

LIGHTCURVES OF TWENTY-TWO ASTEROIDS

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(Received: 2024 October 14 Revised: 2024 November 19)

We present lightcurves and synodic rotation periods for twenty-two asteroids.

Photometric observation of these minor planets was conducted from 2023 October through 2024 October at Dimension Point Observatory (MPC V42) located 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 mounts. Image acquisition was with a Finger Lakes Instrumentation Kepler KL400 back-illuminated CMOS camera. The equipment was operated remotely using *ACP Expert* (Denny, 2024) and *MaximDL* (George, 2021).

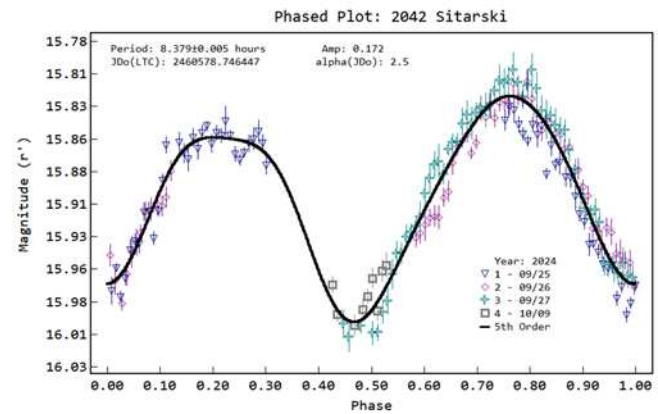
Target selection and planning was performed using the authors own Python scripts. Orbital elements, ephemeris and other information were obtained from the Minor Planet Center (MPC) (<http://www.minorplanet.net>), the JPL Solar System Dynamics (<http://ssd.jpl.nasa.gov>) and the Lowell Observatory Minor Planet Services (<http://asteroid.lowell.edu>) websites and the LCDB database (Warner et al., 2009).

Images were made unguided in HDR mode, either unfiltered or with a yellow long-pass blue-blocking filter, 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 (Parrott, 2024). Comparison stars of near solar color were chosen from the ATLAS refcat2 star catalog using Sloan *r'* magnitudes (Tonry et al., 2018) using the comparison star selection feature of *Tycho-Tracker*.

2042 Sitarski is a middle main-belt asteroid that is a member of the Merxia dynamical family. It was discovered in 1960 by van Houten and van Houten-Groeneveld at Palomar on plates taken by T. Gehrels. It is named in honor of Grzegorz Sitarski, an astronomer at the Polish Academy of Sciences. We observed Sitarski on four nights in 2024 September and October resulting in a total of 393 total observations.

We found one prior rotation period report from Warell (2017) of 2.63 hours. Analysis of our data resulted in a best-fit period of 8.377 ± 0.004 hours with an amplitude of 0.1727 ± 0.0123 mag resulting in a typical bimodal lightcurve, disagreeing with Warell.

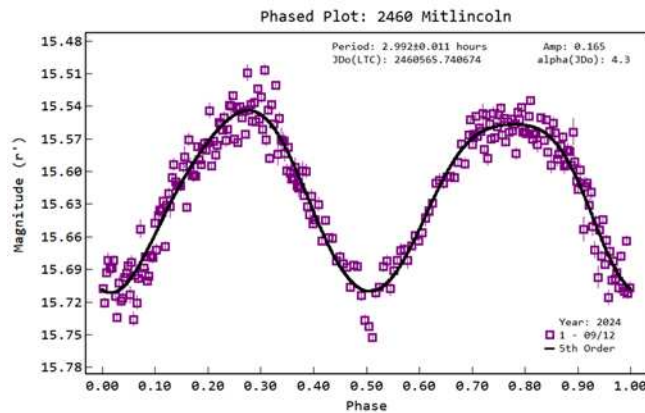


Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2042	Sitarski	2024 09/25-10/09	*1.6, 4.3	7	0	8.377	0.004	0.17	0.01	MERXIA
2460	Mitlincoln	2024 09/12-09/12	4.2, 4.4	358	0	2.992	0.011	0.17	0.02	MB-I
2935	Naerum	2024 04/30-07/11	9.5, 24.1	231	17	450.8	0.2	0.55	0.02	MB-M
3654	AAS	2024 09/09-09/10	12.9, 13.6	5	1	3.545	0.002	0.15	0.02	MB-I
3869	Norton	2024 08/15-08/19	8.9, 10.8	340	6	7.606	0.003	0.15	0.02	MB-I
3895	Earhart	2024 07/12-07/16	8.8, 10.0	305	16	3.565	0.002	0.51	0.03	MB-I
4222	Nancita	2023 11/15-11/17	10.0, 8.7	64	-2	3.873	0.002	0.56	0.03	MC
4706	Dennisreuter	2024 09/25-09/28	4.6, 6.1	13	-1	3.685	0.003	0.10	0.02	MB-M
5725	Nordlingen	2024 04/29-05/09	4.9, 7.4	216	9	3.412	0.002	0.15	0.02	MB-I
6026	Xenophanes	2024 09/09-09/11	7.4, 8.2	8	1	4.106	0.002	0.44	0.03	MB-O
7079	Baghdad	2024 07/17-08/21	*6.7, 13.2	312	7	2.860	0.003	0.06	0.01	MC
8356	Wadhwa	2023 09/24-10/15	7.6, 20.7	351	1	3.080	0.002	0.29	0.02	MB-I
9436	Shudo	2024 04/26-05/02	11.7, 14.5	197	5	3.779	0.002	0.14	0.01	NYSA
13713	1998 QN30	2024 10/05-10/11	8.5, 4.8	25	-1	6.312	0.004	0.87	0.03	MB-I
16693	Moseley	2024 09/08-10/14	*12.3, 12.8	2	16	71.72	0.07	1.06	0.5	EUNOMIA
17133	1999 JC81	2024 06/06-06/10	11.8, 10.9	261	19	6.694	0.002	0.27	0.02	MB-M
22074	2000 AB113	2024 10/13-10/14	8.5, 8.8	37	-13	3.806	0.004	0.37	0.03	EOS
37163	Huachucaclub	2024 08/20-09/07	9.5, 16.9	314	6	6.811	0.007	1.01	0.05	MB-I
37187	2000 WP60	2024 05/07-06/30	*7.0, 21.5	249	11	580.1	1.0	0.23	0.03	MB-M
69894	1998 SD125	2024 10/05-10/10	3.6, 5.6	26	-1	3.725	0.002	0.52	0.05	EOS
86608	2000 EK85	2024 05/08-05/13	13.2, 13.9	234	15	3.534	0.007	0.10	0.01	MC
93636	2000 UF81	2024 03/30-06/03	8.5, 23.7	189	16	12.791	0.004	0.32	0.02	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).

