NINE MAIN BELT ASTEROIDS, ONE NEAR EARTH, AND TWO POTENTIALLY HAZARDOUS ASTEROID LIGHTCURVES

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We report on the photometric analysis result of nine main-belt (MBA), one near-Earth (NEA), and two Potentially Hazardous (PHA) asteroids by the Asociación Valenciana de Astronomía (AVA). The work was done from the Astronomical Center Alto Turia (CAAT; MPC J57), located in Aras de los Olmos, Valencia, and operated by members of AVA (*http://www.astroava.org*). This database shows graphic results of the data, mainly lightcurves, with the plot phased to a given period.

We have managed to obtain a number of accurate and complete lightcurves as well as some additional incomplete lightcurves to help analysis at future oppositions.

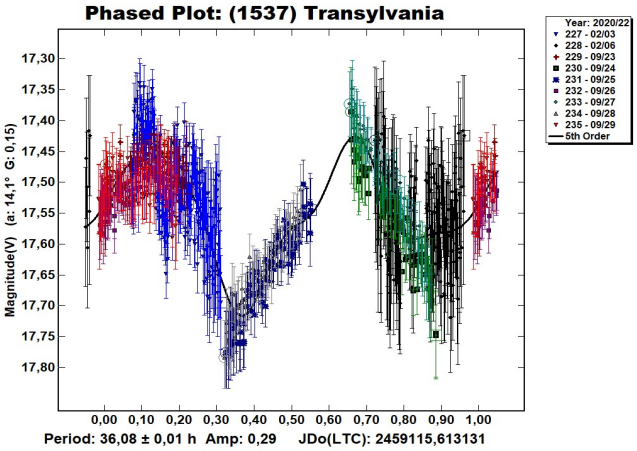
Observatory	Telescope	CCD
C.A.A.T.	43 cm D-K	SBIG STXL-11002
	106 mm Refractor	ZWO ASI 1600

Table I. List of instruments used for the observations. DK is Dall-Kirkham.

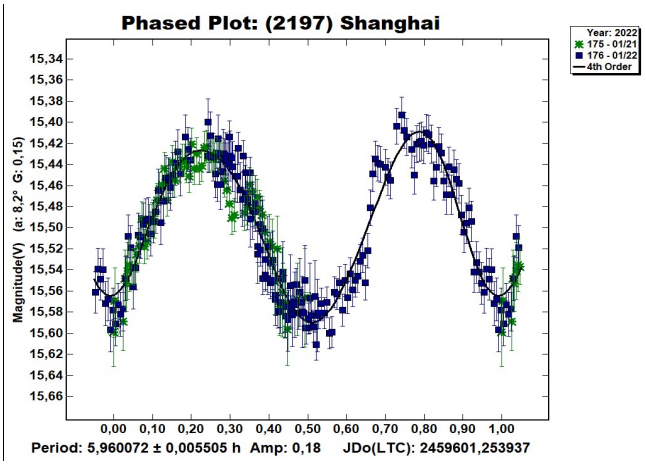
We concentrated on asteroids with no reported period and those where the reported period was poorly established and needed confirmation. All the targets were selected from the Collaborative Asteroid Lightcurve (CALL) website at (*http://www.minorplanet.info/call.html)* and Minor Planet Center (*http://www.minorplanet.net*).

Images were measured using *MPO Canopus* (Bdw Publishing) with a differential photometry technique. The comparison stars were restricted to near solar-color to reduce color dependencies, especially at larger air masses. The lightcurves give the synodic rotation period. The amplitude (peak-to-peak) that is shown is that for the Fourier model curve and not necessarily the true amplitude.

