

LIGHTCURVE ANALYSIS FOR SEVENTEEN MAIN-BELT AND TWO MARS-CROSSING ASTEROIDS

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Photometric observations of seventeen main-belt asteroids and two Mars-crossers were obtained between 2014 and 2019. We derived the following rotational periods: 174 Phaedra, 5.7396 ± 0.0029 h; 218 Bianca, 6.3380 ± 0.0005 h; 267 Tirza, 7.662 ± 0.003 h; 375 Ursula, 16.89839 ± 0.00024 h; 398 Admete, 20.991 ± 0.002 h; 1013 Tombecka, 6.04933 ± 0.00037 h; 1135 Colchis, 23.416 ± 0.007 h; 1795 Woltjer, 13.2574 ± 0.0034 h; 2078 Nanking, 6.4599 ± 0.0001 h; 2947 Kippenhahn, 10.952 ± 0.001 h; 3637 O'Meara, 5.7967 ± 0.0008 h; 3977 Maxine, 3.10 ± 0.01 h; 3999 Aristarchus, 12.6087 ± 0.0108 h; 4775 Hansen, 3.12349 ± 0.00004 h; 6729 Emiko, 3.1335 ± 0.0005 h; 6979 Shigefumi, 11.9455 ± 0.0023 h; (7774) 1992 UU₂, 3.86752 ± 0.00017 h; 9956 Castellaz, 2.3903 ± 0.0017 h; and (28892) 2000 LZ₂, 10.787 ± 0.003 h.

We report on the photometric analysis results for seventeen main-belt and two Mars-crosser asteroids by Asociación Valenciana de Astronomía (AVA). The data were obtained over several years, starting in 2014. We present graphic results of data analysis, mainly lightcurves, with the plot phased to a given period. We managed to obtain a number of accurate and complete lightcurves as well as some additional incomplete lightcurves to help analysis at future oppositions.

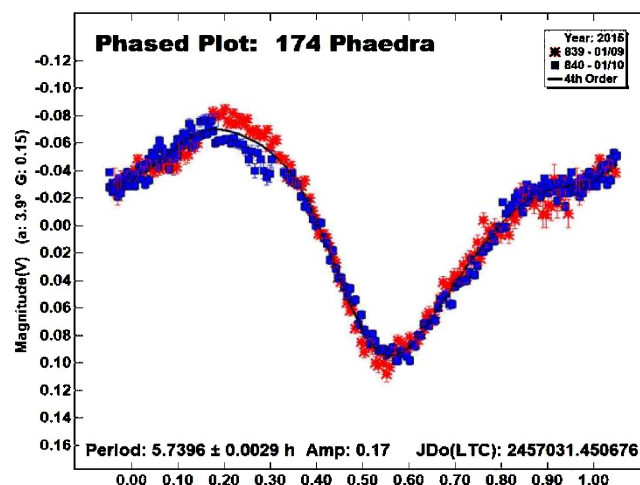
Observatory	Telescope (meters)	CCD
C.A.A.T.	0.45 DK	SBIG STL-11002
Zonalunar	0.20 NW	QHY6
Vallbona	0.25 SCT	SBIG ST7-XME
TRZ	0.20 R-C	QHY8
Elche	0.25 DK	SBIG ST8-XME

Table I. List of instruments used for the observations.

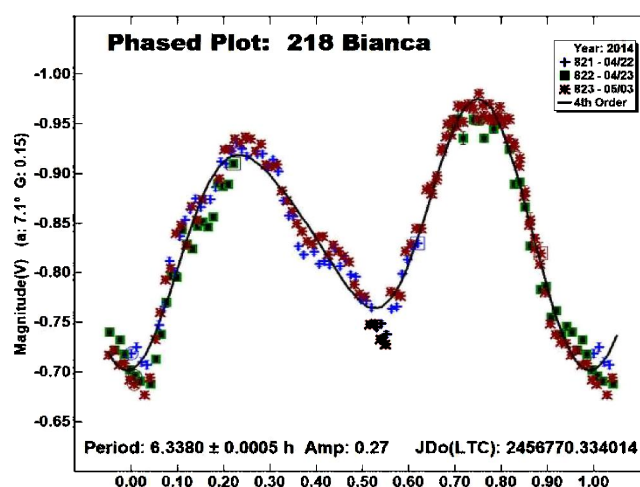
We concentrated on asteroids with no reported period and those where the reported period was poorly established and needed confirmation. All the targets were selected from the Collaborative Asteroid Lightcurve (CALL) website (<http://www.minorplanet.info/call.html>) and the Minor Planet Center (<http://www.minorplanet.net>). 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 minimize color dependencies, especially at larger air masses. The lightcurves show 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.