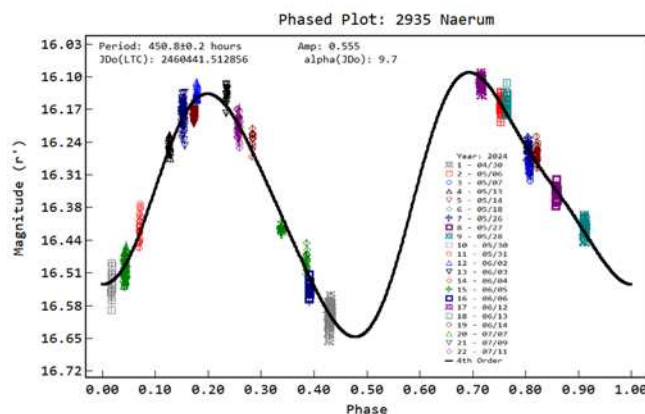
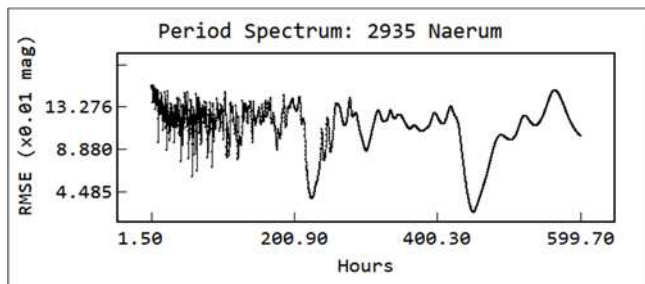
2460 Mitlincoln is an inner main-belt asteroid discovered in 1980 by L.G. Taff and D. Beatty at Socorro. It is named after the MIT Lincoln Laboratory. We observed it on one night in 2024 September resulting in a total of 252 observations.

A search of the LCDB showed six prior reported periods: 2.77 h by Warner (2002), 3.009 by Behrend (2004web), 2.667 by Warner (2011), 2.8277 by Kryszczyńska et al. (2012), 3.0068 by Benishek (2019) and 3.0052 by Mannucci (2020). Analysis of our data resulted in a bimodal lightcurve with a best fit of 2.992 ± 0.011 hours and an amplitude of 0.1653 ± 0.0153 mag, in close agreement with Benishek and Mannucci.



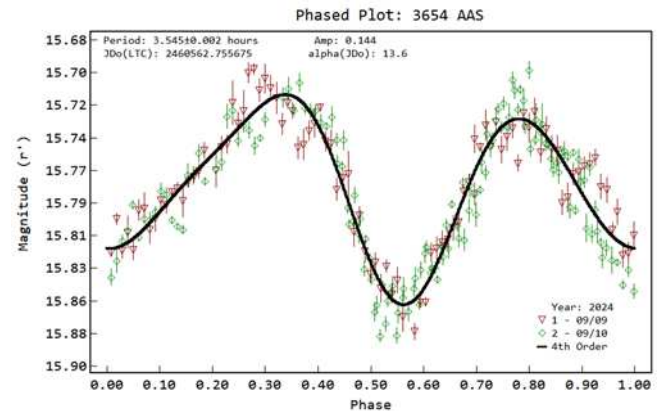
2935 Naerum is a middle main-belt asteroid discovered in 1976 by R.M. West at La Silla. We observed it on 22 nights in 2024 April through July resulting in a total of 708 observations.

No prior period reports were found in the LCDB. Analysis of our data resulted in a best fit of 450.8 ± 0.2 hours with an amplitude of 0.555 ± 0.023 mag. The period spectrum shows spikes at 225 and 450 hours. We adopted the latter value which gave a bimodal result. Coverage is incomplete so this result could be wrong.



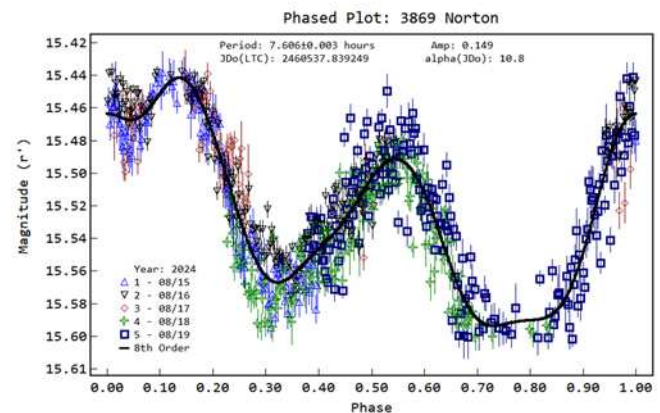
3654 AAS is a main-belt asteroid discovered in 1949 by Goethe Link Observatory in Brooklyn. We observed it on two nights in 2024 September resulting in 235 observations.

