Number	Name	2021/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
22	Kalliope	11/26-12/05	14.1,11.1	97	7	4.1479	0.0001	0.49	0.03
6249	Jennifer	12/31-12/31	*20.3,19.7	0	0	4.958	0.001	0.55	0.02
12198	1980 PJ1	12/12-12/20	10.9,15.7	68	3	5.505	0.001	0.59	0.01
45687	Pranverahyseni	11/30-12/04	13.0,12.1	101	-19	17.85	0.03	0.51	0.05
52800	1998 QT60	12/16-01/04	19.9,7.5	106	12	T136.4	0.1	0.82	0.03

Table II. Observing circumstances and results. TDominant period for a tumbling asteroid. 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_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984).

Acknowledgements

This work includes data from the Asteroid Terrestrial-impact Last Alert System (ATLAS) project. ATLAS is primarily funded to search for near earth asteroids through NASA grants NN12AR55G, 80NSSC18K0284, and 80NSSC18K1575; byproducts of the NEO search include images and catalogs from the survey area. The ATLAS science products have been made possible through the contributions of the University of Hawaii Institute for Astronomy, the Queen's University Belfast, the Space Telescope Science Institute, and the South African Astronomical Observatory. The authors gratefully acknowledge Shoemaker NEO Grants from the Planetary Society (2007, 2013). These were used to purchase some of the telescopes and CCD cameras used in this research.

References

Carreño, A.; Arce, E.; Fornas, G.; Mas, V. (2019). "Eleven Main-belt Asteroids and One Near-Earth Asteroid Lightcurves at Asteroids Observers (OBAS) - MPPD: 2017 May - 2019 Jan." *Minor Planet Bul.* **46**, 200-203.

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.

Harris, A.W.; Young, J.W.; Contreiras, L.; Dockweiler, T.; Belkora, L.; Salo, H.; Harris, W.D.; Bowell, E.; Poutanen, M.; Binzel, R.P.; Tholen, D.J.; Wang, S. (1989). "Phase relations of high albedo asteroids: The unusual opposition brightening of 44 Nysa and 64 Angelina." *Icarus* **81**, 365-374.

Harris, A.W.; Pravec, P.; Galad, A.; Skiff, B.A.; Warner, B.D.; Vilagi, J.; Gajdos, S.; Carbognani, A.; Hornoch, K.; Kusnirak, P.; Cooney, W.R.; Gross, J.; Terrell, D.; Higgins, D.; Bowell, E.; Koehn, B.W. (2014). "On the maximum amplitude of harmonics on an asteroid lightcurve." *Icarus* **235**, 55-59.

Masiero, J.R.; Mainzer, A.K.; Bauer, J.M.; Cutri, R.M.; Grav, T.; Kramer, E.; Pittichova, J.; Wright, E.L. (2021). "Asteroid Diameters and Albedos from NEOWISE Reactivation Mission Years Six and Seven." *Plan. Sci. J.* **2**, id.162.

Tonry, J.L.; Denneau, L.; Flewelling, H.; Heinze, A.N.; Onken, C.A.; Smartt, S.J.; Stalder, B.; Weiland, H.J.; Wolf, C. (2018). "The ATLAS All-Sky Stellar Reference Catalog." *Astrophys. J.* **867**, A105.

Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2021 August. *http://www.minorplanet.info/lightcurvedatabase.html*

Warner, B.D. (2015). "Asteroid Lightcurve Analysis at CS3-Palmer Divide Station: 2015 March-June." *Minor Planet Bul.* **42**, 267-276.

COLLABORATIVE ASTEROID PHOTOMETRY OF SIX MAIN-BELT ASTEROIDS

Stephen M. Brincat
Flarestar Observatory (MPC 171)
Fl.5/B, George Tayar Street,
San Gwann SGN 3160, MALTA
stephenbrincat@gmail.com

Charles Galdies
Znith Observatory
Naxxar NXR 2217, MALTA

Martin Mifsud
Manikata Observatory
Manikata MLH 5013, MALTA

Kevin Hills
Tacande Observatory
El Paso, La Palma, SPAIN

(Received 2021 Nov 17)

Synodic rotation periods of six main-belt asteroids were derived from photometric observations obtained from 2021 July 21 through November 2 from three observatories situated in Malta and one from Spain. We provide lightcurve rotation periods for (1713) Bancilhon, (2232) Altaj, (2458) Veniakaverin, (6681) Prokopovich, (6787) 1991 PF15, and (18863) 1999 RC191.

