

Acknowledgments

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<http://www.minorplanet.info/lightcurvedatabase.html>

LIGHTCURVES FOR
SIXTEEN MINOR PLANETS

Tom Polakis
Command Module Observatory
121 W. Alameda Dr.
Tempe, AZ 85282
tpolakis@cox.net

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Photometric measurements of CCD observations on 16 main-belt asteroids were made from 2022 April through May. Phased lightcurves were created for twelve asteroids, while four did not yield period solutions. All the data have been submitted to the ALCDEF database.

CCD photometric observations of 16 main-belt asteroids were performed at Command Module Observatory (MPC V02) in Tempe, AZ. Images were taken using a 0.32-m f/6.7 Modified Dall-Kirkham telescope, SBIG STXL-6303 CCD camera, and a ‘clear’ glass filter. Exposure time for all the images was 2 minutes. The image scale after 2×2 binning was 1.76 arcsec/pixel. Table I shows the observing circumstances and results. All of the images for these asteroids were obtained between 2022 April and May.

Images were calibrated using a dozen bias, dark, and flat frames. Flat-field images were made using an electroluminescent panel. Image calibration and alignment was performed using *MaxIm DL* software.

Data reduction and period analysis were done using *MPO Canopus* (Warner, 2020). The 45′×30′ field of the CCD typically enables the use of the same field center for three consecutive nights. In these fields, the asteroid and three to five comparison stars were measured. Comparison stars were selected with colors within the range of $0.5 < B-V < 0.95$ to correspond with color ranges of asteroids. In order to reduce the internal scatter in the data, the brightest stars of appropriate color that had peak ADU counts below the range where chip response becomes nonlinear were selected. *MPO Canopus* plots instrumental vs. catalog magnitudes for solar-colored stars, which is useful for selecting comp stars of suitable color and brightness.

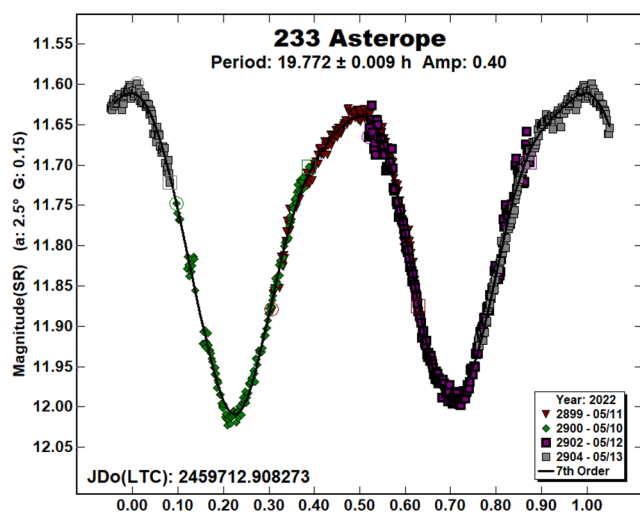
Since the sensitivity of the KAF-6303 chip peaks in the red, the clear-filtered images were reduced to Sloan r' to minimize error with respect to a color term. Comparison star magnitudes were obtained from the ATLAS catalog (Tonry et al., 2018), which is incorporated directly into *MPO Canopus*. The ATLAS catalog derives Sloan $griz$ magnitudes using a number of available catalogs. The consistency of the ATLAS comp star magnitudes and color-indices usually allowed the separate nightly runs to be linked with no zero-point shifts and occasionally only a few hundredths of a magnitude.

A 9-pixel (16 arcsec) diameter measuring aperture was used for asteroids and comp stars. It was typically necessary to employ star subtraction to remove contamination by field stars. For the asteroids described here, I note the RMS scatter on the phased lightcurves, which gives an indication of the overall data quality including errors from the calibration of the frames, measurement of the comp stars, the asteroid itself, and the period-fit. Period determination was done using the *MPO Canopus* Fourier-type FALC fitting method (cf. Harris et al., 1989). Phased lightcurves show the maximum at phase zero. Magnitudes in these plots are apparent and scaled by *MPO*

