

## ASTEROID PHOTOMETRY AND LIGHTCURVE RESULTS FOR SEVEN ASTEROIDS

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

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Santa Rosa (La Pampa-ARGENTINA)

Observatorio Orbis Tertius (MPC X14)  
Córdoba (Córdoba-ARGENTINA)

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

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

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Observatorio de Ariel Stechina 2 (GORA OA2)  
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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 Stemberga.

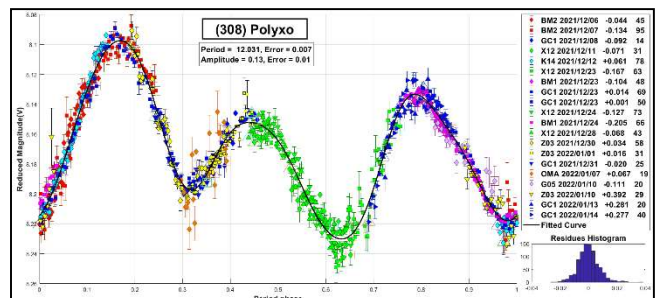
The periods and amplitudes of asteroid lightcurves presented here are the product of collaborative work by GORA (Grupo de Observadores de Rotaciones de Asteroides) group. In all the studies we have applied relative photometry assigning V magnitudes to the calibration stars.

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).

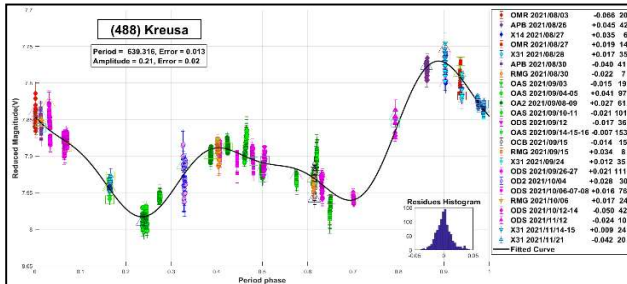
Below, we present the results for each asteroid under study. The lightcurve figures contain the following information: the estimated period and period error and the estimated amplitude and amplitude error. In the reference boxes, the columns represent, respectively, the marker, observatory MPC code,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

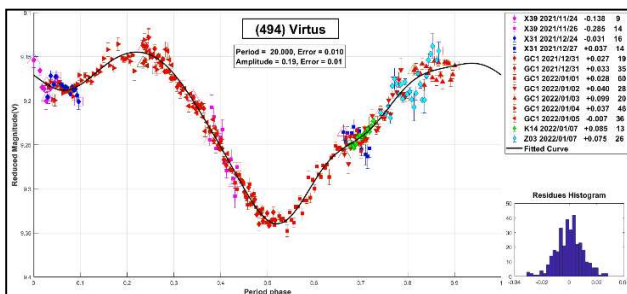
**308 Polyxo** is a T-type asteroid discovered in 1891 by Alphonse Borrelly. Previous reports of the period include  $12.032 \pm 0.008$  h (Debehogne and Zapalá, 1980),  $12.01 \pm 0.02$  h (Higgins, 2011), and  $12.029 \pm 0.001$  h (Pilcher et al., 2014). As other authors have commented, the period 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  $P = 12.031 \pm 0.007$  h and  $A = 0.13 \pm 0.01$  mag.



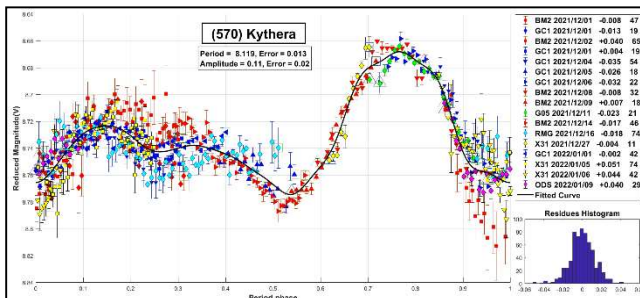
**488 Kreusa** is a C-type asteroid discovered in 1902 by Luigi Camera and Max Wolf. Different authors have measured a variety of periods for this object. For example,  $65.3 \pm 0.1$  h (Behrend, 2007web),  $19.26$  h (Robinson, 2011web),  $32.666 \pm 0.003$  h (Stephens, 2014), and  $32.645 \pm 0.001$  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  $P = 639.319 \pm 0.013$  h and  $A = 0.21 \pm 0.02$  mag.



