

THE MINOR PLANET BULLETIN

BULLETIN OF THE MINOR PLANETS SECTION OF THE
ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

VOLUME 50, NUMBER 3, A.D. 2023 JULY-SEPTEMBER

183.

LIGHTCURVE ANALYSIS FOR SIXTEEN MAIN-BELT ASTEROIDS

Gonzalo Fornas, AVA – J57, CAAT
Centro Astronómico del Alto Turia, SPAIN
gon@iicv.es

Fernando Huet, AVA – Z93

Enrique Arce, AVA – J67
Vallbona Observatory

Alvaro Fornas, AVA – J57, CAAT
Centro Astronómico del Alto Turia, SPAIN

(Received: 2023 January 26)

Photometric observations of sixteen main-belt asteroids were obtained on the nights from 2022 August - December. We derived the following rotational periods: 1055 Tynca 11.893 ± 0.001 h, 1417 Walinska, 1500 Jyvaskyla 8.827 ± 0.0002 h, 2003 Harding 4.453 ± 0.001 h, 2695 Christabel 5.623 ± 0.004 h, 3686 Antoku 6.744 ± 0.006 h, 4528 Berg 3.564 ± 0.001 h, 5501 1982 FF2 2.464 ± 0.002 h, 5643 Roques 7.490 ± 0.03 h, 7195 Danboice 8.689 ± 0.007 h, 7317 Cabot 2.345 ± 0.002 h, 12999 Torun 4.020 ± 0.002 h, 15476 Narendra, 19750 2000 CM62 6.518 ± 0.001 h, 23892 1998 SH49 3.722 ± 0.001 h, 33697 1999 KJ11 4.876 ± 0.003 h.

We report on the photometric analysis results for sixteen main-belt asteroids performed by Asociación Valenciana de Astronomía (AVA). This work has been done from the Astronomical Center Alto Turia (CAAT), with the MPC code J57, located in Aras de los Olmos, Valencia, and Observatorio Polop MPC Z93 (Alicante), both operated by members of the Valencian Astronomy Association (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.

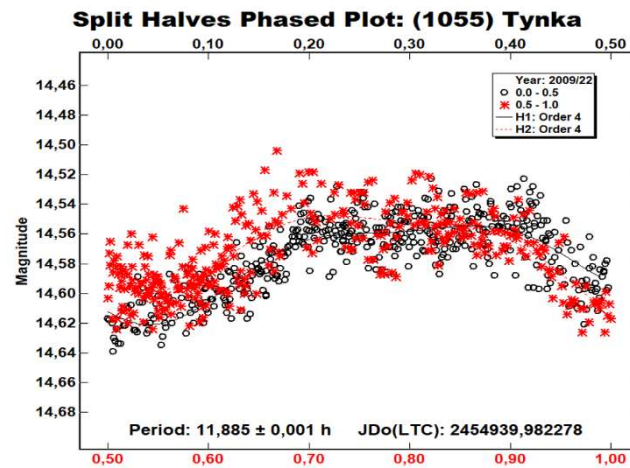
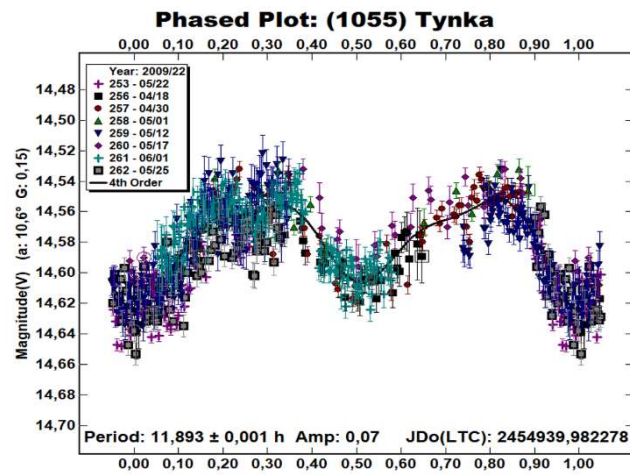
Observatory	Telescope (meters)	CCD
C.A.A.T. J57	43 cm DK	SBIG STXL-11002
C.A.A.T. J57	106 mm Refr	ZWO ASI 1600
Z93	SC 8"	SBIG ST8300
J67	SC 10"	SBIG ST7

Table I. List of instruments used for the observations.