We found no prior reports of a rotation period. Analysis of our data resulted in a best fit period of 3.545 ± 0.002 h with an amplitude of 0.1445 ± 0.0146 mag.



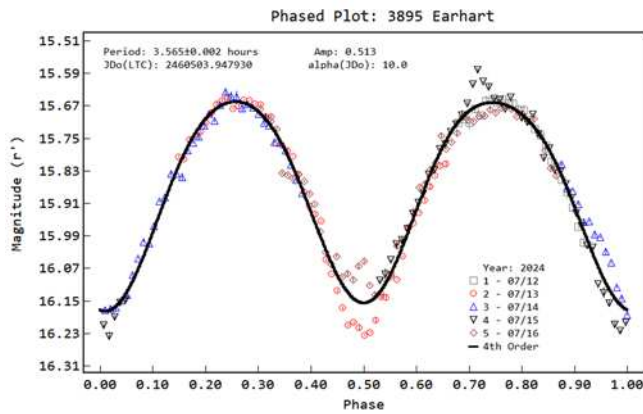
3869 Norton is a main-belt asteroid discovered in 1981 by Bowell at Flagstaff. We observed Norton on five nights in 2024 August resulting in a total of 875 observations.

We found two prior reports. Pál et. al. (2020) reported 7.0957 h and Benishek (2022) reported 7.605 h. Analysis of our data resulted in a best fit of 7.606 ± 0.003 h with an amplitude of 0.1489 ± 0.0161 mag, in agreement with Benishek.



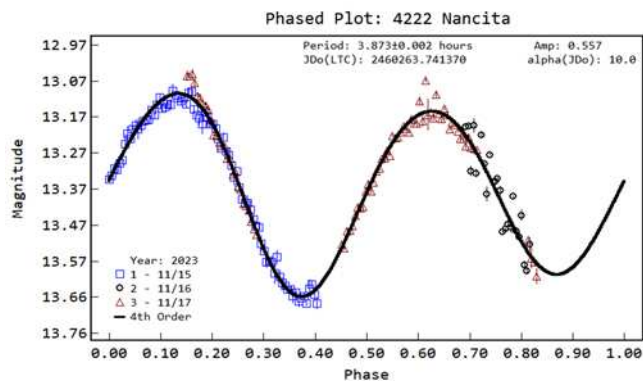
3895 Earhart is an inner main-belt asteroid discovered in 1987 by C. Shoemaker at Palomar. The LCDB shows ten prior rotation period reports and an uncertainty score U of 3 with period 3.5645 hours. We observed it on five nights in 2024 July resulting in a total of 229 observations.

Analysis of our data resulted in a best fit period of 3.565 ± 0.002 h with an amplitude of 0.513 ± 0.029 mag, in close agreement with prior reports.



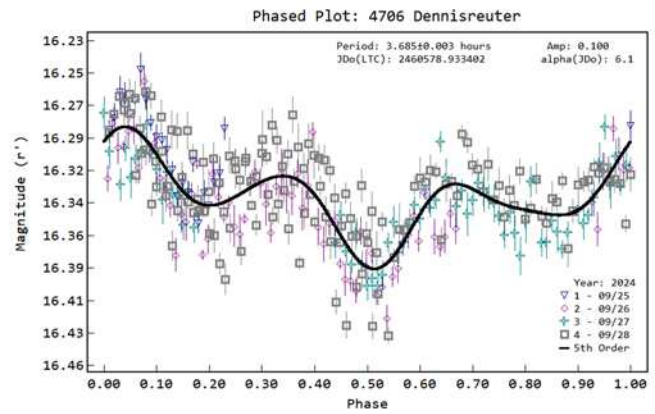
4222 Nancita is a Mars-crossing asteroid discovered in 1988 by E. Helin at Palomar. There were two prior reports in the LCDB of 3.8732 ± 0.0003 by Higgins et al. (2006) and 3.872921 ± 0.000002 by Āurech et al. (2018). We observed on three nights in 2023 November resulting in a total of 177 observations.

Analysis of the data resulted in a best fit of 3.8730 ± 0.002 hours with an amplitude of 0.557 ± 0.03 mag in close agreement with the prior reports.



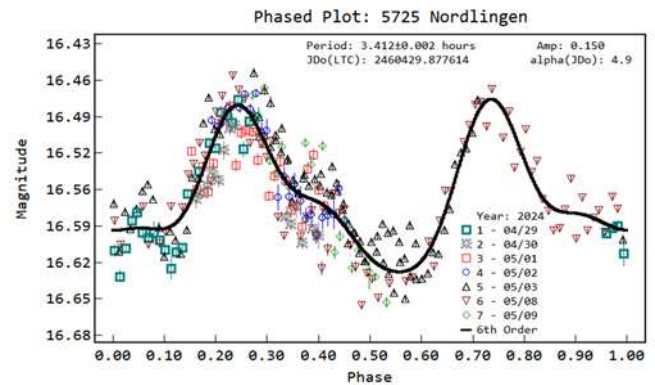
4706 Dennisreuter is an inner main-belt asteroid discovered by R. Rajamohan at Kavalur in 1988. It is named for Dennis C. Reuter, a physical chemist at the Goddard Space Flight Center, who developed instrumentation and techniques to measure the spectra of comets and planetary bodies. We observed it on four nights in 2024 September resulting in a total of 319 observations.

The LCDB shows a period of 2.578 with a uncertainty score U of 1. Waszczak et. al. (2015) reported 2.578 h and Fornas et al. (2022) reported 3.690 h. A fifth order Fourier fit of our data resulted a period of 3.685 ± 0.003 h with an amplitude of 0.1 ± 0.02 mag, in close agreement with Fornas.



