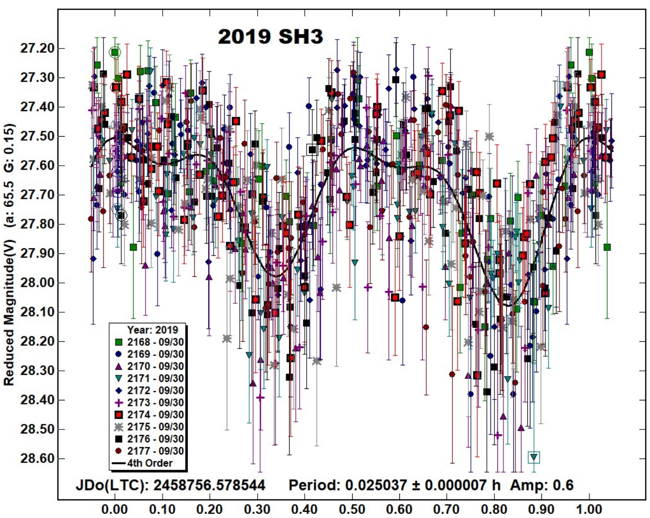
2018 SF2. Another Catalina Sky Survey discovery of an Apollo (H = 24.7, dia. ~34 m), found on 2018 Sep 28.3 UTC (Mikuz et al., 2018). It passed Earth at 3.2 LD on 2018 Sep 29.49 UTC and was observed for 49 minutes starting at 2018 Sep 28.80 UTC and again 2h 40m later for a further 63 minutes. Analysis reveals an asymmetric bimodal lightcurve with period 2.6 minutes and amplitude 0.6. During the 112 minutes it was actively under observation it completed 43 revolutions.





2019 SH3. This Apollo (H = 25.6, dia. ~23 m) was discovered by Pan-STARRS 1 on 2019 Sep 22.4 UTC just over a week before it passed Earth at 3 LD on 2019 Sep 30.07 UTC (Bulger et al., 2019). It was observed for 66 minutes starting on 2019 Sep 30.08 UTC when it had an apparent speed of 145 arcsec/min and exposures were kept between 2.0 - 2.5 seconds throughout to limit trailing. Although the measurements have poor S/N a linearly scaled period spectrum covering periods from 10 s - 3.6 minutes shows the best-fit solution to have a period of 0.025037 ± 0.000007 h with the resulting lightcurve having an amplitude of 0.6.

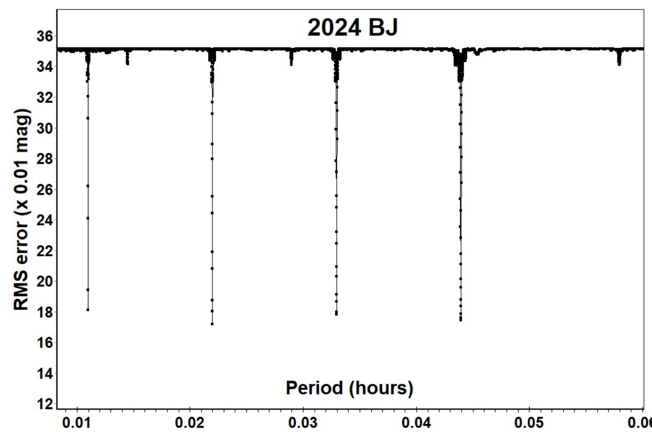




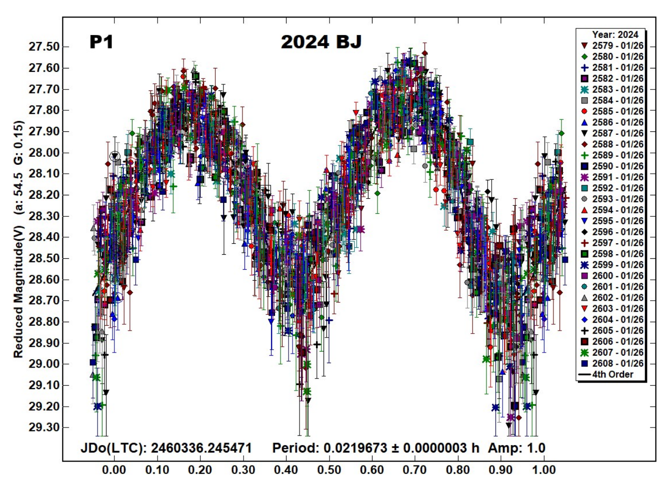
The two broad maxima in the lightcurve appear quite similar, consisting of two humps in each overall peak, suggesting the possibility that the real period may be half of the best-fit period, giving a monomodal lightcurve. However, the minima differ by ~0.15 magnitudes, indicating that the bimodal, best-fit solution is more likely. 44 rotations were completed while 2019 SH3 was under observation.

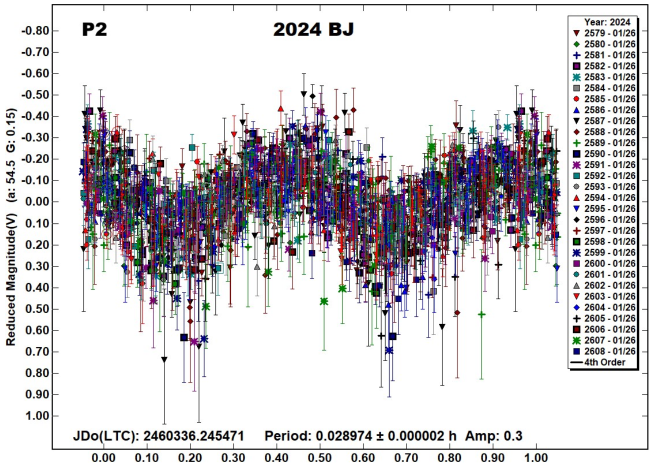
2024 BJ. This was a Mt. Lemmon Survey discovery from 2024 Jan 17.2 UTC and 10 days later, on 2024 Jan 27.73 UTC it approached Earth to 0.92 LD (Lejoly et al., 2024a). It is an Apollo (H=26.3, dia. ~17 m) and was observed for 4.6 h during a 5.3 h period starting 2024 Jan 26.75 UTC when it was at 1.5 LD and its apparent speed accelerated from 69 to 94 arcsec/min. Exposure lengths were varied between 3 and 8.5 seconds and 1638 usable images were obtained. Initial analysis using *MPO Canopus* indicated a strong bimodal solution with period 0.0219675 ± 0.0000004 h and 1 mag amplitude. However, it was evident that during the 5 hours of observation the ephemeris indicated the apparent brightness would be expected to rise by 0.39 magnitudes due to changing distance and phase angle, but the observed magnitude trend was effectively flat. This may be due to some absolute calibration issue due to the observing circumstances but other than apparent speed there appears to be no obvious correlation with e.g. changing phase angle, altitude, exposure length etc. It is noted that from examination of the 33 available astrometric measurements that contain photometry (MPC, 2024) made on or after 2024 Jan 26.82 UTC and corrected to V band, 30 are fainter than predicted by the ephemeris. The flat-lining of the observed magnitudes in this analysis has been compensated for by modifying the zero points of the 30 sessions, with the effect of reducing the apparent scatter in the fitted lightcurves but not affecting the derived periods or conclusions.

A linearly scaled period spectrum covering 30 seconds - 3.6 minutes shows RMS minima for the first four orders of the already determined dominant period, with the strongest signal at 0.022 h. However, another set of four regularly spaced, much weaker minima can be seen at 0.0145, 0.0290 and 0.058 h with one at 0.0435 h almost masked by the quadrimodal solution of the dominant lightcurve at 0.0439 h.

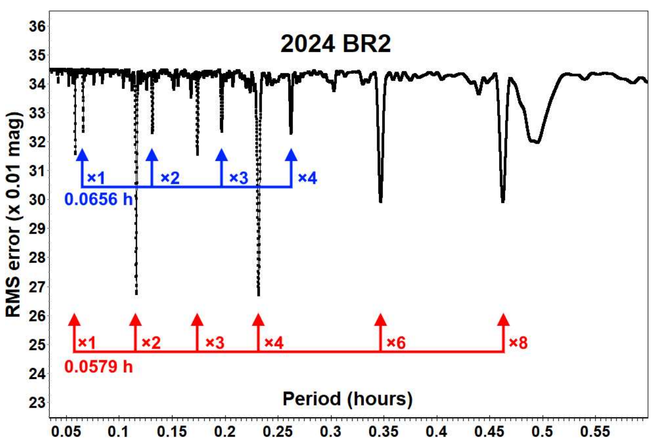


The Dual Period Search function in *MPO Canopus* was again used to try and isolate two possible NPAR periods in case tumbling was present and the resulting best-fit lightcurves are labelled as P1 and P2. The Y-axis has been forced in the P2 figure to have the same range as in the P1 figure to aid comparison. Both periods are well defined and it is expected to be rated as PAR = -3 with NPA rotation reliably detected with the two periods resolved. The NPAR solution indicates the full amplitude of the combined lightcurves is 1.2 magnitudes and the span of observations cover 211 and 160 rotations of the P1 and P2 periods respectively.

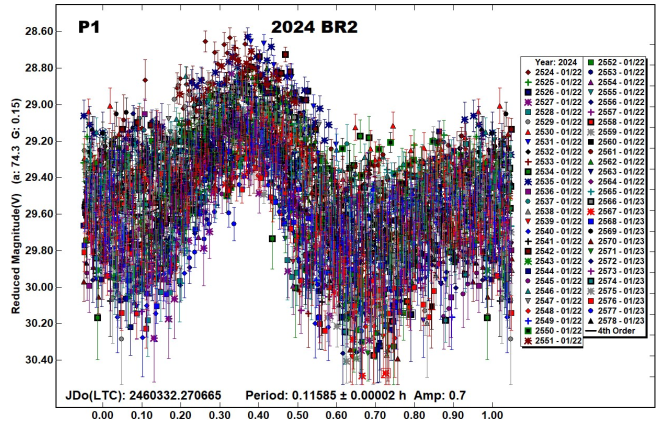


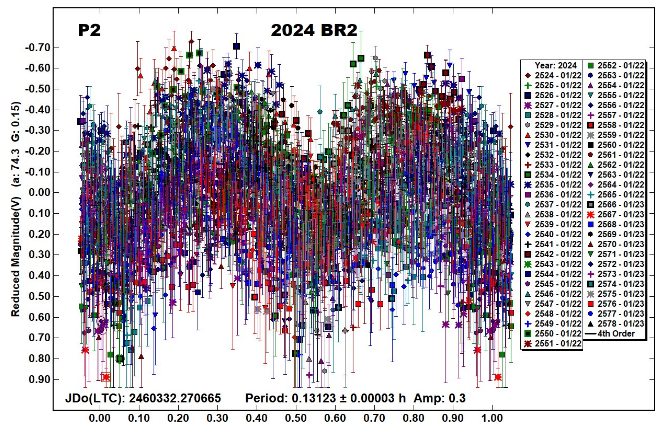


2024 BR2. This Aten (H = 27.1, dia. ~11 m) was discovered at the ATLAS Haleakala station on 2024 Jan 22.58 UTC (Birtwhistle et al., 2024) just 2 hours after passing Earth at 0.76 LD. Starting 4.6 h after discovery, at 2024 Jan 22.77 UTC, it was observed for a total of 5.7 h over a 7.5-h span and 3216 measurable images were obtained, requiring the telescope to be repositioned 55 times. The apparent speed decreased from 150 to 130 arcsec/min and exposures were kept to 4 seconds or shorter to keep trailing within the measurement annulus used in *Astrometrica*. A linearly scaled period spectrum covering 2 - 36 minutes shows many RMS minima with the strongest signals at 0.116 h and 0.232 h, these being ×2 and ×4 multiples of 0.0579 h and other multiples up to ×8 can be seen in the figure. A separate set of four regularly spaced weaker minima are also evident, at multiples of 0.0656 h, from ×1 to ×4, suggesting tumbling rotation may be present.

