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ROTATION PERIOD AND LIGHTCURVE DETERMINATION FOR FOURTEEN MINOR PLANETS

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Photometric measurements of fourteen main-belt asteroids were conducted from 2023 February through 2023 May. Phased lightcurves and rotation periods for each one are presented here. Eight of the asteroids have no prior published period solutions. All lightcurve data has been submitted to the ALCDEF database.

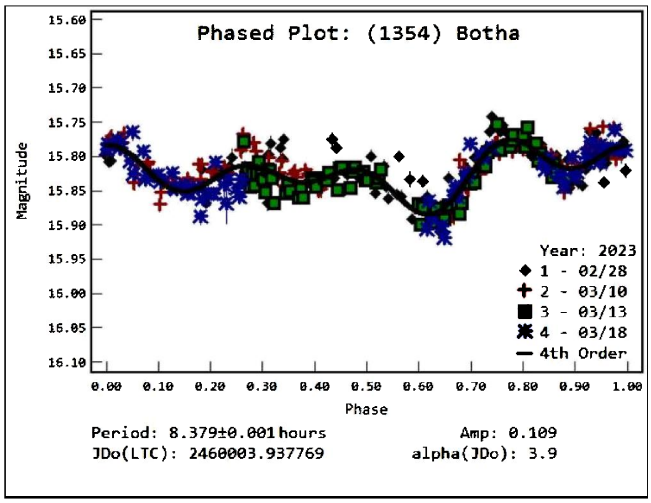
CMOS and CCD observations of fourteen main-belt asteroids were performed at NAC Observatory (MPC U98) in Benson, AZ. Images were taken using a 0.35m f/7.2 Corrected Dall-Kirkham telescope. Some images were captured using a Moravian C5A-100M CMOS camera featuring a Sony IMX-461 sensor. Images were captured at a scale of 1.21 arc seconds per pixel after binning 4×4. In 2023 March the CMOS camera was decommissioned in favor of a SBIG CCD47-10 CCD camera. It utilizes a back-illuminated Teledyne E2V CCD47-10 AIMO sensor and is operated at 1×1 binning with a scale of 1.05 arc seconds per pixel. Table I shows observing circumstances and results. All images for these observations were obtained between 2023 February and 2023 May.

Data reduction and period analysis were done using *Tycho* (Parrott, 2023). The CMOS sensor provided a 58'×44' field of view, enabling the use of the same field center for three to four consecutive nights. The CCD camera provides an 18'×18' field of view. The asteroid and five or more comparison stars were measured. Comparison stars were selected with colors within the range of $0.5 < B\text{-}V < 0.95$ to correspond with color ranges of asteroids.

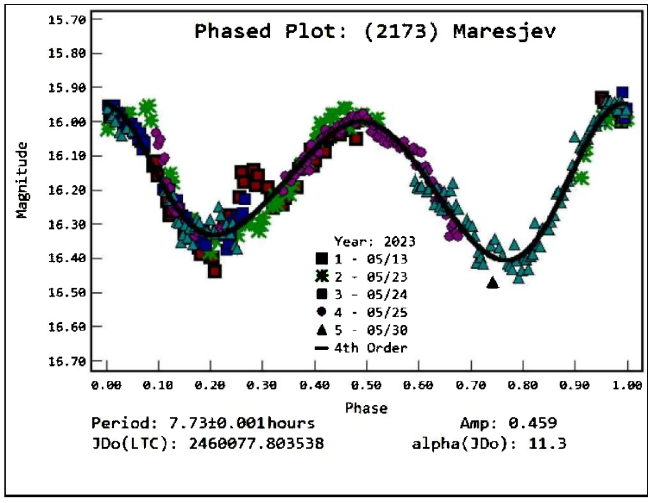
Comparison star magnitudes were obtained from the ATLAS catalog (Tonry et al., 2018), which is incorporated directly into Tycho. The ATLAS catalog derives Sloan *griz* magnitudes using a number of available catalogs. The consistency of the ATLAS comp star magnitudes and color indices allowed the separate nightly runs to be linked often with no zero-point offset required. The measuring aperture diameter was set to value equal to the average FWHM of the session data set multiplied by four. The same size aperture was used for asteroids and comp stars. Interference from field stars resulted in the exclusion of affected observations. Period determination was done using Tycho.

