

ASTEROID PHOTOMETRY FOR 15 MAIN-BELT ASTEROIDS

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Synodic rotation periods and amplitudes are reported for 1068 Nofretete, 1818 Brahms, 1942 Jablunka, 2097 Galle, 2098 Zyskin, 2125 Karl-Ontjes, 3237 Victorplatt, 4583 Lugo, 5256 Farquhar, 7842 Ishitsuka, 8556 Jana, (11564) 1993 FU41, (16009) 1999 CM8, (35539) 1998 FJ91, and (65127) 2002 CG63.

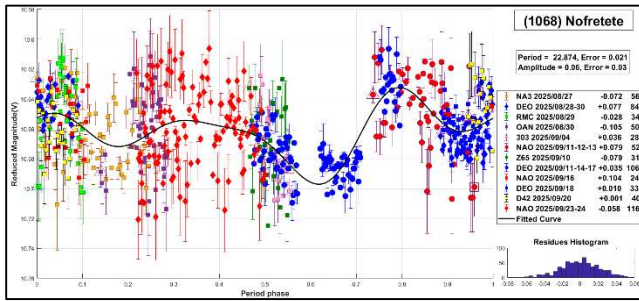
The periods and amplitudes of asteroid lightcurves presented in this paper are the product of collaborative work by the GORA (Grupo de Observadores de Rotaciones de Asteroides) group. In all the studies, we have applied relative photometry assigning V magnitudes to the calibration stars.

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).

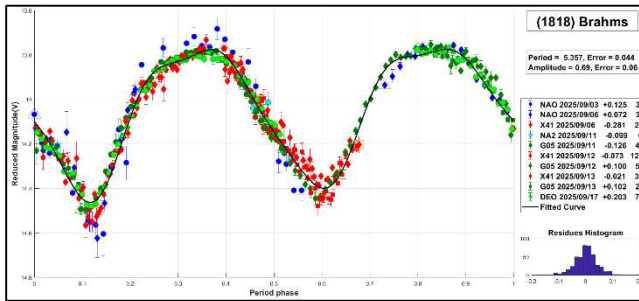
Below, we present the results for each asteroid studied. The lightcurve figures contain the following information: the estimated period and period error and the estimated amplitude and amplitude error. In the reference boxes, the columns represent, respectively, the marker, observatory MPC code, or - 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.

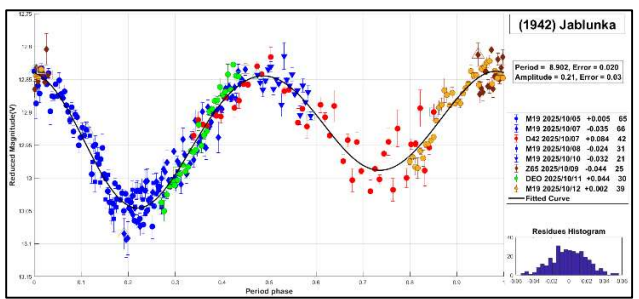
1068 Nofretete is a main-belt asteroid discovered in 1926 by E. Delporte with an estimated diameter of 21.346 km. A previously reported rotational period for this asteroid is $P = 6.15$ h (Binzel, 1987). In this work, we propose a longer period of $P = 22.874 \pm 0.021$ h, with an amplitude of $\Delta m = 0.06 \pm 0.03$ mag.



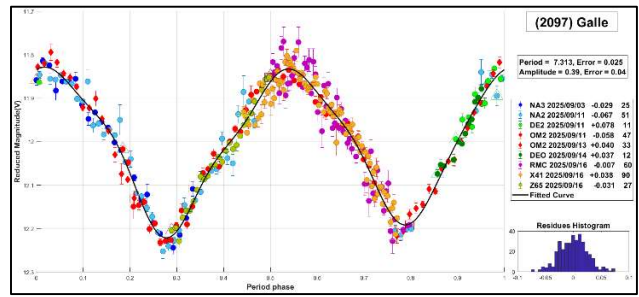
1818 Brahms is a main-belt asteroid with an estimated diameter of 13.747 km. It was discovered in 1939 by K. Reinmuth. We couldn't find a reported period for this object in the literature. In this paper, we present full light curve coverage. We measured a period of $P = 5.357 \pm 0.044$ h with $\Delta m = 0.69 \pm 0.06$ mag.



