ASTEROID PHOTOMETRY OF SEVEN ASTEROIDS

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(MPC I19) - Tanti (Córdoba-Argentina)

Observatorio de Sencelles
(MPC K14) - Sencelles (Mallorca-Islas Baleares-España)

Osservatorio Astronomico “La Macchina del Tempo”
(MPC M24) - Ardore Marina (Reggio Calabria-Italia)

Observatorio Los Cabezones
(MPC X12) - Santa Rosa (La Pampa-Argentina)

Observatorio Galileo Galilei
(MPC X31) - Oro Verde (Entre Ríos-Argentina)

Observatorio Antares
(MPC X39) - Pilar (Buenos Aires-Argentina)

Observatorio Río Cofio
(MPC Z03) - Robledo de Chavela (Madrid-España)

Specola “Giuseppe Pustorino 3”
(GORA GC3) - Palizzi Marina (Reggio Calabria-Italia)

Observatorio de Ariel Stechina 2
(GORA OA2) - Reconquista (Santa Fe-Argentina)

Observatorio de Damián Scotta 1
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Observatorio de Damián Scotta 2
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Synodic rotation periods and amplitudes are reported for: 957 Camelia, 1030 Vitja, 1135 Colchis, 1903 Adzhimushkaj, (97034) 1999 UK7 A and B components, (97514) 2000 DL1, and (199145) 2005 YY128.

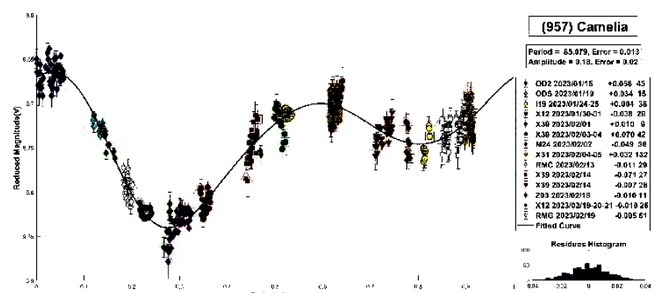
The periods and amplitudes of asteroid lightcurves presented in this paper are the product of collaborative work by the GORA (Grupo de Observadores de Rotaciones de Asteroides) group. In all the studies, we have applied relative photometry assigning V magnitudes to the calibration stars.

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).

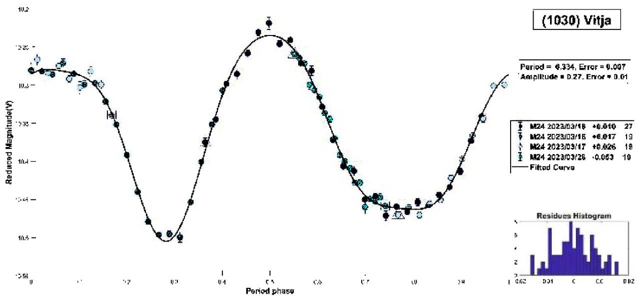
Below, we present the results for each asteroid studied. The lightcurve figures contain the following information: the estimated period and period error and the estimated amplitude and amplitude error. In the reference boxes, the columns represent, respectively, the marker, observatory MPC code, or -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

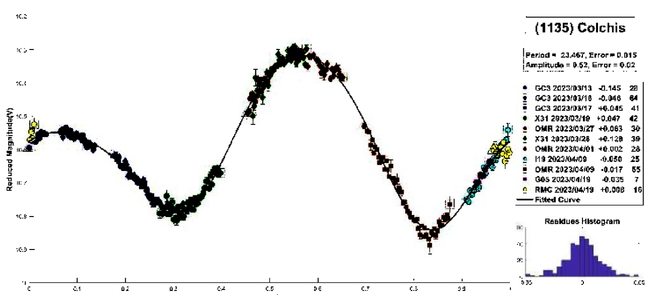
957 Camelia. It is a main-belt asteroid. It was discovered in 1921 by K. Reinmuth. Two authors measured a short period for this asteroid: P = 5.391 ± 0.02 h (Warner, 2001) and P = 8.894 ± 0.004 h (Behrend, 2020web). On the other hand, Polakis (2022a) published a longer period of 85.05 ± 0.11 h. The results we obtained are P = 85.079 ± 0.013 h and Δm = 0.18 ± 0.02 mag. Our period well agrees with the one measured by Polakis. The diagram published by Polakis has the virtue of having extended light curves of many hours each. The light curve presented in this paper has the advantage of showing several light curves with linked nights.