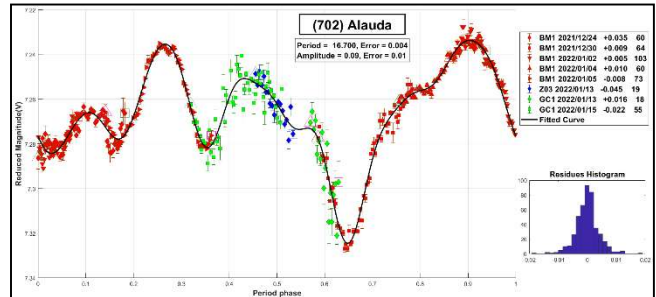
**494 Virtus** is a C-type asteroid discovered in 1902 by Max Wolf. Previous reported periods include  $5.57 \pm 0.01$  h (Warner, 2006),  $4.9903 \pm 0.0004$  h (Behrend, 2008web), and  $5.570 \pm 0.003$  h (Hamanowa and Hamanowa, 2009). However, Tom Polakis (2018) reported a completely different period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



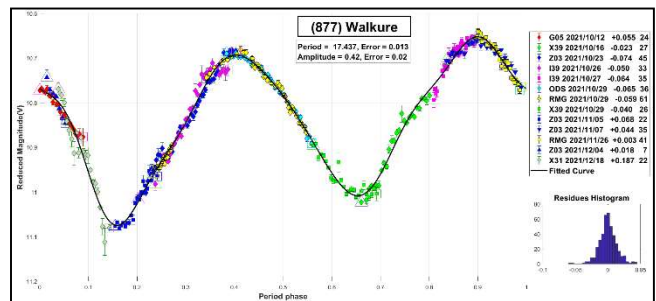
**570 Kythera** is classified as type ST. It was discovered by Max Wolf in 1905. Different periods have been reported before:  $6.903 \pm 0.002$  h (Gil-Hutton, 2003),  $8.120 \pm 0.002$  h (Behrend, 2004web),  $10.5 \pm 0.1$  h (Chavez, 2014),  $8.117 \pm 0.001$  h (Pilcher, 2021). In this paper, we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



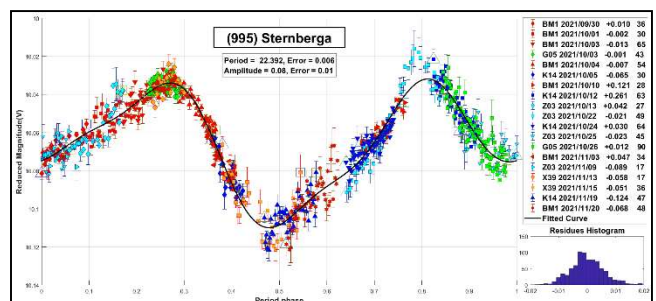
**702 Alauda** is a C-type asteroid discovered in 1910 by Joseph Helffrich. In 2007, it was proposed to be a binary system. We found previous works favored one of two periods, near 8 h or 16 h. Fauerbach and Bennett (2005) reported  $8.348 \pm 0.001$  h while Benishek (2008) reported  $8.3539 \pm 0.0007$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



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



**995 Sternberga** was discovered in 1923 by Serguéi Beliaevski. Several periods have been measured for this asteroid:  $15.26 \pm 0.01$  h (Stephens, 2005),  $14.612 \pm 0.001$  h (Stephens, 2013), and  $22.404 \pm 0.005$  h (Marciniak et al., 2014). We have determined a period of  $22.392 \pm 0.006$  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 <sub>PAB</sub>	B <sub>PAB</sub>	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<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). 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 3831+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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### References