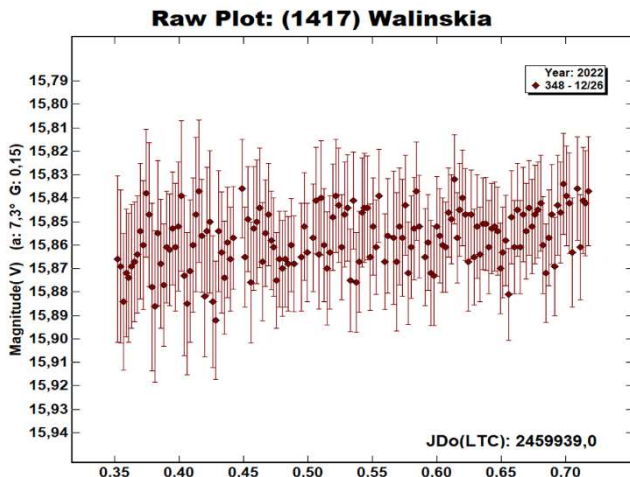
We concentrated on asteroids with no reported period and those where the reported period was poorly established and needed confirmation. All the targets were selected from the Collaborative Asteroid Lightcurve (CALL) website at (<http://www.minorplanet.info/call.html>) and Minor Planet Center (<http://www.minorplanet.net>). The Asteroid Lightcurve Database (LCDB; Warner et al., 2009) was consulted to locate previously published results.

Images were measured using *MPO Canopus* (Bdw Publishing) with a differential photometry technique. The comparison stars were restricted to near solar-color to avoid introducing 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.

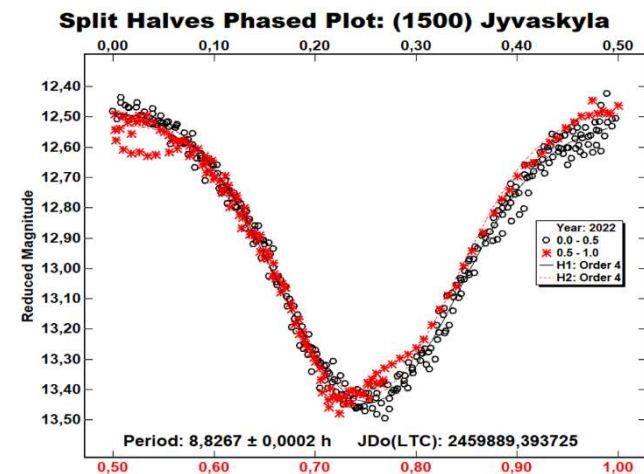
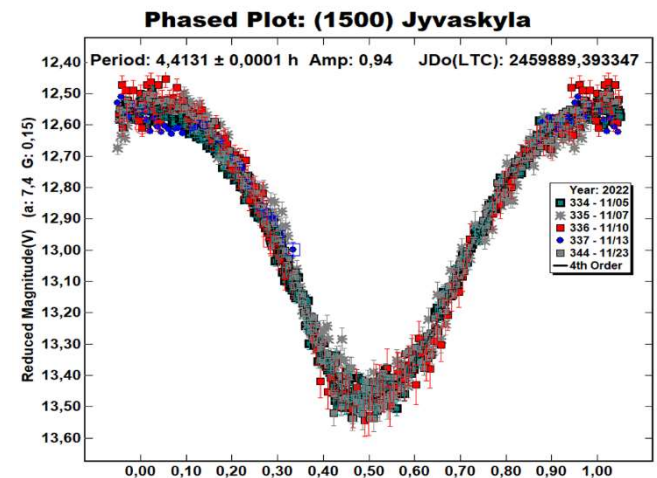
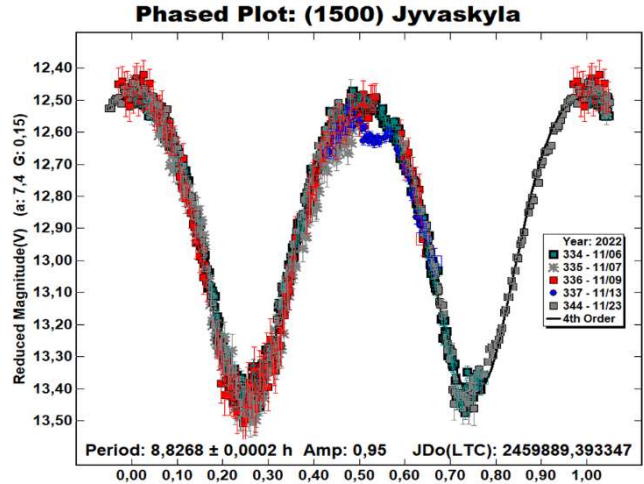
(1055) Tynka. This Main-Belt asteroid (inner) of the FLO category was discovered on 1925 Nov 17 by E. Buchar at the Algiers observatory, Argelia. We made observations on 2022 May 22 to Jun 04. In the ALCDEF we found data from Robert D. Stephens 2012/03/27 - 2012/05/09 and we have joined them to ours to improve the quality of the result. From this data we derive a rotation period of 11.893 ± 0.001 h and an amplitude of 0.07 mag. This is a bimodal period. We agree with Kryszczyńska et al. (2012) and Higgins and Pilcher (2009), with a period of 11.893 h. Durech et al. (2020) and Behrend (2012web, 2021web) have interpreted it's lightcurve as monomodal, with half period. Looking at halves of the period in the graphic, we think it is a bimodal asteroid since the halves are slightly different.