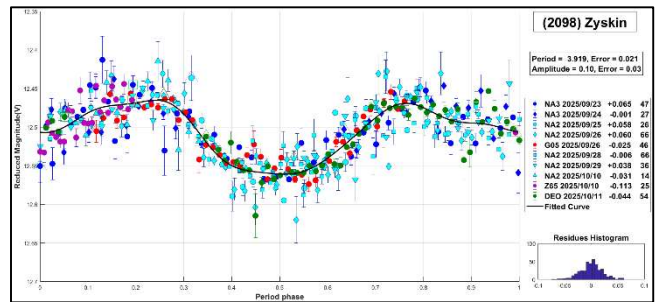
1942 Jablunka is a main-belt asteroid discovered in 1972 by L. Kojoutek. It is a member of the Phocaea family (Nesvorny et al., 2015) with an estimated diameter of 16.766 km. The more recent period published in the literature corresponds to $P = 8.91158$ h (Durech et al., 2016). Our period, $P = 8.902 \pm 0.020$ h, agrees with Durech et al.



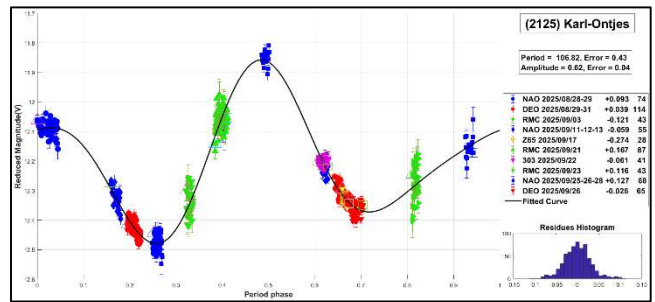
2097 Galle is a main-belt asteroid with an estimated diameter of 26.330 km that was discovered in 1953 by K. Reinmuth. The reported rotational period for this asteroid is $P = 26.330$ h (Yeh et al., 2020). In this work, we propose a shorter period of $P = 7.313 \pm 0.025$ h with $\Delta m = 0.39 \pm 0.04$ mag.



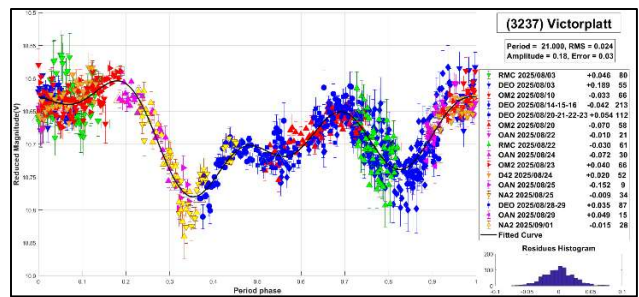
2098 Zyskin is a main-belt asteroid discovered in 1972 by L.V. Zhuravleva. It is a member of the Vesta family (Nesvorny et al., 2015) with an estimated diameter of 12.731 km. The reported rotational period for this asteroid is 3.92 h (Waszczak et al., 2015). We measured a period of $P = 3.919 \pm 0.021$ h, with $\Delta m = 0.10 \pm 0.03$ mag.



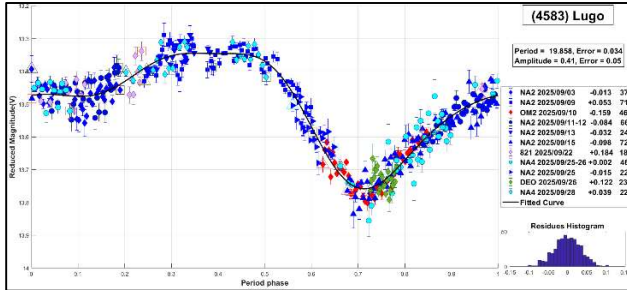
2125 Karl-Ontjes is a main-belt asteroid with an estimated diameter of 11.019 km that was discovered in 1960 at Palomar. No published rotational periods for this asteroid were found in the literature. In this work, we propose a period of $P = 106.82 \pm 0.43$ h with $\Delta m = 0.62 \pm 0.04$ mag.