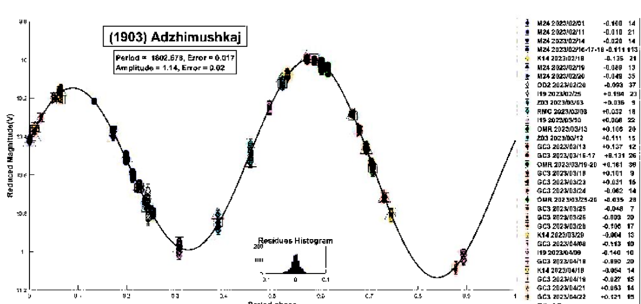
1030 Vitja. It is a main-belt asteroid. It was discovered in 1924 by V. Albitzkig. The three most recent periods published in the literature correspond to P = 6.332 ± 0.001 h (Ferrero, 2014), P = 6.336378 ± 0.000002 h (Ďurech et al., 2019), and P = 6.346 ± 0.008 h (Polakis. 2022b). We have determined a period of 6.334 ± 0.007 h, which is consistent with those previous results. Notably, we present full coverage lightcurve in this work, in contrast to those previously published.



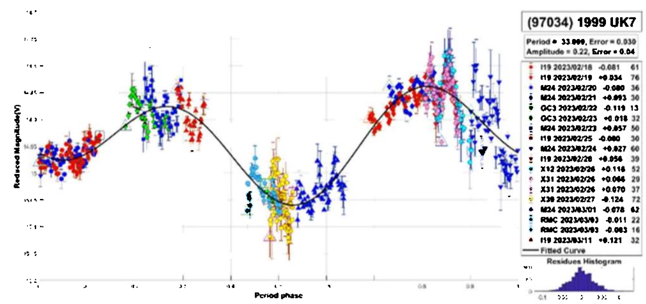
1135 Colchis. It is a main-belt asteroid. It was discovered in 1929 by G. Neujmin. Recent periods in the literature (Hanus et al., 2016; Behrend, 2016web) coincide with the period formerly measured by Hanuš et al., (2016): P = 23.483 h. However, these authors did not present lightcurves with full coverage. In this paper, we present full lightcurve coverage, thus giving confidence to our result. We measured a period of 23.467 ± 0.015 h with Δm = 0.52 ± 0.02 mag.

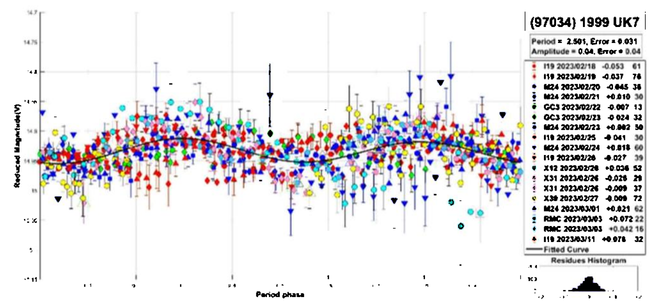


1903 Adzhimushkaj. It is a main-belt asteroid. It was discovered in 1972 by T. Neujmin. We found in the literature two rather different periods calculated for this object: P = 46.65685 ± .0006 h (Ďurech et al., 2020) and P = 1783.8 ± 3.6 h with Δm = 1.17 ± 0.06 mag (Polakis, 2022c). Our period P = 1802.678 ± 0.017 with Δm = 1.14 ± 0.02 mag agrees with the one measured by Polakis. This object is the slowest rotator measured by our group. It was achieved using 668 images taken between February 1 and March 29, 2023. Moreover, its period of about 75 Earth days is one of the slowest known so far by the scientific community (according to the Asteroid Lightcurve Photometry Database).