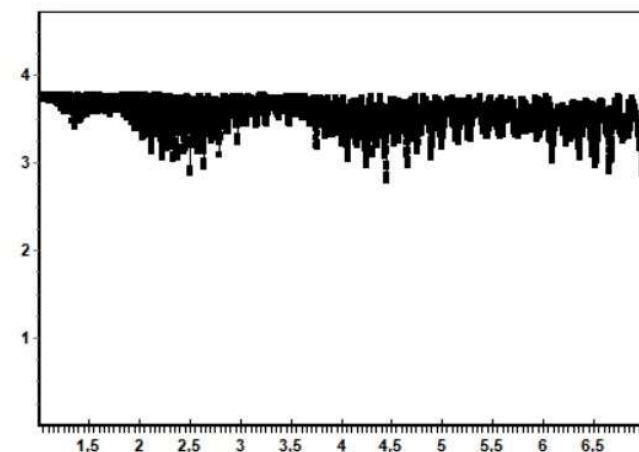
(1417) *Walinskia*. This Main-Belt asteroid (outer) was discovered on 1937 April 1 by K. Reinmuth at Heidelberg. We made observations on 2022 December 26. From our data we are not able to derive any rotation period. In ALCDEF a period of Behrend (2018web) appears, but when consulting the data we found that it is classified as uncertain by a curve provided by R. Roy. We can only confirm the uncertain character. Of course, we cannot confirm the period shown by ALCDEF with 2.93 h and with $A=0.04$. We do find some growth in luminosity, of 0.02 mag, that could indicate a longer period. We do not have better data at the moment.



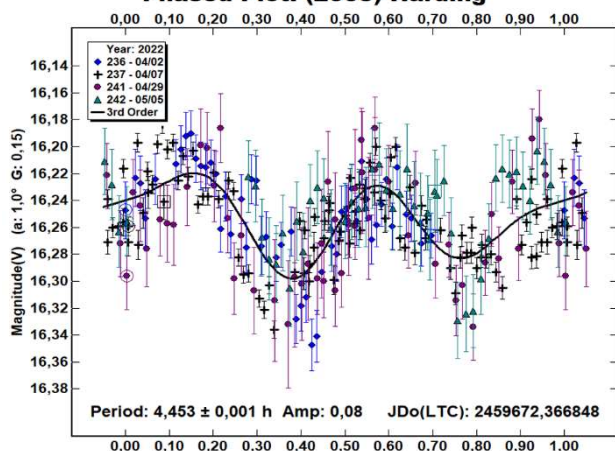
(1500) *Jyväskylä*. This Main-Belt asteroid (inner) was discovered on 1938 Oct 16 by Y. Väisälä at the Turku observatory, Finland. We made observations on 2022 Nov 6 to 23. From our data we derive a rotation period of $8,8268 \pm 0,0002$ h and an amplitude of 0.95 mag. We assume a bimodal lightcurve, but it could be analyzed as monomodal asteroid. We show also the monomodal graphic and the halves. Durech et al. (2016) also found a period of 8.827 h. with incomplete data ($U=2$).



(2003) Harding. This Main-Belt asteroid (outer) was discovered on 1960 Sep 24 by the Palomar Leiden Survey. We made observations on 2022 Apr 4 to May 5. From our data we derive a rotation period of 4.453 ± 0.001 h and an amplitude of 0.08 mag. We assume it as bimodal, even with a very symmetrical drawing. Alvarez-Candal et al. (2004) found a period of 2.96 h. We have reviewed our data with the periodogram and confirm the period of 4.45 h.