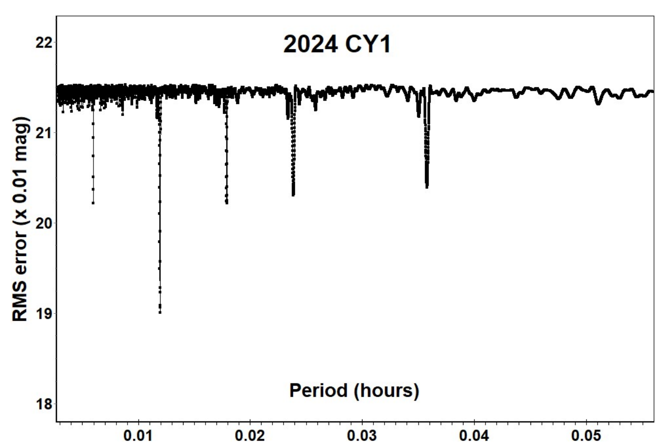


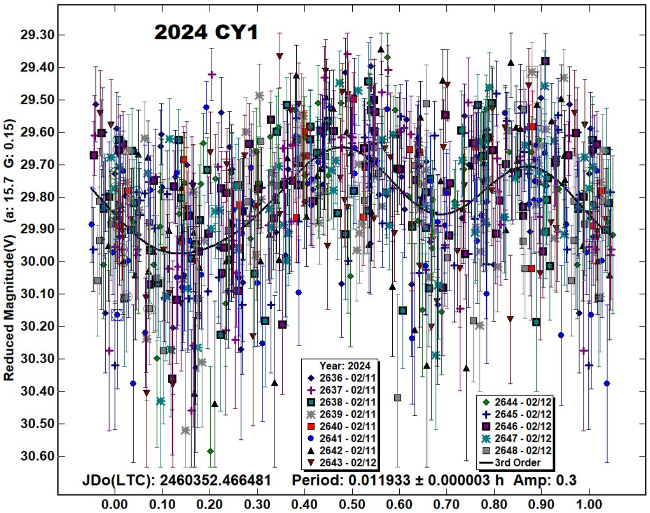
Using the *MPO Canopus* Dual Period Search function, best-fit NPAR periods of P1 = 0.11585 ± 0.00002 h and P2 = 0.13123 ± 0.00003 h are determined. These equate to the RMS minima identified as ×2 multiples in the period spectrum and produce bimodal lightcurves as shown in the figures labelled P1 and P2. Many much weaker minima are identified as aliases of the P1 and P2 frequencies, e.g. a minima P3 at 0.0838 h where 1/P1 + 2/P2 = 2/P3 and the broad minima P4 at 0.49 h equates to 2/P1 – 2/P2 = 1/P4. It is therefore expected that 2024 BR2 may be rated as PAR = -3 (NPA rotation reliably detected with the two periods resolved. An ambiguity of the periods solution may be tolerated provided the resulting spectrum of frequencies with significant signal is the same for the different solutions). (Petr Pravec, personal communication). The NPAR solution indicates the full amplitude of the combined lightcurves is 1.1 magnitudes and the span of observations cover 49 and 43 rotations of the P1 and P2 periods respectively.



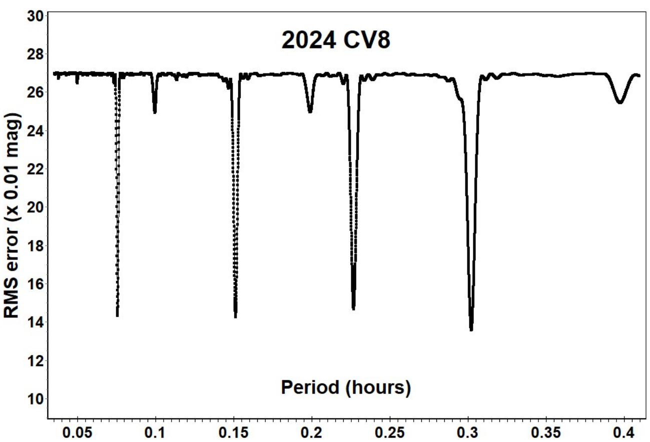


2024 CY1. This very small Apollo (H = 29.2, dia. ~4 m) was a Pan-STARRS 2 discovery from 2024 Feb 9.3 UTC and made an approach to 0.3 LD from Earth on 2024 Feb 12.31 UTC (Cromer et al., 2024). It was observed for 1.4 h starting at 2024 Feb 11.97 UTC and 687 measurable images were obtained. Due to its fast apparent speed increasing from 115 to 160 arcsec/min and low altitude, at best 36° the measurements are of low S/N but analysis identified the best-fit to the data being an asymmetric lightcurve of period 42.96 ± 0.01 seconds and amplitude 0.3.

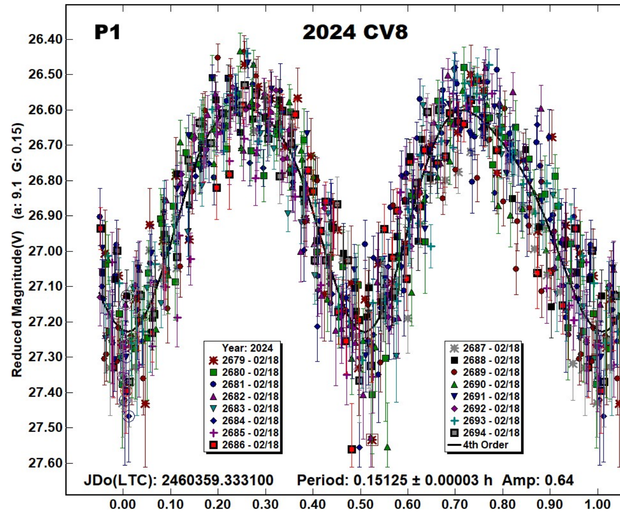


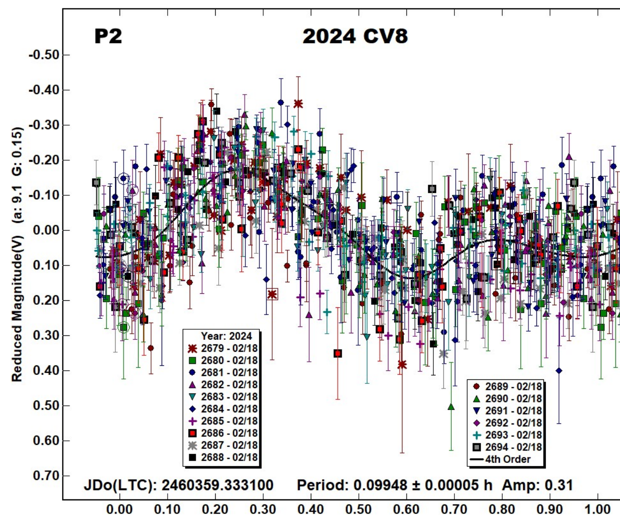


2024 CV8. Pan-STARRS 2 discovered this Apollo (H = 26.3, dia. ~16 m) on 2024 Feb 13 and it passed within 1.2 LD of Earth 6 days later on 2024 Feb 19.8 UTC (Groeller et al., 2024). It was observed for 3.6 h starting at 2024 Feb 18.83 UTC and large peak to peak magnitude variations were evident over 4 or 5 minutes. Assuming a bimodal lightcurve the maximum exposure length, balancing good S/N against minimal lightcurve smoothing would therefore be estimated at 0.185 × 240 seconds × 2 = 89 seconds (Pravec et al., 2000). However, as the apparent speed was initially 42 arcsec/min and increasing through the night, exposure lengths were instead governed by the length of trail of the asteroid, to keep within the photometric aperture used in *Astrometrica*, limiting exposures to 14.5 s, decreasing to 11.7 s. A total of 718 measurable images were obtained and a linearly scaled period spectrum is given, covering periods between 0.035 - 0.4 h.



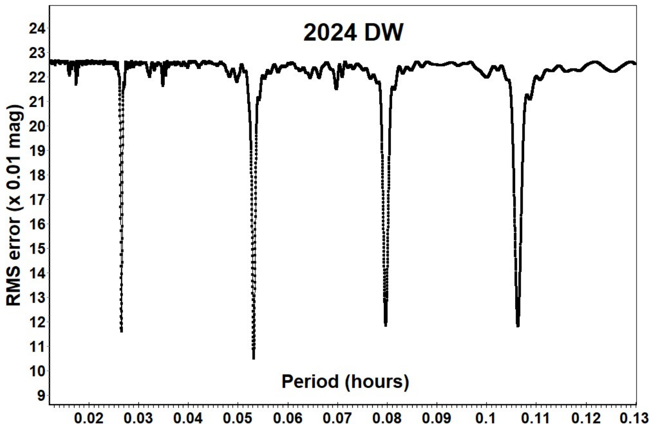
This shows four strong solutions equally spaced at multiples of 0.076 h, with the best-fit at 0.302 h, this equating to an unlikely looking quadrimodal lightcurve, but also three weaker minima are apparent at multiples of 0.100 h, at 0.100 h, 0.199 and 0.397 h, implying another minimum at 0.298 h may be partially obscured by and be intensifying the apparent best-fit solution at 0.302 h. The two sets of minima suggest tumbling may be present and an NPAR analysis using the *MPO Canopus* Dual Period Search function produced a best-fit solution with bimodal lightcurves and rotation periods of P1 = 0.15125 ± 0.00003 h and P2 = 0.09948 ± 0.00005 h. Lightcurves for these are labelled P1 and P2 and, as previously noted, there is an approximate 2×P1 = 3×P2 commensurability but this does not interfere with the reduction and result.

