

**SYNODIC PERIOD DETERMINATION OF SEVEN MAIN-BELT ASTEROIDS FROM MALTESE OBSERVATORIES**

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Photometric observations of seven asteroids were acquired from four Maltese observatories in order to derive or update published synodic periods and lightcurve amplitudes of the asteroids: 1461 Jean-Jacques, 2030 Belyaev, 2149 Schwambraniya, 3114 Ercilla, (7357) 1995 UJ7, 12919 Tomjohnson, and (20895) 2000 WU106.

Photometric observations of seven asteroids were carried out from four observatories located on the Maltese mainland. From our observations, we determined the synodic period for the following asteroids: 1461 Jean-Jacques, 2030 Belyaev, 2149 Schwambraniya, 3114 Ercilla, 12919, Tomjohnson, and (20895) 2000 WU106. Our observatories used the configurations shown in Table 1. All of our images were dark subtracted and flat-fielded.

Observatory	Telescope	CCD	Asteroids (#Sessions)
Flarestar (MPC 171)	0.25-m SCT	Moravian G2-1600	2030 (5) 2149 (2) 7357 (6) 12919 (5)
Znith	0.2-m SCT	Moravian G2-1600	2149 (1) 3114 (4)
Manikata	0.2-m SCT	SBIG ST-9	1461 (5) 2149 (1)
Antares	0.27-m SCT	SBIG ST-11000	2149 (3)

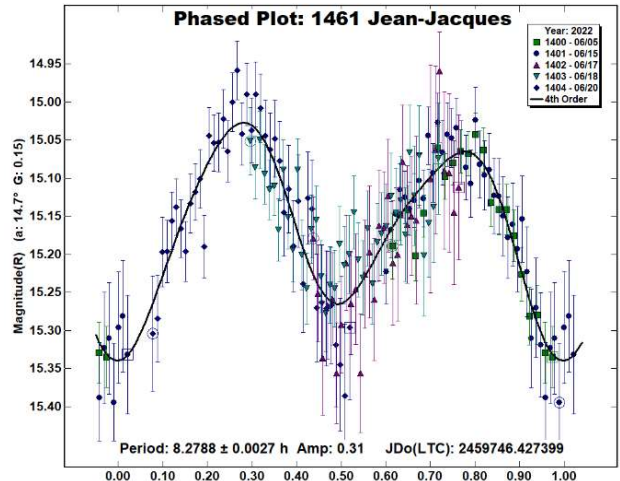
Table 1 - Instrumentation. SCT: Schmidt-Cassegrain Telescope.

All telescopes and cameras were controlled remotely over the Internet either from a location near the telescope or through remote programming. All observatories employed the *Sequence Generator Pro* Software (Binary Star Software) for observatory control and ancillary equipment. Photometric reduction, lightcurve construction, and analyses were derived through *MPO Canopus* software using version 10.8.6.11(Warner, 2017). The Comparison Star Selector (CSS) feature of *MPO Canopus* was used to select comparison stars of near-solar color. In cases where the asteroid passed in proximity of a background star, we used the *MPO Canopus* “StarBGone” routine to deduct the background signal

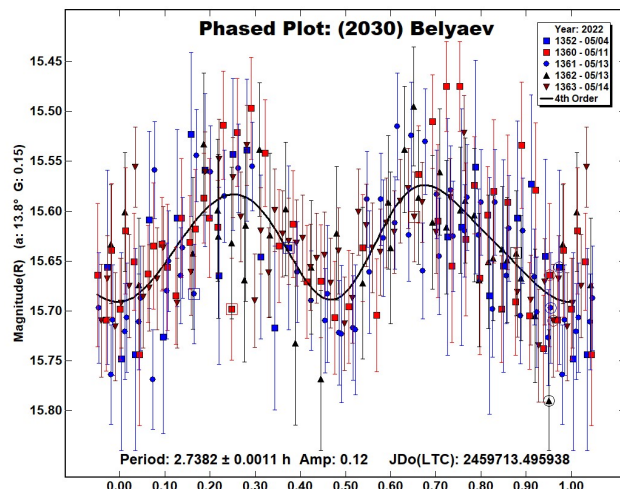
from that of the asteroid. Our magnitude measurements were all carried out through a clear filter with framework magnitude bandpass based on the ATLAS catalogue through the Red (R) bandpass. As a result, our measurements are based on the ‘CR’ bandpass.