Asteroids were selected from the CALL website (Warner, 2011a), either for having uncertain periods or no reported period at all. In this set of observations, eight of the fourteen asteroids had no previous period analysis listed. The Asteroid Lightcurve Database (LCDB; Warner et al., 2009) was consulted to locate previously published results. All new data for these asteroids has been submitted to the ALCDEF database.

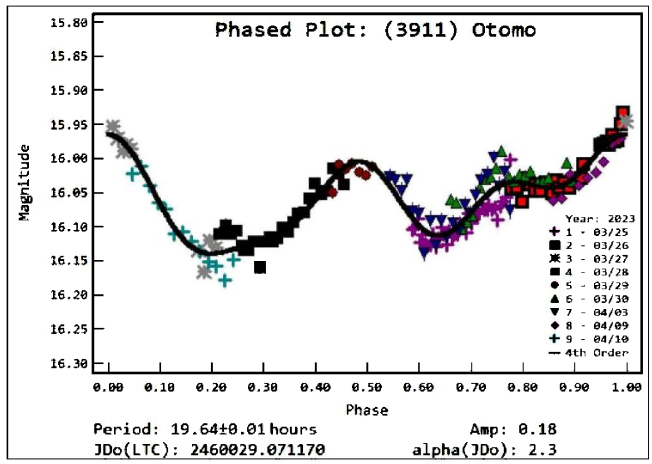
1354 Botha was discovered by C. Jackson at Johannesburg in April 1935. It is an outer main belt asteroid with a semi-major axis of 3.12 AU orbiting the sun in 5 years, 6 months. A previously reported period of 4 hours and amplitude 0.21 mag (Behrend, 2003web) was reported from observations made in September 2003. Over the course of four nights 334 observations were made and used to calculate a rotation period of 8.379 ± 0.001 hours and amplitude of 0.109 ± 0.019 mag., disagreeing with Behrend's result.



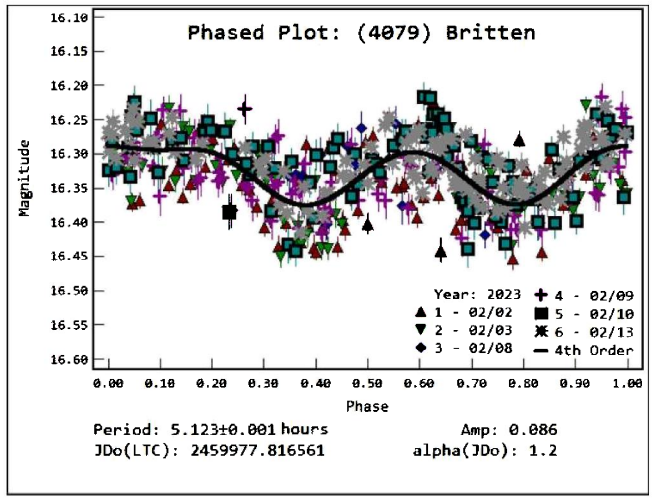
2173 Maresjev was discovered at the Crimean Astrophysical Observatory in 1974 by L. V. Zhuravleva. Two period solutions were found in the LCDB. The earliest reported period by Shipley et al (2008) is 11.6 ± 0.1h; Durech et al (2020) reported a period of 7.72956 ± 0.00003 h. A light curve was constructed from 390 data points obtained during five nights in 2023 May. The calculated period of 7.730 ± 0.001 h agrees with the period published by Durech. The amplitude of the lightcurve is 0.459 ± 0.037 mag.