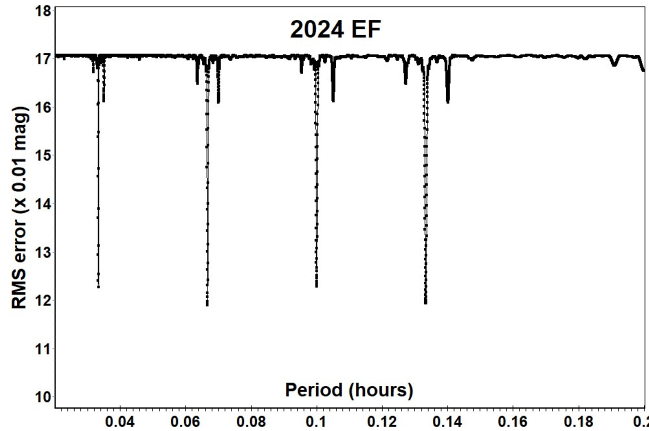


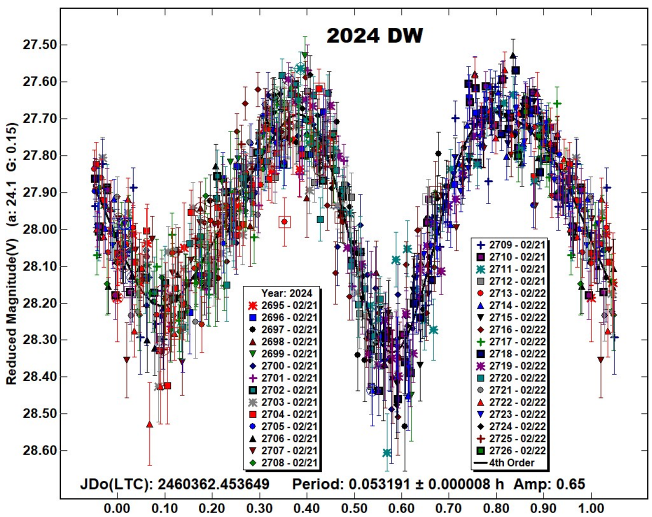


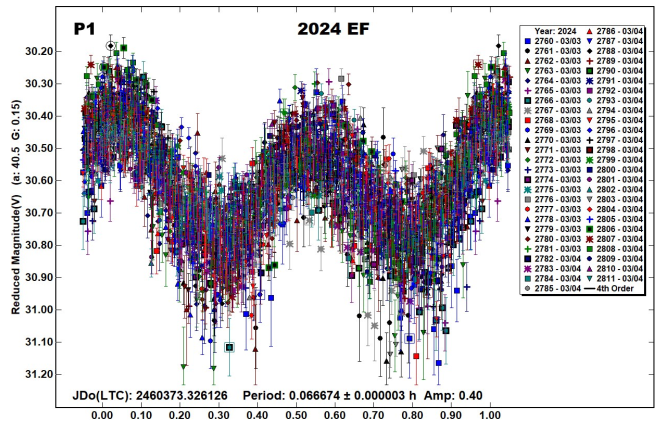
On the scale defined in Pravec et al. (2005) it is expected to be rated as PAR = -3 with NPA rotation reliably detected with the two periods resolved. (Petr Pravec, personal communication). The NPAR solution indicates the full amplitude of the combined lightcurves is 0.94 magnitudes and that 2024 CV8 completed 24 rotations of the P1 period and 36 of the P2 period while under observation.

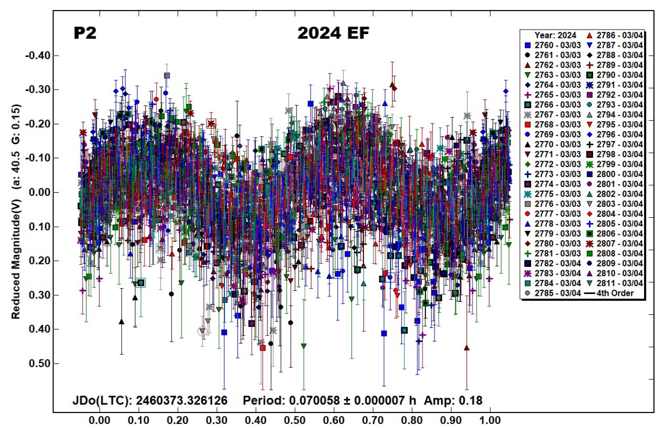
2024 DW. This Apollo (H = 27.1, dia. ~11 m) was a Mt. Lemmon discovery on 2024 Feb 19 and passed Earth at 0.6 LD on 2024 Feb 22.19 UTC (Bacci et al., 2024). It was observed for 1.7 h starting on 2024 Feb 21.95 UTC when it was at a distance of 1.1 LD and moving at 270 arcsec/min and when last recorded it was at 0.9 LD and moving at 420 arcsec/min. Exposures were limited to 2.2 seconds, reducing to 1.6 seconds to keep trailing of the target within the measurement aperture used in *Astrometrica* and 763 usable images were obtained, with the telescope being repositioned 32 times. A period spectrum shows the best-fit solution at 0.053 h and this is represented by an asymmetric bimodal lightcurve. Other minor minima in the spectrum are possible indications of tumbling being present, but further analysis failed to locate any reliable NPAR solutions, amplitudes from secondary periods being significantly less than the noise in the overall solution. Transparency was variable during the observing session and small zero-point adjustments have been applied to the individual sessions to reduce the overall scatter of the lightcurve, the RMS of the corrections being 0.06 mag.

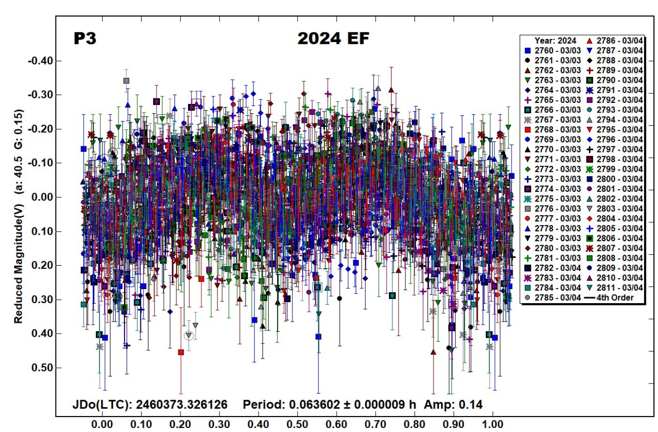










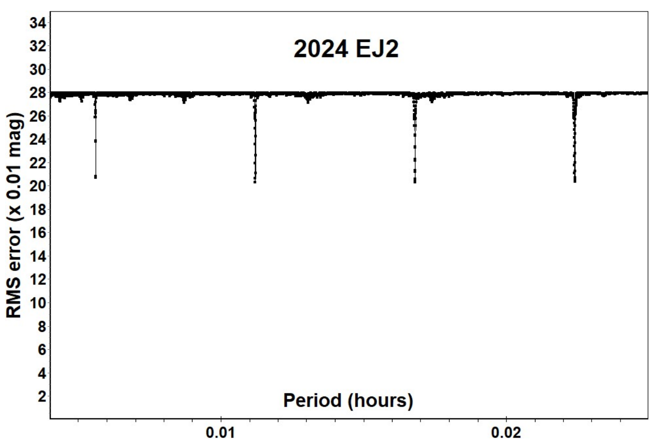


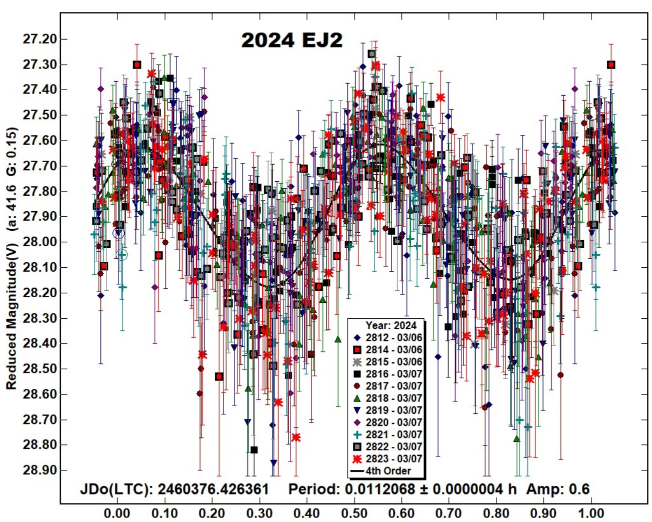
2024 EF. Another very small Apollo (H = 29.1, dia. ~4 m), discovered by the Mt. Lemmon Survey on 2024 Mar 2.3 UTC, it made a very close approach, to 0.15 LD on 2024 Mar 4.29 UTC (Lejoly et al., 2024b). It was observed continuously for 6.7 h starting at 2024 Mar 3.83 UTC and 2723 usable images were obtained. It was obvious from the first sets of images that maximum to maximum light variations were occurring within 1 or 2 minutes, so appropriate maximum exposure lengths for an assumed bimodal lightcurve may be of the order 0.185×60×2 seconds = 22 seconds to limit the effects of lightcurve smoothing (Pravec et al., 2000). With its distance decreasing from 0.8 to 0.4 LD and apparent speed increasing from 55 to 310 arcsec/min, to limit trailing of the target to keep it enclosed within the *Astrometrica* measurement annulus, in practice exposures were initially limited to 11.5 seconds, reducing to 2.1 seconds by the end. A period spectrum covering 0.02 - 0.2 hours shows four strong minima in multiples of 0.033 h with the best-fit solution at 0.067 h but with lesser minima on either side of these four solutions, these being multiples of 0.032 and 0.035 h. This is an indication of possible tumbling and an NPAR solution derived using the *MPO Canopus* Dual Period Search function locates the dominant period P1 = 0.066674 ± 0.000003 h and a secondary period P2 = 0.070058 ± 0.000007 h, lightcurves for these being labelled P1 and P2. A separate search finds a slightly inferior fit, again with the dominant period P1 = 0.066674 ± 0.000003 h but with a secondary period P3 = 0.063602 ± 0.000009 h, the lightcurve for this third period is labelled P3.

