

# PHOTOMETRY AND LIGHT CURVE ANALYSIS OF EIGHT ASTEROIDS BY GORA'S OBSERVATORIES.

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Estación Astrofísica Bosque Alegre (MPC 821) -  
Bosque Alegre (Córdoba- ARGENTINA)

Observatorio Astronómico Giordano Bruno (MPC G05) -  
Piconcillo (Córdoba-ESPAÑA)

Observatorio Cruz del Sur (MPC I39)  
San Justo (Buenos Aires- ARGENTINA)

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

Observatorio Los Cabezones (MPC X12)  
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)

Observatorio AstroPilar (GORA APB)  
Pilar (Buenos Aires- ARGENTINA)

Observatorio Astronómico Calchaquí (GORA OAC)  
El Bañado (Tucumán- ARGENTINA)

Observatorio de Aldo Mottino (GORA OAM)  
Rosario (Santa Fe- ARGENTINA)

Observatorio Astronómico Aficionado Omega (GORA OAO)  
Córdoba (Córdoba- ARGENTINA)

Observatorio de Ariel Stechina 1 (GORA OAS)  
Reconquista (Santa Fe- ARGENTINA)

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

Observatorio de Damián Scotta 1 (GORA ODS)  
San Carlos Centro (Santa Fe- ARGENTINA)

Observatorio de Damián Scotta 2 (GORA OD2)  
San Carlos Centro (Santa Fe- ARGENTINA)

Observatorio Chopis (GORA OM1) -  
Alta Gracia (Córdoba- ARGENTINA)

Observatorio Astronómico Municipal Reconquista (GORA OMR)  
Reconquista (Santa Fe- ARGENTINA)

Observatorio Río Cofio (GORA ORC)  
Robledo de Chavela (Madrid-ESPAÑA)

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Synodic rotation periods and amplitudes are reported for  
128 Nemesis, 236 Honoria, 329 Svea, 1021 Flammario,  
1026 Ingrid, 1034 Mozartia, 1938 Lausanna, and  
(285571) 2000 PQ9.

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.

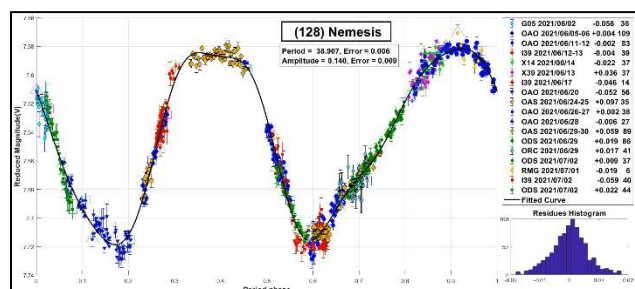
Image acquisition was performed without filters and with exposure  
times of a few minutes. All images used were corrected using dark  
frames and, in some cases, bias and flat-field were also used.  
Photometry measurements were performed using *FotoDif* software  
and, for the analysis, we employed *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.

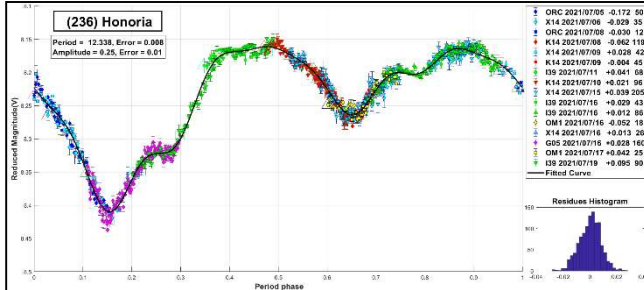
Targets were selected based on the following criteria: 1) those  
asteroids with magnitudes accessible to the equipment of all  
participants, 2) those with favorable observation conditions from  
Argentina or Spain, i.e., with negative or positive declinations  $\delta$ ,  
respectively, and 3) objects with few periods reported in the  
literature and/or with Lightcurve Database (LCDB) (Warner et al.,  
2009) quality codes (U) of less than 3.