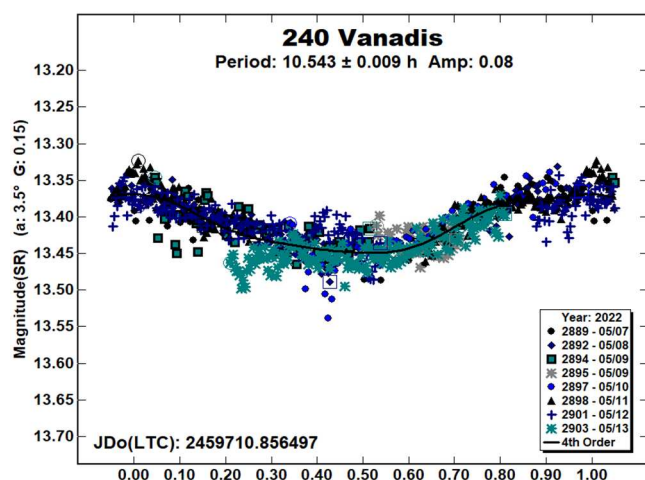
Canopus to the first night. In cases where rotation periods could not be determined, raw lightcurves are presented, with “Raw” appearing in the upper right-hand corner of the plots.

Asteroids were selected from the CALL website (Warner, 2011a), either for having uncertain periods or for needing more lightcurves for shape modeling. In this set of observations, 1 of the 16 asteroids had no previous period analysis, 2 had $U = 1$, and 6 had $U=2$. The Asteroid Lightcurve Database (LCDB; Warner et al. (2009) was consulted to locate previously published results. All the new data for these asteroids can be found in the ALCDEF database.

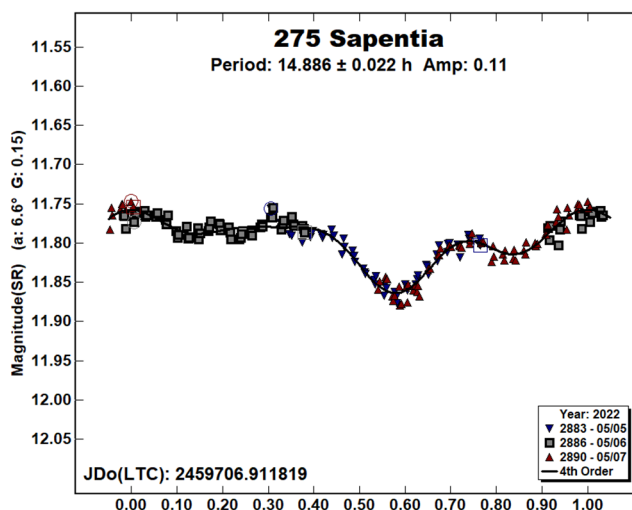
233 Asterope was discovered by Alphonse Borrelly at Marseille in 1883. Papers showing similar rotational periods include Hanus et al. (2016, 19.69801 h) and Hanus et al. (2017, 19.69803 $\pm$ 0.00002 h. During four nights, 249 data points were gathered to determine a period of 19.772 ± 0.009 h, agreeing with previous values. The amplitude of the lightcurve is 0.40 ± 0.01 mag.



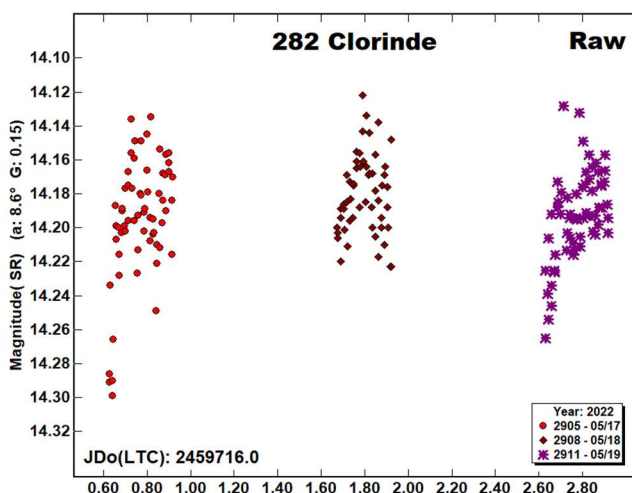
240 Vanadis. This middle main-belt asteroid is another of Borrelly's discoveries, this one in 1884. Its eccentric orbit brought it to an unfavorable opposition in 2022. Denchev (2000) computed a rotation period of 10.64 h and Alton (2016) published 10.57 ± 0.01 h. A total of 905 images were taken in eight nights, producing a period of 10.543 ± 0.009 h and an amplitude of 0.08 ± 0.02 mag. The monomodal lightcurve results in a solution that matches previous values, and a “split halves” plot does not support the bimodal solution.



