ASTEROID PHOTOMETRY AND LIGHTCURVE RESULTS FOR SEVEN ASTEROIDS

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Synodic rotation periods and lightcurve amplitudes are reported for: 308 Polyxo, 488 Kreusa, 494 Virtus, 570 Kythera, 702 Alauda, 877 Walkure, and 995 Sternberga.

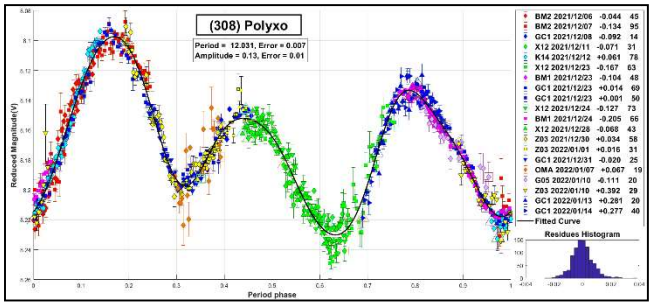
The periods and amplitudes of asteroid lightcurves presented here are the product of collaborative work by GORA (Grupo de Observadores de Rotaciones de Asteroides) group. In all the studies we have applied relative photometry assigning V magnitudes to the calibration stars.

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-fields were also used. Photometry measurements were performed using *FotoDif* software and for the analysis, we employed *Periodos* software (Mazzone, 2012).

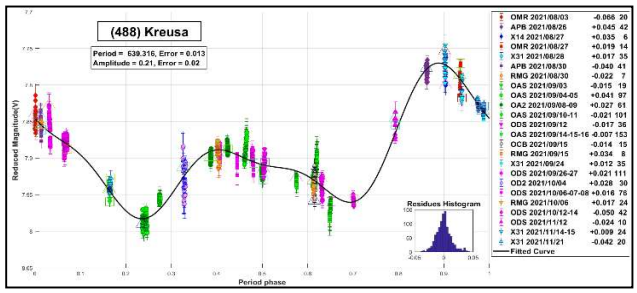
Below, we present the results for each asteroid under study. The lightcurve figures contain the following information: the estimated period and period error and the estimated amplitude and amplitude error. In the reference boxes, the columns represent, respectively, the marker, observatory MPC code, or – failing that – the GORA internal code, session date, session offset, and several data points.

Target selection was 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, Spain, and/or Italy, and 3) objects with few periods reported in the literature and/or in the Lightcurve Database (LCDB) (Warner et al., 2009) with quality codes (U) of less than 3.

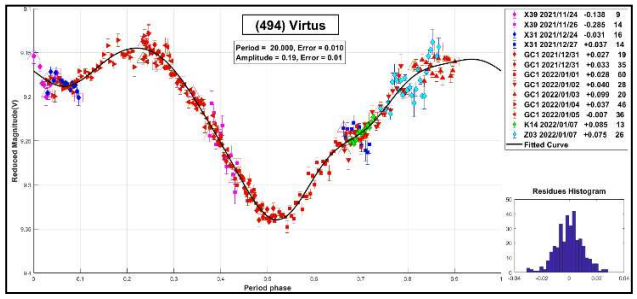
308 Polyxo is a T-type asteroid discovered in 1891 by Alphonse Borrelly. Previous reports of the period include 12.032 ± 0.008 h (Debehogne and Zapalà, 1980), 12.01 ± 0.02 h (Higgins, 2011), and 12.029 ± 0.001 h (Pilcher et al., 2014). As other authors have commented, the period is very close to commensurability with the terrestrial diurnal period. In this work, we present full lightcurve coverage, taking advantage of the several observatories belonging to GORA that are distributed at different longitudes. The results, consistent with previous reports, are P = 12.031 ± 0.007 h and A = 0.13 ± 0.01 mag.