The dominant period P1 is well established, but it is noted that the frequencies for the three periods are related, where 2/P1 – 1/P2 =

1/P3 and it is not clear which of P2 or P3 is the real second period of the tumbler and which is a beat between the two main frequencies. It is therefore expected that 2024 EF may be rated on the scale defined in Pravec et al. (2005) as PAR = -3 (NPA rotation reliably detected with the two periods resolved. An ambiguity of the periods solution may be tolerated provided the resulting spectrum of frequencies with significant signal is the same for the different solutions). The full amplitude suggested by the NPAR solution is ~0.6 magnitudes and during the time it was under observation it completed 100 rotations of the P1 period.

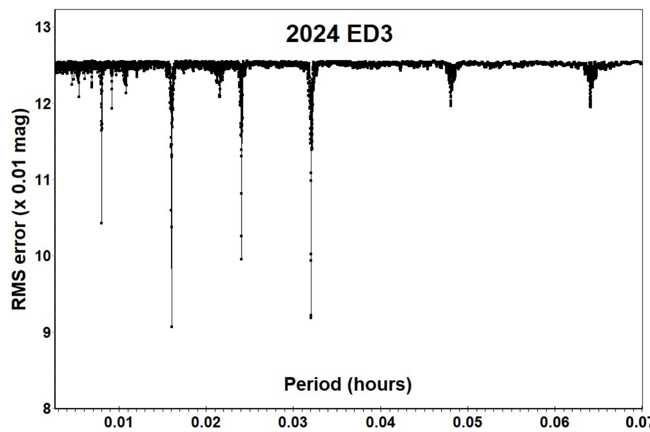
2024 EJ2. The ATLAS team discovered this small Apollo (H = 26.4, dia. ~15 m) from their Haleakala station on 2024 Mar 6.4 UTC and it made an approach to 1.5 LD on 2024 Mar 8.08 UTC (Dupouy et al., 2024). It was observed for 2.4 h over a span of 4.3 h starting on 2024 Mar 6.93 UTC when 914 usable images were obtained. The object was relatively faint, around apparent magnitude +18, resulting in low S/N in the measurements but the period spectrum shows a well-defined set of minima, with the strongest from a period of 40.344 ± 0.001 seconds. A number of minor minima in the period spectrum hint at the possibility of some tumbling being present but with the degree of scatter in the measurements no meaningful determination can be made. During the 2.4 h it was under observation 2024 EJ2 completed 213 rotations.

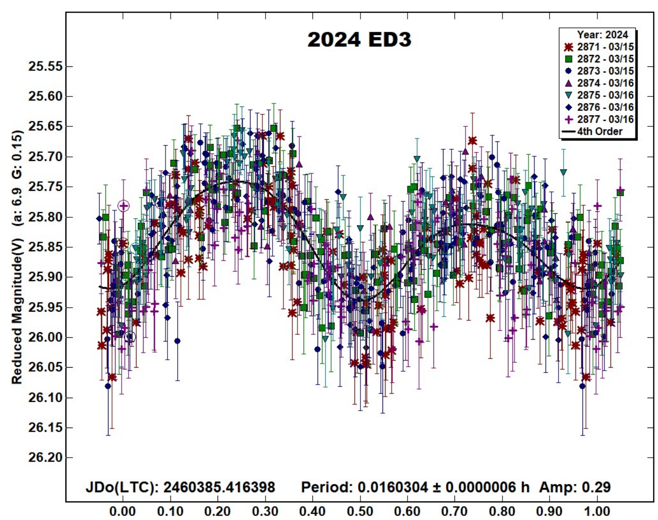




2024 ED3. An Apollo (H = 25.3, dia. ~26 m) discovered by the Catalina Sky Survey on 2024 Mar 11 and which made an approach to 3.5 LD on 2024 Mar 18.4 UTC (Melnikov et al., 2024). It was actively observed for 2.3 h during a 5.7-h period starting on 2024 Mar 15.92 UTC, after an initial set of short 3- and 5-sec exposures had been obtained to determine whether it was a very fast rotator, a likely period being determined to be ~60 seconds. All subsequent images were taken using 10 second exposures to limit lightcurve smoothing and the resulting linearly scaled period spectrum gives a best-fit period of 57.709 ± 0.002 seconds. As well as minima related to the best-fit period that are small integer multiples of 1/3 or 1/2 of that period there are also a number of low amplitude, very short period minima and these are likely to be spurious, apparently relating to multiples of the imaging cadence of ~11.5 seconds. During the 2.3 h of active observation 2024 ED3 completed 142 rotations.

The derived period is in good agreement with that determined by Pravec (2024web) from observations made between 2024 Mar 13.1-13.3 UTC. Possible low amplitude tumbling also reported in those results is however not detected in the current analysis, likely due to the RMS magnitude error of 0.09 being three or four times larger here than that achieved by Pravec.

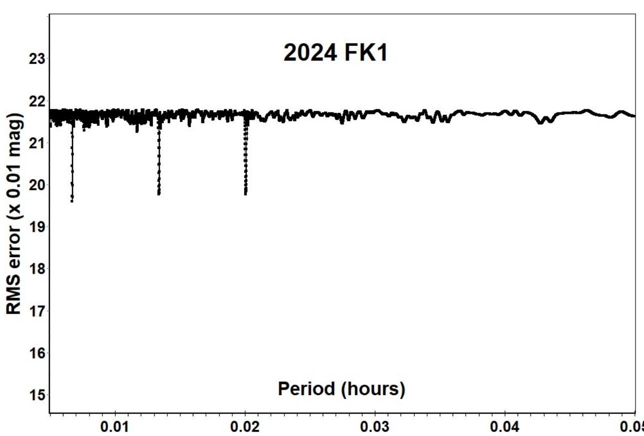


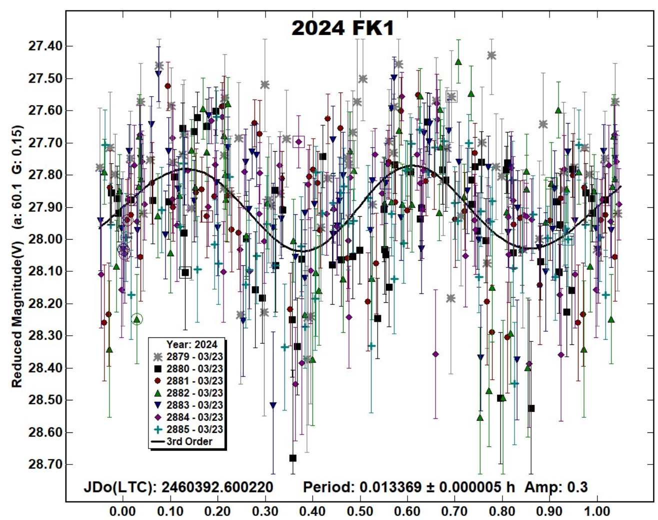


Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E	PAR	H
488515	2001 FE90	2009 06/26-06/26	79.2-79.1	240	24			2.16	0.14		20.7
		2009 06/26-06/26	68.4-67.3	246	20	0.4771	0.0002	2.00	0.11		
		2009 06/27-06/28	52.4-50.5	254	15	0.47738	0.00006	1.71	0.04		
		2009 06/29-06/30	20.0-18.7	269	3	0.4770	0.0002	1.02	0.06		
	2010 JO33	2014 05/20-05/21	66.4-66.4	238	34	1.138	0.003	0.8	0.3	-2	25.0
						2.842	0.009	1.9	0.3		
	2014 BW32	2014 02/02-02/03	33.8-35.4	127	16	0.1233	0.0002	0.5	0.2		26.6
	2014 DX110	2014 03/04-03/05	25.6-27.1	151	0	0.06016	0.00001	0.42	0.09		25.7
	2018 BE6	2018 01/29-01/29	49.7-51.2	105	-5	0.1113	0.0001	0.8	0.3	-3	24.5
						0.0822	0.0002	0.4	0.3		
	2018 SS1	2018 09/25-09/26	43.4-39.0	355	20	0.11573	0.00003	0.5	0.2		23.8
		2018 09/26-09/26	21.6-20.9	356	8	0.1159	0.0002	0.39	0.12		
	2018 SF2	2018 09/28-09/28	45.0-53.7	9	25	0.042943	0.000003	0.6	0.2		24.7
	2019 SH3	2019 09/29-09/30	65.5-68.1	28	26	0.025037	0.000007	0.6	0.3		25.6
	2024 BJ	2024 01/26-01/26	54.4-53.3	100	-7	0.021967	0.000001	1.0	0.2	-3	26.3
						0.028974	0.000002	0.3	0.2		
	2024 BR2	2024 01/22-01/23	74.0-64.0	125	34	0.11585	0.00002	1.1	0.3	-3	27.1
						0.13123	0.00003	0.3	0.3		
	2024 CY1	2024 02/11-02/12	16.2-19.4	143	-9	0.011933	0.000003	0.3	0.3		29.2
	2024 CV8	2024 02/18-02/18	8.9-10.8	145	2	0.15125	0.00003	0.64	0.15	-3	26.3
						0.09948	0.00005	0.31	0.15		
	2024 DW	2024 02/21-02/22	24.3-33.2	163	10	0.053191	0.000008	0.65	0.12		27.1
	2024 EF	2024 03/03-03/04	40.3-33.7	163	18	0.066674	0.000003	0.40	0.14	-3	29.1
						0.070058	0.000007	0.18	0.14		
	2024 EJ2	2024 03/06-03/07	41.5-45.1	153	18	0.0112068	0.0000004	0.6	0.3		26.4
	2024 ED3	2024 03/15-03/16	6.8-5.0	173	0	0.0160304	0.0000006	0.29	0.13		25.3
	2024 FK1	2024 03/23-03/23	60.1-61.5	192	29	0.013369	0.000005	0.3	0.3		26.1

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 an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Amplitude error (A.E.) is calculated as √2 × (lightcurve RMS residual). PAR is the expected Principal Axis Rotation quality detection code (Pravec et al., 2005) and H is the absolute magnitude at 1 au from Sun and Earth taken from the Small-Body Database Lookup (JPL, 2024).

2024 FK1. This Aten (H=26.1, dia. ~18 m) was an ATLAS discovery from their Southerland station in South Africa on 2024 Mar 19.0 UTC (Hidas et al., 2024). It was at its closest to Earth on 2024 Mar 22.73 UTC when it approached to 2.6 LD. Observations were made over a 68-minute interval starting on 2024 Mar 23.10 UTC, with 402 measurements being obtained. Scatter in the points is of a similar order of magnitude to the apparent amplitude but in this 3rd order period spectrum, well-defined monomodal, bimodal and trimodal solutions, all with similar RMS residuals are apparent. The bimodal solution with a period of 48.13 ± 0.02 seconds is adopted here as the most likely and indicates that 84 rotations occurred during the time 2024 FK1 was being observed.





