

ASTEROID PHOTOMETRY FOR THIRTEEN MAIN-BELT ASTEROIDS AND ONE APOLLO OBJECT

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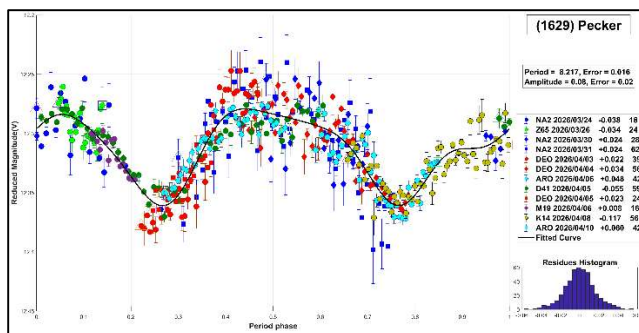
(Received: 2026 July 15)

Synodic rotation periods and amplitudes are reported for:
1629 Pecker, 1678 Hveen, 1684 Iguassu, 1733 Silke,
2149 Schwambraniya, 2307 Garuda, 2832 Lada, 3668
Ilfpetrov, 3840 Mimistrobell, 4408 Zlata, 5557
Chimikeppuko, 6152 Empédocles, 9191 Hokuto, 52340
1992 SY.

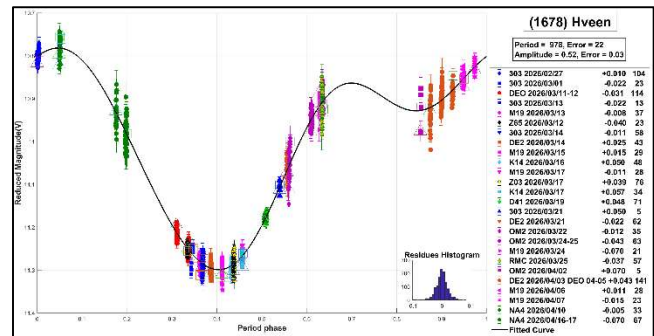
The periods and amplitudes of asteroid lightcurves presented in this paper are the product of collaborative work by the GORA (Grupo de Observadores de Rotaciones de Asteroides) group. In all the studies, we have applied relative photometry assigning V magnitudes to the calibration stars. The image acquisition 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 and for the analysis, we employed *Periodos* software (Mazzone, 2012).

Below, we present the results for each asteroid studied. The lightcurve figures contain the following information: 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 the following criteria: 1) those asteroids with magnitudes accessible to the equipment of all participants, 2) those with favorable observation conditions from Argentina, Venezuela, Spain, Italy, or Croatia, i.e. with negative or positive declinations δ , and 3) objects with few periods reported in the literature and/or with Lightcurve Database (LCDB) (Warner et al., 2009) quality codes (U) of less than 3.

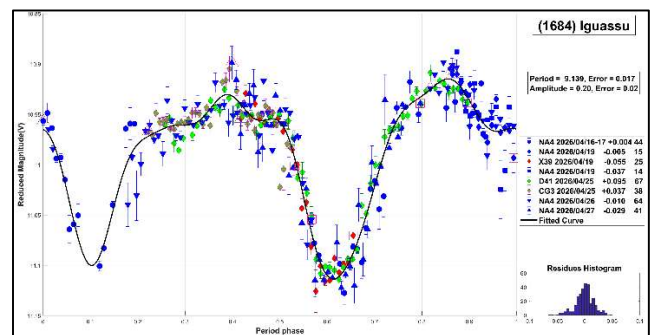
1629 Pecker is a main-belt asteroid discovered in 1952 by L. Boyer, with an estimated diameter of 8.536 km. A previously reported rotational period for this asteroid is $P = 8.2166$ h (Pravec et al., 2006web). We measured a period of $P = 8.217 \pm 0.016$ h, with an amplitude of $\Delta m = 0.08 \pm 0.02$ mag.