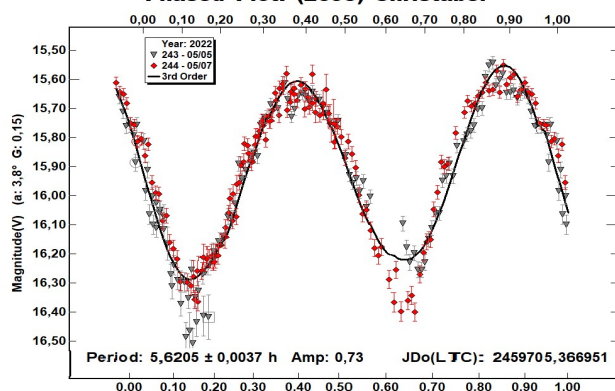


Phased Plot: (2003) Harding



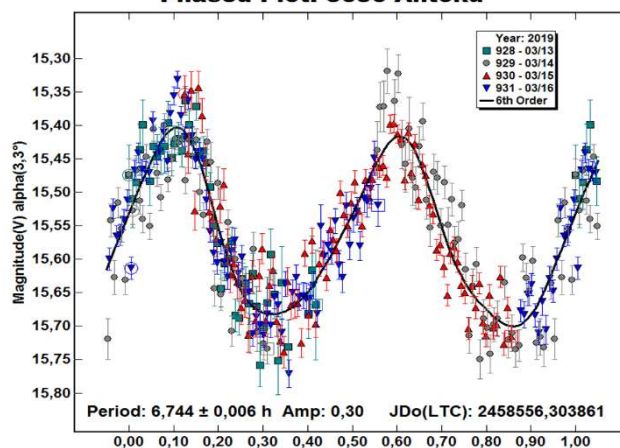
(2695) Christabel. This Main-Belt asteroid (middle) was discovered on 1979 Oct 17 by E. Bowell at Anderson Mesa Station, Arizona. We made observations on 2022 May 5-7. From our data we derive a rotation period of 5.623 ± 0.004 h and an amplitude of 0.73 mag. We assume it as bimodal, even with a very symmetrical drawing. Behrend (2018web) found a period of 6.009 h.

Phased Plot: (2695) Christabel



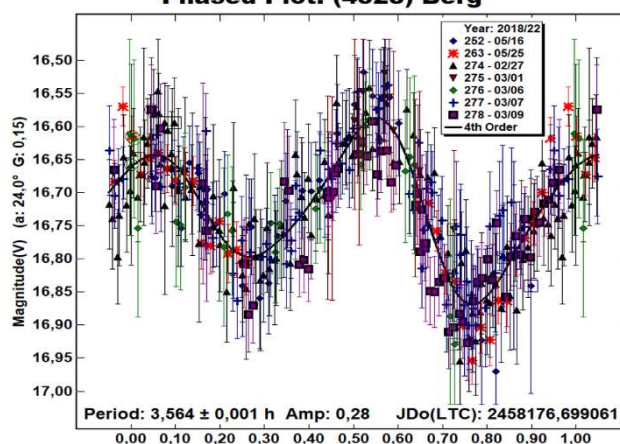
(3686) Antoku. This Main-Belt asteroid (middle) was discovered on 1987 March 3 by T. Nijima and, T. Urata at Ojima. We made observations on 2019 March 13-16. From our data we derive a rotation period of 6.744 ± 0.006 h and an amplitude of 0.3 mag. Waszczak et al. (2015) found 6.73 h and Behrend (2019web) found 6.374 h, which agrees with our observations.

Phased Plot: 3686 Antoku



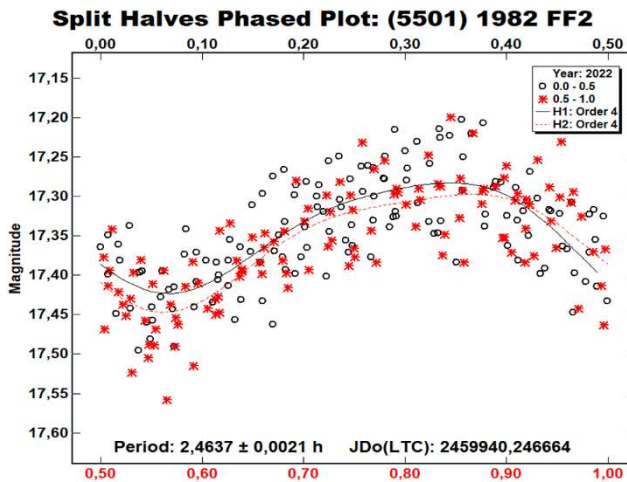
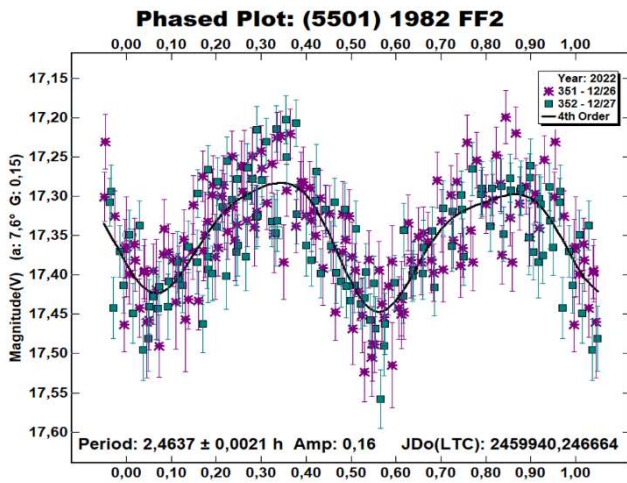
(4528) Berg. This Main-Belt asteroid (middle) was discovered on 1983 Aug 13 by E. Bowell at Anderson Mesa observatory. We made observations on 2022 May 16 -25. In the ALCDEF we found data from T.A. Polakis 2018/02/27 - 2018/03/12 and we have joined them to ours to improve the quality of the result. Data analysis found a rotation period of 3.564 ± 0.001 h and an amplitude of 0.28 mag. Behrend (2006web) found a period of 3.52 h, Setcher (2015) found 3.47 h and Polakis (2018) found 3.56 h.