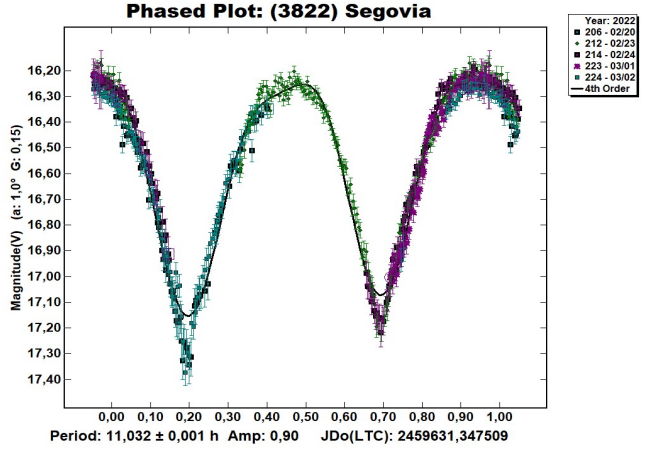
(1537) Transylvania. This outer main-belt asteroid was discovered on 1940 Aug 27 by G. Strommer from the Konkoly Obs, Hung. We made observations on 2022 Feb 3-6. In the ALCDEF database (*https://alcdef.org*), we found data from Polakis (2021). We joined those data to ours to improve the quality of the result. From the data we derive a rotation period of 36.08 ± 0.01h and an amplitude of 0.29 mag. This period doesn't match with the 144.2 h from Polakis (2021) and 141.8 h from Ďurech et al. (2019). We recommend new observing sessions to help find the actual period.



(2197) Shangai. This Themis group asteroid was discovered on 1965 Dec 30 from the Purple Mountain Observatory. We made observations on 2021 Jan 21-22. From our data we derive a rotation period of 5.95 ± 0.005 h and an amplitude of 0.18 mag. Behrend (2011web) found a period of 5.99 h, which is consistent with our observations. Waszczak et al. (2015) found 5.938 h and Ďurech et al. (2020) found 5.94 h.

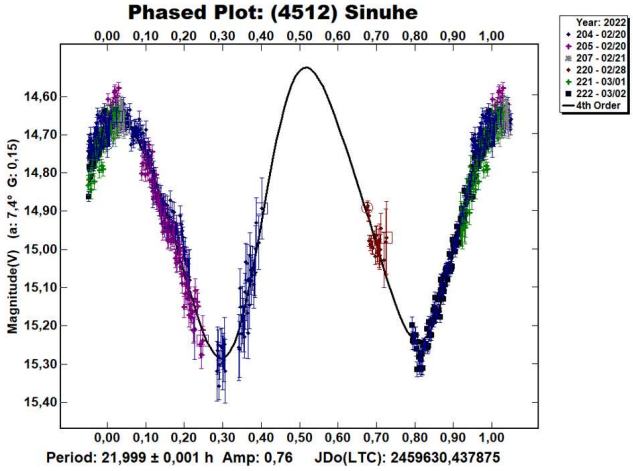


(3822) Segovia. This inner main-belt asteroid was discovered on 1988 Feb 21 by T. Seki at Geisei Observatory in Japan. We made observations on 2022 Feb 20 - March 2.

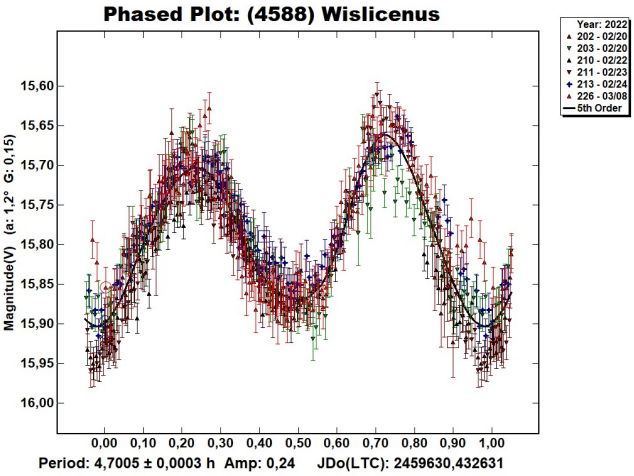


From our data we derive a rotation period of 11.032 ± 0.001 h and an amplitude of 0.90 mag. We assume the lightcurve is bimodal, even with a very symmetrical drawing. Ďurech et al. (2016) found a similar period of 11.03 h.