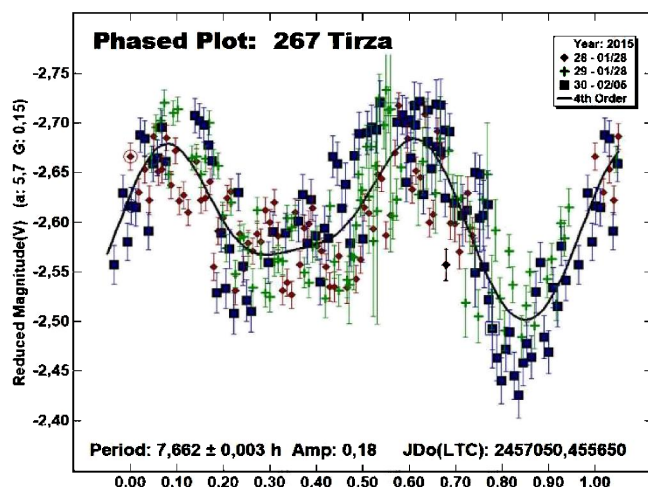
174 Phaedra. This outer main-belt asteroid was discovered on 1877 September 2 by J.C. Watson at Ann Arbor Observatory. We made observations on 2015 Jan 9 and 10. We derived a rotation period of 5.7396 ± 0.003 h and an amplitude of 0.17 mag. This is not consistent with the previous result of 5.75025 h from Āurech (2006), Marciniak et al. (2011) and Hanus et al. (2011).



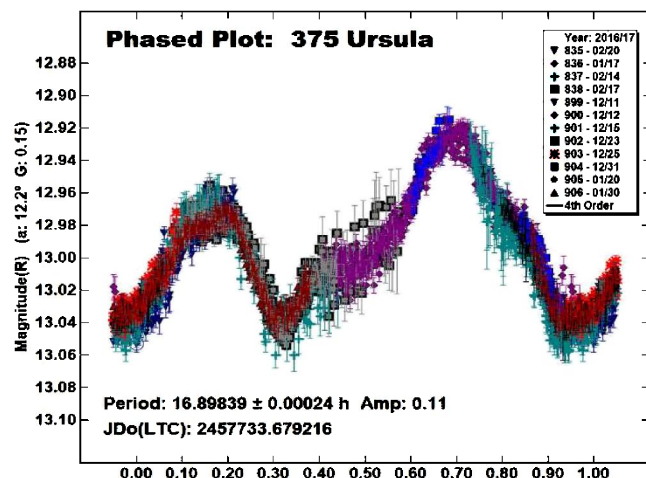
218 Bianca. This Flora group member was discovered on 1880 Sep 4 by J. Palisa at Pula. We made observations from 2014 April 22 to May 3. From our data we derive a rotation period of 6.3380 ± 0.0005 h and an amplitude of 0.27 mag. We agree with Kryszczyńska et al. (1996), Āurech et al. (2007), and Āurech et al. (2011) who reported a period close to 6.337 h.



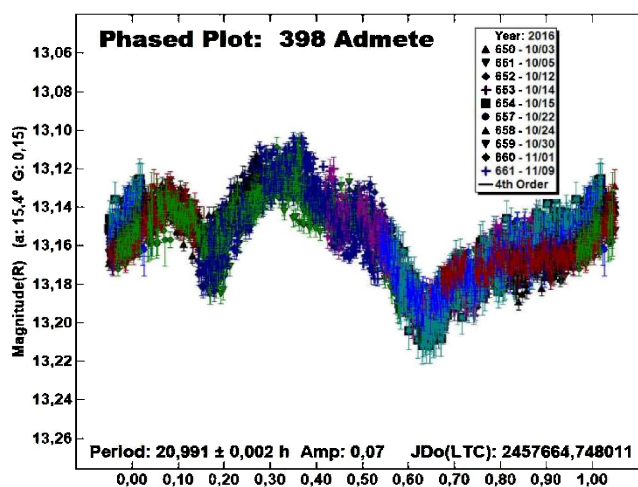
267 Tirza. This middle main-belt asteroid was discovered on 1887 May 27 by K.A. Charlois at Nice. We made observations on 2015 Jan 28 to Feb 5. From our data we derive a rotation period of 7.662 ± 0.003 h and an amplitude of 0.18 mag. This is consistent with the previous result from Āurech et al. (2020), who got a 7.653 h period, and Behrend (2004web; 2006web), 7.658 h.