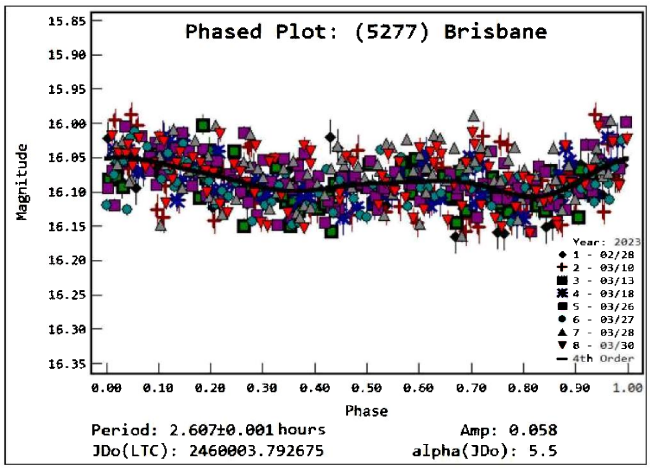
3911 Otomo is the first minor planet observed at this observatory since installing a back illuminated CCD camera in place of the CMOS sensor. The LCDB lists a single previously reported period of 10.6 ± 0.06 hours by Behrend (2014web). The Behrend observations note that the result is provisional with an unreliable period. Over a period of 9 nights 464 data points were obtained and binned in sets of 3 with a maximum time difference of 3 minutes. This data produced a light curve with a rotation period of 19.64 ± 0.01 hours and an amplitude of 0.18 ± 0.018 magnitude, disagreeing with Behrend's previous result.

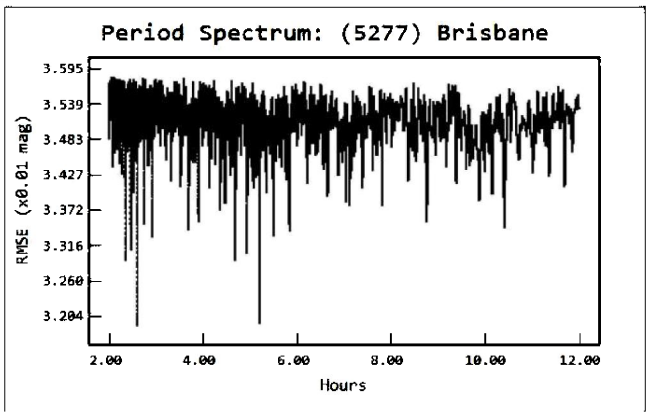


4079 Britten is a Themis family asteroid, discovered by E. Bowell at Flagstaff in 1983. No published period was found in the LCDB. During a six-night interval, 551 images were obtained for calculation of the rotation period. Upon further inspection 69 of the images were not used because of interference from field stars. A rotation period of 5.123 ± 0.001 hours was calculated from remaining data. The amplitude is 0.086 mag., and the RMS error on the fit is 0.040 mag.

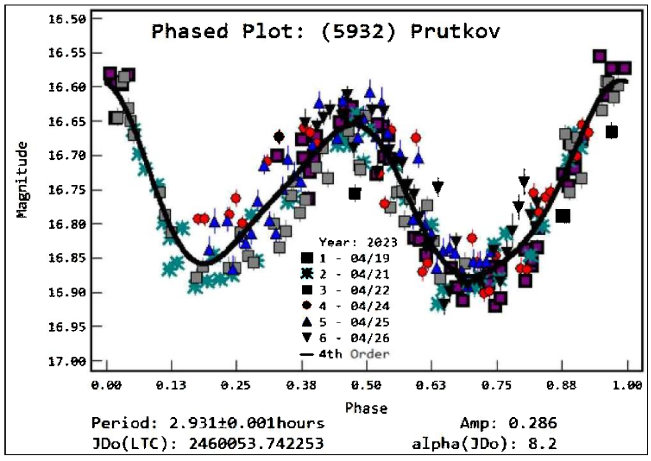


5277 Brisbane is an inner main belt asteroid discovered by R.H. McNaught at Siding Spring in 1988. No periods are shown in the LCDB. During the first four nights of observation, 261 images were gathered with the CMOS camera prior to its decommissioning. The four subsequent nights of observations were done with the newly installed CCD camera contributing an additional 384 images. Using a custom G value of 0.24 noted in the asteroid's entry in the LCDB produced a better fit between sessions as the phase angle changed significantly during the window of observations. The period search yielded a result of 2.607 ± 0.001 h with an amplitude of 0.058 mag. The RMS error on the fit is 0.032 mag.

