

## ROTATION PERIODS AND LIGHTCURVE AMPLITUDES FOR ELEVEN MAIN-BELT AND ONE MARS-CROSSING ASTEROID

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Synodic rotation periods and amplitudes are reported for:  
845 Naema, 981 Martina, 1365 Henyey, 2232 Altaj,  
2675 Tolkien, 2905 Plaskett, 3066 McFadden,  
3507 Vilas, 4838 Billmclaughlin, 5778 Jurafrance,  
6914 Becquerel, and 7747 Michalowski.

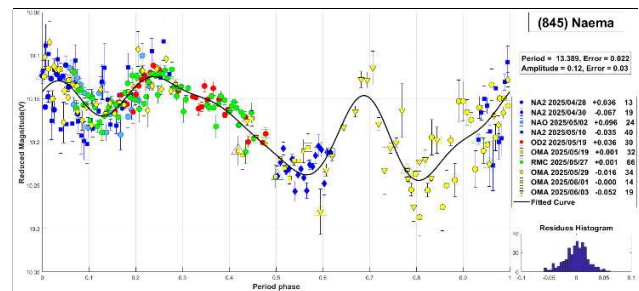
The periods and amplitudes of asteroid lightcurves presented in this paper are the product of collaborative work by the GORA (Grupo de Observadores de Rotaciones de Asteroides) group. In all the studies, we have applied relative photometry assigning  $V$  magnitudes to the calibration stars.

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).

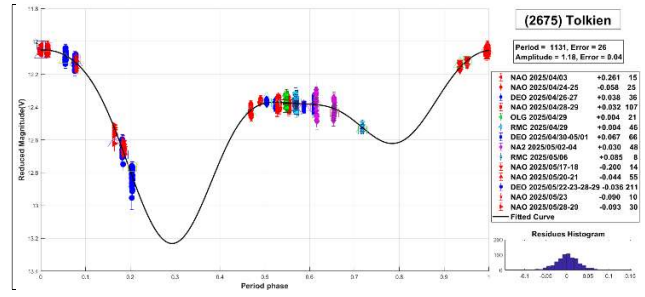
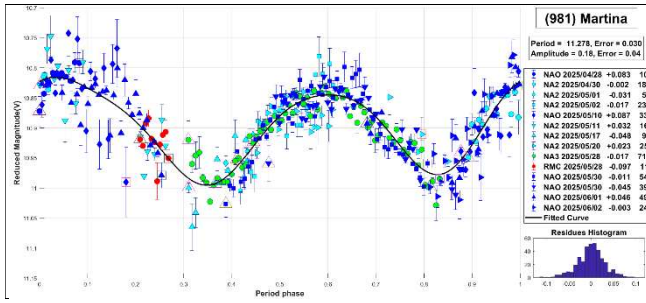
Below, we present the results for each asteroid studied. The lightcurve figures contain the following information: the estimated period and period error and the estimated amplitude and amplitude error. In the reference boxes, the columns represent, respectively, the marker, observatory MPC code, or -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

**(845) Naema.** This main-belt asteroid was discovered in 1916 by M. Wolf. Classified as a C-type asteroid according to the SMASSII taxonomy (Xu et al., 1995; Bus and Binzel, 2002), it is the parent body of the Naema family (Nesvorný et al., 2015). Its estimated diameter is 52.677 km. A previously reported rotational period for this asteroid is  $P = 20.892$  h (Bembrick et al., 2008). In this work, we propose a shorter period of  $P = 13.389 \pm 0.022$  h, with an amplitude of  $\Delta m = 0.12 \pm 0.03$  mag.

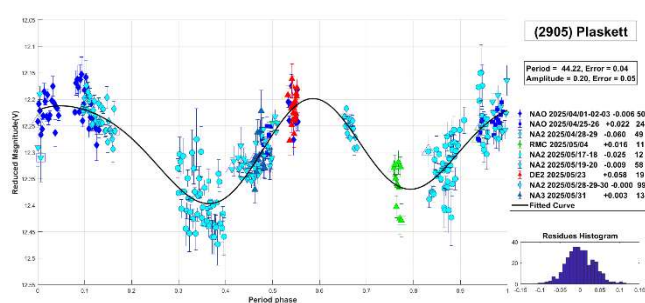
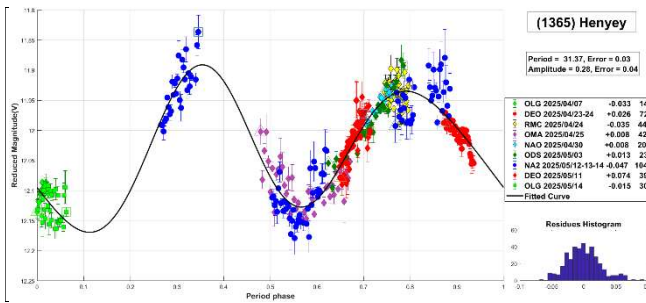