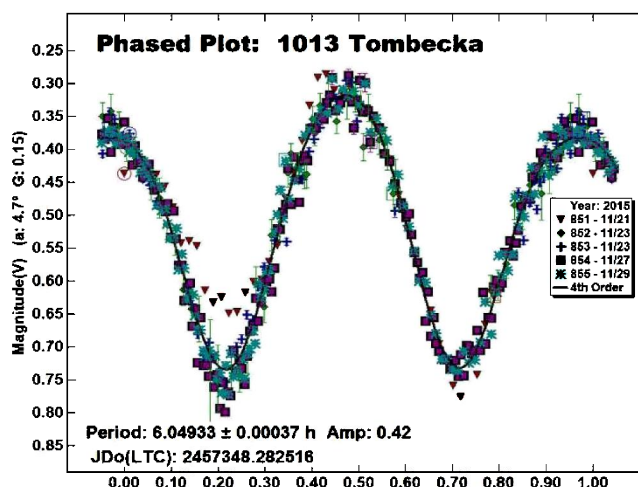
375 Ursula. This outer main-belt asteroid was discovered on 1893 Sep 18 by A. Charlois at Nice. We made observations on 2017 Jan 17 to Feb 17. From our data, we derive a rotation period of 16.89839 ± 0.00024 h and an amplitude of 0.14 mag. We joined data from Pilcher in the ALCDEF database (<https://alcdef.org>) covering 2016 Dec 11 through 2017 Feb 20 with ours to improve the quality of the result. From this data set we derive a rotation period of 16.8984 ± 0.0004 h and an amplitude of 0.11 mag. This is consistent with Āurech et al. (2020, 16.8937 h), Pilcher (2017b, 16.899 h), and Franco et al. (2021, 16.900 h).



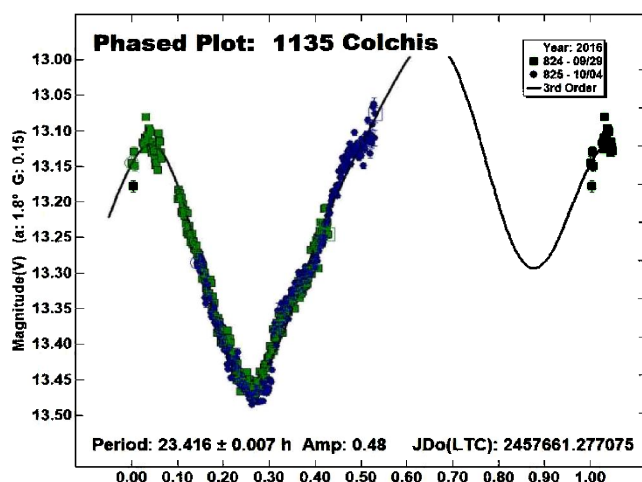
398 Admete. This inner main-belt asteroid was discovered on 1894 Dec 28 by A. Charlois at Nice. We made observations on 2016 Oct 3 to Nov 9. From our data, we derive a rotation period of 20.991 ± 0.0002 h and an amplitude of 0.07 mag. This agrees with the results from with Pilcher (2017a) who reported a period of 20.998 h based on data with a mid-date of 2016 Oct 10 and a period of 21.010 h based on data with a mid-date of 2016 Oct 25.