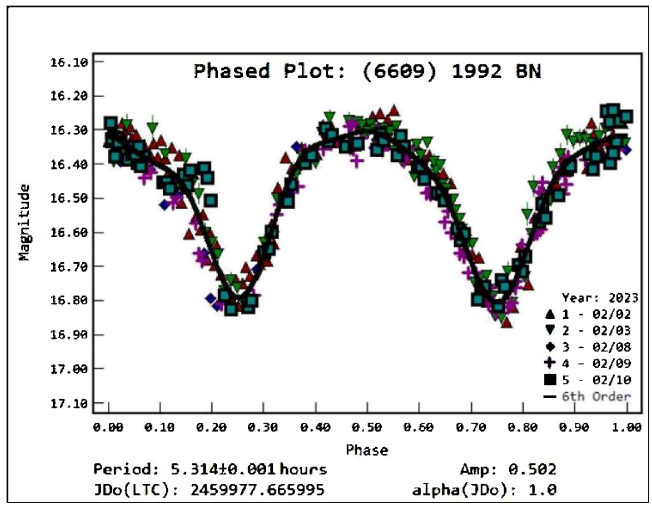




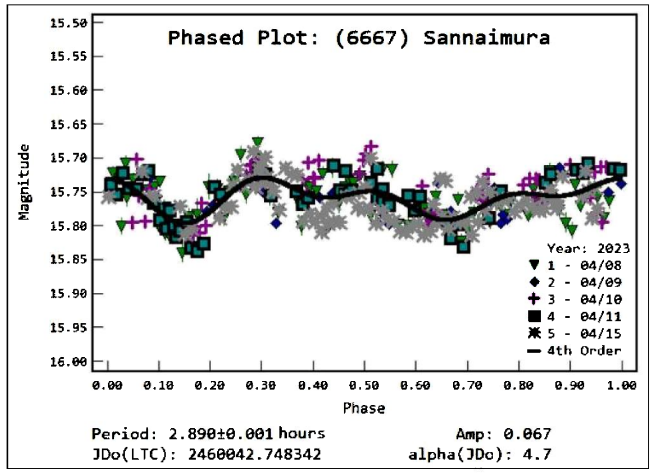
5932 Prutkov is a main belt asteroid without a listed period in the LCDB. In 2023 April, during six nights observing, 254 images were taken. Subsequent analysis produced a period solution of 2.931 ± 0.001 h. The amplitude is 0.286 mag., and the RMS error on the fit is 0.037 mag.



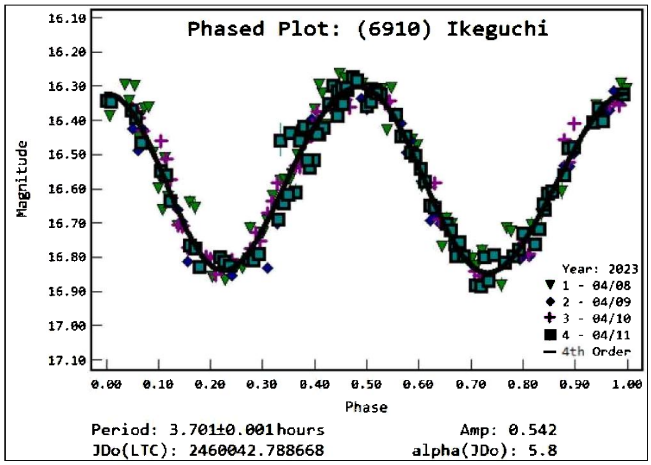
6609 1992 BN is an Eos-family asteroid, discovered at Kushiro in 1940. No published period was found in a search of the LCDB. Observing five nights over a nine-night interval, 391 images were obtained, yielding a rotation period of 5.314 ± 0.001 h. The amplitude is 0.502 mag., and the RMS error on the fit is 0.045 mag.