Photometric observations of six asteroids were carried out from four observatories located on the Maltese mainland and another located on the island of La Palma, Spain. Observations of asteroids for (1713) Bancilhon, (2232) Altaj, (2458) Veniakaverin, (6681) Prokopovich, and (6787) 1991 PF15 were obtained from the Maltese observatories, while the data for (18863) 1991 RC191 were obtained from Spain. Our observatories used the configurations shown in Table 1. All of our images were dark subtracted and flat-fielded.

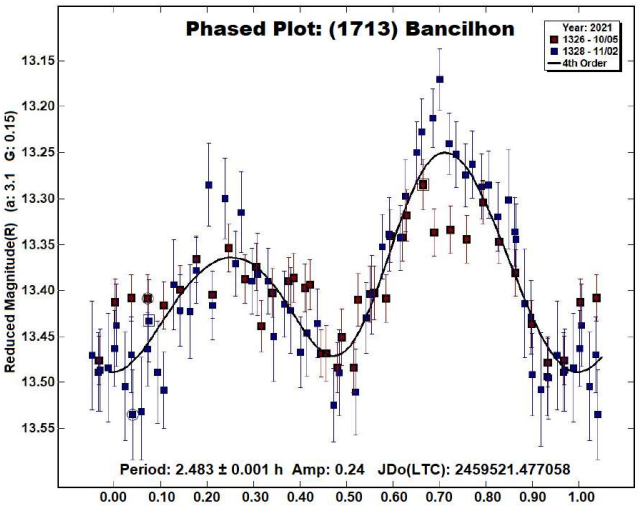
All telescopes and cameras were controlled remotely over the internet either from a location near each telescope via *Sequence Generator Pro* (Binary Star Software) or through remote programing for the La Palma Observatory. Photometric reduction, lightcurve construction and analyses were derived through *MPO Canopus* software (Warner, 2017) where differential aperture photometry was used. The Comparison Star Selector (CSS) feature of *MPO Canopus* was used to select comparison stars of near-solar color. Our magnitude measurements were based on the ATLAS catalogue through the Red (r) bandpass.

Observatory	Tel	F	CCD	Observed
Flarestar (MPC171)	0.25m SCT	C	Moravian G2-1600	2232(3) 2458(4)
Znith	0.20m SCT	C	Moravian G2-1600	2232(2) 2458(2) 6681(3)
Manikata	0.20m SCT	C	SBIG ST-9	1713(2) 2232(3)
Tancade	0.50m CDK	Rc	QHY-600	18863(1)

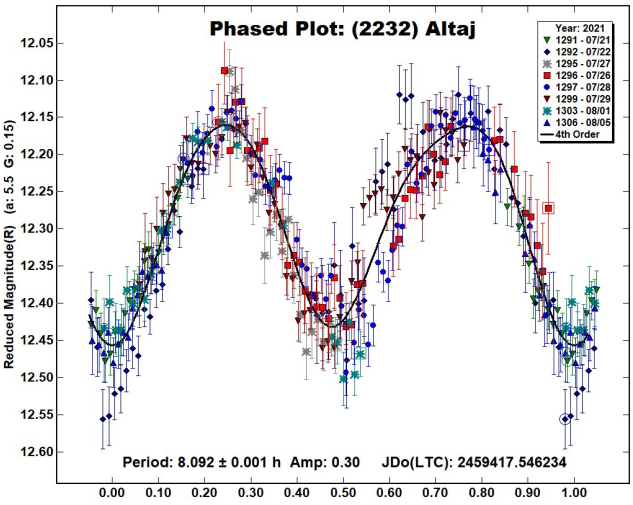
Table I. Instruments used. The F column gives the filter. The Observed column gives the asteroid number and, in parentheses, the number of observing sessions contributed by the observatory. SCT: Schmidt- Cassegrain; CDK: Corrected Dall-Kirkham.

1713 Bancilhon is a main-belt asteroid that was discovered on 1951 September 27 by L. Boyer at Algiers Observatory. It is named in honor of the French astronomer Odette Bancilhon (1908 - 1998), who discovered the asteroid (1333) Cevenola from the same observatory (Schmadel, 2012). The estimated diameter of 5.716 ± 0.113 km based on an absolute magnitude H = 13.34. The semi-major axis = 2.223 au, the eccentricity = 0.184, and the orbital period = 3.32 years (JPL, 2021).