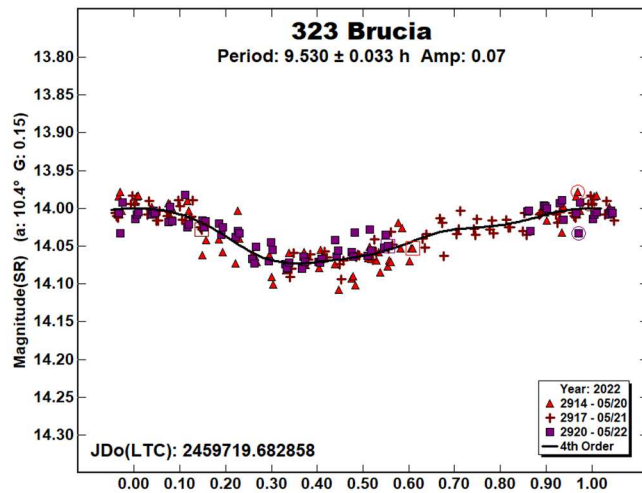
275 Sapientia was discovered by Johann Palisa in 1888 at Vienna. Warner (2007) published a period of 14.766 ± 0.006 h and Pilcher (2016) computed 14.932 ± 0.001 h. Three nights and 187 images were sufficient to produce a period solution of 14.886 ± 0.022 h. The amplitude of the lightcurve is 0.11 mag, with an RMS error on the fit of 0.009 mag.



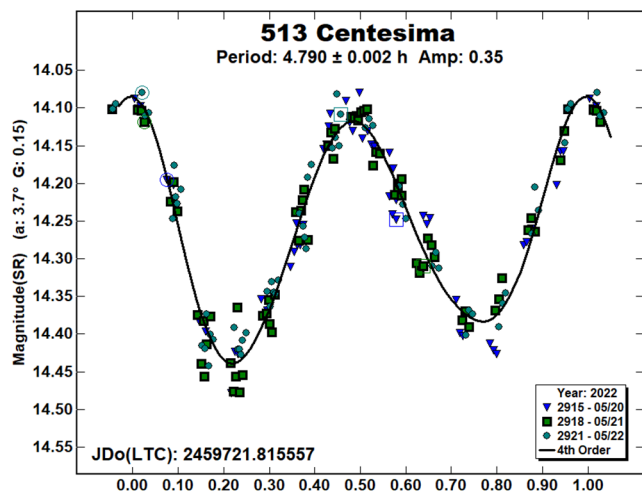
282 Clorinde lies in the inner main belt. It was discovered at Nice by Auguste Charlois in 1889. The period shown by Durech et al. (2020) is 49.365 ± 0.002 h while Bonamico and van Belle (2021) published 49.352 ± 0.004 h. In three nights, 177 images were taken. The raw lightcurve was flat, so no further imaging was done because a period solution could not be determined.



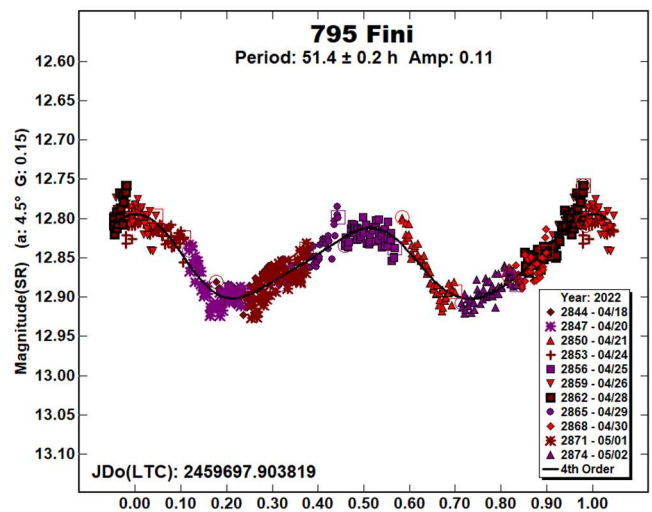
323 Brucia is a Phocaea-family minor planet in a highly inclined and eccentric orbit. It had an unfavorably distant, but northerly opposition in 2022. Discovered at Heidelberg in 1891, it was Max Wolf's first of his 248 asteroid discoveries. Seven agreeing period solutions appear in the LCDB. The most recent are Warner (2018, 9.458 ± 0.008 h); Behrend (2021web, 9.463 ± 0.001 h); and Stephens et al. (2021, 9.457 ± 0.002 h). A three-night run with 196 images produced a similar rotational period of 9.530 ± 0.033 h and an amplitude of 0.07 ± 0.014 mag.