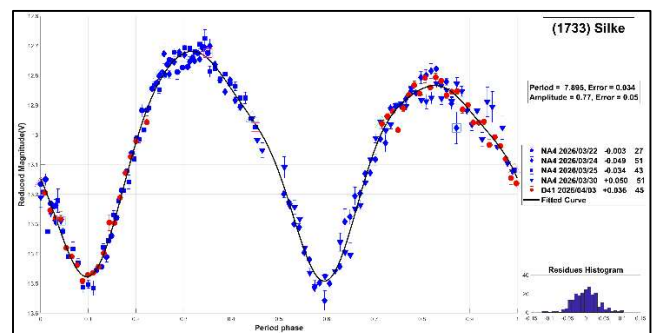
1678 Hveen is a main-belt asteroid discovered in 1678 by Y. Vaisala. It has an estimated diameter of 42.665 km. The reported rotational period for this asteroid is $P = 5.987$ h (Carbognani, 2014). Our observations suggest a long period, yielding a value of $P = 978 \pm 22$ h with $\Delta m = 0.52 \pm 0.03$ mag.



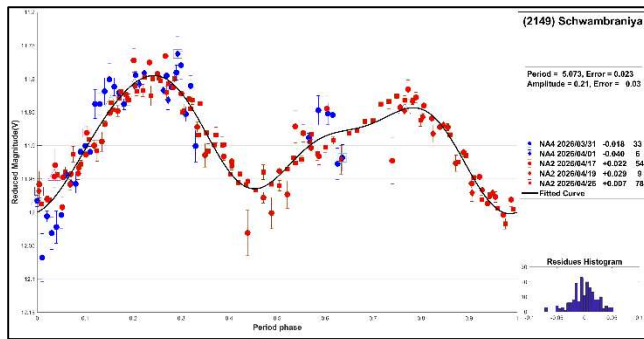
1684 Iguassu is a main-belt asteroid with an estimated diameter of 30.21 km, discovered in 1951 by M. Itzigsohn. The reported rotational period for this asteroid is $P = 6.4156$ h (Skiff, 2018web). Our observations suggest a longer period, yielding a value of $P = 9.139 \pm 0.017$ h with $\Delta m = 0.77 \pm 0.05$ mag.



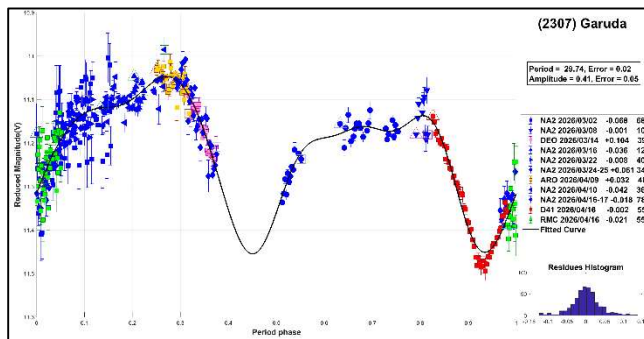
1733 Silke. This main-belt asteroid was discovered in 1938 by A. Bohrmann and has an estimated diameter of 6.715 km. A rotational period of $P = 7.89393$ h was previously reported for this asteroid (Pál et al., 2020). Our results are consistent with this rotation period, giving a value of $P = 7.895 \pm 0.034$ h and an amplitude of $\Delta m = 0.77 \pm 0.05$ mag.



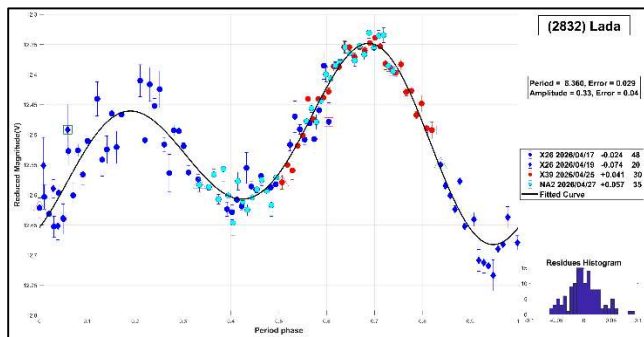
2149 Schwambraniya is a main-belt asteroid discovered in 1977 by N.S. Chernykh, with a diameter of 11.180 km. The reported rotational period for this asteroid is $P = 5.676$ h (Brincat et al., 2023). In this work, we propose a period of $P = 5.073 \pm 0.023$ h with $\Delta m = 0.21 \pm 0.03$ mag.