1461 Jean-Jacques is an outer main-belt asteroid that was discovered on 1937 December 30 by M. Laugier at Nice. The discoverer named this minor planet after her son Jean-Jacques (Schmadel, 2012). The estimated diameter was derived to be  $35.145 \pm 0.172$  km diameter based on an absolute magnitude  $H = 10.15$  and orbits the sun with a semi-major axis of 3.126 au. Its orbit has an eccentricity of 0.049 and a period of 5.52 years (JPL, 2022).

1461 Jean-Jacques was observed from Manikata Observatory during five nights on 2022 June 5-20. Our results yielded a synodic period of  $8.2788 \pm 0.0027$  h and amplitude of  $0.31 \pm 0.05$  mag. Our lightcurve results are in line with Āurech et al., (2020) in the Asteroid Lightcurve Data Base (LCDB; Warner et al, 2009).



2030 Belyaev is an inner main-belt asteroid that was discovered in 1969 Oct. 8 by L.I. Chernykh at Nauchnyj. It was named in honor of Colonel Pavel Ivanovich Belyaev (1925-1970), a Soviet cosmonaut and commander of the spaceship Voskhod 2. A lunar crater was also named ‘Belyaev’ for his honor (Schmadel, 2012).

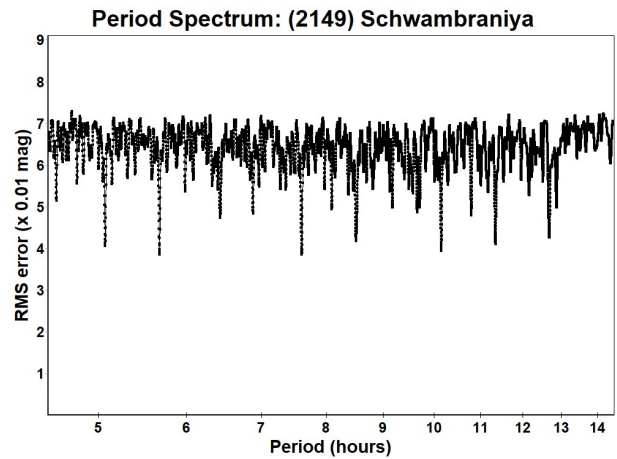
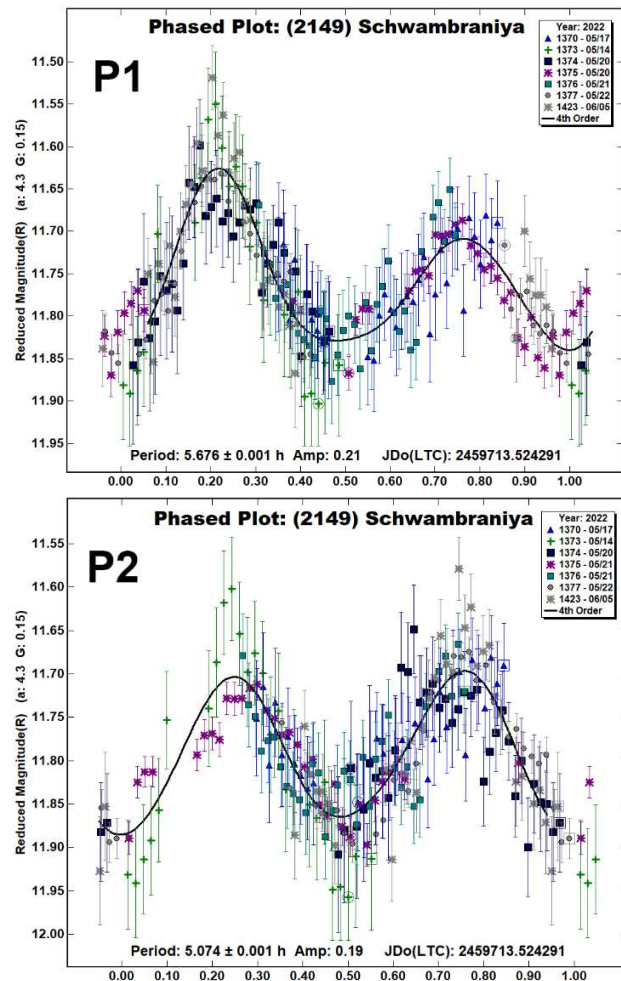


This minor planet orbits the sun with a semi-major axis of 2.247 au, eccentricity 0.093, and orbital period of 3.37 years (JPL, 2022). The JPL Small-Bodies Database Browser does not list the diameter of (2030) Belyaev, however an absolute magnitude of  $H = 13.63$  is quoted (JPL, 2022).