**981 Martina.** It is a main-belt asteroid discovered in 1917 by S. Belyavskij. It is a member of the Themis family (Nesvorný et al., 2015), with a diameter of 11.267 km. It is a C-type asteroid in the SMASSII spectral type scheme (Xu et al., 1995; Bus and Binzel, 2002). The reported rotational period for this asteroid is 11.267 h (Erasmus et al., 2020). We measured a period of  $P = 11.278 \pm 0.030$  h, with  $\Delta m = 0.18 \pm 0.04$  mag.



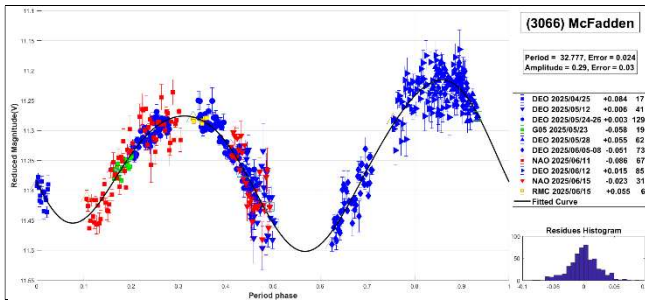
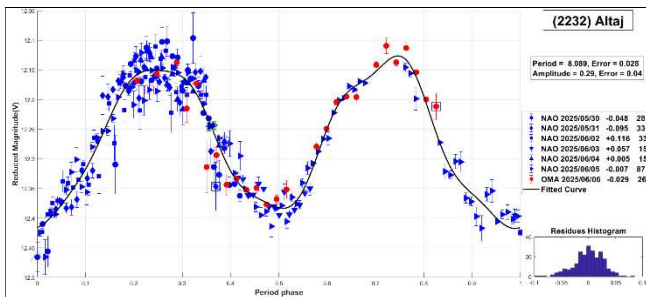
**1365 Henyey.** Henyey is a main-belt asteroid discovered in 1928 by M. Wolf. It is a member of the Flora family (Nesvorny et al., 2015), with a diameter of 10.958 km. A previously reported rotational period for this asteroid is  $P = 18.986$  h (Klingsmith III et al., 2013). In this work, we propose a longer period of  $P = 31.37 \pm 0.03$  h, with an amplitude of  $\Delta m = 0.28 \pm 0.04$  mag.

**2905 Plaskett.** This main-belt asteroid was discovered in 1982 by E. Bowell. Based on the SMASSII taxonomy (Xu et al., 1995; Bus and Binzel, 2002), it is classified as an S-type and belongs to the Gefion family (Nesvorny et al., 2015). The asteroid has an estimated diameter of 10.224 km. For this asteroid, we could not find published periods in the literature. In this work, we propose a period of  $P = 44.22 \pm 0.04$  h with  $\Delta m = 0.20 \pm 0.05$  mag.



**2232 Altaj.** Altaj is a main-belt Asteroid with a diameter of 11.78 km, discovered in 1969 by B.A. Burnasheva. The reported rotational period for this asteroid is 8.089 h (Marchini et al., 2022). We also measured a period of  $P = 8.089 \pm 0.028$  h, with  $\Delta m = 0.29 \pm 0.04$  mag.

**3066 McFadden.** Asteroid 3066 McFadden is a main-belt asteroid with a diameter of 13.526 km, discovered in 1984 by E. Bowell. The more recent period published in the literature corresponds to  $P = 32.7314$  h (Pál et al., 2020). Our period  $P = 32.777 \pm 0.024$  h agrees with the one measured by Pál and collaborators.