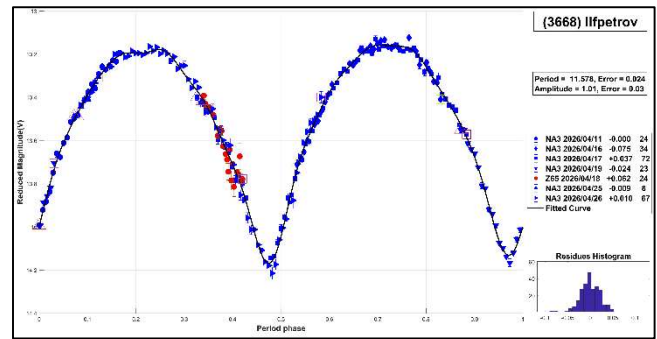
2307 Garuda is a main-belt asteroid with an estimated diameter of 40.139 km, discovered in 1957. The more recent period published in the literature corresponds to $P = 29.76$ h (Behrend, 2020web). Our period $P = 29.74 \pm 0.02$ h with $\Delta m = 0.41 \pm 0.05$ mag agrees with the one measured by Behrend.



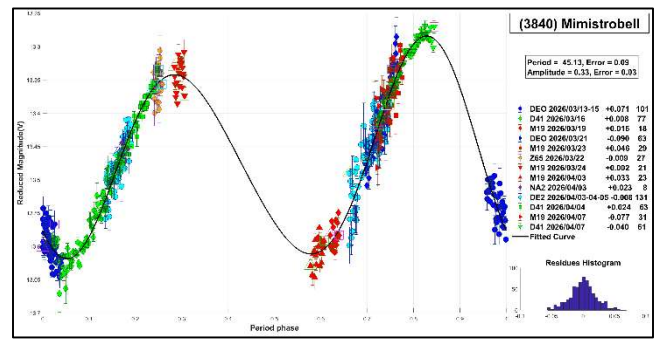
2832 Lada is a main-belt asteroid discovered in 1975 by N. Chernykh, with a diameter of 6.090 km. A previously reported rotational period for this asteroid is $P = 8.357$ h (Durech et al., 2020). In this work, we measured a period of $P = 8.360 \pm 0.029$ h and an amplitude of $\Delta m = 0.33 \pm 0.04$ mag.



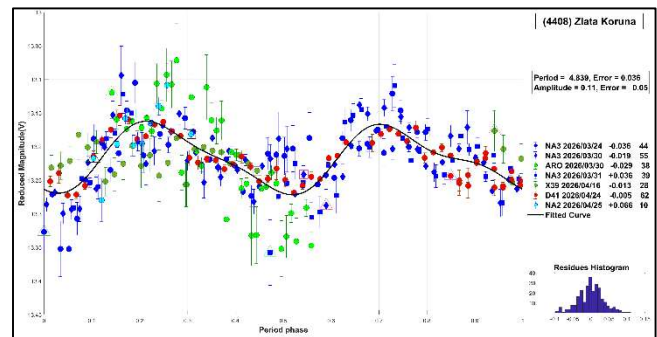
3668 Il'fpetrov is a main-belt asteroid with an estimated diameter of 6.496 km, discovered in 1982 by L.G. Karachkina. The reported rotational period for this asteroid is $P = 15.268$ h (Waszczak et al., 2015). In this work, we propose a shorter period of $P = 11.578 \pm 0.024$ h with $\Delta m = 1.01 \pm 0.03$ mag.



3840 Mimistobell is a main-belt asteroid with an estimated diameter of 5.174 km, discovered in 1980 by C. Shoemaker. No published rotational periods for this asteroid were found in the literature. In this work, we propose a period of $P = 45.13 \pm 0.09$ h with $\Delta m = 0.33 \pm 0.03$ mag.