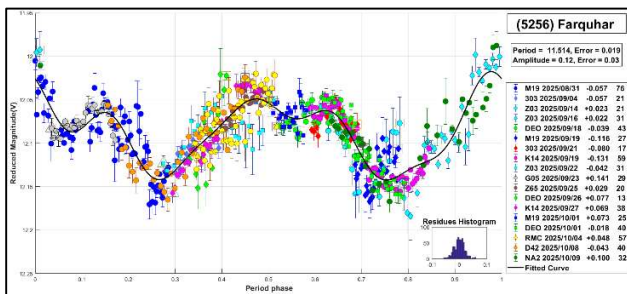
3237 Victorplatt is a main-belt asteroid discovered in 1984 by J. Platt. It belongs to the Eos family (Nesvorny et al., 2015) and has an estimated diameter of 27.751 km. The reported rotational period for this asteroid is $P = 10.36$ h (Behrend, 2010web). Our observations suggest a longer period, yielding a value of $P = 21.000 \pm 0.024$ h with $\Delta m = 0.18 \pm 0.03$ mag.



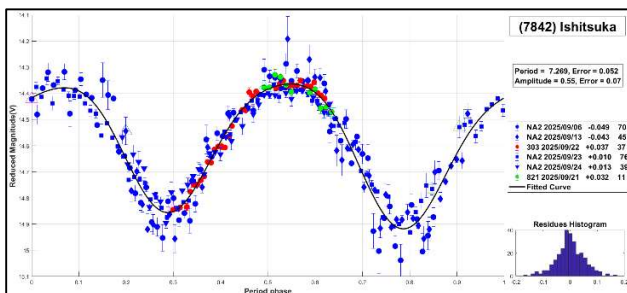
4583 Lugo is a main-belt asteroid discovered in 1989 at Smolyan. It is classified as a X-type asteroid according to the SDSS-based Asteroid Taxonomy (Hasselmann et al., 2012), with a diameter of 13.761 km. A previously reported rotational period for this asteroid is 12 h (Behrend, 2021web). Our measurements indicate a slightly longer period of $P = 19.858 \pm 0.034$ h, with a lightcurve amplitude of $\Delta m = 0.41 \pm 0.05$ mag.



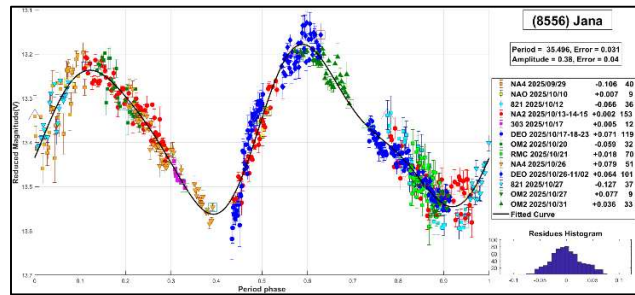
5256 Farquhar is a main-belt asteroid that was discovered in 1988 by Helin-Mikolaj.-Coker and has an estimated diameter of 11.990 km. A rotational period of $P = 11.504$ h was previously reported for this asteroid (Farfan et al., 2022). Our results are consistent with this rotation period, giving a value of $P = 11.514 \pm 0.019$ h and an amplitude of $\Delta m = 0.12 \pm 0.03$ mag.



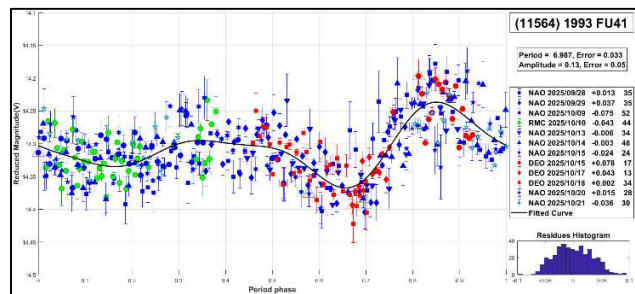
7842 Ishitsuka is a main-belt asteroid that was discovered in 1994 by K. Endate and K. Watanabe, with an estimated diameter of 3.710 km. For this asteroid, we could not find any published rotational periods in the literature. In this work, we propose a period of $P = 7.269 \pm 0.052$ h with $\Delta m = 0.55 \pm 0.07$ mag.