Phased Plot: (4528) Berg

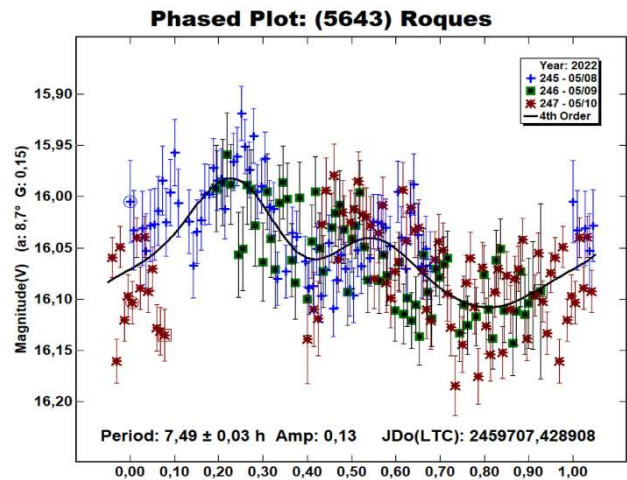


(5501) 1982 FF2. This Main-Belt asteroid (inner) was discovered on 1982 March 30 by L. G. Taff at SOCORRO, USA. We made observations on 2022 December 26-27. From our data we derive a rotation period of 2.464 ± 0.002 h and an amplitude of 0.16 mag. Chang et al. (2016) found a similar period of 2.46 h with U=1.

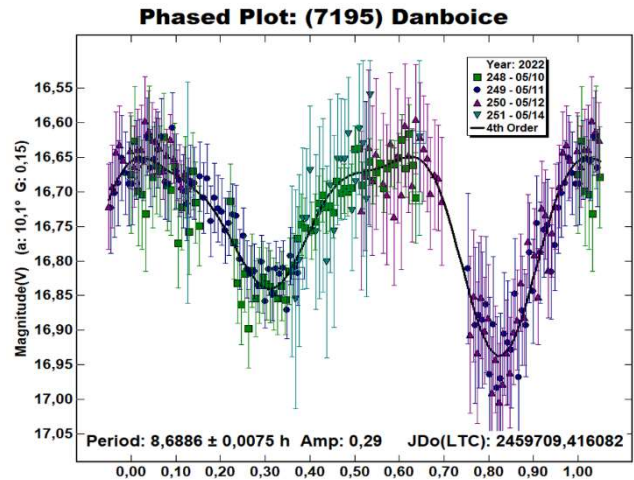
The asteroid could be perfectly monomodal since the lightcurve is completely symmetric. In any case we accept the bimodal form as good. This point is outside the accuracy of our team at this time. We attach the graph with helvets.



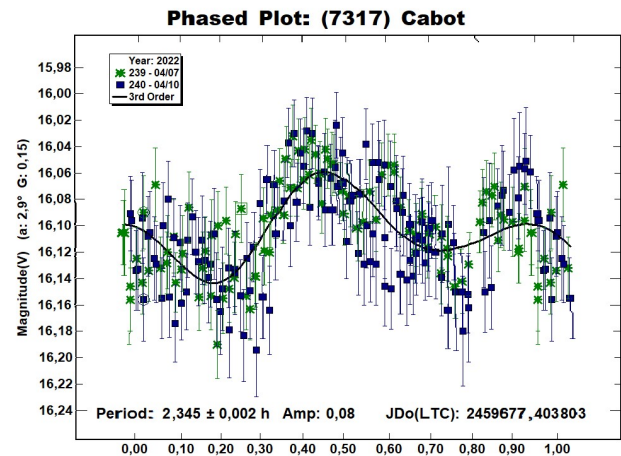
(5643) Roques. This Main-Belt asteroid (inner) of the FLO category was discovered on 1990 Aug 22 by H. E. Holt at Palomar Observatory, California. We made observations on 2022 May 8-10. From our data we derive a rotation period of 7.49 ± 0.03 h and an amplitude of 0.13 mag. Chang et al. (2016) found an ambiguous period of 3.89 / 7.78 h. with incomplete data ($U=1$).