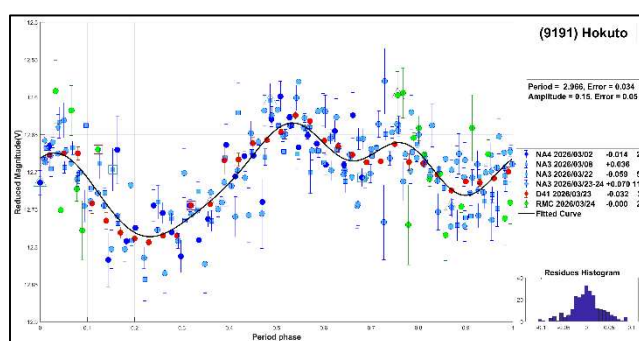
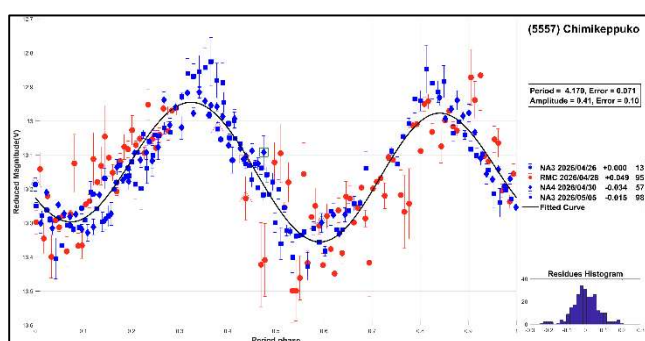
4408 Zlata Koruna is a main-belt asteroid discovered in 1988 by A. Mrkos. The more recent period published in the literature corresponds to $P = 4.392$ h (Olguín et al., 2020). Our period $P = 4.839 \pm 0.036$ h with $\Delta m = 0.11 \pm 0.05$ mag agrees with the one measured by Olguín and collaborators.



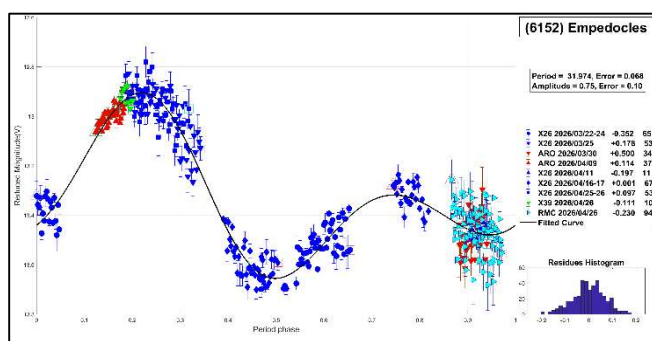
5557 Chimikeppuko is a main-belt asteroid discovered in 1989 by Endate and Watanabe, with a diameter of 7.1 km. The reported rotational period for this asteroid is $P = 4.168$ h (Waszczak et al., 2015). In this work, we measure a period of $P = 4.170 \pm 0.071$ h with $\Delta m = 0.41 \pm 0.10$ mag.

Number	Name	yy/ mm/dd- yy/ mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1629	Pecker	26/03/24-26/04/10	*12.8, 09.2	199	13	8.217	0.016	0.08	0.02	MB-I
1678	Hveen	26/02/27-26/04/17	*05.3, 12.7	171	-1	978	22	0.52	0.03	MB-O
1684	Iguassu	26/04/16-26/04/27	*03.6, 02.6	213	4	9.139	0.017	0.20	0.02	Them
1733	Silke	26/03/22-26/04/04	*07.0, 02.2	193	3	7.895	0.034	0.77	0.05	Flora
2149	Schwambraniya	26/03/31-26/04/26	13.4, 02.8	219	5	5.073	0.023	0.21	0.03	MB-I
2307	Garuda	26/03/02-26/04/17	*08.5, 10.3	181	-9	29.74	0.02	0.41	0.05	MB-O
2832	Lada	26/04/17-26/04/27	*05.5, 02.5	216	5	8.360	0.029	0.33	0.04	MB-I
3668	Ilfpetrov	26/04/11-26/04/26	*02.5, 06.9	205	1	11.578	0.024	1.01	0.03	MB-I
3840	Mimistrobell	26/03/13-26/04/08	03.5, 16.4	169	4	45.13	0.09	0.33	0.03	MB-I
4408	Zlata Koruna	26/03/24-26/04/25	*12.9, 03.6	208	-2	4.839	0.036	0.11	0.05	MB-I
5557	Chimikeppuko	26/04/26-26/05/05	09.7, 05.6	231	-5	4.170	0.071	0.41	0.10	MB-I
6152	Empédocles	26/03/22-26/04/27	*08.8, 10.1	198	-2	31.974	0.068	0.75	0.10	MB-I
9191	Hokuto	26/03/02-26/03/25	*08.9, 10.4	171	-15	2.966	0.034	0.15	0.05	Euno
52340	1992 SY	26/03/11-26/03/16	31.3, 25.8	158	9	2.900	0.036	0.07	0.05	NEA