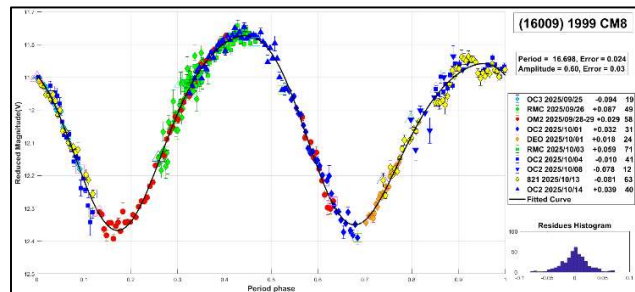
8556 Jana is a main-belt asteroid that was discovered in 1995 by Z. Morave and has an estimated diameter of 7.343 km. For this asteroid as well, we could not find published periods in the literature. In this work, we propose a period of $P = 35.496 \pm 0.031$ h with $\Delta m = 0.38 \pm 0.04$ mag.



(11564) 1993 FU41 is a main-belt asteroid with an estimated diameter of 4.997 km that was discovered in 1993 by UESAC at La Silla. Based on the SDSS taxonomy (Hasselmann et al., 2012), it is classified as a C-type and belongs to the Flora or Baptistina family (Nesvorný et al., 2015). We couldn't find a reported period for this object in the literature. We measured a period of $P = 6.987 \pm 0.033$ h with $\Delta m = 0.13 \pm 0.05$ mag.



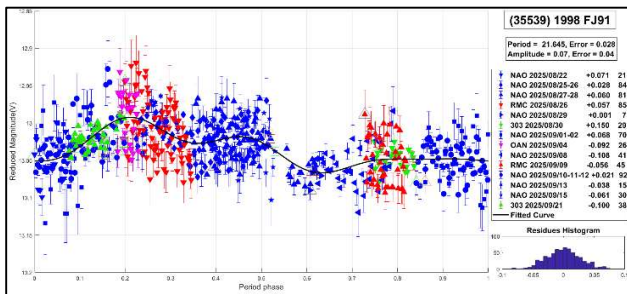
(16009) 1999 CM8 is a main-belt asteroid with an estimated diameter of 10.143 km; it was discovered in 1999 by T. Kobayashi. It is a member of the Maria family (Nesvorný et al., 2015). The more recent period published in the literature corresponds to $P = 16.7$ h (Waszczak et al., 2015). Our period, $P = 16.698 \pm 0.024$ h, agrees with the one measured by Waszczak et al.



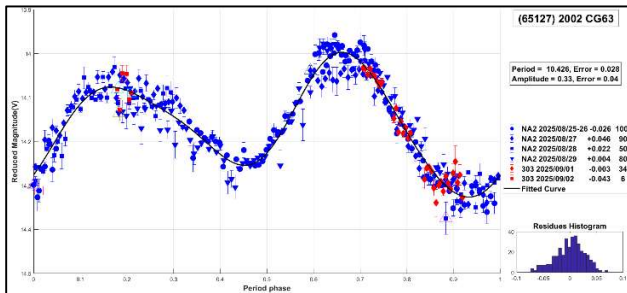
(35539) 1998 FJ91 is a main-belt asteroid with an estimated diameter of 5.877 km. It is classified as an S-type asteroid according to the SDSS-based Asteroid Taxonomy (Hasselmann et al., 2012). It was discovered in 1999 by LINEAR. We couldn't find a reported period for this object in the literature. We propose a period of $P = 21.645 \pm 0.028$ h with $\Delta m = 0.07 \pm 0.04$ mag.