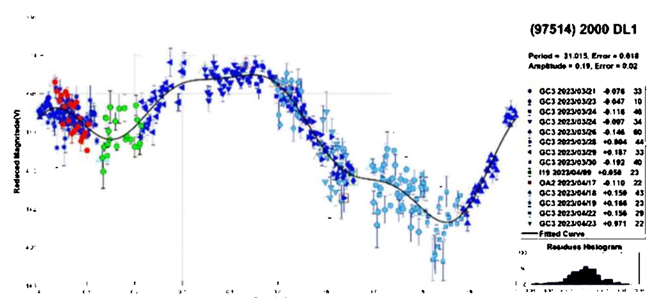


(97034) 1999 UK7 (A & B). It is a Mars-crossing asteroid. It was discovered in 2000 by LINEAR. On March 6, 2023, it had a close encounter with our planet, with a minimum distance of 0.38 AU. We present two diagrams for this asteroid: one of higher amplitude and period, the second of lower amplitude and period, whose curve we detect mounted on the first one. We observed a pattern with two peaks and two valleys in the span of 2.5 h, accompanied by increases or decreases in brightness that showed that we were in the presence of a period of greater amplitude and period. This behavior led us to assume binarity, as confirmed by telegram CBET 5232: 20230312. We obtained a second period of 33.009 ± 0.003 h with Δm = 0.22 ± 0.04 mag. On the other hand, for the primary, we measured a period of 2.501 ± 0.031 h with Δm = 0.04 ± 0.04 mag.

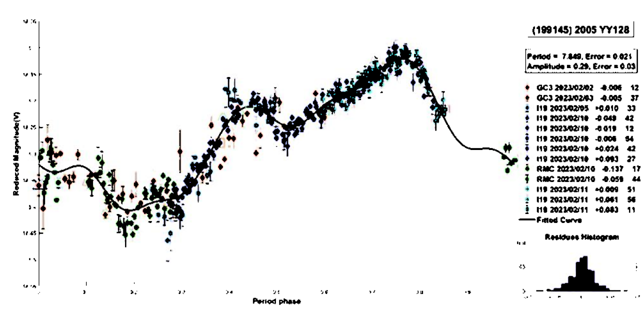




(97514) 2000 DL1. It is a Mars-crossing asteroid. It was discovered in 2000 by LINEAR. We could not find a reported period for this object in the literature. In this paper, we present full lightcurve coverage. We measured a period of 31.015 ± 0.018 h with Δm = 0.19 ± 0.02 mag.



(199145) 2005 YY128. It is an Apollo and potentially hazardous asteroid. It was discovered in 2005 by Spacewatch. On February 16, 2023, it had a close encounter with our planet, with a minimum distance of 0.08 AU. For this asteroid, we could not find a published period in the literature, either. In this work, we propose a period of P = 7.849 ± 0.021 h with Δm = 0.29 ± 0.03 mag.



Number	Name	yy/ mm/dd- yy/ mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
957	Camelia	23/01/15-23/02/21	*11.3,10.4	135	-19	85.079	0.013	0.18	0.02	MB-O
1030	Vitja	23/03/18-23/03/29	12.3,08.4	206	4	6.334	0.007	0.27	0.01	MB-O
1135	Colchis	23/03/13-23/04/20	*3.0,11.6	179	-1	23.467	0.015	0.52	0.02	MB-M
1903	Adzhimushkaj	23/02/01-23/04/22	*2.4,20.1	138	2	1802.678	0.017	1.14	0.02	Eos
97034	1999 UK7 (A)	23/02/18-23/03/11	*17.7,14.6	167	-5	33.009	0.030	0.22	0.04	M-cr
97034	1999 UK7 (B)	23/02/18-23/03/11	*17.7,14.6	167	-5	2.501	0.031	0.04	0.04	M-cr
97514	2000 DL1	23/03/21-23/04/23	10.5,26.9	174	1	31.015	0.018	0.19	0.02	M-cr
199145	2005 YY128	23/02/02-23/02/11	*21.8,26.9	149	-5	7.849	0.021	0.29	0.03	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. LPAB and BPAB 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-M: main-belt middle, Eos: 221 Eos, M-cr: Mars-crosser, NEA: near-Earth asteroids.