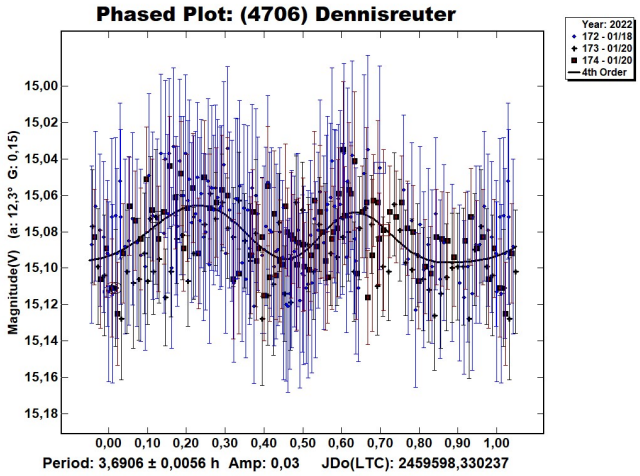
(4512) Sinuhe. This middle main-belt asteroid was discovered on 1939 Jan 20 by Y. Väisälä at Turku observatory in Finland. We made observations on 2022 Feb 20 - March 2. From our data we derive a rotation period of 21.999 ± 0.001 h and an amplitude of 0.76 mag. We assume it is bimodal, even with a very symmetrical drawing. Behrend (2016web) found a period of 21.5 h and Bennefeld et al. (2009) found 18 h.



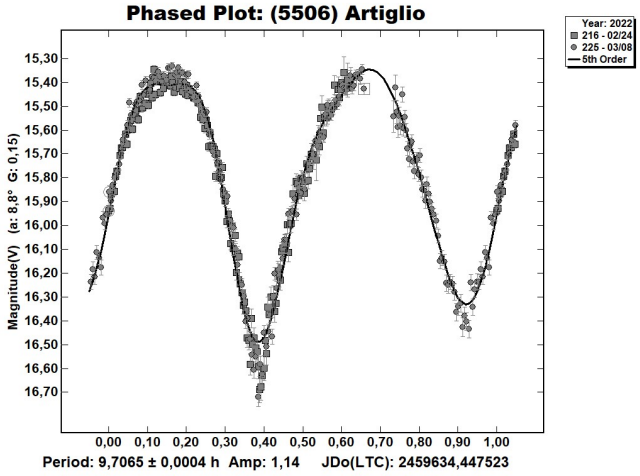
(4588) Wislicenus. This outer main-belt asteroid was discovered in 1931 March 13 by M.F. Wolf at the Heidelberg Observatory, Germany. We made observations on 2022 Feb 20-24. From our data we derive a rotation period of 4.7005 ± 0.0003 h and an amplitude of 0.24 mag. Yeh et al. (2020) found a period of 4.70 h that is rated U = 2 in the LCDB and matches with our results.



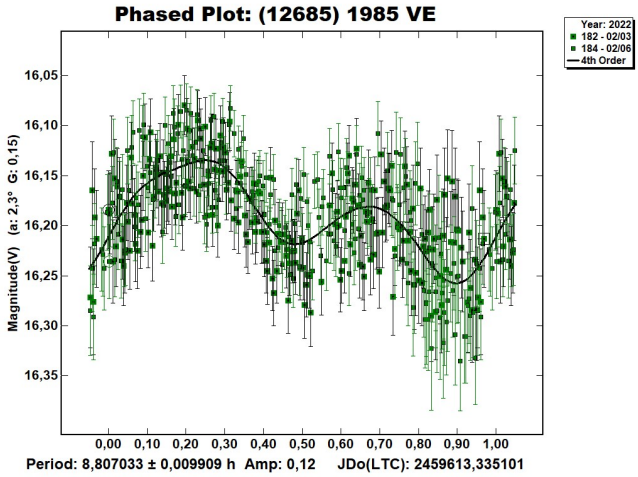
(4706) Dennisreuter. This inner main-belt asteroid was discovered on 1988 Feb 16 by R. Rajamohan at Kavalur Observatory, India. We made observations on 2022 Jan 18-20. From our data we derive a rotation period of 3.69 ± 0.006 h and an amplitude of 0.03 mag. Such a small amplitude pushed the limit the equipment sensitivity. Waszczak et al. (2015) found a period of 2.56 h with incomplete data (U = 1).