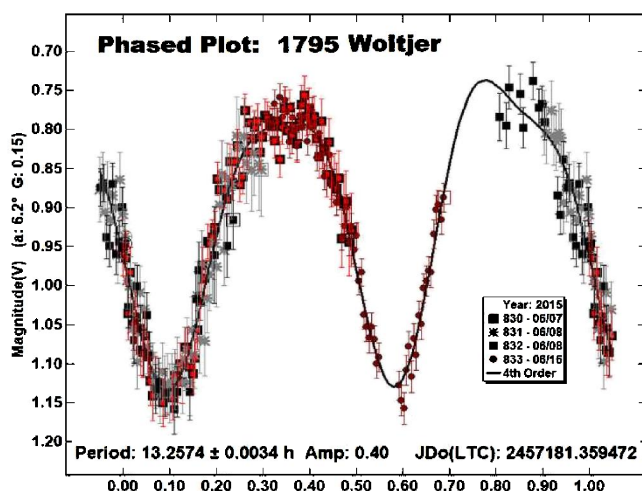
1013 Tombecka. This middle main-belt asteroid was discovered on 1924 Jan 27 by B. Jekhovsky at Algiers. We made observations on 2015 Nov 21-29. From our data we derive a rotation period of 6.04933 ± 0.00037 h and an amplitude of 0.42 mag. There are several results in LCDB consistent with 6.049 h, for example, Āurech et al. (2018, 6.05017 h) and Hanus et al. (2018, 6.05017 h).



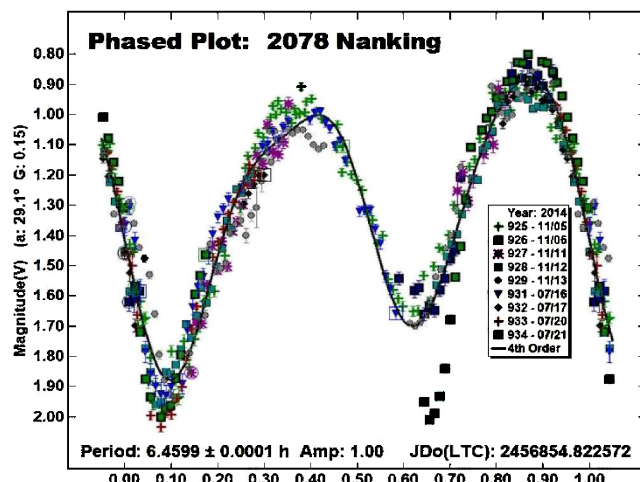
1135 Colchis. This middle main-belt asteroid was discovered on 1929 Oct 3 by G. N. Neujmin at the Crimea-Simeis Observatory. We made observations on 2016 Sep 29 to Oct 4. Data analysis found a rotation period of 23.416 ± 0.007 h and an amplitude of 0.48 mag. Behrend (2016web) and Stephens and Malcolm (2001) found 24.47 h, Hanus et al. (2016) found a period of 23.483 h, and Āurech et al. (2016) found a period of 23.4827 h.



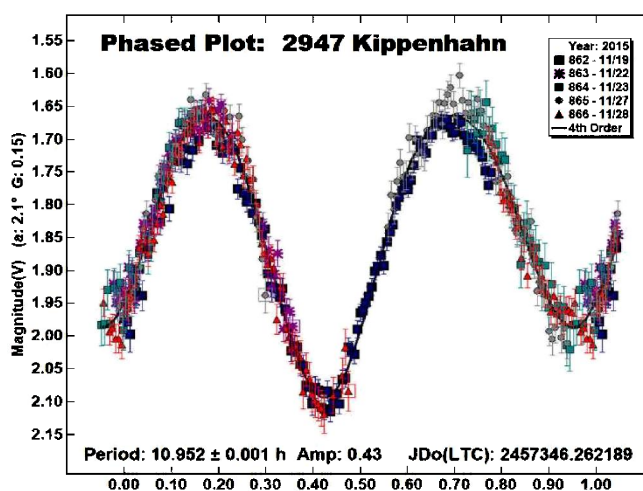
1795 Woltjer. This Dora family member (Nesvorný et al., 2015; Nesvorný et al., 2015) was discovered on 1960 Sep 24 by PLS at Palomar. We made observations on 2015 Jun 7-16. From our data, we derive a rotation period of 13.2574 ± 0.0034 h and an amplitude of 0.4 mag. Garcerán et al. (2016) found a different result with the same data, 12.102 h. We note that different periods are given in the lightcurve and the text. We confirm now a 13.2574 h period.