Observatory	Telescope	Camera
G05 Obs.Astr.Giordano Bruno	SCT (D=203mm; f=6.3)	CCD Atik 420 m
I19 Obs.Astr.El Gato Gris	SCT (D=355mm; f=10.6)	CCD SBIG STF-8300M
K14 Obs.Astr.de Sencelles	Newtonian (D=250mm; f=4.0)	CCD SBIG ST-7XME
M24 Oss.Astr.La Macchina del Tempo	RCT (D250mm; f=8.0)	CMOS ZWO ASI 1600MM
X12 Obs.Astr.Los Cabezones	Newtonian (D=200mm; f=5.0)	CMOS QHY 174M
X31 Obs.Astr.Galileo Galilei	RCT ap (D=405mm; f=8.0)	CCD SBIG STF-8300M
X39 Obs.Astr.Antares	Newtonian (D=250mm; f=4.72)	CCD QHY9 Mono
Z03 Obs.Astr.Río Cofio	SCT (D=254mm; f=6.3)	CCD SBIG ST-8XME
GC3 Specola Giuseppe Pustorino 3	RCT (D=400mm; f=5.7)	CCD Atik 383L+Mono
OA2 Obs.Astr.de Ariel Stechina 2	Newtonian (D=305mm; f=5.0)	CMOS QHY 174M
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
OMR Obs.Astr.Municipal Reconquista	Newtonian (D=254mm; f=4.0)	Player One Ceres-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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We want to thank Julio Castellano as we used his *FotoDif* program for preliminary analyses, Fernando Mazzone for his *Periods* program, used in final analyses, and Matías Martini for his *CalculadorMDE_v0.2* used for generating ephemerides used in the planning stage of the observations. This research has made use of the Small Bodies Data Ferret (*http://sbn.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.

We dedicate this work to our dear Aldo Mottino. A great person, researcher at CONICET, renowned astrophotographer in our amateur community in our country, and member and co-founder of GORA. Thank you for sharing your love for astronomy with us over these years. May your memory and your passion be with us always.

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LIGHTCURVES FOR KORONIS FAMILY OBJECTS (2498) TSESEVICH AND (2742) GIBSON

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We present lightcurves for (2498) Tsesevich and (2742) Gibson during 2022. Observations of Tsesevich made at the Union College Observatory are consistent with the previous period (Wilkin and Schechter, 2022). Observations of Gibson on two nights at Chi-4 yielded a partial lightcurve which we combined with ATLAS sparse survey data to obtain a doubly-periodic composite with period 20.60±0.01 h.

We continue our project (Wilkin et al., 2022; Wilkin et al., 2023; Crowley and Wilkin, 2023) to obtain rotation periods and lightcurves for Koronis family asteroids to facilitate subsequent shape and spin solutions. Asteroid spins are subject to YORP torques (Rubincam, 2000) due to interaction with sunlight and subsequent thermal emission. Observations of members of a common family avoid difficulties of interpreting heterogenous samples (see, e.g., Slivan et al., 2008; 2023).

Observation planning was performed using the *Koronisfamily.com* webtool (Slivan, 2003). Telescope and camera properties are given in Table I. Bias, dark, and flat field corrections and subsequent photometry were performed in *AstroImageJ* (Collins et al., 2017). Corrections for light-travel time, unit distance, and solar phase angle were applied using ephemerides from the NASA Horizons app assuming a slope parameter G=0.23 typical for Koronis family members (Slivan, personal communication).