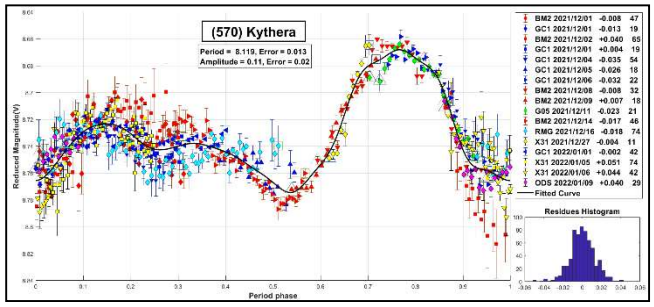
488 Kreusa is a C-type asteroid discovered in 1902 by Luigi Carnera and Max Wolf. Different authors have measured a variety of periods for this object. For example, 65.3 ± 0.1 h (Behrend, 2007web), 19.26 h (Robinson, 2011web), 32.666 ± 0.003 h (Stephens, 2014), and 32.645 ± 0.001 h (Pilcher, 2019). The coverage of these lightcurves was not completely reliable. In this work, we provide rather different results and propose this asteroid to be a slow rotator with a period of P = 639.319 ± 0.013 h and A = 0.21 ± 0.02 mag.



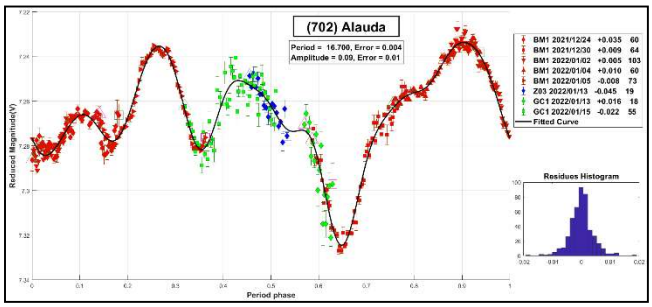
494 Virtus is a C-type asteroid discovered in 1902 by Max Wolf. Previous reported periods include 5.57 ± 0.01 h (Warner, 2006), 4.9903 ± 0.0004 h (Behrend, 2008web), and 5.570 ± 0.003 h (Hamanowa and Hamanowa, 2009). However, Tom Polakis (2018) reported a completely different period of 49.427 ± 0.022 h. In this paper we present a new, intermediate value of P = 20.000 ± 0.010 h and A = 0.19 ± 0.01 mag.



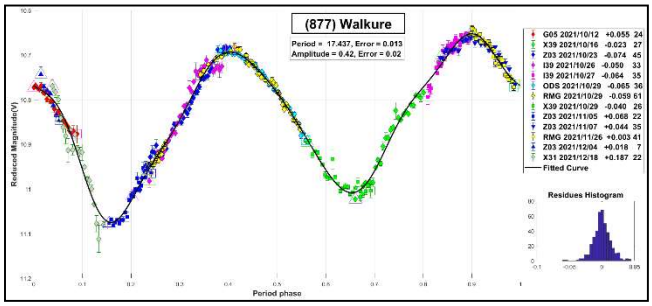
570 Kythera is classified as type ST. It was discovered by Max Wolf in 1905. Different periods have been reported before: 6.903 ± 0.002 h (Gil-Hutton, 2003), 8.120 ± 0.002 h (Behrend, 2004web), 10.5 ± 0.1 h (Chavez, 2014), 8.117 ± 0.001 h (Pilcher, 2021). In this paper, we present a result of P = 8.119 ± 0.013 h, which agrees with those from Behrend and Pilcher.



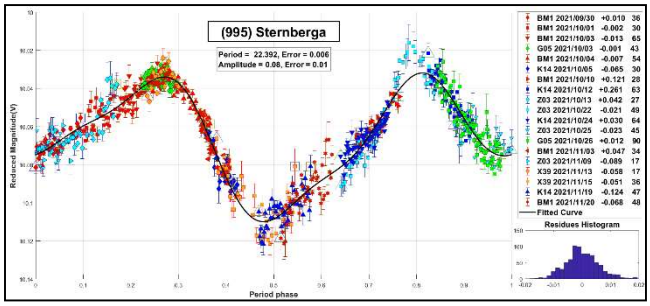
702 Alauda is a C-type asteroid discovered in 1910 by Joseph Helffrich. In 2007, it was proposed to be a binary system. We found previous works favored one of two periods, near 8 h or 16 h. Fauerbach and Bennett (2005) reported 8.348 ± 0.001 h while Benishek (2008) reported 8.3539 ± 0.0007 h and Alkema (2014) found 8.3531 ± 0.0004 h. On the other hand, Behrend (2014web) found a period of 16.7025 ± 0.0002 h. The results we obtained are P = 16.700 ± 0.004 h and A = 0.09 ± 0.01 mag. Our period well agrees with the one measured by Behrend.