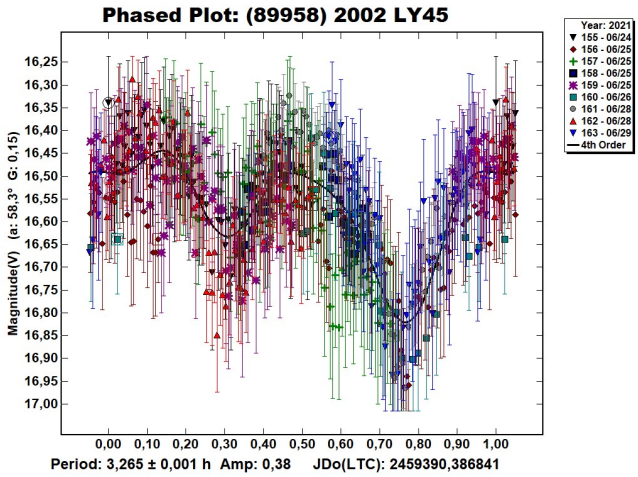
(5506) Artiglio. This member of the Erigone group was discovered on 1987 Sep 24 by H. Debehogne at La Silla, Chile. We made observations on 2022 Feb 24 - March 8. From our data we derive a rotation period of 9.7065 ± 0.0004 h and an amplitude of 1.14 mag. Waszczak et al. (2015) found a period of 9.406 h, Ďurech et al. (2020) found 9.41309 h, and Pál et al. (2020) found 9.409 h. The period we found is not the same, but our data seem to be good.



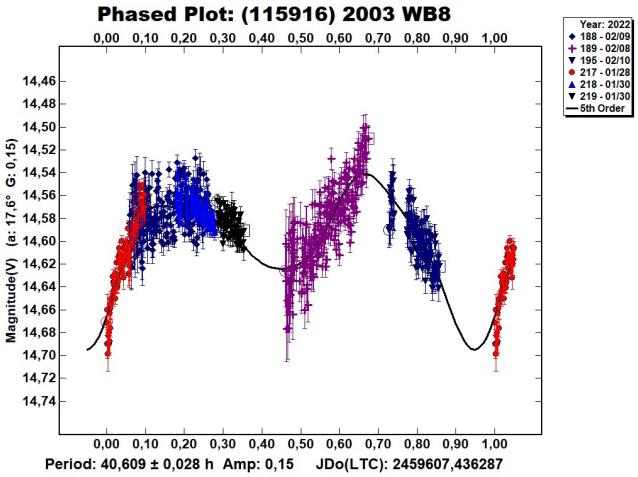
(12685) 1985 VE. This Flora group member was discovered on 1985 Nov 14 by P. Jensen at Brorfelde Observatory, Denmark. We made observations on 2022 Feb 03-06. From our data we derive a rotation period of 8.807 ± 0.01 h and an amplitude of 0.12 mag. The LCDB did not list any previous period results.



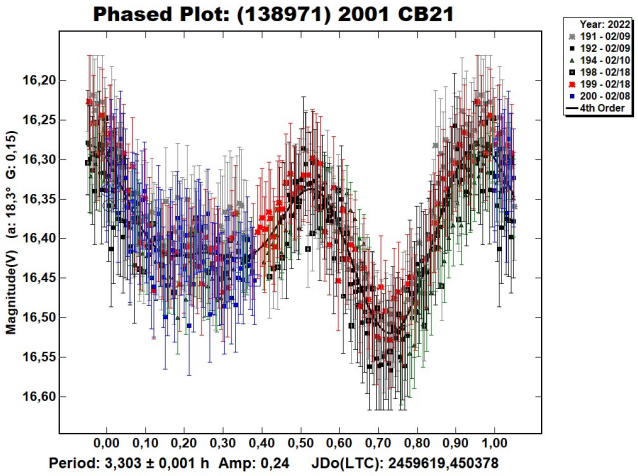
(89958) 2002 LY45. This is a PHA, discovered on 2002 Jun 14 by the project LINEAR at Socorro. We made observations in 2021 June. From our data we derive a rotation period of 3.265 ± 0.001 h and an amplitude of 0.38 mag. The LCDB did not list any previous period results.