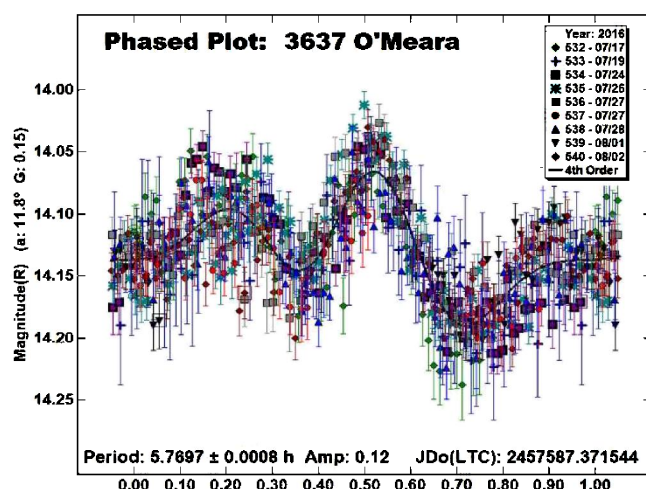
2078 Nanking. This Mars-crosser asteroid was discovered on 1975 Jan 12 at the Purple Mountain Obs. We made observations on 2014 Nov 5-13. From our data we derive a rotation period of 6.460 ± 0.001 h and amplitude of 0.96 mag. We found data in the ALCDEF database from Warner covering 2014 Jul 15-22 and joined them with ours to improve the quality of the result. From this data set we derive a rotation period of 6.4599 ± 0.00001 h and amplitude of 1.00 mag. Warner (2015) found a period of 6.459 h and Pal et al. (2020) reported 6.46122 h; these are consistent with our analysis.



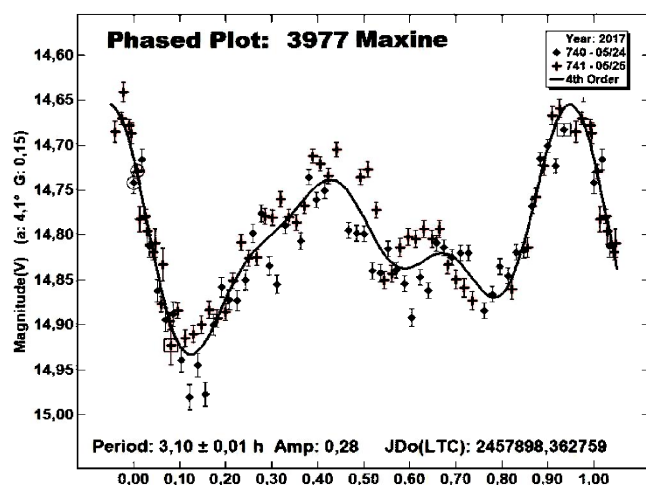
2947 Kippenhahn. This inner main-belt asteroid was discovered on 1955 Aug 22 by I. van Houten-Groeneveld at Heidelberg. We made observations on 2015 Nov 19-28. From our data we derive a rotation period of 10.952 ± 0.001 h and an amplitude of 0.43 mag. Ďurech et al. (2018; 2020) found, respectively, periods of 10.95528 and 10.95526 h. Aznar Macías et al. (2016) found 10.43 h and Chytrný et al. (2011) found 10.5 h.



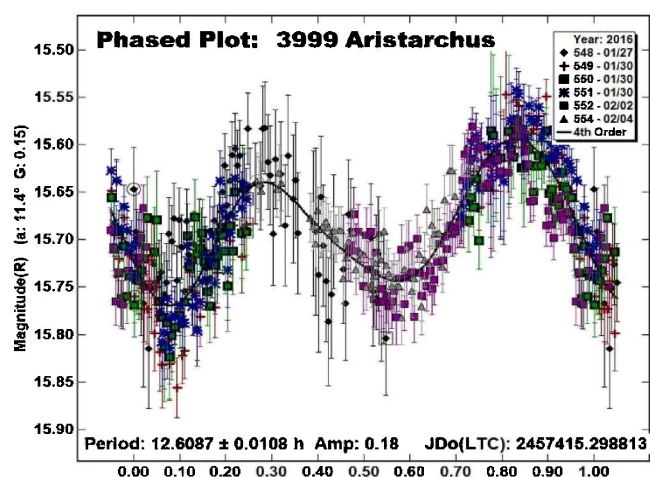
3637 O'Meara. This middle main-belt asteroid was discovered on 1984 Oct 23 by B.A. Skiff at Anderson Mesa Observatory. We made observations on 2016 Jul 7 to Aug 2. From our data we derive a rotation period of 5.7967 ± 0.00008 h and an amplitude of 0.12 mag. Consistent with our results are those from Polakis (2020, 5.751 h) and Pal et al. (2020, 5.77146 h). Results from Behrend (2008web, 5.49 h; 2018web, 7.710 h) are more divergent.