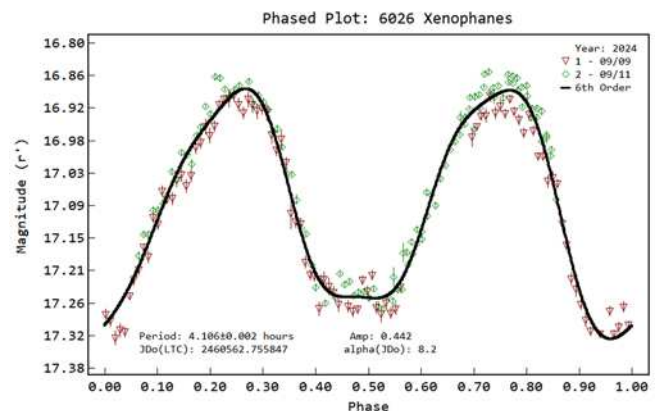
5725 Nordlingen is an inner main-belt asteroid discovered in 1988 by C. Shoemaker at Palomar. We observed it on seven nights in 2024 April and May resulting in a total of 263 observations.

We were unable to find any prior period reports. Analysis of our data resulted in a best fit of 3.412 ± 0.002 hours with an amplitude of 0.15 ± 0.02 mag.



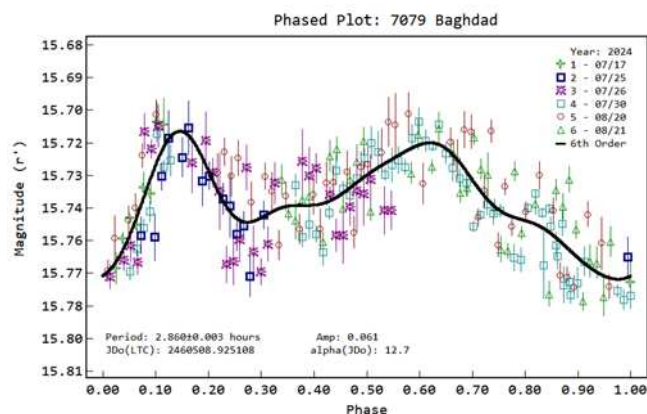
6026 Xenophanes is an inner main-belt asteroid discovered in 1993 by E.W. Elst at La Silla. We observed it on two nights in 2024 September for a total of 206 observations.

We found three prior reports in the LCDB. Two by Waszczak et al. (2015) of 4.490 h and 4.109 h along with one from Hanuš et al. (2016) of 3.7817. The LCDB quality score U was 2. Analysis of our data resulted in a clear bimodal lightcurve with best fit period of 4.106 ± 0.002 h with an amplitude of 0.4424 ± 0.0249 mag, close to the second report from Waszczak et al.



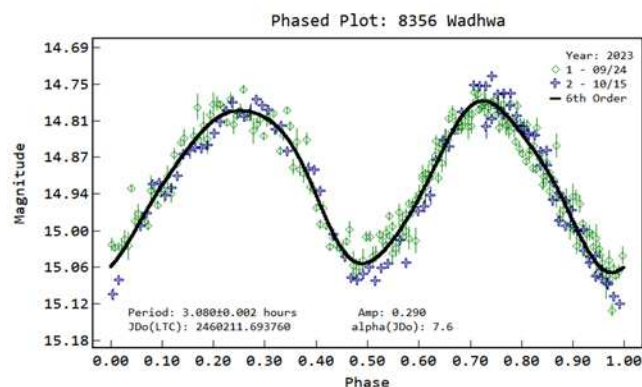
7079 Baghdad is a Mars-crosser discovered in 1986 by E. Elst and V. Ivanova at Smolyan. We observed it on six nights in 2024 July and August resulting in a total of 256 observations.

We were unable to find any prior rotation period reports. Analysis of our data resulted in a best fit of 2.86 ± 0.003 h with an amplitude of 0.06 ± 0.012 mag.



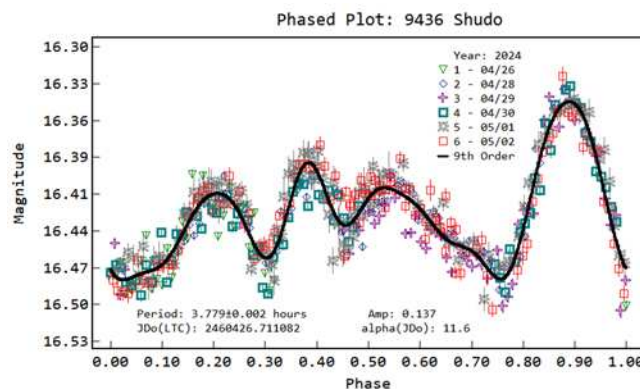
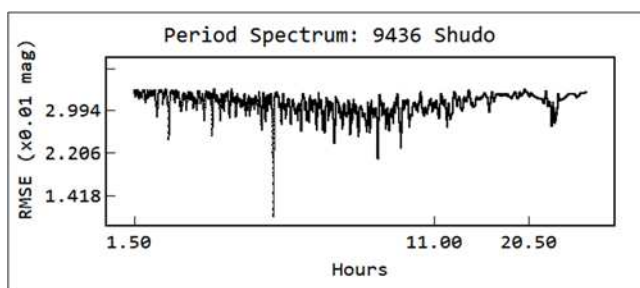
8356 Wadhwa is an inner main-belt asteroid discovered in 1989 by C. Shoemaker and E. Shoemaker at Palomar. It is named in honor of Dr. Meenakshi Wadhwa, who is currently the director of the Arizona State University School of Earth and Space Exploration. We observed Wadhwa on two nights in 2023 September and October resulting in a total of 296 observations.