(7195) Danboice. This-Main Belt asteroid (inner) was discovered on 1994 Jan 2 by H. E. Holt at Palomar Observatory, California. We made observations on 2022 May 10-14. From our data we derive a rotation period of 8.689 ± 0.0075 h and an amplitude of 0.29 mag. Chang et al. (2014) found a period of 8.67 h with incomplete data ($U=1+$), which is consistent with our observations.



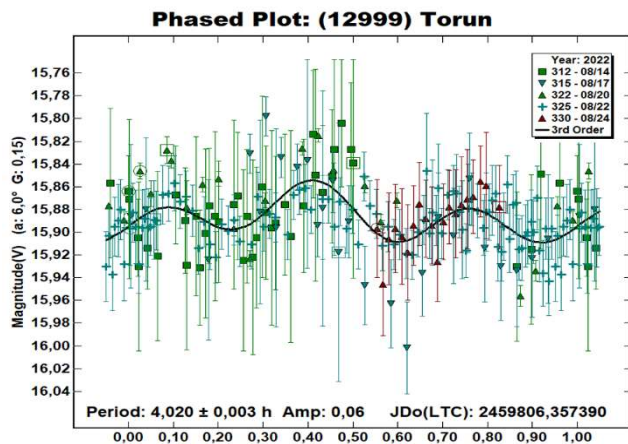
(7317) Cabot. This Main-Belt asteroid (inner) was discovered on 1940 March 12 by G. Kulin from the Konkoly Obs, Hungary. We made observations on 2022 Apr 4-10. From our data we derive a rotation period of 2.345 ± 0.002 h and an amplitude of 0.08 mag. Waszczak et al. (2015) found a period of 2.237 h with incomplete data ($U=1$).



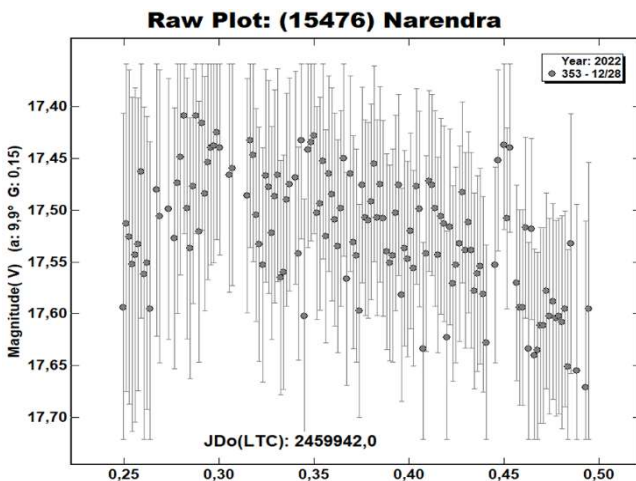
(12999) Torun. This Main-Belt asteroid (inner) of the FLO family was discovered on 1981 Aug 30 by E. Bowell at Anderson Mesa observatory in USA. We made observations on 2022 Aug 14-24. From our data we derive a rotation period of 4.020 ± 0.003 h and an amplitude of 0.06 mag. Waszczak et al. (2015) found a period of 3.552 h with incomplete data ($U=1$). We note these data are near the limit of our equipment.

Number	Name	mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1055	Tynka	22/05/02-06/04 (from Stephens) 2012 03/27-05/09	805	11.08	224.7	7.4	11.893	0.001	0.07	0.01	MB-I
1417	Walinskia	22/12/25	156	6.94	113.2	2.4	---	---	---	---	MB-O
1500	Jyvaskyla	2022/11/6-23	922	6.84-8.22	51.5	6.2	8.8268	0.0002	0.95	0.05	MB-I
2003	Harding	2022/04/04-05/05	250	4.73-6.27	195.9	0.35	4.453	0.001	0.08	0.01	MB-O
2695	Christabel	2022/05/ 5-7	250	3.98-4.23	219.4	7.3	5.623	0.004	0.73	0.05	MB-M
3686	Antoku	2019/03/13-16	340	24.69-24.55	240.9	6.45	6.744	0.006	0.3	0.05	MB-M
4528	Berg	2022/05/16-25 (from Polakis) 2018/02/27-02/12	363	24.05-24.65	174.95	4.35	3.564	0.001	0.28	0.05	MB-M
5501	1982 FF2	2022/12/26-27	255	20.77-20.85	28.1	1.2	2.464	0.002	0.16	0.02	MB-I
5643	Roques	2022/05/8-10	206	8.22-7.37	236.15	7.3	7.49	0.03	0.13	0.02	MB-I
7195	Danboice	2022/05/10-14	238	9.75-8.38	245.05	10.9	8.689	0.007	0.29	0.01	MB-I
7317	Cabot	2022/04/4-10	227	7.37-1.49	201.1	1.8	2.345	0.002	0.08	0.01	MB-I
12999	Torun	2022/08/14-24	205	6.05-11.77	313.85	2.2	4.020	0.002	0.06	0.01	MB-I
15476	Narendra	2022/12/28	137	10.36	80.8	-7.4	---	---	---	---	MB-I
19750	2000 CM62	2022/06-5/7-6	149	11.65-12.63	267	19.7	6.518	0.001	0.22	0.05	MB-M
23892	1998 SH49	2022/07/3-22	270	11.25-15.57	280	18.1	3.722	0.001	0.11	0.02	MB-
33697	1999 KJ11	2022/12/23-24	235	6.09-5.54	102.4	0.55	4.876	0.003	0.36	0.05	MB-I