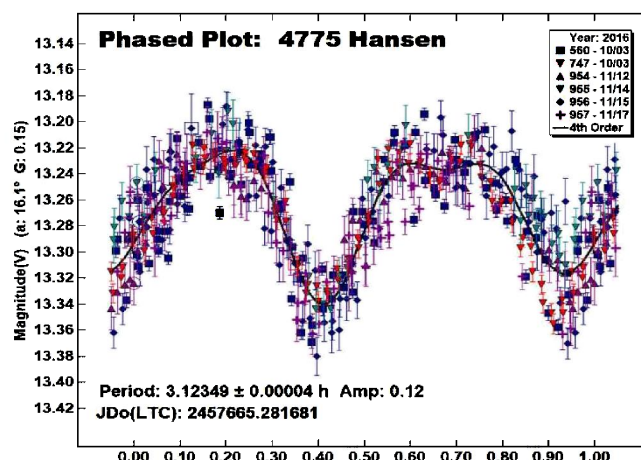
3977 Maxine. This Eunomia family member (Nesvorny, 2015; Nesvorny et al., 2015) was discovered on 1983 Jun 14 by C.S. Shoemaker and E.C. Shoemaker at Palomar Observatory in USA. We made observations on 2017 May 24-25. From our data we derive a rotation period of 3.10 ± 0.01 h and an amplitude of 0.28 mag. Franco et al. (2014) and Benishek (2023) both found a period of 3.081 h.



3999 Aristarchus. This inner main-belt asteroid was discovered on 1989 Jan 5 by T. Kojima at Chiyoda. We made observations on 2016 Jan 27 to Feb 4. From our data, we derive a rotation period of 12.6087 ± 0.0108 h and an amplitude of 0.18 mag. Diteon et al. (2010) found a period of 12.58 h.

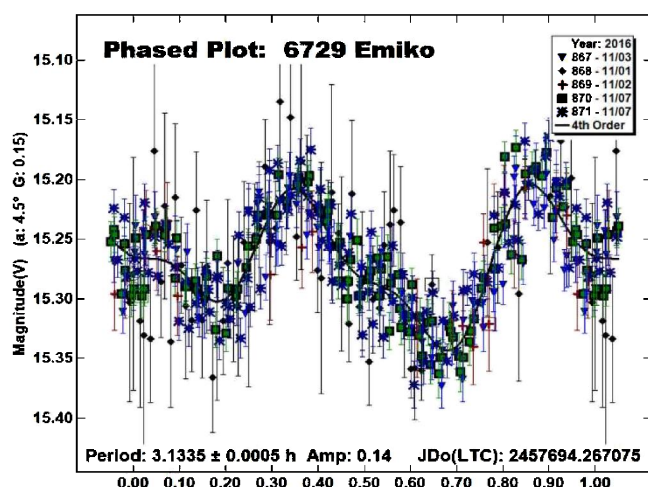


4775 Hansen. This Mars-crosser asteroid was discovered on 1927 Oct 3 by M.F. Wolf at Heidelberg Observatory. We made observations on 2016 Oct 3 and 4. From our data we derive a rotation period of 3.12349 ± 0.00004 h and an amplitude of 0.12 mag.

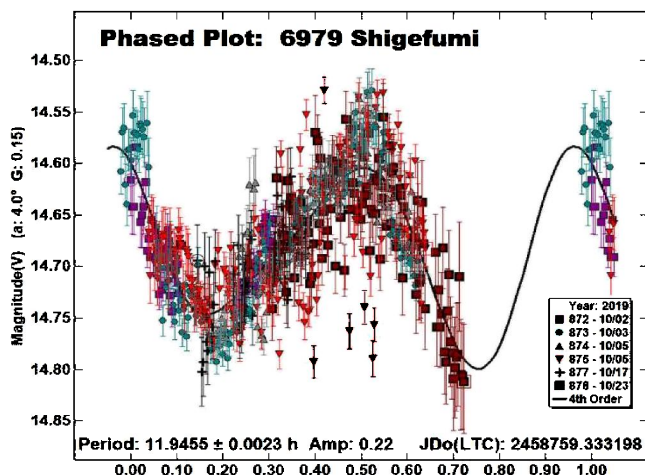


Pravec et al. (2016web) found a period of 3.1185h; Warner (2017) found 3.124 h, and Sada et al. (2017) reported 3.1182 h using data with a mid-date of 2016 Aug 20 and 3.1182 h using data with a mid-date of 2016 Oct 7. We found data from Warner in the ALCDEF database covering 2016 Nov 11-17. We joined them with ours to improve the quality of the result. From this data set we derive $P = 3.12349 \pm 0.00004$ h and $A = 1.12$ mag