Acknowledgements

The author would like to express his gratitude to Petr Pravec for his ongoing help in interpretating tumbling asteroid light curves. The author also gratefully acknowledges a Gene Shoemaker NEO Grant from the Planetary Society (2005) and a Ridley Grant from the British Astronomical Association (2005), both of which facilitated upgrades to observatory equipment used in this study.

Integration Number	Name	Max times	Min intg/Pd	a/b	Pts	Flds
488515	2001 FE90	5,6,8	0.005	1.8[1]	1641	23
	2010 JO33	4,10	<0.003[2]	1.8*	659	13
	2014 BW32	4	0.009	1.3	272	7
	2014 DX110	8	0.037	1.2	628	9
	2018 BE6	2,4	0.014	1.5*	522	10
	2018 SS1	4-7.5	0.018	1.2	1495	23
	2018 SF2	2-3.7	0.024	1.2*	961	20
	2019 SH3	2,2.5	0.055	1.2*	601	10
	2024 BJ	3-8.5	0.107	1.5*	1638	30
	2024 BR2	2-4	0.010	1.4*	3216	55
	2024 CY1	3.3-4	0.093	1.2	687	13
	2024 CV8	11.7-14.5	0.040	2.0	718	16
	2024 DW	1.6-2.2	0.011	1.4	763	32
	2024 EF	2.1-11.5	0.048	1.3	2723	52
	2024 EJ2	6-7.4	0.183	1.4*	914	12
	2024 ED3	10	0.173	1.3	655	7
	2024 FK1	3-7.7	0.160	1.1*	402	7

Table II. Ancillary information, listing the integration times used (seconds), the fraction of the period represented by the longest integration time (Pravec et al., 2000), the calculated minimum elongation of the asteroid (Zappala et al., 1990), the number of data points used in the analysis and the number of times the telescope was repositioned to different fields. Notes: 1 = calculated using information from 2009 June 30.0 when phase angle was smallest, 2 = Information for 2014 apparition using an assumed minimum period of 0.8 h, * = Value uncertain, based on phase angle > 40°.

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COLLABORATIVE ASTEROID PHOTOMETRY FROM UAI: 2024 JANUARY-MARCH

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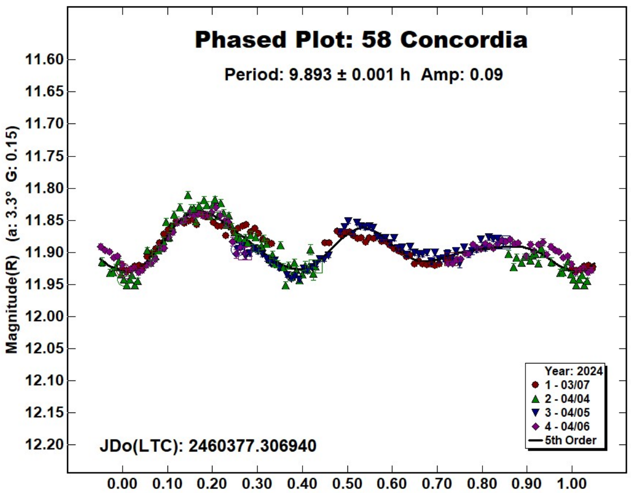
(Received: 2024 April 7)

Photometric observations of eight asteroids were made in order to acquire lightcurves for shape/spin axis modeling. Lightcurves were acquired for 58 Concordia, 78 Diana, 462 Eriphyla, 3223 Forsius, 4673 Bortle, 6460 Bassano, (187026) 2005 EK70, and 2023 SP1.

Collaborative asteroid photometry was done within the Italian Amateur Astronomers Union (UAI; 2024) group. The targets were selected mainly in order to acquire lightcurves for shape/spin axis modeling. Table I shows the observing circumstances and results.

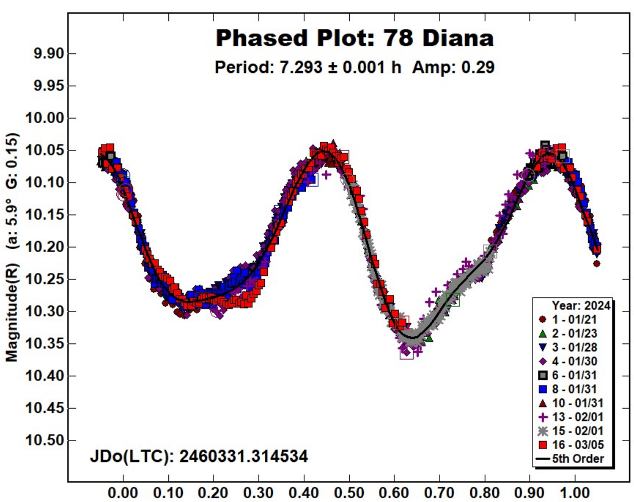
The CCD observations of eight asteroids were made in 2024 January-March using the instrumentation described in the Table II. Lightcurve analysis was performed at the Balzaretto Observatory with *MPO Canopus* (Warner, 2023). All the images were calibrated with dark and flat frames and converted to standard magnitudes using solar colored field stars from CMC15 and ATLAS catalogues, distributed with *MPO Canopus*. For brevity, "LCDB" is a reference to the asteroid lightcurve database (Warner et al., 2009).

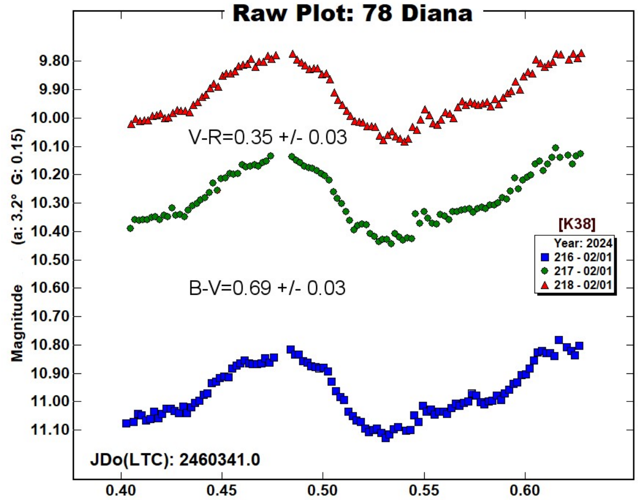
58 Concordia is a Ch-type (Bus and Binzel, 2002) middle main-belt asteroid. Observations were made over four nights by A. Marchini (K54). The period analysis shows a synodic period of $P = 9.893 \pm 0.001$ h with an amplitude $A = 0.09 \pm 0.02$ mag. The period is close to the previously published results in the LCDB.

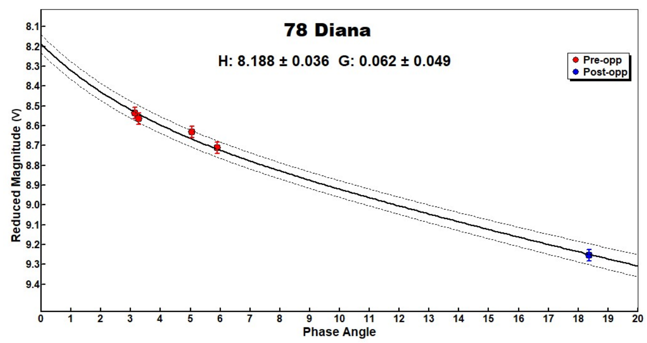


78 Diana is a Ch-type (Bus and Binzel, 2002) middle main-belt asteroid. Collaborative observations were made over six nights. The period analysis shows a synodic period of $P = 7.293 \pm 0.001$ h with an amplitude $A = 0.29 \pm 0.01$ mag. The period is close to the previously published results in the LCDB. Multiband photometry was made by G. Galli (203) and G. Baj (K38), respectively on 2024 January 31 and February 1. We found B-V = 0.69 ± 0.03 and V-R = 0.35 ± 0.03 averaging the two independent acquired values. These color indices are consistent with a C-type asteroid (Shevchenko and Lupishko, 1998).

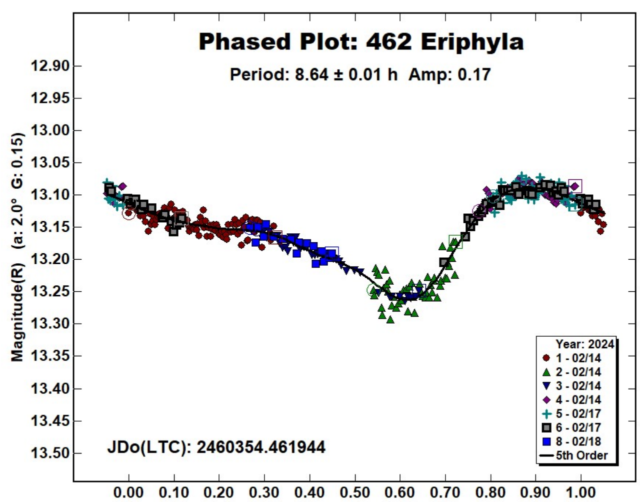
For H-G parameters the R band magnitudes were evaluated, for each lightcurve, as half peak-to-peak amplitude and converted to V band adding the color index V-R. We found $H_V = 8.19 \pm 0.04$ and $G = 0.06 \pm 0.05$. This last is consistent with C-type asteroid (Shevchenko and Lupishko, 1998).







462 Eriphyla is an S-type (Bus and Binzel, 2002) outer main-belt asteroid. Collaborative observations were made over three nights. The period analysis shows a synodic period of $P = 8.64 \pm 0.01$ h with an amplitude $A = 0.17 \pm 0.02$ mag. The period is close to the previously published results in the LCDB.