We observed 2030 Belyaev for five nights from 2022 May 4-14 from Flarestar Observatory. Our results yielded a synodic rotation period of  $2.7382 \pm 0.0011$  h and amplitude of  $0.12 \pm 0.07$  mag. The LCDB did not contain any references of the synodic period for this asteroid.

2149 Schwambraniya is an inner main-belt asteroid that was discovered on 1977 March 22 by N.S. Chernykh at Nauchnyj. It has been named for the ‘wonderland’ created by the characters in L.A. Kassil’s children’s novel, “*Conduite and Schwambraniya*” (Schmadel, 2012). The estimated diameter of 2149 Schwambraniya was derived to be  $11.180 \pm 0.122$  km diameter based on an absolute magnitude  $H = 11.89$ . This asteroid orbits the sun at a semi-major axis of 2.549 au, an eccentricity of 0.107, and a period of 4.07 years (JPL, 2022).

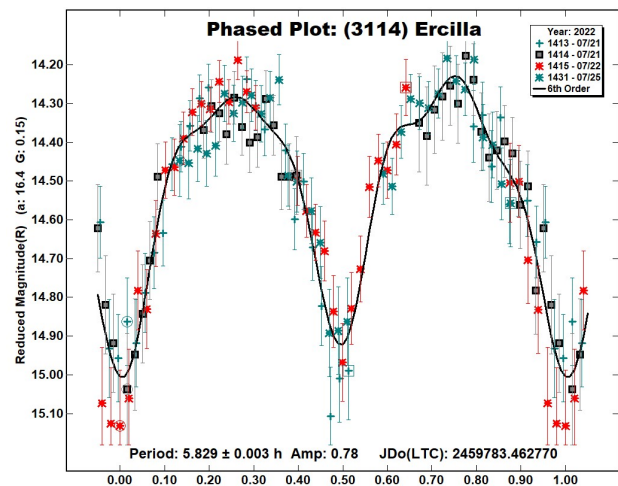
The asteroid was observed by our group on seven nights from 2022 May 17 to June 5. Our analysis has yielded the lowest RMS rotational period of  $5.676 \pm 0.001$  h with an amplitude of  $0.21 \pm 0.07$  mag (“P1” figure).



The LCDB shows a period of  $5.070 \pm 0.0034$  h (Waszczak, 2015) with a rating of  $U = 2$ . Āurech et al. (2020) also yields a sidereal period of  $5.07348 \pm 0.00001$  h with an  $Q = R$  quality value in the LCDB, showing that a retrograde rotation has been determined but not specific pole position.

Our period spectrum also includes a relative minimum at the above mentioned 5.074 h period but when the data are phased to this period (P2 figure), the RMS value of 4.057 is higher than that of the derived period of 5.676 (RMS 3.857). The third lowest minima shown in the period spectrum displays a period of  $7.611 \pm 0.001$  h that exhibits a trimodal lightcurve when data are phased to this period.

3114 Ercilla is main-belt asteroid that belongs to the 2004 Hertha family. It was discovered by C. Torres at Cerro El Roble on 1980 March 19. Ercilla is named in memory of Don Alonso de Ercilla y Zuniga (1533-1594), a Spanish poet and soldier who distinguished himself in the campaign in Chile against the Araucanians and is considered by many as the first chronicler of the history of Chile.

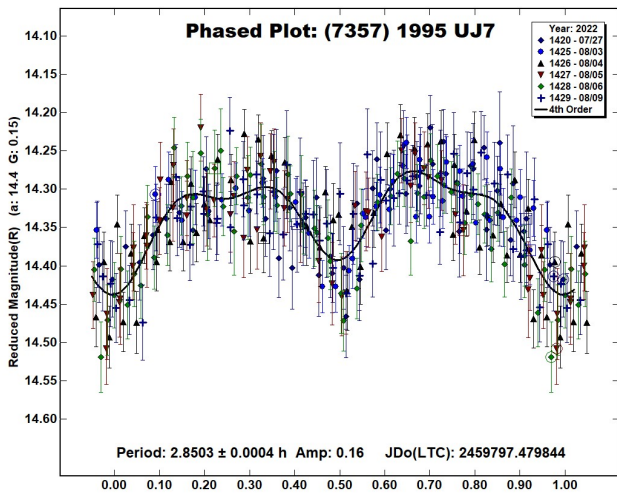


The estimated diameter of 3114 Ercilla was derived to be  $5.040 \pm 0.048$  km based on an absolute magnitude  $H = 13.96$  and orbits the sun with a semi-major axis of 2.419 au. Its orbit has an eccentricity of 0.197 and a period of 3.76 years (JPL, 2022).