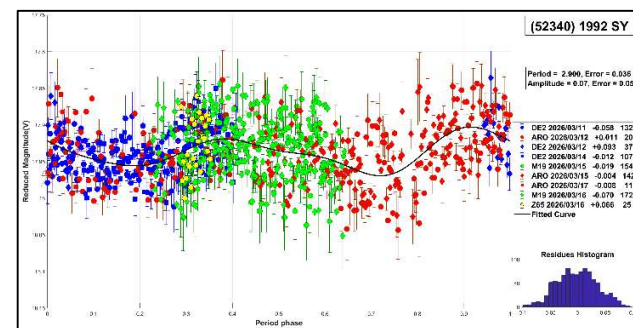
Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extremum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009). MB-I: main-belt inner; MB-O: main-belt outer; Them: 24 Themis; Flora: 8 Flora; Euno: 15 Eunomia; NEA: NEA.



6152 *Empédocles* is a main-belt asteroid with a diameter of 6.889 km, discovered in 1989 by E.W. Elst. For this asteroid, we couldn't find published periods in the literature either. Based on our observations and thorough analysis, we propose a period of $P = 31.974 \pm 0.068$ h and $\Delta m = 0.75 \pm 0.10$ mag.



9191 *Hokuto* is a main-belt asteroid discovered in 1991 by S. Otomo. For this asteroid, we could not find any published rotational periods in the literature. In this work, we propose a short period of $P = 2.966 \pm 0.034$ h with $\Delta m = 0.15 \pm 0.05$ mag.



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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. We also used *Seqplot* (<https://www.aavso.org/seqplot>), which proved very effective for checking the magnitudes of the calibration stars. This research has made use of the Small Bodies Data Ferret (<https://sbnapps.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.

Observatory	Telescope	Camera
303 Obs. Astr. Nacional Llano del Hato	Newtonian (D=1000mm; f=5.5)	CCD FLI PL4240
D41 Osservatorio Astronomico di Orciatico	SCT (D=355mm; f=7.4)	CCD SBIG ST10XME
K14 Obs. Astronómico de Sencelles	Newtonian (D=250mm; f=4.0)	CCD SBIG ST-7XME
M19 Osservatorio Explorer	RCT (D=304 mm; f=6,5)	CMOS Player One-Poseidon
X26 Obs. Astronómico Naos	Newtonian (D=250mm; f=4.0)	CMOS QHY 163M
X39 Obs. Astronómico Antares	Newtonian (D=250mm; f=4.72)	CCD QHY9 Mono
Z03 Obs. Astr.RioCofio	SCT (D=254mm; f=6.3)	CCD SBIG ST-8XME
Z65 Obs. Astronómico Corgas	Newtonian (D=310mm; f=4.8)	CMOS ZWO ASI 294 MM
ARO Obs. Astronómico de Albatàrrec	Refractor (D=160mm; f=5.6)	CMOS Player O-P M Pro
DEO Dark Energy Observatory	Refractor (D=115mm; f=7.0)	CMOS QHY 294M pro
DE2 Dark Energy Observatory 2	RCT (D=200mm; f=5.4)	CMOS Player One Ares-M
GC3 Specola Giuseppe Pustorino 2	RCT (D=400mm; f=8.0)	CCD Atik 383L+Mono
NA2 Obs. Astronómico Naos 2	Newtonian (D=200mm; f=5.0)	CMOS ZWO ASI 174
NA3 Obs. Astronómico Naos 3	SCT (D=279; f=10)	CMOS ZWO 183
NA4 Obs. Astronómico Naos 4	Newtonian (D=200mm; f=5.0)	CMOS ZWO ASI 17
OM2 Obs. Astr.Vuelta por el Universo 2	Newtonian (D=200mm; f=5.0)	CMOS POA Neptune-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.

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