Bachilon was observed from Manikata Observatory during two nights on 2021 October 5 and November 2. Weather conditions prevented us from obtaining additional data during the interim period. Our results yielded a synodic period of 2.483 ± 0.001 h and amplitude of 0.24 ± 0.05 mag. The Lightcurve Database (LCDB from hereon; Warner et al., 2009) did not contain any references of the synodic period for this asteroid.



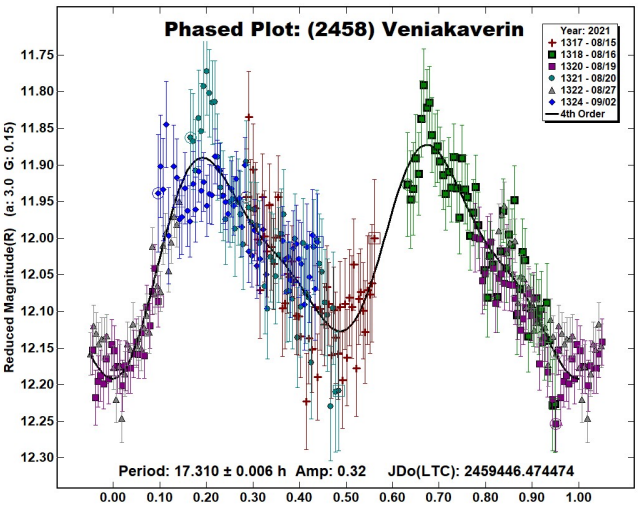
2232 Altaj (1969 RD2) is a main-belt asteroid that was discovered by B.A. Burnasheva at the Crimean Astrophysical Observatory on 1969 Sept. 15. It was named by the discoverer for the place of residence of her mother, Elena Andreevna Vasil'eva (Schmadel, 2012). Some orbital properties are semi-major axis = 2.668AU, eccentricity = 0.1433, and orbital period = 4.36 years (JPL, 2021). The JPL Small-Bodies Database Browser lists the diameter of 2232 Altaj as 11.780 ± 0.212 km based on an absolute magnitude H = 12.18.



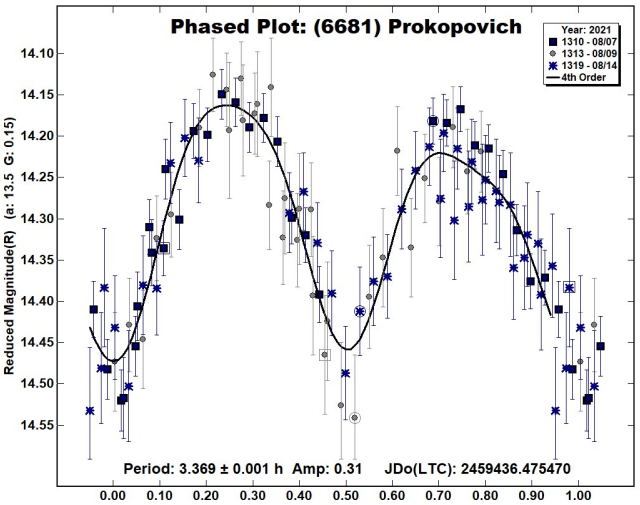
2232 Altaj was observed over eight nights from 2021 July 21 to August 5. Our analysis yielded a synodic rotation period of 8.092 ± 0.001 h and amplitude of 0.30 ± 0.06 mag. This is consistent with Ďurech et al. (2020).

2458 Veniakaverin (1977 RC7) is a main-belt asteroid that was discovered on 1977 Sep 11 by N. Chernykh at Nauchnyj. It was named after Soviet writer Veniamin Aleksandrovich Kaverin (1902-1989) (Schmadel, 2012). The estimated diameter is 22.764 ± 0.138 km based on an absolute magnitude of H = 12.05. The orbital semi-major axis is 3.131AU, the eccentricity is 0.144, and the orbital period is 5.54 years (JPL, 2021).

Observations were conducted by Flarestar and Znith Observatories over six nights from 2021 August 15 to September 2. Our analysis indicates a synodic period of 17.310 ± 0.006 h and amplitude of 0.32 ± 0.06 mag. The LCDB did not contain any references of the synodic period for this asteroid.