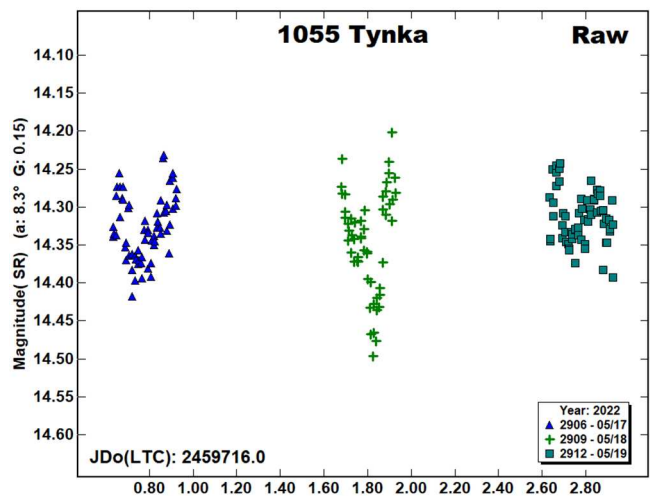
513 Centesima is another of Max Wolf's discoveries. Durech et al. (2016) published a period of 5.32399 ± 0.00001 h and Behrend (2021web) shows 4.794 ± 0.001 h. During three nights, 181 data points were acquired to produce a period solution of 4.790 ± 0.002 h, in agreement with Behrend. The lightcurve has an amplitude of 0.35 ± 0.03 mag.



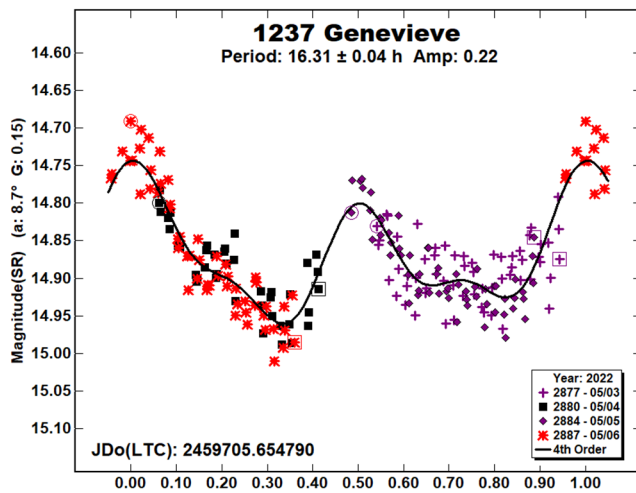
795 Fini was discovered at Vienna in in 1914 by Johann Palisa. Several uncertain period solutions appear in the LCDB, including Warner (2011b, 7.49 ± 0.02 h), Pravec (2012web, 4.65 h), and Waszczak et al. (2015, 26.971 ± 0.0557 h). A total of 600 images were taken during 11 nights. These produced a synodic period of 51.40 ± 0.20 h, disagreeing with all previous assessments. The amplitude is 0.11 ± 0.01 mag.