We found three prior reports for Wadhwa, 3.04303 ± 0.00004 by Pravec et al. (2008web), 3.04 ± 0.01 by Buchheim (2009) and 3.0411 ± 0.0001 by Pravec et al. (2019web). Analysis of our data resulted in a best fit of 3.080 ± 0.002 hours with an amplitude of 0.29 ± 0.02 mag, slightly longer than the prior reports.



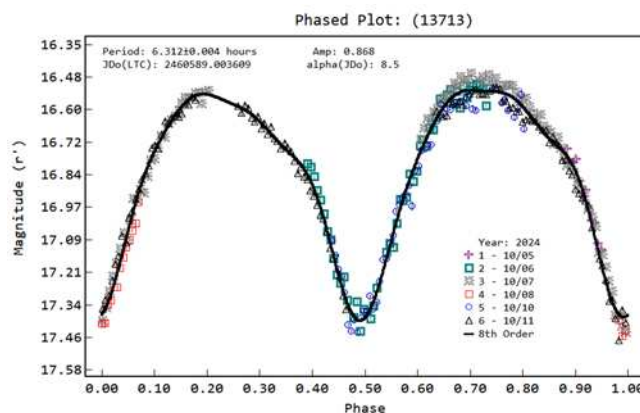
9436 Shudo is an inner main belt asteroid discovered in 1997 by T. Kobayashi at Oizumi. It is a member of the Nysa family. It is named for a private boys' junior and senior high school in Hiroshima, Japan. We observed it on six nights in 2024 April and May resulting in a total of 475 observations.

A search of the LCDB did not reveal any reports of a synodic period. Analysis of our data resulted in a best fit of 3.779 ± 0.002 hours with an amplitude of 0.14 ± 0.01 mag. Due to the relatively short period several nights covered complete or nearly cycles. The period spectrum is unambiguous, with no other meaningful signals.



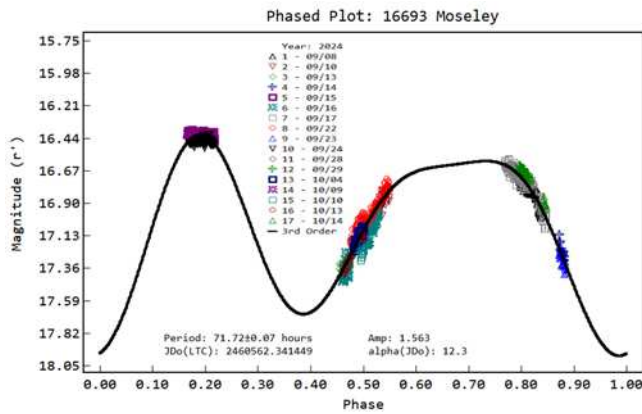
13713 1998 QN30 is an inner main-belt asteroid. We observed it on six nights in 2024 October resulting in a total of 346 observations.

We found one prior report by Waszczak et al. (2015) of 6.338 hours. The LCDB lists the quality score U as 2. Analysis of our data resulted in a best fit period of 6.312 ± 0.0004 hours with an amplitude of 0.868 ± 0.0331 mag, in close agreement with Waszczak et al. The small gap at phase 0.2 was caused by data points removed due to contamination by a background star. If not for that, the coverage would be complete.



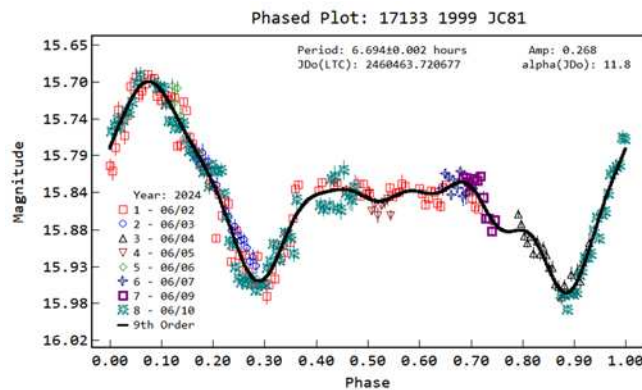
16693 Moseley is a middle main-belt asteroid of the Eunomia family. It was discovered in 1994 by D.J. Asher at Siding Spring. It is named for Terence J.C.A. Moseley, editor of Stardust, and a founding member of the Irish Federation of Astronomical Societies. We observed Moseley on seventeen nights in 2024 September and October resulting in a total of 979 observations.

We found no prior rotation period reports. Analysis of our data resulted in a best fit of 71.71 ± 0.07 hours. Since we were unable to observe a clear minimum, the amplitude is uncertain, but appears to exceed 1 magnitude and is likely between 1 and 1.5 magnitude. Coverage is incomplete so this result could be wrong. Further observations are needed.