128 Nemesis is a C-type asteroid. It was discovered in 1872 by  
James Craig Watson. Our analysis yields a period  $P = 38.907 \pm$   
0.006 h with  $\Delta m = 0.140 \pm 0.009$  mag. In previous observations,  
Scaltriti et al. (1979) reported a period  $P = 39$  h and Pilcher (2015)  
a period  $P = 77.81 \pm 0.01$  h.

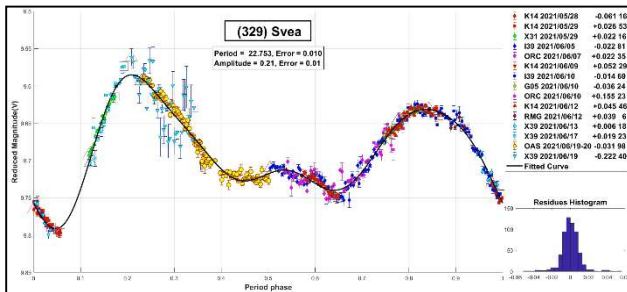
Note that our period is in good agreement with the one reported by  
Scaltriti et al. and is half the one measured by Pilcher. Irrespective  
of such dissimilarities, it is clear that this asteroid constitutes a long  
period example.



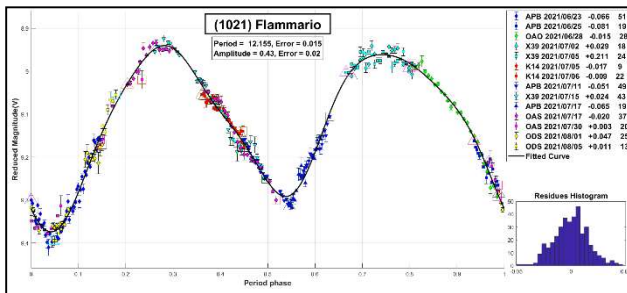
**236 Honoria** is an S-type asteroid. It was discovered in 1884 by Johann Palisa. We found in the literature two different periods calculated for this object:  $P = 12.338 \pm 0.002$  h with  $\Delta m = 0.27 \pm 0.02$  mag (Marciniak et al., 2014) and  $P = 16.8 \pm 0.1$  h with  $\Delta m = 0.05 \pm 0.01$  mag (Behrend, 2006web). The results we obtained are  $P = 12.338 \pm 0.008$  h and  $\Delta m = 0.25 \pm 0.01$  mag, with full coverage of the lightcurve. Our period agrees well with the one measured by Marciniak et al. (2014).



**329 Svea** is classified as type C in the Tholen taxonomy. It was discovered by Max Wolf in 1892. Two different periods were reported in the literature. Marciniak et al. (2017) found a period of  $22.778 \pm 0.006$  h, whereas Pray (2006) measured a period of  $P = 15.201 \pm 0.005$  h. We have determined a period of  $22.753 \pm 0.010$  h, which is consistent with the one proposed by Marciniak.

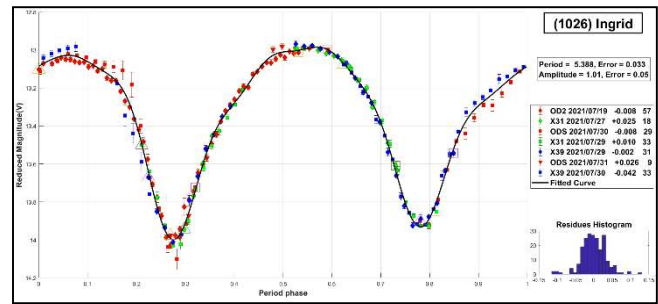


**1021 Flammario** is an F-type asteroid, discovered in 1924 by Max Wolf. The period more recently reported in the literature is  $P = 12.15186 \pm 0.00005$  h (Hanus et al., 2016).