(115916) 2003 WB8. This outer main-belt asteroid, classified as "Unusual" by the Minor Planet Center, was discovered on 2003 Nov 18 by the LINEAR project at Socorro We made observations from 2022 Feb 8-10. In the ALCDEF database we found data from S.C. Percy covering 2022 Jan 18 through 2022 Feb 10. We joined those data to ours to improve the quality of the result. Data analysis found a rotation period of 40.609 ± 0.028 h and an amplitude of 0.15 mag. There are no more previous data on the rotation period of this asteroid.



(138971) 2001 CB21. This is a PHA in the Apollo group that was discovered on 2001 Feb 2 Jan 24 by project LINEAR at Socorro.

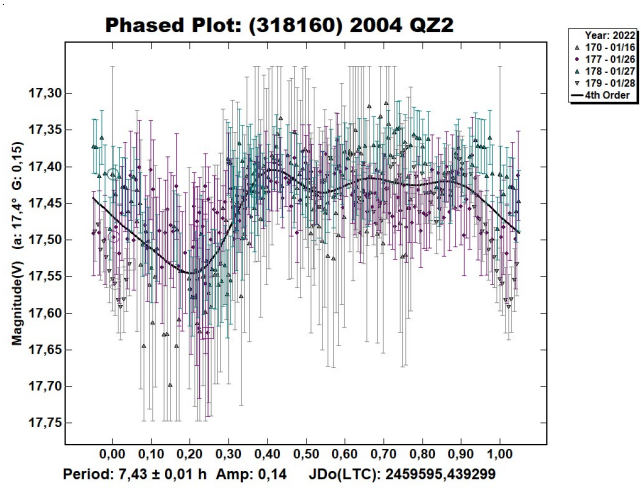


We made observations in 2021 Feb 8-18. From our data, we derive a rotation period of 3.303 ± 0.001 h and an amplitude of 0.24 mag. Galad et al. (2005) found a period of 3.302 h.

(318160) 2004 QZ2. This near-Earth asteroid is in the Amor group. It was discovered on 2004 Aug 20 by the Catalina Sky Survey. We made observations from 2022 Jan 16-28. Data analysis found a rotation period of 7.43 ± 0.01 h and an amplitude of 0.14 mag. The LCDB didn't list any previous period results for this asteroid.

Number	Name	yyyy/mm/dd	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
1537	Transylvania	2022/02/03-02/06	1.8,2.4	132	-5	36.08	0.01	0.29	0.05	MB-O
	(from Polakis)	2020/09/24-09/29	3.7,5.9	357	4					
2197	Shanghai	2022/01/21-22	8.5,9.0	101	2	5.96	0.005	0.18	0.05	MB-O
3822	Segovia	2022/02/20-03/01	0.5,5.03	153	0	11.032	0.001	0.90	0.05	MB-I
4512	Sinuhe	2022/02/20-03/02	7.4,12.04	139	6	21.999	0.001	0.76	0.05	MB-M
4588	Wislicenus	2022/02/20-24	0.74,1.03	153	0	4.7005	0.0003	0.24	0.05	MB-O
4706	Dennisreuter	2022/01/18-20	12.7,13.6	104	-12	3.69	0.006	0.03	0.01	MB-I
5506	Artiglio	2022/02/24-03/03	9.4,15.9	143	5	9.7065	0.0004	1.14	0.05	MB-I
12685	1985 VE	2022/02/3-6	2.46,3.99	132	-4	8.807	0.01	0.12	0.02	MB-I
89958	2002 LY45	2021/06/24-29	58.3,81.9	258	42	3.265	0.001	0.38	0.02	PHA
115916	2003 WB8	2022/02/8-10	17.6,17.7	152	14	40.609	0.028	0.15	0.03	MB-O
	(from Percy)	2022/01/18-02/10	26.5,17.1	149	10					
138971	2001 CB21	2022/02/9-18	39.2,42.7	161	159	3.303	0.001	0.24	0.03	PHA
318160	2004 QZ2	2022/01/16-28	7.3,5.6	132	-2	7.43	0.01	0.14	0.02	NEA

Table II. Observing circumstances and results. Pts is the number of data points. The phase angle values are for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009). ERI: Erigone; EUN: Eunomia; MB-I/O: Main-belt inner/outer; MC: Mars-crosser; NEA: near-Earth; THM: Themis; TRJ: Jupiter Trojan.



Acknowledgements

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