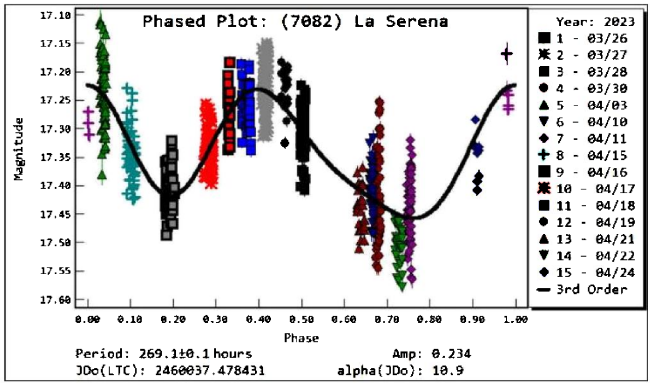
6667 Sannaimura was discovered in 1994 Y. Kushida and O. Muramatsu at the Yatsugatake South Base Observatory. A period solution by Pál et al (2020) of 2.89282 ± 0.00005 h is listed in the LCDB. A total of 323 data points obtained during five nights were used to calculate a period solution of 2.890 ± 0.001 h, agreeing with Pál. The amplitude of the lightcurve is 0.067 ± 0.026 mag.

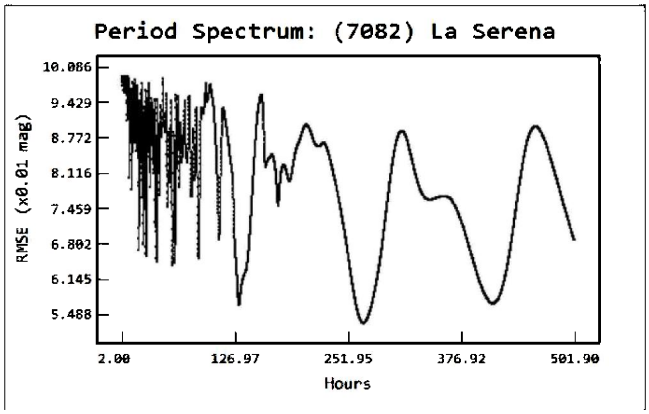


6910 Ikeguchi is an Eos-family asteroid, discovered at Kiyosato by S. Otomo and O. Muramatsu in 1991. There are no published periods listed in the LCDB. 241 total images were taken and measured on four consecutive nights in April 2023. Plotting the measurements yielded a nearly symmetrical bimodal curve with a period of 3.701 ± 0.001 hours and an amplitude of 0.542 magnitude. The RMS error on the fit is 0.043 magnitude.

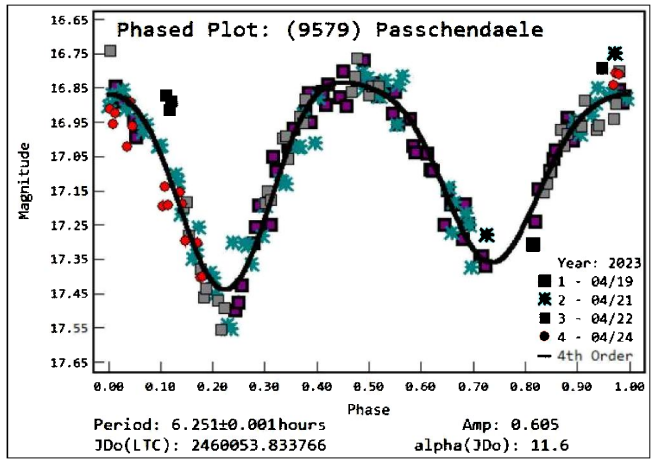


7082 La Serena was discovered in 1987 by E.W. Elst and G. Pizarro at the European Southern Observatory. There are no reported period solutions for this minor planet in the LCDB. In a one-month period, 743 total observations were made over sixteen separate sessions to get full coverage of the period of this slow rotator. Analysis of the observations produced a period of 269.1 ± 0.1 h with an amplitude of 0.234 ± 0.05 mag.