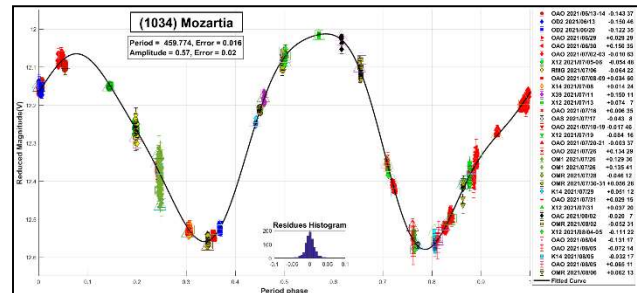


The results we obtained are  $P = 12.155 \pm 0.015$  h and  $\Delta m = 0.43 \pm 0.02$  mag. Our period agrees well with the one measured by Hanus et al. (2016).

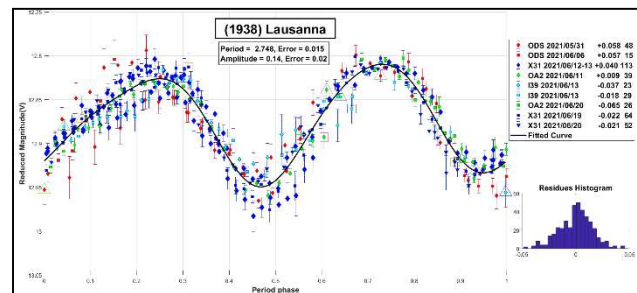
**1026 Ingrid** was discovered in 1923 by Karl Wilhelm Reinmuth. We measured a period of  $5.388 \pm 0.033$  h with  $\Delta m = 1.01 \pm 0.05$  mag. A similar period was previously reported by Székely et al. (2005), consisting of  $P = 5$  h. A large amplitude was also reported by these authors, resulting in  $\Delta m > 0.5$  mag.



**1034 Mozartia** is an S-type asteroid in the Bus-taxonomy, discovered in 1924 by Vladimir Albitski. Interestingly, we couldn't find a reported period for this object in the literature. According to our observations and after a thorough analysis, we propose a long-term period of  $P = 459.774 \pm 0.016$  h and  $\Delta m = 0.57 \pm 0.02$  mag. As can be seen, we have performed numerous observations on this object, with permanent generation of ephemeris to fill the gaps, which successfully allowed us to complete the curve. More important, we have observations on consecutive days, using same calibration stars, so that they were taken as a single observation. That way we were able to solve the puzzle related to this slow rotator.



**1938 Lausanna** is an S-type asteroid. It was discovered in 1974 by Paul Wild. The period reported in the literature is  $P = 2.748 \pm 0.001$  h with  $\Delta m = 0.12 \pm 0.02$  mag (Warell and Pappini, 2015). Our observations resulted in  $P = 2.748 \pm 0.015$  h with  $\Delta m = 0.14 \pm 0.02$  mag, consistent with a short-period asteroid, and in good agreement with the results from Warell & Pappini.



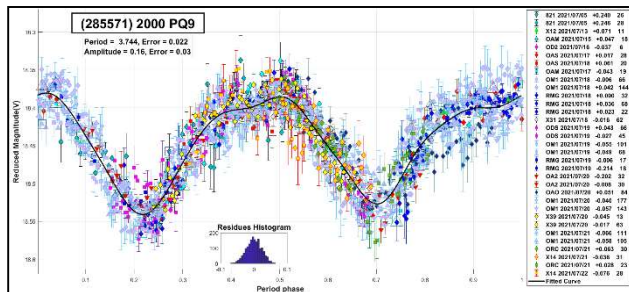
**(285571) 2000 PQ9** was discovered in 2000 by LINEAR. It is a poorly studied object. Here we propose a candidate period of  $P = 3.744 \pm 0.022$  h and  $\Delta m = 0.16 \pm 0.03$  mag. This fast rotator hypothesis is consistent with its small estimated diameter of  $\sim 1$  km. Also, it is important to note that we have performed several observations on this object leading to a very good coverage of the lightcurve.