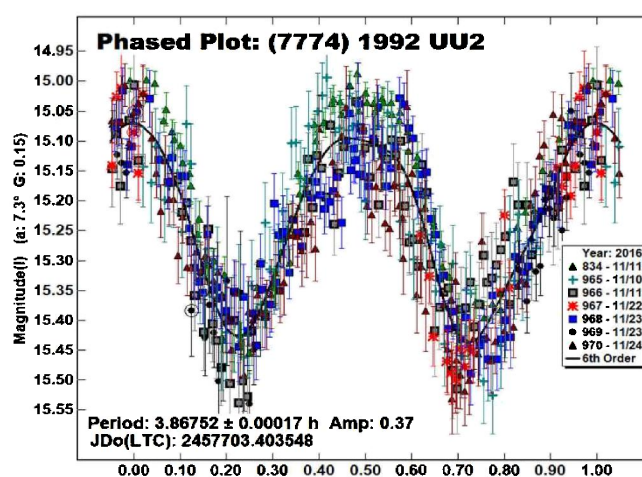
6729 Emiko. This middle main-belt asteroid was discovered on 1991 Nov 4 by S. Otomo at Kiyosato Observatory. We made observations on 2016 Nov 3-7. From our data we derive a rotation period of 3.1335 ± 0.0005 h and an amplitude of 0.14 mag. Behrend (2016web) reported 3.13 h and Benishek (2022) found 3.14 h.



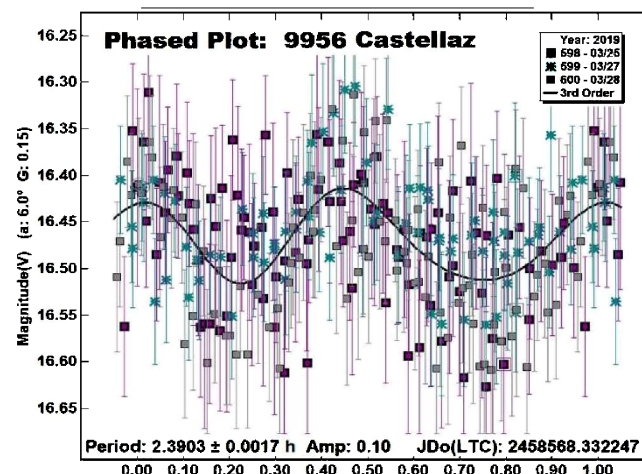
6979 *Shigefumi*. This inner main-belt asteroid was discovered on 1993 Sep 12 by K. Endate and K. Katanabe at Kitami. We made observations on 2019 Oct 2-23. From our data we derive a rotation period of 11.9455 ± 0.0023 h and an amplitude of 0.22 mag. Āurech et al. (2018) found a period of 12.10795 h.



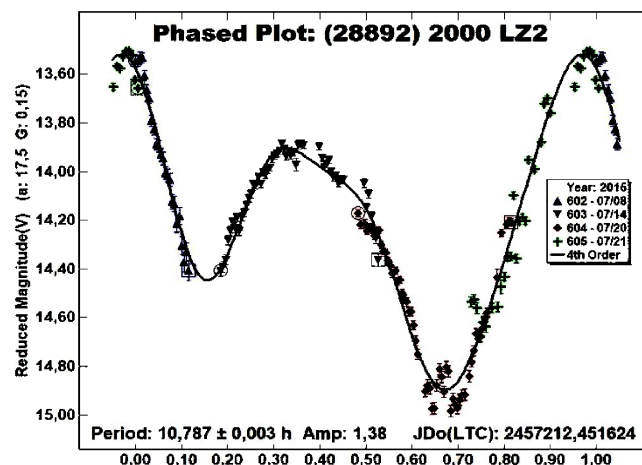
(7774) 1992 UU2. This inner main-belt asteroid was discovered on 1992 Oct 19 by K. Endate and K. Katanabe at Kitami. We made observations on 2016 Nov 10. From our data we derive a rotation period of 3.86752 ± 0.00017 h and an amplitude of 0.42 mag. Other results are from Krotz et al. (2010, 3.87 h), Foylan (2017, 3.868 h), Aznar (2017, 3.869 h), and Āurech et al. (2020, 3.867221 h). Data from Foylan in the ALCDEF database (2016 Nov 10-24) were joined with ours to improve the result. From this data set we derive $P = 3.86752 \pm 0.00017$ h and $A = 0.37$ mag.