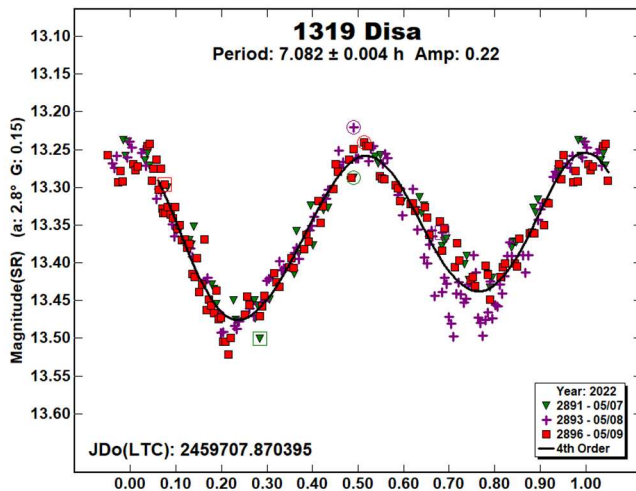
1055 Tynka is a Flora-family asteroid in an eccentric orbit. discovered by Emil Buchar at Algiers in 1912. The most recent period solutions are Stephens (2012, 11.75 ± 0.01 h) and Durech et al. (2020, 5.94680 ± 0.00002 h). During three nights, 180 images were gathered, but the lightcurve remained too flat to achieve a period solution.



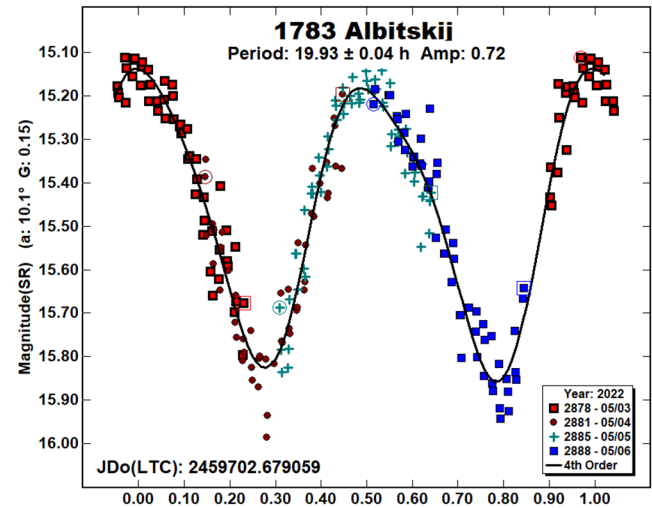
1237 Genevieve was discovered by Guy Reiss in 1951 at Algiers. Polakis (2018) shows a period of 16.48 ± 0.02 h and Durech et al. (2019) published 24.6982 ± 0.002 h. The asteroid was observed on four nights, and 213 images were obtained, yielding a synodic rotation period of 16.31 ± 0.04 h. The lightcurve has an amplitude of 0.22 mag and an RMS error on the fit of 0.031 mag.



1319 Disa. This outer-belt asteroid was discovered by Cyril Jackson at Johannesburg in 1934. Period solutions in the LCDB include Warner (2006, 7.080 ± 0.003 h) and Waszczak et al. (2015, 7.082 ± 0.0077 h). After three nights, 281 images were used to calculate a synodic period of 7.082 ± 0.004 h, in agreement with previous solutions. The amplitude of the lightcurve is 0.22 mag with an RMS error of 0.022 mag.



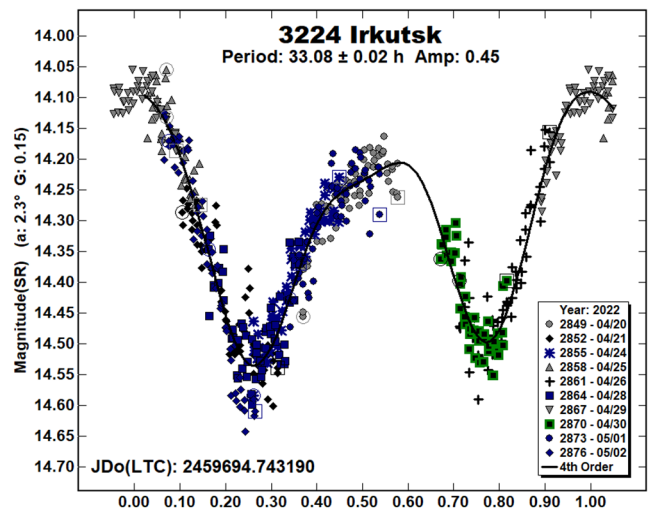
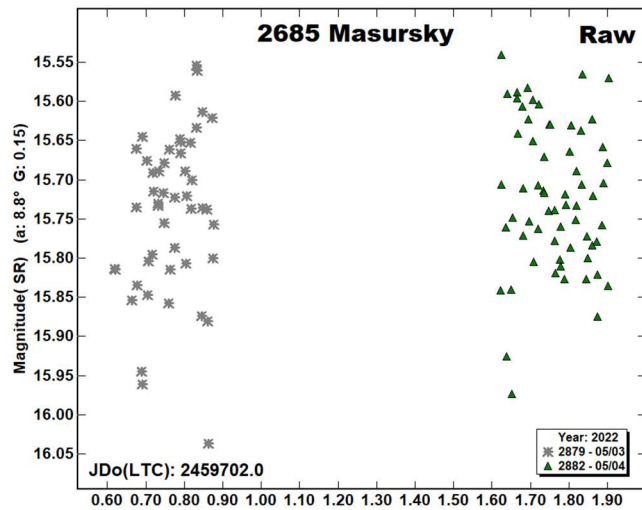
1783 Albitskij is an Adeona-family asteroid, first identified by Grigory Neujmin in 1935 at Simeis. Durech et al. (2020) published a period of 19.9375 ± 0.0001 h. A total of 222 images were taken during four nights, producing a rotational period of 19.93 ± 0.04 h and amplitude of 0.72 ± 0.04 mag.