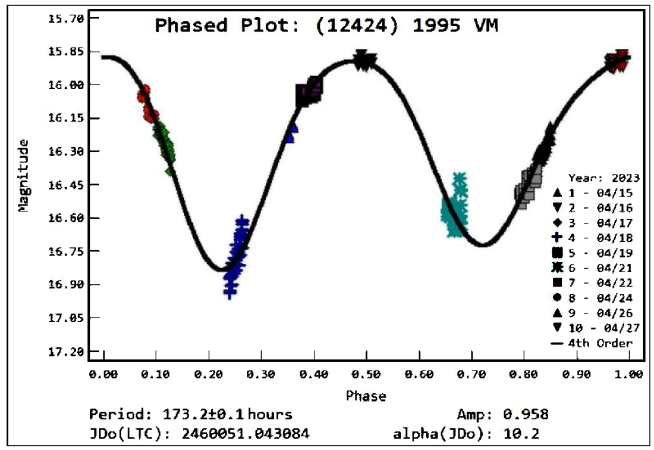




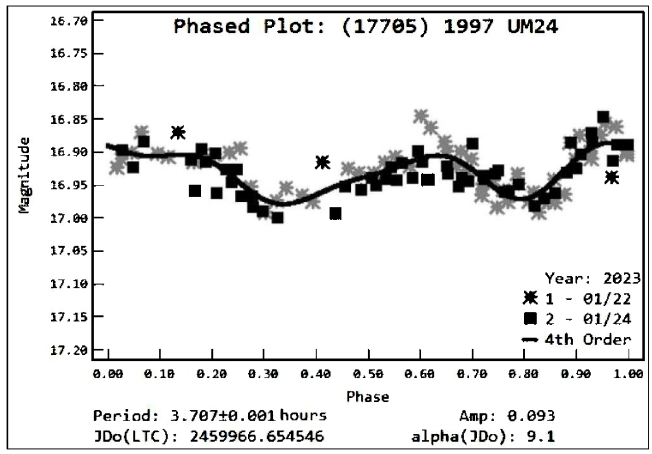
9579 Passchendaele is a Hertha-family asteroid, discovered at the European Southern Observatory by E.W. Elst in 1989. During a four-night interval, 186 images were obtained, establishing a rotation period of 6.251 ± 0.001 h. No published period was found in the LCDB. The amplitude is 0.605 mag., and the RMS error on the fit is 0.059 mag.



12424 1995 VM was discovered in 1994 by T. Kobayashi at Oizumi. Two period solutions are listed the LCDB; Waszczak et al. (2015), 173.772 ± 0.6533 h, and Pál et al (2020), 176.94 ± 0.05 h. A total of 293 data points obtained over ten nights were used to calculate a period solution of 173.2 ± 0.1 h, agreeing with Waszczak and Pál. The amplitude of the lightcurve is 0.958 ± 0.037 mag.