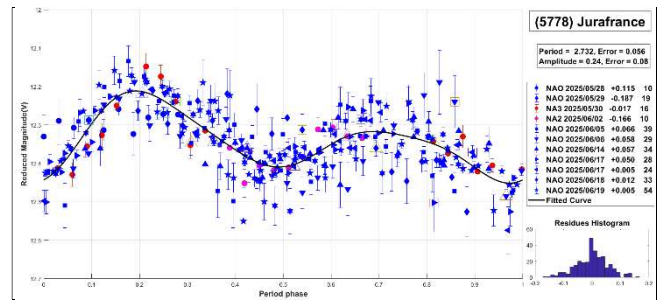
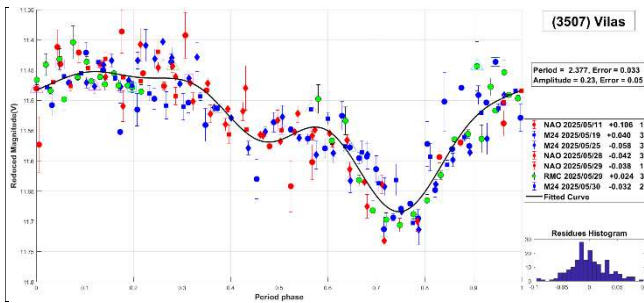


**2675 Tolkien.** Tolkien is a main-belt asteroid discovered in 1989 by M. Watt. It is classified as a S-type asteroid according to the SMASSII spectral type scheme (Xu et al., 1995; Bus and Binzel, 2002), with a diameter of 10.960 km. The reported rotational period for this asteroid is  $P = 1060$  h (Durkee et al., 2011). In this work, we propose an even longer period of  $P = 1131 \pm 26$  h with  $\Delta m = 1.18 \pm 0.04$  mag.

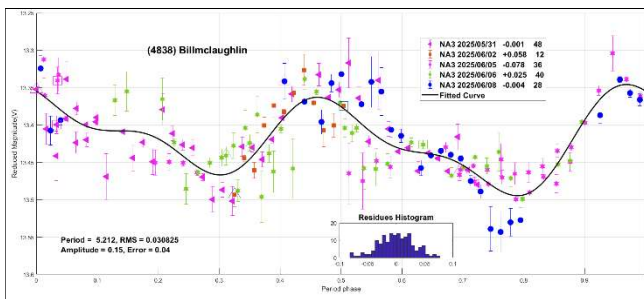
**3507 Vilas.** Main-belt Asteroid Vilas was discovered in 1982 by E. Bowell, with a diameter of 24.917 km. Classified as a Ch-type asteroid according to the SMASS II taxonomy (Xu et al., 1995; Bus and Binzel, 2002), it is a member of the Themis family (Nesvorny et al., 2015). The reported rotational period for this asteroid is  $P = 3.959$  h (Wisniewski et al., 1997). Our observations also support the short-period hypothesis, yielding a value of  $P = 2.377 \pm 0.033$  h with  $\Delta m = 0.26 \pm 0.05$  mag.

Number	Name	yy/mm/dd-yy/mm/dd	Phase	L <sub>PAB</sub>	B <sub>PAB</sub>	Period(h)	P.E.	Amp	A.E.	Grp
845	Naema	25/04/28-25/06/04	*04.5,09.8	229	-2	13.389	0.022	0.12	0.03	Naem
981	Martina	25/04/28-25/06/03	*07.7,05.3	239	-1	11.278	0.030	0.18	0.04	Them
1365	Heney	25/04/07-25/05/15	04.4,21.1	197	-6	31.37	0.03	0.28	0.04	Matt
2232	Altaj	25/05/30-25/06/06	*02.8,01.9	253	3	8.089	0.028	0.29	0.04	MB-M
2675	Tolkien	25/04/03-25/05/29	*10.4,16.2	213	-2	1131	26	1.18	0.04	MB-I
2905	Plaskett	25/04/01-25/05/31	*10.8,15.4	215	-5	44.22	0.04	0.20	0.05	MB-O
3066	McFadden	25/04/25-25/06/15	*12.9,13.1	241	18	32.777	0.024	0.29	0.03	MB-I
3507	Vilas	25/05/11-25/05/30	08.6,00.9	249	2	2.377	0.033	0.23	0.05	Them
4838	Billmclaughlin	25/05/31-25/06/08	13.8,10.4	269	9	5.215	0.029	0.16	0.04	MB-I
5778	Jurafrance	25/05/28-25/06/20	*05.2,09.1	252	-8	2.732	0.056	0.24	0.08	Maria
6914	BecquereI	25/03/23-25/05/14	*11.3,17.4	203	-2	16.469	0.035	0.37	0.05	MB-I
7747	Michalowski	25/06/09-25/06/21	11.7,04.6	274	-2	4.496	0.063	0.50	0.09	M-cros

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<sub>PAB</sub> and B<sub>PAB</sub> 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). Naem: 845 Naema; Them: 24 Themis; Matt: 883 Matteredania; MB-M: main-belt middle; MB-I: main-belt inner; MB-O: main-belt outer; Maria: 170 Maria; M-cros: Mars-crosser.