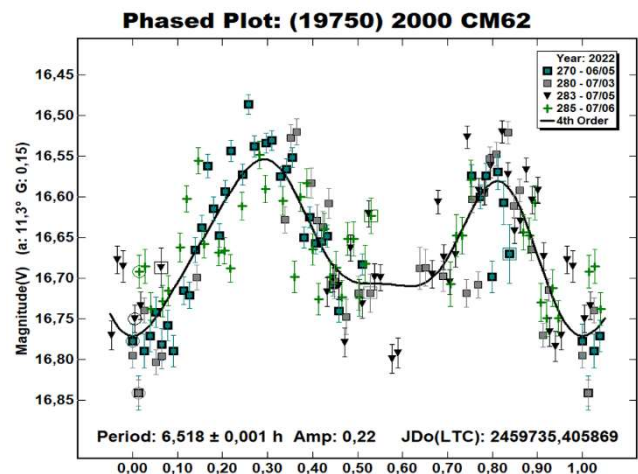
Table I. Observing circumstances and results. Pts is the number of data points. The phase angle values are for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner 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.



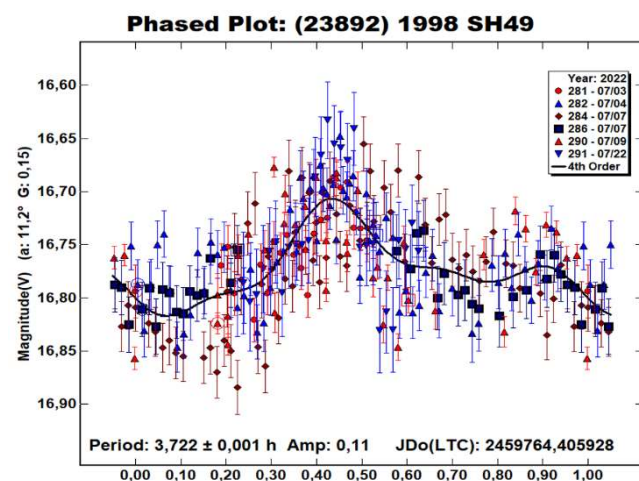
(15476) Narendra. This Main-Belt asteroid (inner) was discovered on 1999 Jan 18 by LINEAR at Socorro, USA. We made observations on 2022 December 28. From our data we are not able to derive any rotation period. In ALCDEF a period of Waszczak et al. (2015) appears, but when consulting the data we found that it is classified as uncertain U=1. We can only confirm the uncertain character. Of course, we cannot confirm the period shown by ALCDEF with 3.036 h and with A=0.08.



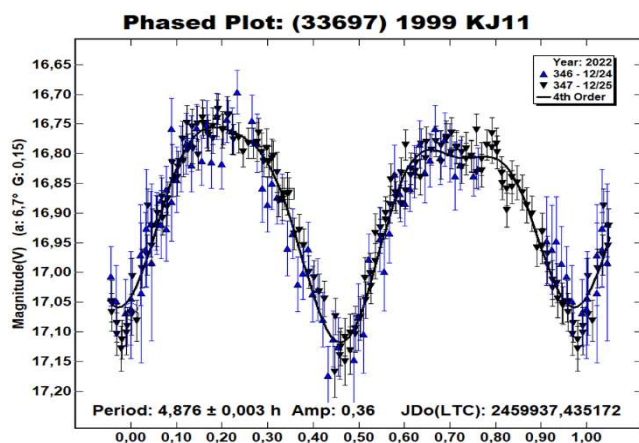
(19750) 2000 CM62. This Main-Belt asteroid (middle) of the MAR family was discovered on 2000 Feb 2 by LINEAR at Socorro in USA. We made observations on 2022 Jun 05 - Jul 06. From our data we derive a rotation period of 6.518 ± 0.001 h and an amplitude of 0.22 mag. Waszczak et al. (2015) found a period of 6.462 h which agrees with our observations.