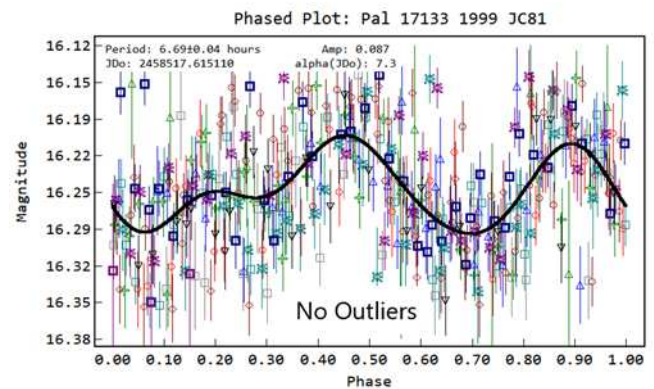
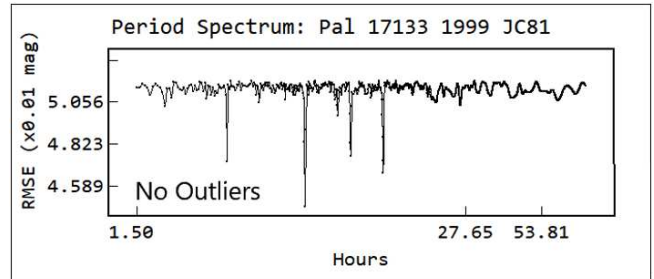
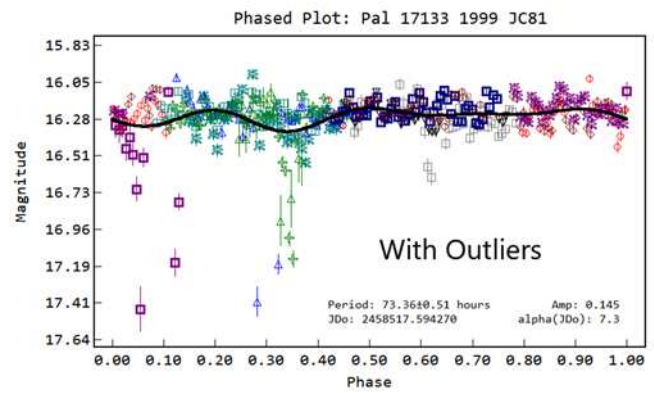
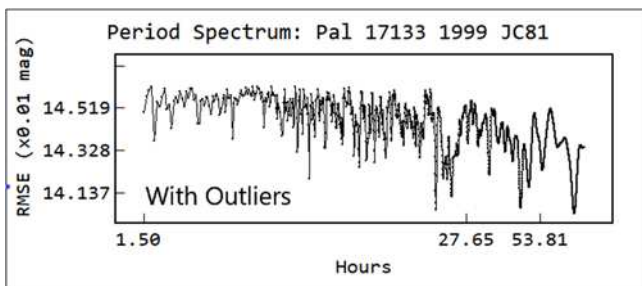
17133 1999 JC81 is a middle main-belt asteroid discovered by LINEAR at Socorro. We observed it on eight nights in 2024 June, resulting in a total of 269 observations.

A search of the ALCDEF revealed one report by Pál et al. (2020) of 48.1942 ± 0.0005 hours with an amplitude of 0.14 ± 0.03 magnitude based on data extracted from TESS observations. Analysis of our data resulting in a best fit of 6.694 ± 0.002 hours with an amplitude of 0.268 ± 0.015 mag, disagreeing with Pál et al.



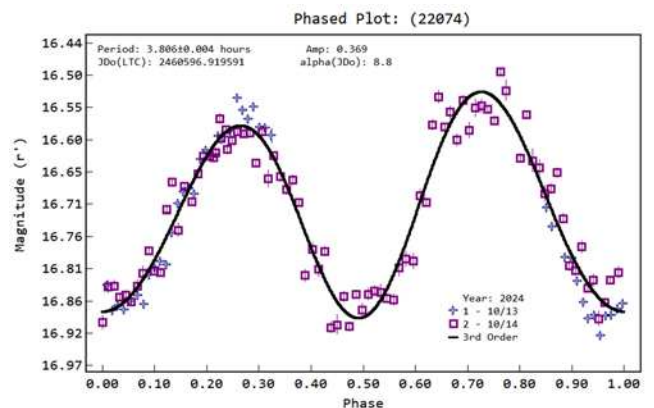
Pál et al. provided data to the ALCDEF database which we downloaded and analyzed to try to understand the discrepancies with our results.

There are a small number of significant outliers in the Pál et al. data as shown in the plots below. Including these outliers results in a spectrum with several peaks, one peak is near the reported 48.19 hours. Suppressing these outliers results in a spectrum with a peak at 6.69 hours, in close agreement with our result, but with a much lower amplitude. The lightcurve shape is also different from our result. We are unable to explain these discrepancies.



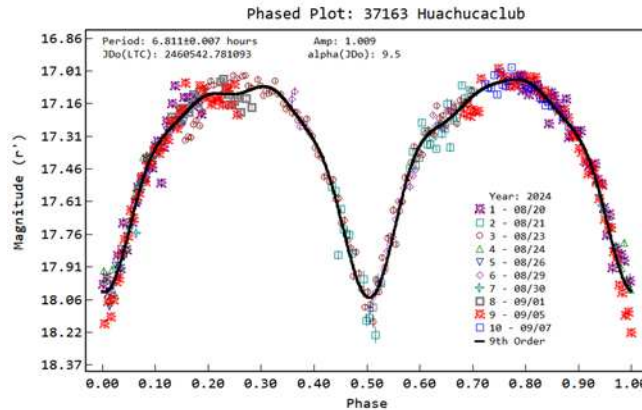
22074 2000 AB113 is an outer main-belt asteroid that is a member of the Eos family. It was discovered in 2000 by LINEAR at Socorro. We observed it on two nights in 2024 October for a total of 129 observations.

We found one prior report from Āurech et al. (2020) of 3.801 hours with a quality score U of 2. Analysis of our data resulted in a best fit of 3.806 ± 0.004 hours with an amplitude of 0.369 ± 0.0314 mag, in close agreement with Āurech et al.