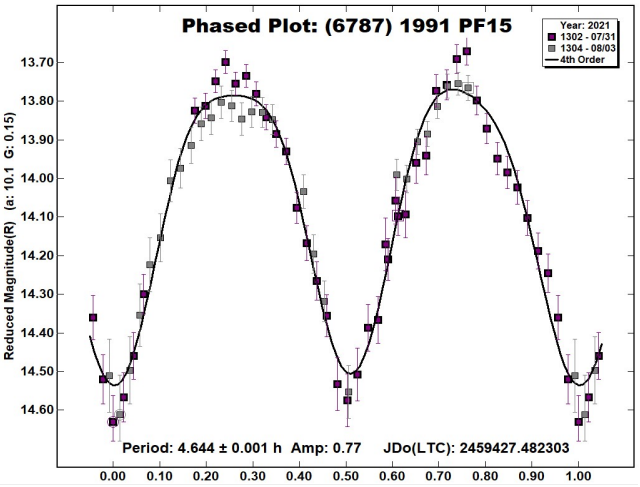
6681 Prokopovich (1972 RU3) is a main-belt asteroid that was discovered on 1972 Sep 6 by L.V. Zhuravleva at Nauchnyj. It is named after Feofan Prokopovich (1681-1736), a Ukrainian and Russian writer, archbishop, and associate of Peter the Great (Schmadel, 2012).



The estimated diameter is 4.288 ± 0.107 km based on an absolute magnitude of H = 13.9. The orbital semi-major axis is 2.205 au and the eccentricity is 0.146. The orbital period is about 3.27 years (JPL, 2021).

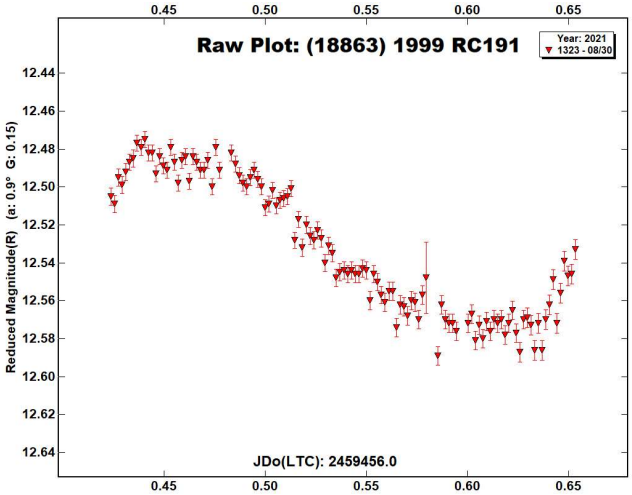
The Flora main-belt asteroid was observed by our group on three nights from 2021 August 7-14. Our analysis yields a rotation period of 3.369 ± 0.001 h with an amplitude of 0.31 ± 0.05 mag. The LCDB did not report any references regarding the synodic period for this asteroid.

(6787) 1991 PF15 is a main-belt asteroid that belongs to the Flora family. It was discovered on 1991 Aug 7 by H.E. Holt at Palomar (Schmadel, 2012). The estimated diameter is 4.865 ± 0.117 km based on H = 13.57. The orbital eccentricity is 0.1475 and the semi-major axis is 2.232 au. The orbital period is 3.34 years (JPL, 2021).



We observed 1991 PF15 on two nights from Manikata Observatory, Malta, and derived a synodic period of 4.644 ± 0.001 h with a lightcurve amplitude of amplitude of 0.77 ± 0.05 mag. This main-belt asteroid did not have any rotational period recorded in the LCDB.

(18863) 1999 RC191 is a main-belt asteroid that was discovered on 1999 September 11 by LINEAR at Socorro. The estimated diameter is 7.629 ± 0.133 km diameter based on an absolute magnitude of H = 12.75. The semi-major axis is 2.668 au and the eccentricity 0.176. The orbital period is 4.360 years (JPL, 2021).



This asteroid was observed from Tacande Observatory on 2021 August 29 from 22:20 UT to 03:50 UT. Due to technical problems and weather conditions, we were unable to obtain additional data because the asteroid was too faint for our smaller instruments and the amplitude too low amplitude to overcome low SNR noise.

The data set of 119 data points provided limited coverage of the full lightcurve. This prevented finding a precise period solution but we did determine that a period of 11.6 h ± 0.1 h with an amplitude of 0.09 ± 0.01 mag based on half-period solution was possible. This main-belt asteroid did not have any rotational period recorded in the LCDB.

Acknowledgements

We would like to thank Brian Warner for his work in the development of *MPO Canopus* and for his efforts in maintaining the CALL website (Warner, 2009; 2016). This research has made use of the JPL's Small-Body Database.