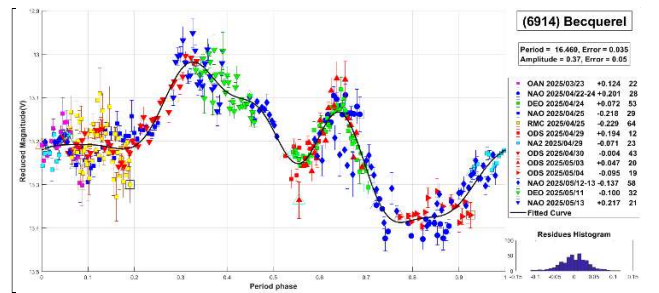


**4838 Billmclaughlin.** This main-belt asteroid was discovered in 1989 by E.F. Helin and has an estimated diameter of 10.251 km. It is classified as an Xc-type asteroid based on the SMASS II taxonomy (Xu et al., 1995; Bus and Binzel, 2002). A rotational period of  $P = 5.199$  h was previously reported for this asteroid (Albers et al., 2010). Our results are consistent with a short rotation period, giving a value of  $P = 5.212 \pm 0.031$  h and an amplitude of  $\Delta m = 0.15 \pm 0.04$  mag.

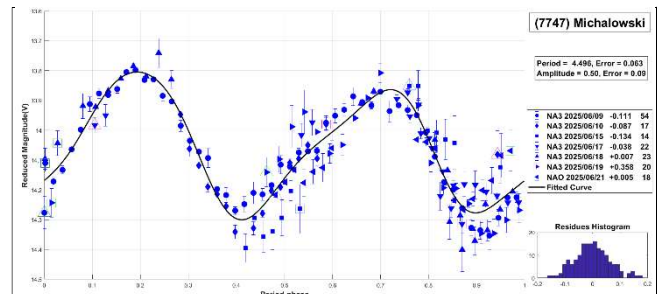


**5778 Jurafrance.** Main-belt asteroid 5778 was discovered in 1984 by E.W. Elst. It belongs to the Maria family (Nesvorny et al., 2015) and has an estimated diameter of 10.206 km. A previously reported rotational period for this asteroid is 4.14 h (Aznar, 2013web). Our measurements indicate a slightly shorter period of  $P = 2.732 \pm 0.056$  h, with a lightcurve amplitude of  $\Delta m = 0.24 \pm 0.08$  mag.

**6914 BecquereI.** Asteroid 6914 orbits in the main belt and was discovered in 1992 by C.S. Shoemaker. For this asteroid, we could not find any published rotational periods in the literature. In this work, we propose a period of  $P = 16.469 \pm 0.035$  h with  $\Delta m = 0.37 \pm 0.05$  mag.



**7747 Michalowski.** This Mars-crossing asteroid was discovered in 1987 by E. Bowell, with an estimated diameter of 4.596 km. A previously reported rotational period for this asteroid is  $P = 4.5$  h (Waszczak et al., 2015). Our observations also support the short-period interpretation, yielding a value of  $P = 4.496 \pm 0.063$  h with a lightcurve amplitude of  $\Delta m = 0.50 \pm 0.09$  mag.



Observatory	Telescope	Camera
G05 Obs.Astr.Giordano Bruno	SCT (D=203mm; f=6.3)	CCD Atik 420 m
M24 Oss.Astr.LaMacchina del Tempo	RCT (D250mm; f=8.0)	CMOS ZWO ASI 1600MM
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
OAN Obs.Astr.Nacional Llano del Hato	Cámara Schmidt (D=1000mm; f=3.0)	CMOS Fujifilm GFX 50R
ODS Obs.Astr.de Damián Scotta 1	Newtonian (D=300mm; f=4.0)	CMOS QHY 174M
OD2 Obs.Astr.de Damián Scotta 2	Newtonian (D=250mm; f=4.0)	CCD SBIG STF-8300M
OLG Observatorio Las Grutas	Newtonian (D=200mm; f=5.0)	CCD ATIK 414EX MONO
OMA Obs.Astr.Vueltaporel Universo	Newtonian (D=150mm; 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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