9956 *Castellaz*. This inner main-belt asteroid was discovered on 1991 Oct 5 by L.D. Schmadel and F. Börngen at Tautenburg Observatory. We made observations on 2019 March 25-28. From our data we derive a rotation period of 2.390 ± 0.002 h and an amplitude of 0.1 mag. There were no previous rotation period results in the LCDB.



(28892) 2000 LZ2. This inner main-belt asteroid was discovered on 2000 at LINEAR, Socorro. We made observations from 2015 Jul 8-21. From our data we derive $P = 10.787 \pm 0.003$ h and $A = 1.38$ mag. Pravec et al. (2015web) found $P = 11.2575$ h



Number	Name	20yy/mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
174	Phaedra	15/01/09-01/10	369	4.0, 4.2	103	10	5.7396	0.0029	0.17	0.01	MB-O
218	Bianca	14/04/22-05/03	203	7.1, 9.2	208	14	6.3380	0.0005	0.27	0.01	MB-M
267	Tirza	15/01/28-02/05	268	6.6, 8.8	112	5	7.662	0.003	0.18	0.03	MB-M
375	Ursula (Pilcher)	17/01/04-02/20 16/12/11-17/02/20	175	4.4, 11.9	113	13	16.89839	0.00024	0.11	0.01	MB-O
398	Admete	16/10/03-11/09	3986	15.4, 7.5	38	12	20.991	0.002	0.07	0.01	MB-M
1013	Tombecka	15/11/21-11/29	454	4.7, 7.9	52	7	6.04933	0.00037	0.42	0.02	MB-M
1135	Colchis	16/09/29-10/04	475	1.7, 1.5	8	2	23.416	0.007	0.48	0.05	MB-M
1795	Woltjer	15/06/07-06/16	259	5.9, 19.9	253	9	13.2574	0.0034	0.40	0.03	MC
2078	Nanking (Warner)	14/11/05-11/13 14/07/15-07/22	430	29.1, 37.1	22	27	6.4599	0.0001	1.00	0.02	MB-I
2947	Kippenhahn	15/11/19-11/28	452	2.1, 5.3	55	3	10.952	0.001	0.43	0.01	MB-I
3637	O'Meara	16/07/17-08/02	714	11.6, 15.1	289	19	5.7697	0.0008	0.12	0.02	MB-M
3977	Maxine	17/05/24-05/25	109	4.0, 4.3	240	7	3.10	0.01	0.28	0.02	MB-M
3999	Aristarchus	16/01/27-02/04	499	10.9, 14.7	107	0	12.6087	0.0108	0.18	0.03	MB-I
4775	Hansen (Warner)	16/10/03-10/04 16/11/12-11/17	463	15.7, 29.5	13	12	3.12349	0.00004	0.12	0.01	MC
6729	Emiko	16/11/03-11/07	395	4.5, 5.3	40	8	3.1335	0.0005	0.14	0.02	MB-M
6979	Shigefumi	19/10/02-10/23	660	4.3, 9.3	14	6	11.9455	0.0023	0.22	0.03	MB-M
7774	1992 UU2 (Foylan)	16/11/10 16/11/10-11/24	524	7.9, 2.3	59	-3	3.86752	0.00017	0.37	0.02	MB-I
9956	Castellaz	19/03/25-03/28	272	5.4, 7.2	175	0	2.3903	0.0017	0.1	0.03	MB-I
28892	2000 LZ2	15/07/08-07/21	168	17.7, 15.1	307	19	10.787	0.003	1.38	0.02	MB-I

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). MB-I/O: Main-belt inner/outer; MC: Mars-crosser.

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