Number	Name	2021 mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1713	Bancilhon	10/05-11/02	4.1,3.0,15.7	14	4	2.483	0.001	0.24	0.05	MB
2232	Altaj	07/21-08/05	5.4,2.9,4.2	308	5	8.092	0.001	0.30	0.06	MB
2458	Veniakaverin	08/15-09/02	3.1,4.7	330	-1	17.310	0.006	0.32	0.06	MB
6681	Prokopovich	08/07-08/14	13.1,9.5	333	-7	3.369	0.001	0.31	0.05	MB
6787	1991 PF15	07/31-08/03	10.2,8.5	323	4	4.644	0.001	0.77	0.05	MB
18863	1999 RC191	08/03	13.1	334	-1	11.6	0.1	0.09	0.01	MB

Table II. Observing circumstances and results. The phase angle is given for the first and last date. LPAB and BPAB 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).

References

Ďurech, 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 the asteroids 82 Alkmene and 444 Gyptis." *Icarus* **57**, 251-258.

JPL (2021). Small-Body Database Browser - JPL Solar System Dynamics web site. Last accessed: 11 July 2021. *http://ssd.jpl.nasa.gov/sbdb.cgi*

Schmadel, L.D. (2012). *Dictionary of Minor Planet Names (3rd edition)*. pp. 216, 288, 317, 807, 815. Springer, Berlin.

Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The asteroid lightcurve database." *Icarus* **202**, 134-146. Updated 2021 June. *https://minplanobs.org/MPInfo/php/lcdbsummaryquery.php*

Warner, B.D. (2016). *Collaborative Asteroid Lightcurve Link website*. Last accessed: 26 September 2018. *http://www.minorplanet.info/call.html*

Warner, B.D. (2017). MPO Software, *MPO Canopus* version 10.7.10.0. Bdw Publishing. *http://www.minorplanetobserver.com/*

DETERMINING THE LIGHTCURVES AND ROTATIONAL PERIODS OF FIVE MAIN BELT ASTEROIDS

Harum Ahmed
Kent Montgomery
Michael Cheek
Texas A&M University-Commerce
P.O. Box 3011
Commerce, TX 75429-3011
Kent.Montgomery@tamuc.edu

(Received: 2021 October 26)

Lightcurves and rotational periods were determined for the following five main belt asteroids: 3942 Churivannia, 2.516 ± 0.002 h; 4673 Bortle, 2.643 ± 0.001 h; 5186 Donalu, 3.154 ± 0.001 h; 8441 Lapponica, 3.285 ± 0.001 h; and 12259 Szukalski, 5.986 ± 0.001 h.

Introduction

The objective of this research was to determine the rotational periods for the following five asteroids: 3942 Churivannia, 4673 Bortle, 5186 Donalu, 8441 Lapponica, and 12259 Szukalski, by plotting their lightcurves derived from photometric data taken over several nights. These lightcurves were analyzed to determine the asteroid's rotational period and from the shape of the lightcurve create a possible model of the asteroid.

Asteroid 3942 Churivannia was discovered by Chernykh, N. at the Crimean Astrophysical Observatory in 1977. It has an orbital eccentricity of 0.197 and a semi-major axis of 2.39 AU (JPL). Asteroid 4673 Bortle was discovered by Shoemaker, C.S. at the Palomar Observatory in 1988. The asteroid has an orbital eccentricity of 0.057 and a semi-major axis of 2.55 AU (JPL). Asteroid 5186 Donalu was discovered by Roman, B. at the Palomar Observatory in 1990. It has an orbital eccentricity of 0.084 and a semi-major axis of 2.58 AU (JPL). Asteroid 8441 Lapponica was discovered by C.J. van Houten and I. van Houten-Groeneveld at the Palomar Observatory in 1977. It has an orbital eccentricity of 0.139 and a semi-major axis of 2.19 AU (JPL). Asteroid 12259 Szukalski was discovered by E.W. Elst at the European Southern Observatory in 1989. It has an orbital eccentricity of 0.161 and a semi-major axis of 2.19 AU (JPL).

Asteroids were selected through the website which catalogs all known asteroids (CALL). The asteroid's apparent magnitude, declination, and opposition date, were the criterion used to choose these asteroids. Asteroids at or near opposition were chosen to ensure the maximum amount of data each night. For the ideal signal to noise ratio, asteroids with magnitude of 16 or brighter were chosen. When observing asteroids in the northern hemisphere, asteroids with more positive declinations were chosen and when observing in the southern hemisphere, asteroids with more negative declinations were chosen.