(23892) 1998 SH49. This Main-Belt asteroid (outer) was discovered in 1998 Sep 23 by T. Pawels at the Royal Observatory of Belgium. We made observations on 2022 Jul 3-22. From our data we derive a rotation period of 3.722 ± 0.001 h and an amplitude of 0.11 mag. Waszczak et al. (2015) found a period of 3.72 h which agrees with our observations.



(33697) 1999 KJ11. This Main-Belt asteroid (inner) was discovered on 1999 May 18 at the LINEAR Observatory, Socorro, USA. We made observations on 2022 December 23-24. From our data we derive a rotation period of 4.876 ± 0.003 h and an amplitude of 0.36 mag. Pál et al. (2020) found a period of 4.888 h with $U=1$.



Acknowledgements

We would like to express our gratitude to Brian Warner for supporting the CALL web site and his suggestions.

References

- Alvarez-Candal, A.; Duffard, R.; Angeli, C.A.; Lazzaro, D.; Fernández, S. (2004). "Rotational lightcurves of asteroids belonging to familie." *Icarus* **172**, 388-401.
- Behrend, R. (2006web, 2012web, 2018web, 2019web, 2021web). Observatoire de Genève web site.
http://obswww.unige.ch/~behrend/page_cou.html
- Chang, C.-K.; Ip, W.-H.; Lin, H.-W.; Cheng, Y.-C.; Ngeow, C.-C.; Yang, T.-C.; Waszczak, A.; Kulkarni, S.R.; Levitan, D.; Sesar, B.; Laher, R.; Surace, J.; Prince, T.A. (2014). "313 new asteroid rotation periods from Palomar Transient Factory Observations." *Astrophys. J.* **788**, A17.
- Chang, C.-K.; Ip, W.-H.; Lin, H.-W.; Prince, T.A.; Kulkarni, S.R.; Levitan, D.; Laher, R.; Surace, J.; (2016). "Large super-fast rotator hunting using the Intermediatae Palomar Transient Facility." *Astrophys. J. Supp.* **227**, A20.
- Durech, J.; Hanuš, J.; Oszkiewicz, D.; Vančo, R. (2016). "Asteroid models from the Lowell photometric database." *Astron. Astrophys.* **587**, A48.
- Durech, J.; Tonry, J.; Erasmus, N.; Denneau, L.; Heinze, A.N.; Flewelling, H.; Vančo, R. (2020). "Asteroid models reconstructed from ATLAS photometry." *Astron. Astrophys.* **643**, A59.
- Harris, A.W.; Young, J.W.; Scaltriti, F.; Zappala, V. (1984). "Lightcurves and phase relations of asteroids 82 Alkmene and 444 Gyptis." *Icarus* **57**, 251-258.
- Higgins, D.; Pilcher, F. (2009). "Lightcurve analysis of 48 Doris and 1055 Tynka." *Minor Planet Bull.* **36**, 143-144.
- Kryszczyńska, A.; Colas, F.; Polinska, M.; Hirsch, R. and 26 colleagues (2012). "Do Silvan states exist in the Flora Family? I. Photometric Survey of the Flora region." *Astron. Astrophys.* **546**, A72.
- Pál, A.; Szakáts, R.; Kiss, C.; Bódi, A.; Bognár, Z.; Kalup, C.; Kiss, L.L.; Marton, G.; Molnár, L.; Plachy, E.; Sárneczky, K.; Szabó, G.M.; Szabó, R. (2020). "Solar System Objects Observed with TESS - First Data Release: Bright Main-belt and Trojan Asteroids from the Southern Survey." *Ap. J.* **247**, A26.
- Polakis, T. (2018). "Lightcurve analysis for eleven main-belt minor planets." *Minor Planet Bull.* **45**, 269-273.
- Stecher, G.; Ford, L.; Bluem, J.; Smith, B.; Fahey, S. (2015). "The rotation period of 4528 Berg." *Minor Planet Bull.* **42**, 148.
- Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2016 Sep.
<http://www.minorplanet.info/lightcurvedatabase.html>
- Waszczak, A.; Chang, C.-K.; Ofek, E.O.; Laher, R.; Masci, F.; Levitan, D.; Surace, J.; Cheng, Y.-C.; Ip, W.-H.; Kinoshita, D.; Helou, G.; Prince, T.A.; Kulkarni, S. (2015). "Asteroid light curves from the Palomar Transient Factory survey: rotation periods and phase functions from sparse photometry." *Astronomical Journal* **150**, 75.