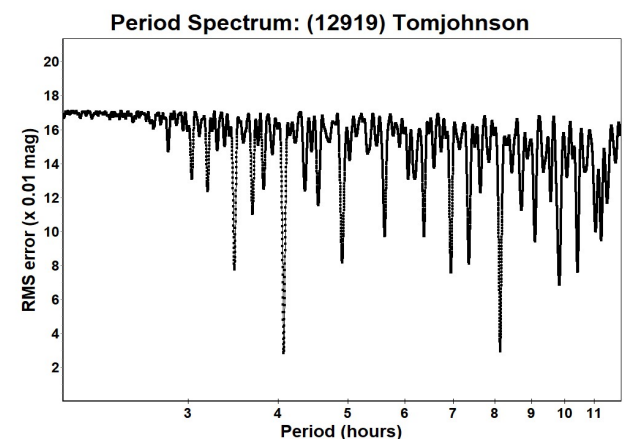
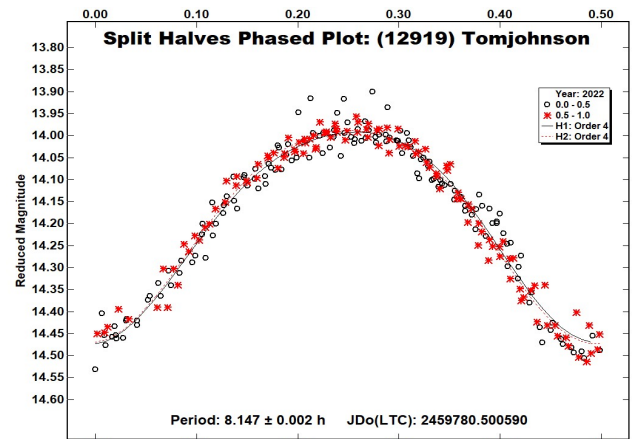
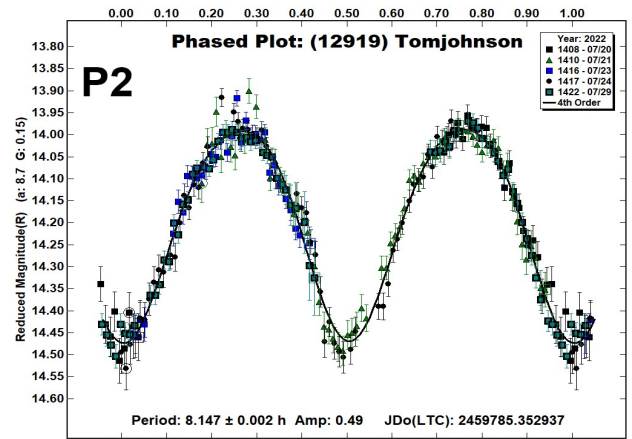
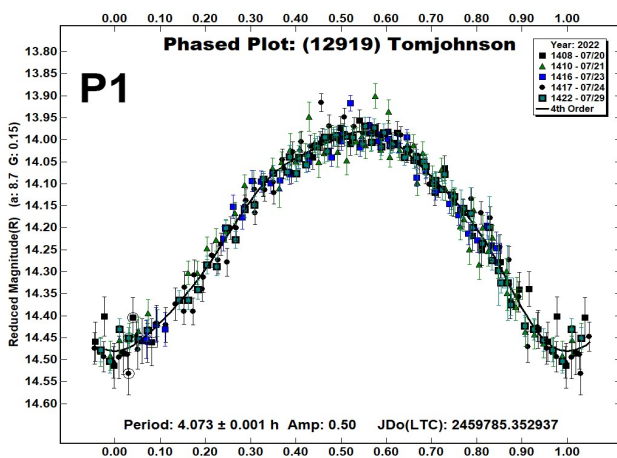
Observations were conducted by Znith Observatory over four nights: 2022 July 21-25. Our results indicate a synodic period of  $5.829 \pm 0.003$  h and amplitude of  $0.78 \pm 0.05$  mag. The LCDB did not contain any references of the synodic period for this asteroid.

(7357) 1995 UJ7 is an inner main-belt asteroid that was discovered on 1995 October 27 by S. Ueda and H. Kaneda at Kushiro, Japan. The estimated diameter of (7357) is estimated to be  $3.992 \pm 0.308$  km based on an absolute magnitude  $H = 14.03$ . The asteroid orbits the sun at a semi-major axis of 2.268 au and eccentricity of 0.182. The orbital period of 3.41 years (JPL, 2022).