<u>(2498) Tsesevich</u>. Period determinations and lightcurves have been published by Fauerbach and Brown (2019) and Wilkin and Schechter (2022). We performed imaging observations at the Union College Observatory on two nights in September, 2022 with 240s exposure time, R filter and 2×2 binning. Significant light pollution was present due to nearby athletic facilities, and images from a third night had to be rejected. Magnitude values for Sep 24 were shifted relative to those of Sep 16 to obtain a self-consistent composite. Our resulting lightcurve is consistent with the period obtained from the previous apparition (Wilkin and Schechter, 2022), assuming that the lightcurve is doubly-periodic. The amplitude 0.26 mag was the same as in the 2021 apparition. We also examined ATLAS sparse survey data (Tonry et al., 2018) for 2022 at telescope T08 in the o filter (orange, 560-820 nm) folded at the same 2.8734-h period, which results in a similar lightcurve (not shown).

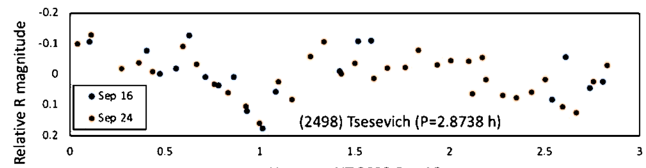

Figure 1. Lightcurve for (2498) Tsesevich.

<u>(2742) Gibson</u>. No previously published lightcurves for Gibson were found in the literature and no rotation period was listed on the NASA Horizons system. We obtained imaging observations of Gibson on two nights at the telescope Chi-4 operated by *Telescope.Live*. Exposures in color-separation Red filter were 300s and unbinned. Each individual night showed significant variation, but neither exhibited an unambiguous local extremum. A common comparison star was used for both nights to create a partial lightcurve (see Fig. 2), but these two nights were insufficient to establish a unique period. Additionally, a gradient of background across the images on Sep 06 suggests that the relative calibration of the two nights is slightly ambiguous.

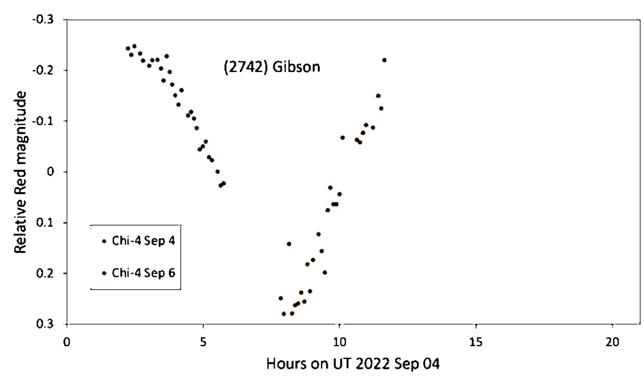

Figure 2. Partial lightcurve for (2742) Gibson from Chi-4 folded at P=20.60 h.

Name	Site	Telescope	Camera	Array	Filter	FOV(')	Scale ("/pix)
UCO	Schenectady, NY	0.50-m RC f/8.1	SBIG STXL-11002	2004×1336x9µm	R	30×20	0.93
Chi-4	Rio Hurtado, Chile	0.50-m RC f/6.8	FLI PL16803	4096×4096x9µm	Red	65×65	0.96

Table I. Telescopes and Cameras. RC=Ritchey-Chrétien; CDK = Planewave with f/4.5 focal reducer. UCO = Union College Observatory

Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2498	Tsesevich	2022 09/16-09/24	4.0,0.5	2	1	2.8738	0.0002	0.26	0.04	MB-KOR
2742	Gibson	2022 09/04-09/06	3.2,4.0	334	-2	20.60	0.01	0.60	0.05	MB-KOR

Table II. Observing circumstances and results. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range. Grp is the asteroid family/group.