877 Walkure is an F-type asteroid discovered in 1915 by Grigori Neúimin. Binzel (1987) determined a synodic period of 17.49 h. In this work, we present a lightcurve with full coverage with a similar period, P = 17.437 ± 0.013 h with A = 0.42 ± 0.02mag.



995 Sternberga was discovered in 1923 by Serguéi Beliavski. Several periods have been measured for this asteroid: 15.26 ± 0.01 h (Stephens, 2005), 14.612 ± 0.001 h (Stephens, 2013), and 22.404 ± 0.005 h (Marciniak et al., 2014). We have determined a period of 22.392 ± 0.006 h, which is consistent with the one proposed by Marciniak. Noticeably, we present a lightcurve with full coverage.



Number	Name	yy/ mm/dd- yy/ mm/dd	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
308	Polyxo	21/12/06-22/01/14	2.2,14.8	73	-5	12.031	0.007	0.13	0.01	MB-O
488	Kreusa	21/08/03-21/11/22	*4.6,15.2	319	-11	639.316	0.013	0.21	0.02	MB-O
494	Virtus	21/11/24-22/01/07	3.9,15.8	51	3	20.000	0.010	0.19	0.01	MB-O
570	Kythera	21/12/01-22/01/09	*12.0,9	107	-2	8.119	0.013	0.11	0.02	MB-O
702	Alauda	21/12/24-22/01/15	15.9,11.9	148	-13	16.700	0.004	0.09	0.01	MB-O
877	Walkure	21/10/12-21/12/18	4.6,26.8	18	-6	17.437	0.013	0.42	0.02	MB-O
995	Sternberga	21/09/30-21/11/20	*11.5,14.6	27	4	22.392	0.006	0.08	0.01	MB-O

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.

Observatory	Telescope	Camera
G05 Obs.Astr.Giordano Bruno	SCT (D=203mm; f=6.0)	CCD Atik 420 m
I39 Obs.Astr.Cruz del Sur	Newtoniano (D=254mm; f=4.7)	CMOS QHY 174
K14 Obs.Astr.de Sencelles	Newtoniano (D=250mm; f=4.0)	CCD SBIG ST-7XME
X12 Obs.Astr.Los Cabezones	Newtoniano (D=200mm; f=5.0)	CMOS QHY 174M GPS
X14 Obs.Astr.Orbis Tertius	Newtoniano (D=200mm; f=5.0)	CMOS P1 Neptune M
X31 Obs.Astr.Galileo Galilei	RCT ap (D=405mm; f=8.0)	CCD SBIG STF8300M
X39 Obs.Astr.Antares	Newtoniano (D=250mm; f=4.7)	CCD QHY9 Mono
Z03 Obs.Astr.Río Cofio	SCT (D=254mm; f=6.3)	CCD SBIG ST8-XME
APB Obs.Astr.AstroPilar	Refractor (D=150mm; f=7.0)	CCD ZWO-ASI183
BM1 Oss.Astr.La Macchina del Tempo 1	Ritchey-Chretien (D250mm; f=8)	CMOS ZWO ASI 1600 MM
BM2 Oss.Astr.La Macchina del Tempo 2	Newtoniano (D=200mm; f=5.0)	CMOS ZWO ASI 294 MM
GC1 Specola Giuseppe Pustorino 1	Newtoniano (D=254mm; f=4.7)	CCD Atik 383l+Mono
OAS Obs.Astr.de Ariel Stechina 1	Newtoniano (D=254mm; f=4.7)	CCD SBIG STF402
OA2 Obs.Astr.de Ariel Stechina 2	Newtoniano (D=305mm; f=5.0)	CMOS QHY 174M
OCB Obs.Astr.Cielos de Banfield	Newtoniano (D=150mm; f=5.0)	CMOS QHY5L-II M
ODS Obs.Astr.de Damián Scotta 1	Newtoniano (D=300mm; f=4.0)	CMOS QHY 174M
OD2 Obs.Astr.de Damián Scotta 2	Newtoniano (D=250mm; f=4.0)	CCD Atik 314L+
OMA Obs.Astr.Vuelta por el Universo	Newtoniano (D=150mm; f=5.0)	CMOS Neptune-M
OMR Obs.Astr.Municipal Reconquista	Newtoniano (D=254mm; f=4.0)	CMOS QHY5 Mono
RMG Obs.Astr.de Raúl Melia	Newtoniano (D=254mm; f=4.7)	CMOS QHY 174M GPS