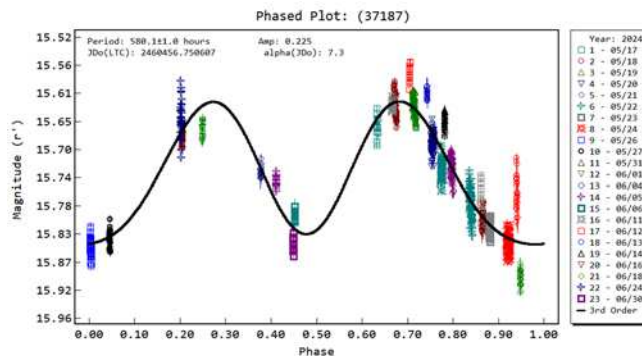
37163 Huachuclab, an inner main-belt asteroid, was discovered by Medkeff and Healy at Junk Bond Observatory in 2000. It is named after the Huachuca Astronomy Club of Sierra Vista, AZ. We observed it on 10 nights in 2024 August and September resulting in a total of 454 observations.

Waszczak et. al. (2015) reported a period of 5.967 hours and an amplitude of 0.8 mag. The LCDB shows a quality score of 2. Analysis of our observations resulted in a best fit of 6.811 ± 0.007 hours with an amplitude of 1.01 ± 0.05 mag, longer than the Waszczak et al. report.



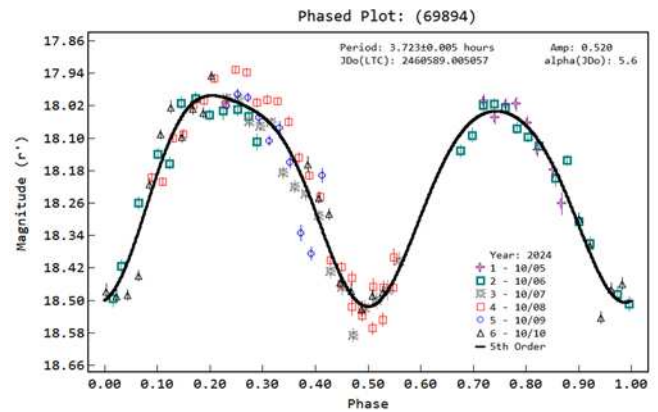
37187 2000 WP60 is a middle main-belt asteroid discovered in 2000 by LINEAR at Socorro. We observed it on 26 nights in 2024 May through July resulting in a total of 1017 observations.

We were unable to find any prior rotation period reports. Analysis of our data resulted in a best fit of 580.1 ± 1.0 hours with an amplitude of 0.225 ± 0.028 mag. The lightcurve shows signs indicating it may be tumbling.



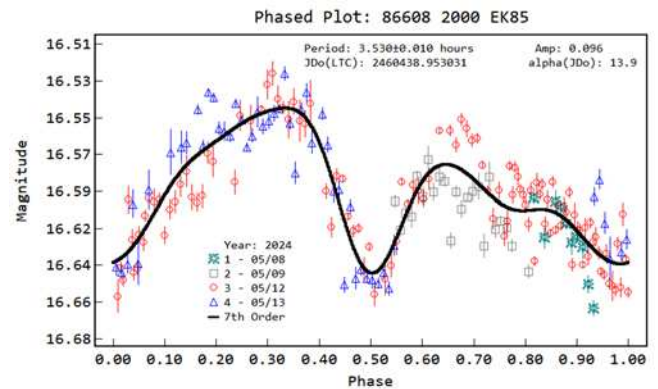
69894 1998 SD125 is an outer main-belt asteroid that is a member of the Eos family. It was discovered in 1998 by LINEAR at Socorro. We observed it on six nights in 2024 October resulting in a total of 223 observations.

We found no prior rotation period reports. Analysis of our data resulting in a best fit period of 3.725 ± 0.002 hours with an amplitude of 0.521 ± 0.047 mag.



86608 2000 EK85 is a Mars crossing asteroid discovered by LINEAR at Socorro. We observed it on four nights in 2024 May resulting in a total of 197 observations.

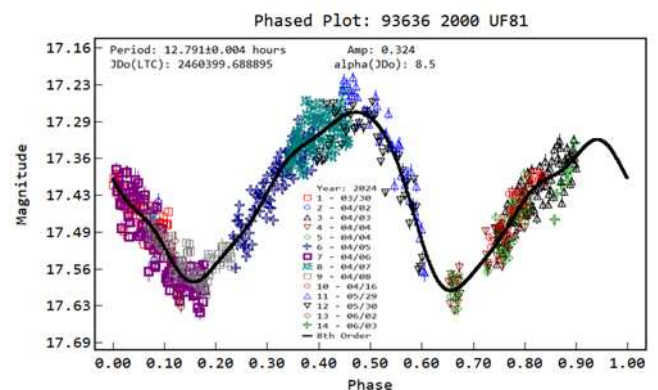
We found no prior rotation period reports. Analysis of our data resulted in a best fit of 3.534 ± 0.007 hours with an amplitude of 0.097 ± 0.02 mag.



93636 2000 UF81 is a middle main-belt asteroid discovered by LINEAR at Socorro. We observed it on twelve nights in 2024 March, April and May resulting in a total of 625 observations.

We found no prior rotation period reports. Analysis of our data resulted in a best fit period of 12.791 ± 0.004 hours with an amplitude of 0.32 ± 0.03 mag.

The period spectrum contains aliases at one-half the proposed period. While there is a small gap in the lightcurve, given the large number of cycles covered, and the relatively poor fit for the aliases, we are confident that this bimodal lightcurve is the correct period.



Acknowledgements

The author gratefully acknowledges the generosity of Dr. Richard Post for ongoing use of one of his domes to house the author's telescope.

The author thanks Brian Warner, Tom Polakis, Mike Wiles and Eric Dose for their advice and guidance that has improved the results of this research.