(7357) was observed from Flarestar Observatory on six nights during the period from 2022 July 27 to August 9. We derived its synodic period to be  $2.803 \pm 0.0004$  h with an amplitude of  $0.16 \pm 0.07$  mag. The Asteroid Lightcurve Database (LCDB; Warner et al., 2009) did not show any reference period for this asteroid.



12919 Tomjohnson is an inner main-belt asteroid that was discovered on 1998 November 11 by the Catalina Sky Survey. This asteroid was named after Thomas J. Johnson (1923-2012) who developed a technique for creating Schmidt telescope correctors that allowed the mass production of Schmidt-Cassegrain telescopes. In 1978 the Optical Society of America awarded him the David Richardson Medal for this work.



The diameter of this asteroid is estimated to be  $4.882 \pm 0.468$  km based on  $H = 14.03$ . The asteroid orbits at a semi-major axis of 2.273. The eccentricity is 0.281 and the orbital period is 3.42 years (JPL, 2022).

We observed the asteroid on five nights from Flarestar Observatory and derived its synodic period to be  $4.073 \pm 0.001$  h with a lightcurve amplitude of  $0.50 \pm 0.03$  mag. A second period was also derived at  $8.147 \pm 0.002$  h with an amplitude of  $0.49 \pm 0.03$  mag; however, on inspection through split-half analysis, the average shape of both phases of the light curve are very identical and hence we believe that the correct synodic period of this asteroid is  $4.073 \pm 0.001$  h. The former period solution (P1) also has a slightly lower RMS residual, at 2.8515 and 2.944 (P2) respectively. The LCDB did not show any reference period for this asteroid.

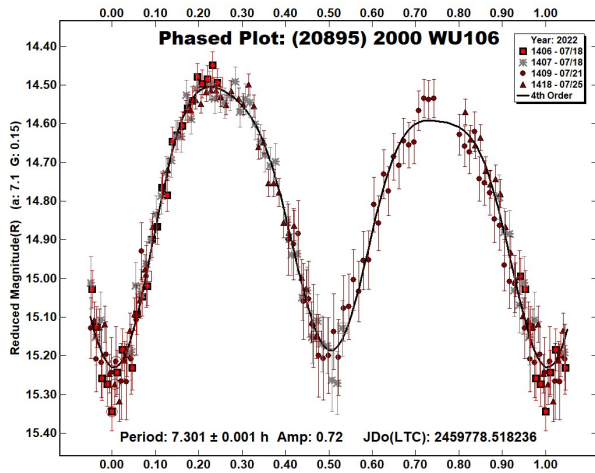


Number	Name	2022 mm/dd	Phase	L <sub>PAB</sub>	B <sub>PAB</sub>	Period(h)	P.E.	Amp	A.E.	Grp
1461	Jean-Jacques	07/05-07/20	17.9, 18.2	214	14	8.2788	0.0027	0.31	0.05	MB
2030	Belyaev	05/04-05/14	13.8, 8.7	246	4	2.7382	0.001	0.12	0.07	MB
2149	Schwambraniya	05/17-06/05	4.2, 13.0	229	2	5.676	0.001	0.21	0.07	MB
3114	Ercilla	07/21-07/25	16.5, 14.5	324	2	5.829	0.003	0.78	0.05	MB
7357	1995 UJ7	07/27-08/09	13.9, 6.4	325	1	2.803	0.0004	0.16	0.07	MB
12919	Tomjohnson	07/20-07/29	8.4, 6.3	306	8	4.073	0.001	0.50	0.03	MB
20895	2000 WU106	07/18-07/25	6.7, 2.7	304	2	7.301	0.001	0.72	0.07	MB

Table I. Observing circumstances and results. Pts is the number of data points. 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).

20895 2000 WU106 is an inner main-belt asteroid that was discovered in 2000 November 20 by Lincoln Near-Earth Asteroid Research (LINEAR) at Socorro, USA. The minor planet has an absolute magnitude  $H = 14.64$  and orbits the sun with a semi-major axis of 2.184 au, eccentricity of 0.199, and a period of 3.223 years (JPL, 2022).

This asteroid was observed from Flarestar Observatory from 2022 July 18-25. We derived its synodic period to be  $7.301 \pm 0.001$  h with an amplitude of  $0.72 \pm 0.07$  mag. The LCDB did not show any reference period for this asteroid.



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This research has made use of the JPL's Small-Body Database.

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