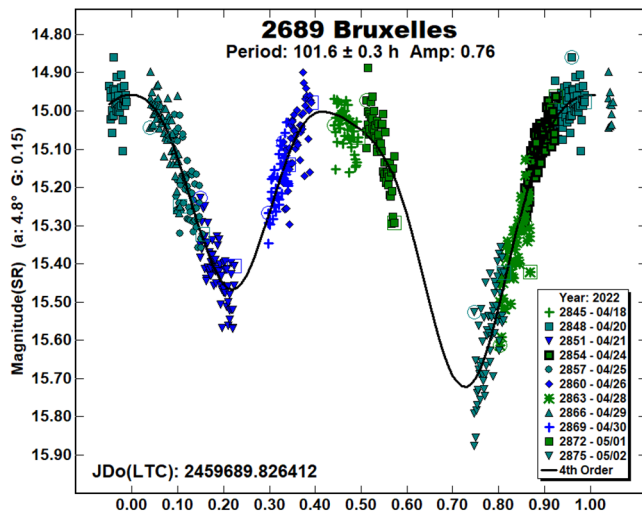
2685 Masursky is a Eunomia-family asteroid that was discovered by Edward Bowell at Flagstaff in 1981. No period solutions appear in the LCDB. It became apparent after taking 111 images during two nights that the scatter would be too high to derive a period solution from Tempe. The raw lightcurve is provided.

Number	Name	yy/mm/dd	Phase	LPAB	BPAB	Period(h)	P.E.	Amp	A.E.	Grp
233	Asterope	22/05/10-05/14	13.5, 12.6	235	1	19.772	0.009	0.40	0.01	MB-O
240	Vanadis	22/05/07-05/13	3.5, 1.4	235	2	10.543	0.009	0.08	0.02	MB-O
275	Sapientia	22/05/05-05/07	6.6, 7.4	214	6	14.886	0.022	0.11	0.01	MB-O
282	Clorinde	22/05/17-05/19	8.6, 9.2	223	12	--	--	--	--	MB-M
323	Brucia	22/05/20-05/22	10.4, 10.7	224	23	9.530	0.033	0.07	0.01	MB-O
513	Centesima	22/05/20-05/22	3.7, 4.1	235	9	4.790	0.002	0.35	0.03	MB-M
795	Fini	22/04/18-05/02	4.5, 10.6	199	-3	51.40	0.20	0.11	0.01	MB-O
1055	Tynka	22/05/17-05/19	8.3, 9.2	225	7	--	--	--	--	MB-M
1237	Genevieve	22/05/03-05/06	8.7, 9.8	203	6	16.31	0.04	0.22	0.03	PHO
1319	Disa	22/05/07-05/09	2.8, 3.7	222	-2	7.082	0.004	0.22	0.02	MB-O
1783	Albitskij	22/05/03-05/06	10.1, 11.3	203	5	19.93	0.04	0.72	0.04	MB-O
2685	Masursky	22/05/03-05/04	8.8, 9.2	205	-2	--	--	--	--	MB-O
2689	Bruxelles	22/04/18-05/02	4.8, 12.9	202	2	101.6	0.3	0.76	0.06	MB-O
3224	Irkutsk	22/04/20-05/02	2.3, 8.1	206	-2	33.08	0.02	0.45	0.04	MARS
3306	Byron	22/05/20-05/22	2.1, 2.8	235	3	6.999	0.011	0.29	0.05	MB-M
3469	Bulgakov	22/05/17-05/19	1.5, 1.8	235	3	--	--	--	--	MB-M

Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. LPAB and BPAB are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

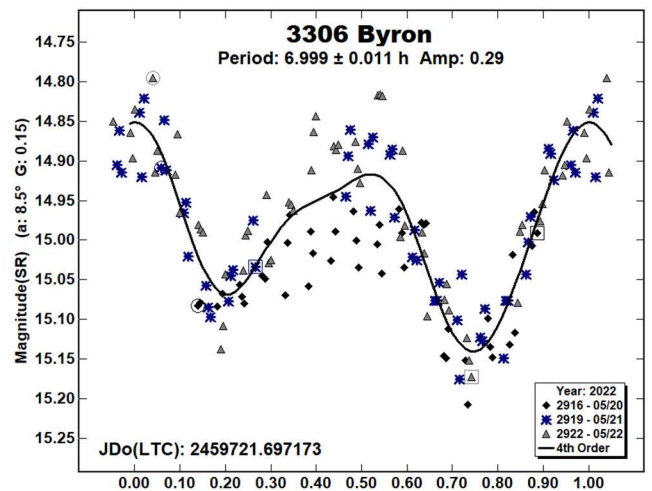


2689 Bruxelles. This Flora-family minor planet was discovered in 1935 at Uccle by Sylvain Arend. Two period solutions were found in the LCDB. Hess and Diteon (2016) reported a period of 8.71 ± 0.05 h, and Dose (2021) computed a much longer period: 101.800 ± 0.026 h. The asteroid was observed on 11 nights, and 626 images were taken. The calculated period is 101.6 ± 0.3 h, supporting Dose's value. The amplitude is 0.76 ± 0.060 mag.

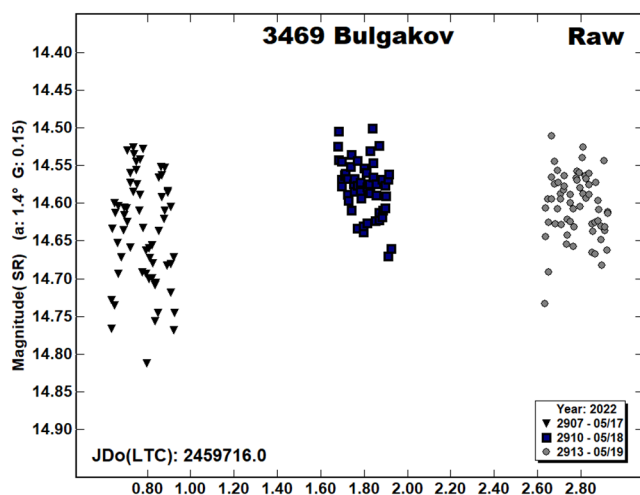


3224 Irkutsk was identified by Nikolai Chernykh at Nauchnyj in 1977. Its eccentric orbit brought it to a favorable 2022 opposition. Period solutions include Waszczak et al. (2015, 33.140 ± 0.0630 h) and Durech et al. (2019, 33.1038 ± 0.0002 h). Over the course of 10 nights, 532 images were used to compute a synodic period of 33.08 ± 0.02 h, in line with published values. The lightcurve amplitude is 0.45 ± 0.04 mag.

3306 Byron is an Eos-family asteroid that was discovered by Nikolai Chernykh in 1979. Moravec et al. (2013) show a rotation period of 7.321 ± 0.005 h and Polakis (2020) computed 6.999 ± 0.005 h. After three nights, 152 data points had been acquired, resulting in a period solution of 6.999 ± 0.011 h, with an amplitude of 0.29 ± 0.05 mag.



3469 Bulgakov. Ludmilla Karachkina discovered this asteroid in 1982 at Nauchnyj. Durech et al. (2020) computed a synodic rotation period of 180.76 ± 0.01 h. However, Behrend (2021web) shows a much shorter period of 6.48 ± 0.05 h. During three nights, 176 images were taken, producing a flat lightcurve, from which no period solution was obtained.



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