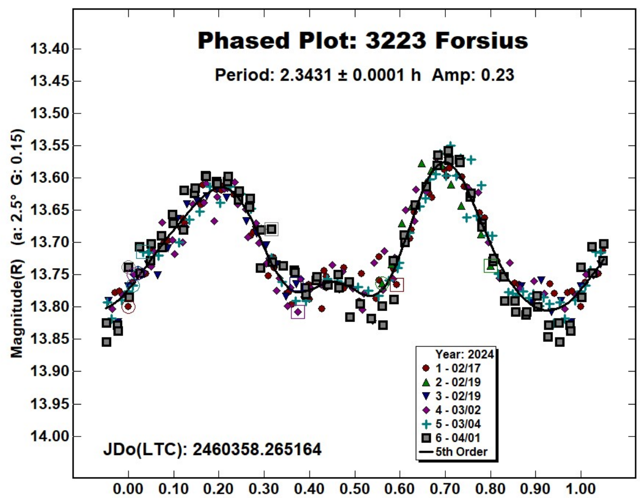


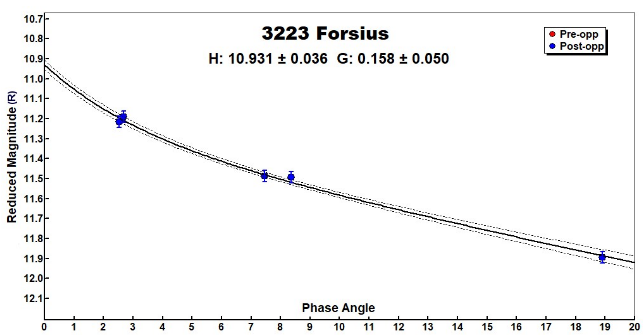
3223 Forsius is a high albedo middle main-belt asteroid. Collaborative observations were made over five nights. The period analysis shows a synodic period of $P = 2.3431 \pm 0.0001$ h with an amplitude $A = 0.23 \pm 0.03$ mag. The period is close to the previously published results in the LCDB.

Number	Name	2024 mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
58	Concordia	03/07-04/06	3.2,15.3	161	1	9.893	0.001	0.09	0.02	MB-M
78	Diana	01/21-03/05	*5.9,18.3	130	4	7.293	0.001	0.29	0.01	MB-M
462	Eriphyla	02/14-02/18	2.2,3.7	140	2	8.64	0.01	0.17	0.02	MB-O
3223	Forsius	02/17-04/01	2.5,18.8	149	-3	2.3431	0.0001	0.23	0.03	MB-M
4673	Bortle	01/21-01/31	3.2,6.2	121	7	2.6398	0.0003	0.14	0.02	MB-M
6460	Bassano	01/11-02/16	*6.2,14.9	122	0	2.9126	0.0001	0.37	0.04	MB-I
187026	2005 EK70	02/13-02/14	24.6,20.6	152	12	4.9	0.1	0.24	0.03	NEA
	2023 SP1	02/18-02/21	17.8,14.8	148	9					NEA

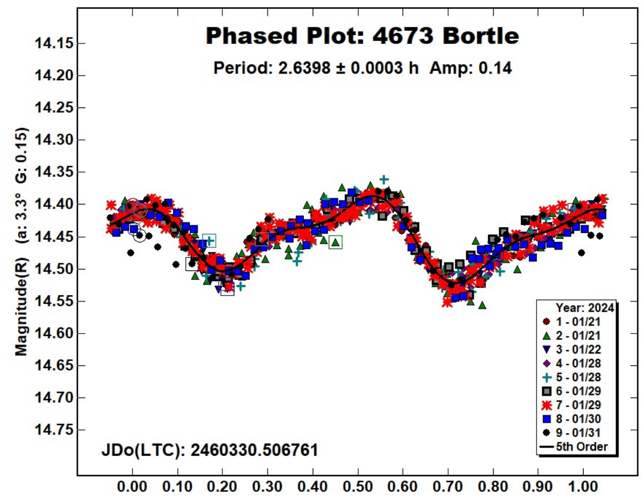
Table I. Observing circumstances and results. The first line gives the results for the primary of a binary system. The second line gives the orbital period of the satellite and the maximum attenuation. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

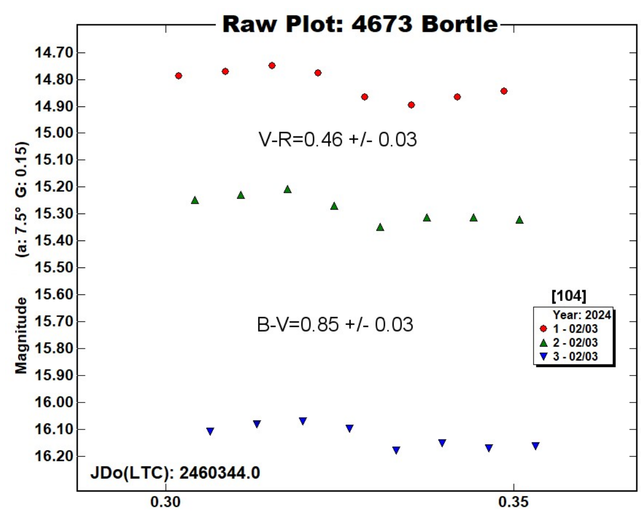
For H-G parameters the R band magnitudes were evaluated, for earch lightcurve, as half peak-to-peak amplitude. We found $H_R = 10.93 \pm 0.04$ and $G = 0.16 \pm 0.05$.





4673 Bortle is a medium albedo middle main-belt asteroid. Collaborative observations were made over five nights. The period analysis shows a synodic period of $P = 2.6398 \pm 0.0003$ h with an amplitude $A = 0.14 \pm 0.02$ mag. The period is close to the previously published results in the LCDB. Multiband photometry was made by P. Bacci and M. Maestripieri (104) on 2024 February 3. We found B-V = 0.85 ± 0.03 and V-R = 0.46 ± 0.03. These color indices are consistent with a S-type asteroid (Shevchenko and Lupishko, 1998).

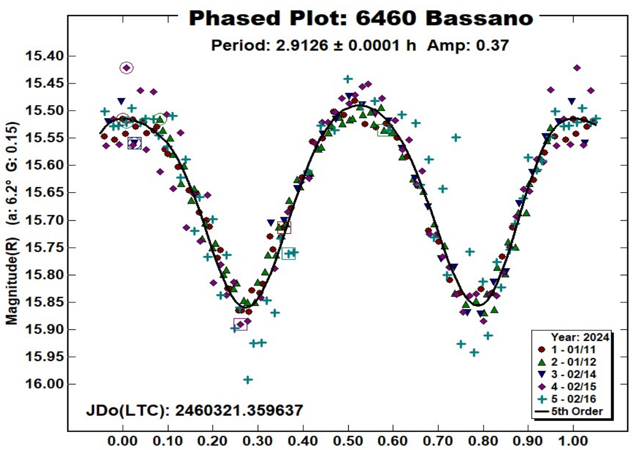


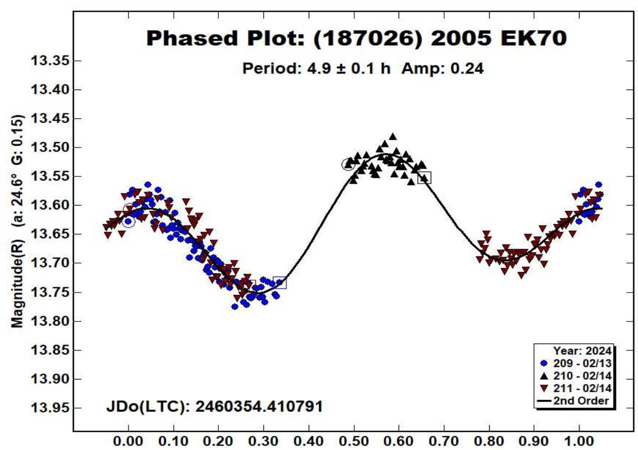


6460 Bassano is a low-medium albedo inner main-belt asteroid. Collaborative observations were made over five nights. The period analysis shows a synodic period of $P = 2.9126 \pm 0.0001$ h with an amplitude $A = 0.37 \pm 0.04$ mag. The period is close to the previously published results in the LCDB.

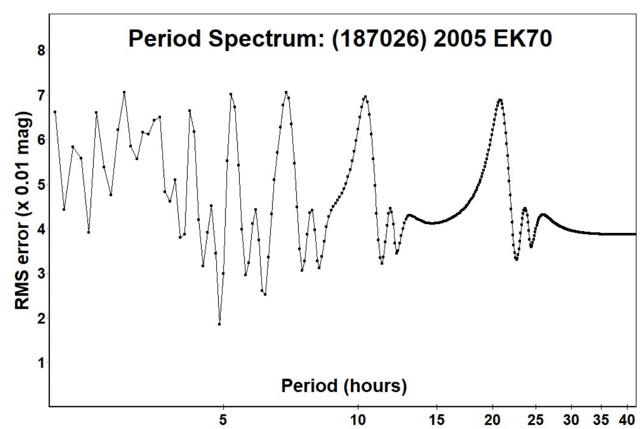
Observatory (MPC code)	Telescope	CCD	Filter	Observed Asteroids (#Sessions)
Astronomical Observatory, University of Siena (K54)	0.30-m MCT f/5.6	SBIG STL-6303e(bin 2x2)	C,Rc	3223(2), 58(4), 78(5)
Osservatorio Astronomico Nastro Verde (C82)	0.35-m SCT f/6.3	SBIG ST10XME (bin 2x2)	C	3223(2), 6460(2), 4673(3)
Blessed Hermann Observatory (L73)	0.30-m SCT f/6.0	QHY 174MGPS (bin 2x2)	Rc	462(4), 3223(1)
San Marcello Pistoiese Observatory (104)	0.60-m NRT f/4.0	Apogee Alta	B,V, Rc	4673(4)
Iota Scorpii(K78)	0.40-m RCT f/8.0	SBIG STXL-6303e (bin 2x2)	Rc	4673(1), 462(2)
M57 (K38)	0.35-m RCT f/5.5	SBIG STT1603ME	B,V, Rc	4673(2), 78(1)
Osservatorio Astronomico Margherita Hack (A57)	0.35-m SCT f/8.3	SBIG ST10XME (bin 2x2)	C	6460(3)
Filzi School Observatory (D12)	0.35-m RCT f/8.0	ASI 2600 MC PRO	C	187026(2)
HOB Astronomical Observatory (L63)	0.20-m SCT f/6.0	ATIK 383L+	V,Rc	2023 SP1(2)
GiaGa Observatory (203)	0.36-m SCT f/5.8	Moravian G2-3200	V,Rc	78(1)

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





[(187026) 2005 EK70]{.underline} is an Aten Near-Earth asteroid. Observations were made over two nights by G. Casalnuovo (D12) on 2024 February 13, 14. The period spectrum shows a deeper minimum with a bimodal solution of $P = 4.9 \pm 0.1$ h with an amplitude $A = 0.24 \pm 0.03$ mag. No others periods were found in the LCDB.



2023 SP1 is an Apollo Near-Earth asteroid, classified as a Potentially Hazardous Asteroid (PHA). Multiband photometry was made by M. Iozzi (L63) on 2024 February 18 and 21, deriving the color index V-R = 0.5 ± 0.1 as the average of two values obtained stacking about 45 pairs of sub-frames for each observing session. This color index is close to the S-type asteroid (Shevchenko and Lupishko, 1998).