- Alkema, M.S. (2014). "Asteroid Lightcurve Analysis at Elephant Head Observatory: 2013 October - November." *Minor Planet Bulletin* **41**, 186-187.
- Behrend, R. (2004web, 2007web, 2008web, 2014web). Observatoire de Geneve website. [http://obswww.unige.ch/~behrend/page\\_cou.html](http://obswww.unige.ch/~behrend/page_cou.html)
- Benishek, V. (2008). "CCD Photometry of Seven Asteroids at the Belgrade Astronomical Observatory." *Minor Planet Bulletin* **35**, 28-30.
- Binzel, R.P. (1987). "A photoelectric survey of 130 asteroids." *Icarus* **72**, 135-208.
- Chavez, C.F. (2014). "Photometric Observations of Asteroid 570 Kythera using the Virtual Telescope Project." *Minor Planet Bulletin* **41**, 60.
- Debehogne, H.; Zappalà, V. (1980). "Photoelectric lightcurves and rotation period of 308 Polyxo, obtained at ESO-La Silla in May 1978." *Astron. Astrophys. Suppl. Series* **39**, 163-165.
- Fauerbach, M.; Bennett, T. (2005). "Photometric lightcurve observations of 125 Liberatrix, 218 Bianca, 423 Diotima, 702 Alauda, 1963 Bezovec, and (5849) 1990 HF1." *Minor Planet Bulletin* **32**, 80-81.
- Gil-Hutton, R. (2003). "Photometry of fourteen main belt asteroids." *Revista Mexicana de Astronomía y Astrofísica* **39**, 69-76.
- Hamanowa, H.; Hamanowa, H. (2009). "Lightcurves of 494 Virtus, 556 Phyllis, 624 Hektor, 657 Gunlod, 111 Reinmuthia, 1188 Gothlandia, and 1376 Michelle." *Minor Planet Bulletin* **36**, 87-88.
- Harris, A.W.; Young, J.W.; Scaltriti, F.; Zappala, V. (1984). "Lightcurves and phase relations of the asteroids 82 Alkmene and 444 Gyptis." *Icarus* **57**, 251-258.
- Higgins, D. (2011). "Period Determination of Asteroid Targets Observed at Hunters Hill Observatory: May 2009 - September 2010." *Minor Planet Bulletin* **38**, 41-46.

Marciniak, A.; Pilcher, F.; Santana-Ros, T.; Oszkiewicz, D.; Kankiewicz, P. (2014). "Against the bias in physics of asteroids: Photometric survey of long-period and low-amplitude asteroids." *Proceedings of Asteroids, Comets, Meteors* **2014**, 333.

Mazzone, F.D. (2012). Periodos software, version 1.0.  
<http://www.astrosurf.com/salvador/Programas.html>

Pilcher, F.; Strabla, L.P.; Quadri, U.; Girelli, R. (2014). "Rotation Period Determination for 308 Polyxo." *Minor Planet Bulletin* **41**, 204.

Pilcher, F. (2019). "Rotation Period Determinations for 58 Concordia, 384 Burdigala, 464 Megaira, 488 Kreusa, and 491 Carina." *Minor Planet Bulletin* **46**, 360-363.

Pilcher, F. (2021). "Lightcurves and Rotation Periods of 67 Asia, 74 Galatea, 356 Liguria, 570 Kythera, 581 Tauntonia, 589 Croatia, and 605 Juvisia." *Minor Planet Bulletin* **48**, 132-135.

Polakis, T. (2018). "Lightcurve Analysis for Eleven Main-belt Asteroids." *Minor Planet Bulletin* **45**, 199-203.

Robinson, L. (2011web). Asteroid Lightcurves from Sunflower Observatory 739. <http://btboar.tripod.com/lightcurves/>.

Stephens, R.D. (2005). "Rotational periods of 743 Eugensis, 995 Sternberga, 1185 Nikko, 2892 Filipenko, 3144 Brosche, and 3220 Murayama." *Minor Planet Bulletin* **32**, 27-28.

Stephens, R.D. (2013). "Asteroids Observed from Santana and CS3 Observatories: 2012 July - September." *Minor Planet Bulletin* **40**, 34-35.

Stephens, R.D. (2014). "Asteroids Observed from CS3: 2014 January - March." *Minor Planet Bulletin* **41**, 171-175.

Warner, B.D. (2006). "Asteroid lightcurve analysis at the Palmer Divide Observatory - late 2005 and early 2006." *Minor Planet Bulletin* **33**, 58-62.

Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2022 feb.  
<http://www.minorplanet.info/lightcurvedatabase.html>