This research used data from the Asteroid Terrestrial-impact Last Alert System (ATLAS) project, funded through NASA grants NN12AR55G, 80NSSC18K0284, and 80NSSC18K1575. The ATLAS science products have been made possible through the contributions of the University of Hawaii Institute for Astronomy, the Queen's University Belfast, the Space Telescope Science Institute, and the South African Astronomical Observatory.

Funding for PDS observations, analysis, and publication was provided by NASA grant NNX13AP56G.

Work on the asteroid lightcurve database (LCDB) was funded in part by National Science Foundation grants AST-1210099 and AST-1507535.

Data from the MPC's database is made freely available to the public. Funding for this data and the MPC's operations comes from a NASA PDCO grant (80NSSC22M0024), administered via a University of Maryland - SAO subaward (106075-Z6415201). The MPC's computing equipment is funded in part by the above award, and in part by funding from the Tamkin Foundation.

This research used data found on the JPL Solar System Dynamics Website. The JPL Solar System Dynamic group's ephemeris development, maintenance, and improvement test are part of NASA's Advanced Multi-Mission Operations System, which is funded by NASA's Science Mission Directorate, Planetary Science Division.

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A NEW SATELLITE OF (172376) 2002 YE25 DETECTED BY STELLAR OCCULTATION

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(Received: 2024 August 17)

Two observers in Australia, at two separate sites, observed (172376) 2002 YE25 occult TYC 6854-1090, an 11th magnitude star, on 2022 May 16.447 UT. The minor planet was nine magnitudes fainter than the star. An occultation at both sites was not expected to be observed due to the small diameter of the asteroid and the cross-path spacing of the two sites being much larger than the asteroid. However, both sites detected a clear occultation that reached the limit of 3 magnitudes fainter than the star for both recordings. We observed chord lengths across one body of 3.8 km and the second body of 3.3 km, with a mid-chord separation of 15.3 km. We rule out the possibility that the two occultations were caused by a double star, or a highly elongate object like 433 Eros or 216 Kleopatra.

D. Gault and P. Nosworthy observed (172376) 2002 YE25 occult TYC 6854-01090-1. An occultation at both sites was not expected due to the 5.7 km diameter of the asteroid and the 15.52 km cross-path spacing of the two sites being much larger than the asteroid. They observed from their home observatories located in The City of The Blue Mountains, west of Sydney, Australia, at Hawkesbury Heights and Hazelbrook. The sites are equipped with 28 and 30 cm Schmidt-Cassegrain telescopes, Watec 910BD video cameras, and IOTA-VTIs (2024), which inserted an accurate GPS-derived time stamp into the video stream. The occultation occurred at an altitude of 19 degrees. Observation circumstances and timings are shown in Table I and lightcurves of the target and a comparison star are shown in Figure. 1.

For this event, the recordings were closely analyzed to determine the limiting magnitude of the recording, noting that during the occultation events, the lightcurve dropped to zero light-level. The occulted star had a Gaia G-band magnitude of 11.0; stars fainter than 13.9 were visible on the recording. The equivalent magnitude drops of at least 3.0 magnitudes for both events in each recording is much larger than the 0.75 mag drop that would occur if the star was a double star of equal magnitude – thereby excluding a double star as being an explanation for the event.

Observer	Longitude	Latitude	Altitude	Event	Time UT	
Gault	150 38 27.9	-33 39 51.90	286m	D	10:43:31.52	+/-0.02
				R	10:43:31.96	+/-0.02
Nosworthy	150 27 06.5	-33 42 26.60	648m	D	10:43:30.07	+/-0.02
				R	10:43:30.46	+/-0.02

Table I. Observation circumstances and disappearance and reappearance times UTC of the 2022 May 16 occultations. The sites were separated by 15.52 km across the occultation path.

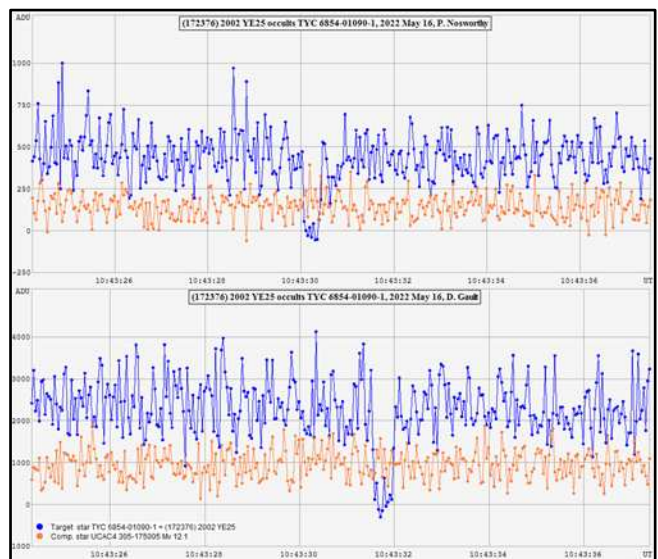


Fig. 1. Lightcurves by Gault and Nosworthy of the 2022 May 16 occultations of the MG 11.0 target star by the asteroid main body and satellite. Light values of the MG 12.1 comparison star are also shown.

Reduction of the Observations

Event times and observation circumstances were entered into *Occult* (Herald, 2024) and reduced for each observation. The sky-plane plots are shown on Figure 2.

The NEOWISE diameter of 2002 YE25, as determined at two epochs in 2010, is 5.7 ± 0.6 km, giving an equivalent cross-sectional area of between 20 and 31 sq km. The two occultation chords were of lengths 3.8 and 3.3 km, with a mid-chord separation of 15.3 km. Assuming a highly elongate cylindrical object similar to that of minor planets 433 Eros or 216 Kleopatra, the minimal apparent cross-sectional area would be greater than 55 sq km (i.e., much larger than that expected from the NEOWISE diameter).