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LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2024 JULY-SEPTEMBER

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We present lists of asteroid photometry opportunities. As part of this, we are making some changes from the template used the past decade or more that affect the presentation and criteria used to build each list. There is still an emphasis on asteroids reaching a favorable apparition and have no or a poorly-defined lightcurve. However, that list and the one for modeling targets was biased towards brighter asteroids. We try to limit that bias by restricting the favorable apparitions and modeling lists to objects 15.0 ≤ V ≤ 16.0 at brightest. Low phase angle observations remain important but, increasingly so, only if placed on a standard photometric system, and better yet, if they are accompanied with observations out to phase angles of 20-30 degrees, something that is more easily achieved with near-Earth asteroids. To be more inclusive of the near-Earth asteroid population, the "NEA Opportunities" list replaces and expands on the long-standing "Radar-Optical Opportunities" section. The MinorPlanet.info web site can be used for those wanting a list of brighter, or fainter, targets.

We present several lists of asteroids that are prime targets for photometry and/or astrometry during the period 2024 July-September. As a permanent change from the template used before 2024 Q3, the emphasis is even more on fainter targets, data placed on a standard photometric system, and near-Earth asteroids as targets for photometry, astrometry, and modeling.

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

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

The ephemeris generator on the MinorPlanet.info web site allows creating custom lists for objects reaching V ≤ 18.0 during any month from 2020 through 2035, e.g., limiting the results by magnitude and declination, family, and more.

https://www.minorplanet.info/php/callopplcdbquery.php

We refer you to past articles, e.g., Warner et al. (2021a; 2021b) 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

The database contains about 10.59 million observations for 24,353 objects (as of 2024 January 6), making it one of the more useful sources for raw data of *dense* time-series asteroid photometry.

Lightcurve/Photometry Opportunities

Objects with U = 3- or 3 are excluded from this list since they will likely appear in other lists. Asteroids rated U = 1/2-, or that have long periods, should be given higher priority. However, 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 highly-rated results have been proven wrong at times. Note that the lightcurve amplitude (peak-to-peak) in the tables could be more or less than what's given. Use the listing only as a guide.

All objects are reaching one of their five brighter apparitions from 1995-2050. Bold text, if any, indicates a near-Earth asteroid (NEA). Periods have been rounded to 0.01 h precision. If a period is followed by *, it is sidereal; if followed by ^, it is a minimum.

Number	Name	Brightest Date	Mag	Dec	LCDB Data Period	Amp	U
2338	Bokhan	07 04.9	15.4	-22	54.58	0.05	2-
2012	Guo Shou-Jing	07 06.0	15.1	-22	228.29*		2
4147	Lennon	07 08.2	15.4	-23	137	0.25-0.6	1
15988	Parini	07 12.3	15.4	-22	95.01	0.34	2
3539	Weimar	07 13.2	15.3	-9	7.29	0.27	2+
3504	Kholshevnikov	07 15.1	15.3	-21	4.72		2
14951	1996 BS2	07 15.9	15.4	-18	10.95	0.54	2
3128	Obruchev	07 16.2	15.5	-22	12.64	0.55	2
3214	Makarenko	07 18.0	15.4	-26	10.11	0.10	2
5077	Favaloro	07 19.8	15.2	-26	4.59		2
4553	Doncampbell	07 21.4	15.4	-3	13.02	0.29	2
9970	1992 ST1	07 24.8	15.2	-23	22.87	0.09	2
3160	Angerhofer	07 24.9	15.3	-21	44.72	0.32	2
5330	Senrikyu	07 27.5	15.2	-23	14.44	0.08	2
19732	1999 XF165	07 29.6	15.3	-34	12.57	0.19	2
6095	1991 UU	07 30.3	15.1	-7	80^	0.3	2
2891	McGetchin	07 30.4	15.3	-21	240.39	0.28	2
11528	Mie	08 03.1	15.2	-16	7.20	0.38	2
4890	Shikanosima	08 08.2	15.3	-20	16.48	0.22	2
5661	Hildebrand	08 14.9	15.2	-12	6.80	0.15-0.21	2+
8577	Choseikomori	08 15.6	15.4	-3	5.57	0.16	2
21479	Marymartha	08 15.9	15.0	-14	5.32	0.52	2
5521	Morpurgo	08 18.7	15.1	-29	6.19	0.89	2
6859	Datemasamune	08 19.0	15.2	-6	5.94	0.06-0.12	2
7318	Dyukov	08 21.3	15.0	-18	4.86	0.63	2
5542	Moffatt	08 22.0	15.3	-26	5.19	0.12	2+
3354	McNair	08 24.0	15.4	-9	7.56	0.03	2+
6537	Adamovich	08 24.0	15.0	-16	2.4	0.13	1
2732	Witt	08 24.5	15.5	-12	12.62	0.50	2
3429	Chuvaev	09 03.2	15.4	-7	3.37	0.18	2
24242	1999 XY100	09 10.8	15.3	+4	49.94	0.6	2
2994	Flynn	09 12.8	15.3	-5	9.75	0.14	2
3775	Ellenbeth	09 14.3	15.4	-12	24.25	0.49	2
9515	Dubner	09 15.0	15.2	-33	12.58	0.12	2
3762	Amaravella	09 16.8	15.5	-3	55.62		2
5416	Estremadoyro	09 22.9	15.5	-13	20.75*		2
2555	Thomas	09 23.4	15.4	+2	2.86*		2
2473	Heyerdahl	09 26.2	15.0	+2	47.78*		2-
7898	Ohkuma	09 26.6	15.2	-13	131.32	0.60	2
2836	Sobolev	09 26.8	15.4	+5	*4.76*		2

Low Phase Angle Opportunities

The Low Phase Angle list includes asteroids that reach very low phase angles ($\alpha < 1°$). The "α" column is the minimum solar phase angle for the asteroid. Calibrated measurements (usually V band) at or very near the day of opposition can provide important information for those studying the "opposition effect."

Calibrated data are more important than ever as the Minor Planet Center works to provide more accurate and precise (to 0.01 mag) *H* values (absolute magnitude). This, in turn, affects statistical studies involving diameters, for example, when examining the percentage of possible vs. actual discoveries in the near-Earth population.

The best chance of success comes with covering at least half a cycle a night, meaning periods generally < 16 h, when working objects with low amplitude. 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. Refer to Harris et al. (1989) for the details of the analysis procedure.

As an aside, it is arguably better for physical interpretation to use the maximum light rather than mean level to find the phase slope parameter (*G*). This resembles more the behavior of a spherically shaped model of the same albedo, but it can produce significantly different values for both *H* and *G* based on average light, which is the method used for values listed by the Minor Planet Center. Using and reporting the results of both methods can provide additional insights into the physical properties of an asteroid.

The International Astronomical Union (IAU) has adopted a new system, H-G_{12}, introduced by Muinonen et al. (2010). It will be some years before H-G_{12} becomes widely used, and hopefully not until a discontinuity flaw in the G_{12} function has been fixed. This discontinuity results in false "clusters" or "holes" in the solution density and makes it impossible to draw accurate conclusions.

We strongly encourage obtaining data as close to 0° as possible and then every 1-2° out to 7°. It's in this range the phase curve is non-linear because of the opposition effect. From 7° out to about 30°, when the curve tends to be linear, observations at 3-6° intervals should be sufficient. Coverage beyond 50° or so is not generally helpful since the H-G system is best defined with data from 0-30°.

It's important to emphasize that all observations should (must) be made using high-quality catalogs to set the comparison star magnitudes. These include ATLAS, Pan-STARRS, SkyMapper, and Gaia2/3. Catalogs such as CMC-15, APASS, or the MPOSC from *MPO Canopus* have too high of systematic errors.

Also important is that there are sufficient data from each observing run to allow finding their location on a combined, phased lightcurve derived from two or more nights obtained *near the same phase angle.* If necessary, the magnitudes for a given run should be adjusted so that they correspond to mid-light of the combined lightcurve. This goes back to the H-G system being based on average, not maximum or minimum light.

Use the on-line query form for the LCDB to get more details about a specific asteroid.

https://www.minorplanet.info/php/callopplcdbquery.php

The list is limited to asteroids 14.0 ≤ V ≤ 15.0, which is possible with the increased capabilities of imaging devices available to the "backyard astronomer." Warner has calculated a more extensive list that includes V ≤ 16.0, α ≤ 1.0°. Contact him via the listed email.

To fit the limited space, periods have been rounded to three decimal places and poor Pluto suffered yet another demotion by having its six-digit number (134340) removed. Column "α" is the minimum solar phase angle.

Num	Name	Date	α	V	Dec	Period	Amp	U
2139	Makharadze	07 04.4	0.93	14.9	-21	11.976	0.34-0.38	3
848	Inna	07 08.3	0.62	14.8	-21	45.479		2
931	Whittemora	07 10.9	0.18	14.3	-22	19.199	0.20-0.25	2+
398	Admete	07 11.3	0.72	14.9	-20	20.998	0.07-0.13	3
3310	Patsy	07 12.5	0.96	14.8	-25	9.36	0.15	3
548	Kressida	07 13.7	0.20	14.3	-22	11.940	0.44	2
	Pluto	07 23.2	0.09	15.0	-23	153.294	0.10-0.30	3
1577	Reiss	08 04.7	0.65	14.9	-18	4.505	0.12-0.20	3
3280	Gretry	08 05.9	0.16	14.5	-17	10.56	0.35-0.51	3-
3698	Manning	08 06.8	0.22	14.0	-17	3.062	0.31-0.44	3
1118	Hanskya	08 07.2	0.47	14.0	-18	15.61	0.18-0.38	2
873	Mechthild	08 08.2	0.97	14.1	-14	11.006	0.18-0.33	3
1804	Chebotarev	08 08.8	0.45	14.9	-17	4.026	0.41-0.48	3
1945	Wesselink	08 13.2	0.19	14.6	-14	3.547	0.45-0.55	3
2829	Bobhope	08 14.4	0.39	14.0	-15	6.333	0.50-0.66	3
21479	Marymartha	08 15.9	0.12	15.0	-14	5.318	0.52	2
2616	Lesya	08 21.6	0.23	14.2	-12	9.217	0.43-0.51	3
1394	Algoa	08 25.1	0.95	14.1	-9	2.768	0.20-0.21	3
1830	Pogson	08 28.8	0.45	15.0	-10	2.570	0.07-0.18	3
733	Mocia	08 29.0	0.77	14.2	-12	11.374	0.29-0.53	3
4603	Bertaud	09 01.6	0.23	14.8	-8	265.343	0.66	3-
180	Garumna	09 09.1	0.25	14.3	-5	23.866	0.42-0.6	3
1642	Hill	09 10.3	0.90	14.7	-2	6.056	0.21-0.25	3
1730	Marceline	09 13.0	0.10	14.4	-4	3.837	0.59-1.00	3
2032	Ethel	09 14.4	0.56	15.0	-5			
1481	Tubingia	09 19.8	0.14	14.2	-1	225.6	0.20-0.63	2
417	Suevia	09 24.4	0.95	14.0	+3	7.034	0.06-0.22	3
280	Philia	09 24.5	0.56	15.0	-1	70.26	0.15	3
2473	Heyerdahl	09 26.2	0.24	15.0	+2	47.779		2-
2433	Sootiyo	09 28.0	0.36	14.9	+3	7.234	0.35-0.54	3
3248	Farinella	09 28.2	0.74	14.6	+0	6.675	0.12-0.25	3

Shape/Spin Modeling Opportunities

With the wide use of sparse data from the surveys for modeling that produces hundreds of statistically valid poles and shapes, the need for data for main-belt objects is not what it used to be. The best use of observing time is to concentrate on near-Earth asteroids, especially if the one period in the LCDB or DAMIT database was derived from sparse data alone.