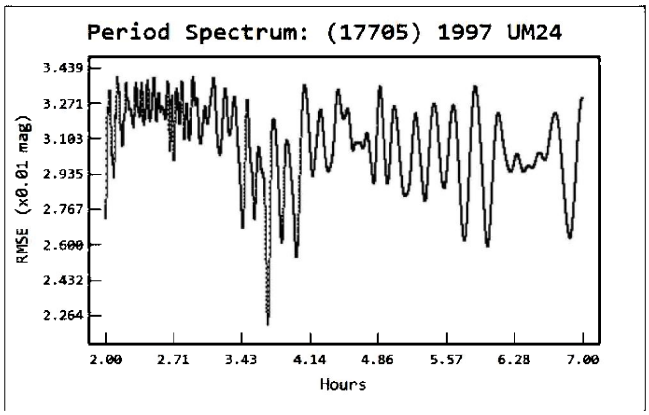


17705 1997 UM24 was discovered in 1997 by the Beijing Schmidt CCD Asteroid Program at Xinglong. No period solutions were found in the LCDB. A total of 114 data points obtained during two consecutive nights were used to calculate a period solution of 3.707 ± 0.001 h. The amplitude of the lightcurve is 0.093 ± 0.023 mag.

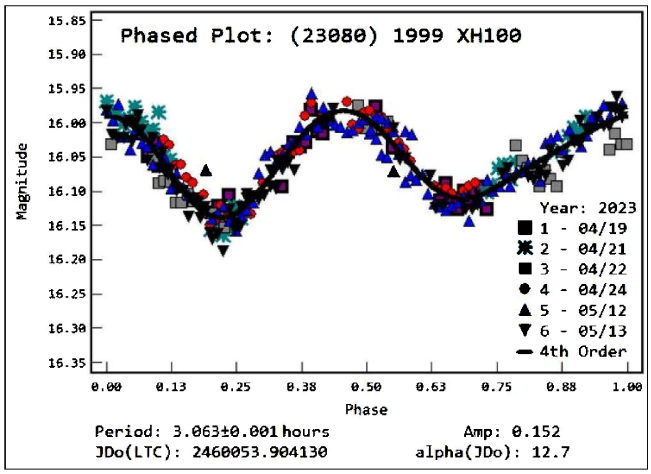


Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1354	Botha	2023 02/28-03/18	3.9,9.25	149	5	8.379	0.001	0.109	0.019	MB-O
2173	Maresjev	2023 05/13-05/30	11.2,7.8	258	17	7.730	0.001	0.459	0.037	MB-O
3911	Otomo	2023 03/25-04/10	*2.4,4.5	188	-4	19.64	0.01	0.18	0.018	Eos
4079	Britten	2023 02/02-02/13	3.6,5.2	131	3	5.123	0.001	0.086	0.04	Themis
5277	Brisbane	2023 02/28-03/30	5.5,18.6	157	-8	2.607	0.001	0.058	0.032	MB-I
5932	Prutkov	2023 04/19-04/26	8.2,11.2	193	3	2.931	0.001	0.286	0.037	MB-M
6609	1992 BN	2023 02/02-02/10	1.1, 3.6	131	3	5.314	0.001	0.502	0.045	Eos
6667	Sannaimura	2023 04/08-04/15	4.7,8.3	191	3	2.890	0.001	0.067	0.026	MB-I
6910	Ikeguchi	2023 04/08-04/11	5.8,6.9	184	-4	3.701	0.001	0.542	0.043	Eos
7082	La Serena	2023 03/26-04/25	12.6,7.4	217	18	269.1	0.1	0.234	0.05	MB-O
9579	Passchendaele	2023 04/19-04/24	11.5,13.9	189	-2	6.251	0.001	0.605	0.059	Herth
12424	1995 VM	2023 04/15-04/27	10.6,5.5	223	7	173.2	0.1	0.958	0.037	Eun
17705	1997 UM24	2023 01/22-01/23	9.1,10	107	9	3.707	0.001	0.093	0.023	Vesta
23080	1999 XH100	2023 04/19-05/13	12.7,7.6	230	10	3.063	0.001	0.152	0.019	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).



23080 1999 XH100 was discovered in December 1999 by LINEAR at Socorro. In the LCDB Pál et al (2020) reported a period solution of 3.06273 ± 0.0005 h. CCD observations by the author in 2023 April and May provided 325 measurements and a calculated period of 3.063 ± 0.001 h. This measurement is in agreement with Pál's result. The amplitude of the lightcurve is 0.152 ± 0.019 mag.



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