Table II. List of observatories and equipment.

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We want to thank Julio Castellano as we use his *FotoDif* program for preliminary analyses, Fernando Mazzone for his *Periodos* 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.

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ROTATION PERIOD DETERMINATION FOR ASTEROIDS (19469) 1998 HV45 AND (51442) 2001 FZ25

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We present the results of observations of the main-belt asteroids (19469) 1998 HV 45 and (51442) 2001 FZ25. Observations were carried out in 2020 September at the Maidanak Astronomical Observatory. We found a synodic period for (19469) 1998 HV 45 of P = 7.035 ± 0.002 h and for (51442) 2001 FZ25 we found P = 4.334 ± 0.001 h.

All observational data reported here were obtained in 2020 September using a 0.6-meter telescope at the Maidanak Astronomical Observatory (MPC 188) of the Ulugh Beg Astronomical Institute (UBAI), Uzbekistan Academy of Sciences. For the observations we used an FLI IMG1001E CCD camera (1K×1K) with a resolution of 0.67 arcsec/pixel, FOV of 10.7×10.7 arcmin, and Bessel R-filter. The temperature of the camera was set to -30°C. Image acquisition was done with *MaxIm DL* (2022). Calibration images were also obtained for each observational date.

All images were reduced with master bias, dark, and flat frames by using *IRAF* (Image Reduction and Analysis Facility; IRAF, 2022). Calibration frames were created also by using *IRAF*. Photometric measurements processing and analysis were done with *MPO Canopus* (Warner, 2021).

(19469) 1998 HV45. The asteroid (19469) 1998 HV45 was discovered by LINEAR (MPC 704) on 1998 April 20 (MPC, 2022; JPL, 2022). This asteroid orbits the Sun with a semi-major axis of 2.5806 AU, eccentricity 0.163, and orbital period of 4.15 years (MPC, 2022). The diameter and the geometric albedo of the asteroid were determined by the NEOWISE project, and are 7.242 km and 0.233, respectively (Mainzer et al., 2019). The synodic period was previously estimated at P = 8.16 ± 0.72 h (Behrend, 2022web), based on observations by René Roy on one night.

Asteroid (19469) 1998 HV45 was observed on August 25 and on four nights from September 21-27. As a result, 477 CCD images were obtained with an exposure of 90 seconds (Sept 25) and 120 seconds for all other nights.

The period analysis shows a synodic period of P = 7.035 ± 0.002 h with an amplitude A = 0.09 ± 0.02 mag. The perceptible difference between our and Behrend's periods is due to the amount of observation data and probably the shape of the asteroid. However, the amplitude of variability coincides within error scatter.

Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
19469	1998 HV45	2020 09/21-09/27	9.1,10.6	351	13	7.035	0.002	0.09	0.02	MB-I
51442	2001 FZ25	2020 09/10-09/13	13.1,10.9	7	1	4.334	0.001	0.16	0.03	MB-O

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).