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.

https://astro.troja.mff.cuni.cz/projects/damit/

to see what, if any, information it has on a chosen target.

Additional lightcurves could lead to the asteroid being added to or improving one in DAMIT.

Included in the list below are objects that:

1. Are rated U = 3– or 3 in the LCDB.
2. Do not have reported pole in the LCDB Summary table.
3. Have at least three entries in the Details table of the LCDB where the lightcurve is rated U ≥ 2.
4. The brightest magnitude is 15.0 ≤ V ≤ 15.5.

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. Check #4 helps eliminate objects that are less likely to be observed under general circumstances. The idea is to help reduce observational biases against fainter objects.

In the list below, favorable apparitions are in italics and near-Earth objects are in bold text.

		Brightest			LCDB Data		
Num	Name	Date	Mag	Dec	Period	Amp	U
1234	Elyna	07 02.8	15.1	-28	5.422	0.14-0.37	3
21088	***Chelyabinsk***	***07 21.8***	***14.0***	***+11***	***11.23***	***0.34***	***3***
2334	*Cuffey*	*07 24.9*	*15.4*	*-20*	*5.858*	*0.30-0.37*	*3*
2050	Francis	07 26.0	15.5	-52	3.066	0.14-0.23	3
13977	Frisch	07 26.2	15.0	+8	4.999	0.15-0.22	3
5905	*Johnson*	*08 02.9*	*15.4*	*-4*	*3.782*	*0.08-0.20*	*3*
1523	Pieksamaki	08 05.1	15.2	-19	5.32	0.28- 0.5	3
1406	Komppa	08 06.2	15.1	-23	3.508	0.14-0.20	3
7593	Cernuschi	08 08.0	15.4	-20	2.557	0.12-0.17	3
5996	*Julioangel*	*08 20.1*	*15.3*	*-5*	*9.741*	*0.24-0.34*	*3-*
2535	Hameenlinna	08 23.9	15.2	-9	3.231	0.07-0.11	3
2162	Anhui	08 28.4	15.0	-12	8.105	0.14-0.18	3
1830	Pogson	08 28.9	15.0	-10	2.57	0.07-0.18	3
4022	Nonna	08 31.5	15.4	+0	2.588	0.04-0.10	3
1688	Wilkens	09 01.9	15.4	+14	7.248	0.23-0.34	3
4935	Maslachkova	09 03.2	15.2	-14	2.902	0.23	3
2008	Konstitutsiya	09 03.7	15.3	-23	11.269	0.06-0.11	3
2442	Corbett	09 06.7	15.1	-2	11.456	0.12-0.29	3
3970	*Herran*	*09 16.2*	*15.1*	*-15*	*8.053*	*0.21-0.59*	*3*
2847	Parvati	09 19.7	15.1	+3	2.636	0.09-0.13	3
2460	Mitlincoln	09 20.7	15.2	-1	3.007	0.03-0.20	3
23997	1999 RW27	09 21.0	15.2	-13	17.828	0.18-0.61	3
66251	***1999 GJ2***	***09 22.0***	***15.4***	***+13***	***2.463***	***0.10-0.27***	***3***

NEA Opportunities

Table I below gives a list of near-Earth asteroids reaching maximum brightness for the current quarter-year based on calculations by Warner.

The initial list of targets started using the planning tool at

https://www.minorplanet.info/php/callopplcdbquery.php

where the search was limited to near-Earth asteroids that were V ≤ 18 for at least part of the quarter.

The final step was to cross-reference our list with that found on the Goldstone planned targets schedule at

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

In Table I, objects in bold text are on the Goldstone proposed observing list as of 2024 March and are usually in need of supplemental astrometry and/photometry.

Table I is based on *known* targets and orbital elements when it was prepared. It is also limited to objects that are V ≤ 18.0 at brightest. It is common for newly discovered objects to move in or out of the list. We recommend that you keep up with the latest discoveries by using the Minor Planet Center observing tools.

In particular, monitor NEAs and allow for those times when the asteroid is observable for only a limited number of days. Be sure to keep in touch with the radar team (through 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.

For observation planning, use these two sites

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

Cross-check the ephemerides from the two sites just in case there is discrepancy that might have you imaging an empty sky.

About YORP Acceleration

Near-Earth asteroids are particularly sensitive to YORP acceleration. YORP (Yarkovsky-O'Keefe-Radzievskii-Paddack; Rubincam, 2000) 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 an asteroid that already has a well-known period remains 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.

The Quarterly Target List Table

The Table I columns are

Num	Asteroid number, if any.
Name	Name (or designation) assigned by the MPC.
H	Absolute magnitude from MPCOrb.
Dkm	Diameter (km) assuming $p_V = 0.2$.
Date	Date (mm dd.d) of brightest magnitude.
Mag	Approximate V magnitude at brightest.
Dec	Approximate declination at brightest.
Period	Synodic rotation period, unless flagged as sidereal, from summary line in the LCDB summary table.
Am	Minimum reported lightcurve amplitude (P-P).
AM	Maximum reported lightcurve amplitude (P-P).
U	LCDB solution quality (U) from 1 (probably wrong) to 3 (secure).
Notes	Comments about the object.

"PHA" is a potentially hazardous asteroid. NHATS is for "Near-Earth Object Human Space Flight Accessible Targets Study." Presume that that astrometry and photometry have been requested to support Goldstone observations. The Notes column gives the reference for the period, if one is reported. The additional line gives the range of dates, solar phase angles, and V magnitudes when the asteroid solar elongation is ≥ 100° and V ≤ 19.0.

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Num	Name	H	Diam	Date	Mag	Dec	Period	Am	AM	U	Notes Date Elong ≥ 100° Ph V Start/End
207398	2006 AS2	20.38	0.249	07 05.5	16.5	1	4.48		0.2	3	Warner (2009) 07/03-07/25 * 72.4-21.0 * 16.7 -18.9
187040	2005 JS108	19.23	0.424	07 08.2	16.3	-5					07/03-07/27 44.7-75.1 * 16.6-16.6
10860	1995 LE	17.32	1.02	07 12.0	10						07/01-07/31 49.0-65.1 * 17.1-17.2
21088	Chelyabinsk	14.43	3.86	07 21.8	14.0	11	11.23		0.34	3	Warner/Stephens (2021) 07/01-09/19 *36.7-48.3 * 14.8-16.12
357621	2005 EG94	18.81	0.514	07 21.9	17.0	-32					07/01-07/23 42.9-71.6 18.1-17.1
31346	1998 PB1	17.27	1.06	07 22.7	16.7	-24	2.7358		0.13	3	**Binary** Pravec et al. (2021) 07/01-10/01 * 48.4-41.2 * 16.7-18.2
5660	1974 MA	15.52	2.34	07 29.5	15.7	-29	17.5		0.3	2	Pravec et al. (2015web) 07/01-08/22 *17.9-55.2 17.4-16.2
523664	**2012 OD1**	**18.59**	**0.569**	**07 31.3**	**15.7**	**56**	**12.63**		**0.63**	**2+**	**Warner/Stephens (2019)** **08/05-08/26 73.6-59.0 16.5-19.0**
495858	2003 MJ4	18.98	0.475	08 01.3	16.1	-53					07/01-08/16 14.9-73.0 17.6-16.8
153267	2001 CB32	17.9	0.782	08 01.6	17.0	-38					07/01-08/04 34.4-67.4 18.7-17.0
164217	2004 PT42	17.29	1.04	08 15.6	15.0	-17					07/15-09/23 * 55.8-52.4 * 18.2-18.6
352143	2007 LR32	17.22	1.07	08 19.9	16.6	29	2.4162		0.14	3-	Behrend (2007web) 07/01-10/01 * 28.0-28.3 *17.7-16.9
39796	1997 TD	15.84	2.02	08 24.0	16.2	-6	223.5		0.92	2	Warner (2015) 08/26-10/01 67.8-40.9 *16.5-17.2
10115	1992 SK	17.12	1.12	09 04.7	16.3	-66	7.319	0.5	1.03	3	Pravec et al. (2017web)
276049	2002 CE26	16.67	1.38	09 09.3	14.9	-6	3.293	0.06	0.07	3	**Binary** Pravec et al. (2006) 07/15-09/21 *39.1-68.2 *19.0-16.0
3122	Florence	14.1	4.5	09 20.4	14.4	-24	2.3581	0.12	0.37	3	**Multiple** Benner et al. 2017 07/01-08/22 34.4-57.9 15.4-14.8
66251	1999 GJ2	17.04	1.16	09 22.0	15.4	13	2.4629	0.1	0.27	3	Pravec et al. (2022web) 07/01-10/01 43.8-15.6 17.6-15.4
2202	Pele	17.14	1.11	09 23.4	16.3	-18					07/01-10/01 * 23.6-44.8 * 19.0-16.3
4954	Eric	12.55	9.18	09 24.3	11.1	-8	12.056	0.52	0.8	3	Pravec et al. (1995) 07/01-10/01 * 31.6-22.6 * 15.3-11.1
620092	2015 HB10	18.4	0.621	09 29.0	16.5	27					08/24-10/01 * 33.4-65.4 * 18.9-16.5

Table I. A partial list of numbered near-Earth asteroids at brightest in 2024 July-September. See the text for an explanation of the columns.

IN THIS ISSUE

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

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The deadline for the next issue (51-4) is July 15, 2024. The deadline for issue 52-1 is October 15, 2024.