Number	Name	yy/mm/dd	Phase	L <sub>PAB</sub>	B <sub>PAB</sub>	Period(h)	P.E.	Amp	A.E.	Grp
128	Nemesis	21/06/02–21/07/02	2.6,13.2	245	1	38.907	0.006	0.14	0.01	MB-O
236	Honorla	21/07/05–21/07/19	9.9,5.4	301	10	12.338	0.008	0.25	0.01	MB-O
329	Svea	21/05/28–21/06/20	10.3,16.0	241	19	22.753	0.010	0.21	0.01	MB-I
1021	Flammario	21/06/23–21/08/05	*5.5,11.9	283	4	12.155	0.015	0.43	0.02	MB-O
1026	Ingrid	21/07/19–21/07/30	3.0,9.8	293	-2	5.388	0.033	1.01	0.05	FLOR
1034	Mozartia	21/06/13–21/08/06	*20.4,12.0	294	-2	459.774	0.016	0.57	0.02	MB-I
1938	Lausanna	21/05/31–21/06/20	*5.0,9.9	255	5	2.748	0.015	0.14	0.02	FLOR
285571	2000 PQ9	21/07/05–21/07/22	*35.3,6.7	287	-11	3.744	0.022	0.16	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. 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-I/O: main-belt inner/outer.

Observatory	Telescope	Camera
821 Est.Astrof.Bosque Alegre	Telesc. Newtoniano (D=1540mm; f=4.9)	CCD APOGEE Alta U9
G05 Obs.Astr.Giordano Bruno	Telesc. SCT (D=203mm; f=6.0)	CCD Atik 420 m
I39 Obs.Astr.Cruz del Sur	Telesc. Newtoniano (D=254mm; f=4.7)	CMOS QHY174
K14 Obs.Astr.de Sencelles	Telesc. Newtoniano (D=250mm; f=4.0)	CCD SBIG ST-7XME
X12 Obs.Astr.Los Cabezones	Telesc. Newtoniano (D=200mm; f=5.0)	CMOS QHY174MGPS
X14 Obs.Astr.Obis Tertius	Telesc. Newtoniano (D=200mm; f=5.0)	CCD QHY6 Mono
X31 Obs.Astr.Galileo Galilei	Telesc. RCT ap (D=405mm; f=8.0)	CCD SBIG STF8300M
X39 Obs.Astr.Antares	Telesc. Newtoniano (D=250mm; f=4.7)	CCD QHY9 Mono
APB Obs.Astr.AstroPilar	Telesc. Refractor (D=150mm; f=7.0)	CCD ZWO-ASI183
OAC Obs.Astr.Calchaquí	Telesc. GSO RC (D=203mm; f=8.0)	CCD QHY9S
OAM Obs.Astr.de Aldo Mottino	Telesc. Newtoniano (D=250mm; f=4.7)	CCD SBIG STF8300M
OAQ Obs.Astr.Aficionado Omega	Telesc. Newtoniano (D=150mm; f=5.0)	CMOS ZWO ASI178mm
OAS Obs.Astr.de Ariel Stechina 1	Telesc. Newtoniano (D=254mm; f=4.7)	CCD SBIG STF402
OA2 Obs.Astr.de Ariel Stechina 2	Telesc. Newtoniano (D=305mm; f=5.0)	CMOS QHY 174M
ODS Obs.Astr.de Damián Scotta 1	Telesc. Newtoniano (D=300mm; f=4.0)	CCD SBIG St-402 XME
OD2 Obs.Astr.de Damián Scotta 2	Telesc. Newtoniano (D=250mm; f=4.0)	CCD Atik 314L+
OM1 Obs.Astr.Chopis	Telesc. Newtoniano (D=200mm; f=4.5)	CMOS Nikon D5200
OMR Obs.Astr.Municipal Reconquista	Telesc. Newtoniano (D=254mm; f=4.0)	CMOS QHY5 Mono
ORC Obs.Astr.Río Cofio	Telesc. SCT (D=254mm; f=6.3)	CCD SBIG ST8-XME
RMG Obs.Astr.de Raúl Melia	Telesc. Newtoniano (D=254mm; f=4.7)	CCD Meade DSI Pro II

Table II. List of observatories and equipment.



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