Number	Name	2025/ mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1068	Nofretete	08/27-09/24	*05.9,05.1	348	3	22.874	0.021	0.06	0.03	MB-O
1818	Brahms	09/03-09/18	13.2,04.6	358	5	5.357	0.044	0.69	0.06	MB-I
1942	Jablunka	10/05-10/12	12.3,13.3	14	18	8.902	0.020	0.21	0.03	Pho
2097	Galle	09/03-09/16	01.2,06.3	341	2	7.313	0.025	0.39	0.04	MB-O
2098	Zyskin	09/23-10/12	*05.8,06.3	9	5	3.919	0.021	0.10	0.03	Vesta
2125	Karl-Ontjes	08/28-09/28	*08.9,05.6	353	1	106.82	0.43	0.62	0.04	MB-O
3237	Victorplatt	08/03-09/02	*03.9,09.4	317	7	21.000	0.024	0.18	0.03	Eos
4583	Lugo	09/03-09/28	*01.3,13.1	343	0	19.858	0.034	0.41	0.05	MB-I
5256	Farquhar	08/31-10/09	*16.6,08.5	5	13	11.514	0.019	0.12	0.03	MB-I
7842	Ishitsuka	09/06-09/24	*10.8,01.3	359	2	7.269	0.052	0.55	0.07	MB-I
8556	Jana	09/29-10/31	*13.0,09.1	25	-8	35.496	0.031	0.38	0.04	MB-O
11564	1993 FU41	08/28-10/21	*04.2,10.5	11	-1	6.987	0.033	0.13	0.05	Levin
16009	1999 CM8	09/25-10/14	*08.4,08.7	9	-11	16.698	0.024	0.60	0.03	Maria
35539	1998 FJ91	08/22-09/21	*04.5,15.0	333	-8	7.313	0.025	0.39	0.04	MB-O
65127	2002 CG63	08/25-09/02	11.2,08.0	340	-10	10.426	0.028	0.33	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 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-O: main-belt outer; MB-I: main-belt inner; Pho: 25 Phocaea; Vesta: 4 Vesta; Eos: 221 Eos; Levin: 2076 Levin; Maria: 170 Maria; MB-M: main-belt middle.



65127 2002 CG63 is a main-belt asteroid with an estimated diameter of 8.813 km. It was discovered in 2002 by LINEAR. We couldn't find a reported period for this object in the literature. We propose a period of $P = 10.426 \pm 0.028$ h with $\Delta m = 0.33 \pm 0.04$ 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, and Matías Martini for his *CalculadorMDE_v0.2* used for generating ephemerides used in the planning stage of the observations. 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.

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Observatory	Telescope	Camera
303 Obs.Astr.Nacional Llano del Hato	Newtonian (D=1000mm; f=5.5)	CCD FLI PL4240
821 Est.Astrof.Bosque Alegre	Newtonian (D=1540mm; f=4.9)	CCD APOGEE Alta U9
D42 OsservatorioAstronomico Piero Angela	SCT (D=300mm; f=6.2)	CMOS Touptek 2600 KMA
G05 Obs.Astr.Giordano Bruno	SCT (D=203mm; f=6.3)	CCD Atik 420 m
K14 Obs.Astr.de Sencelles	Newtonian (D=250mm; f=4.0)	CCD SBIG ST-7XME
M19 Osservatorio Explorer	RCT (D=304 mm; f=6,5)	CCD Moravian G2 4000
X41 ObservatorioProtón-Protón	Newtonian (D=250mm; f=5.0)	CMOS ZWO ASI120MINI MM
Z03 Obs.Astr.RíoCofio	SCT (D=254mm; f=6.3)	CCD SBIG ST-8XME
Z65 Obs.Astr.Corgas	Newtonian (D=310mm; f=4.8)	CMOS ZWO ASI 294 MM
DE0 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
NAO Obs.Astr.Naos	Newtonian (D=250mm; f=4.0)	CMOS ZWO 183
NA2 Obs.Astr.Naos 2	Newtonian (D=200mm; f=5.0)	CMOS ZWO ASI 174
NA3 Obs.Astr.Naos 3	SCT (D=279; f=10)	CMOS QHY 163M
NA4 Obs.Astr.Naos 4	Newtonian (D=200mm; f=5.0)	CMOS ZWO ASI 174
OAN Obs.Astr.Nacional Llano del Hato	Cámara Schmidt (D=1000mm; f=3.0)	CMOS Fujifilm GFX 50R
OC2 Obs.Astr.de Carlos Ambrosioni	SCT (D=150mm; f=6.7)	CCD FLI 8300
OC3 Obs.Astr.de Carlos Ambrosioni	SCT (D=279mm; f=7)	CCD SBIG ST8XME
OM2 Obs.Astr.Vueltoporel 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.