PHOTOMETRY OF 10 ASTEROIDS AT SOPOT ASTRONOMICAL OBSERVATORY: 2022 MAY - OCTOBER

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(Received: 2022 October 14)

Lightcurves and synodic rotation periods established for 10 asteroids using photometric observations carried out at Sopot Astronomical Observatory in the time span 2022 May - October are presented in this paper.

Photometric observations of 10 asteroids were conducted at Sopot Astronomical Observatory (SAO) from 2022 May through 2022 October in order to determine the asteroids' synodic rotation periods. For this purpose, two 0.35-m *f*/6.3 Meade LX200GPS Schmidt-Cassegrain telescopes were employed. The telescopes are equipped with a SBIG ST-8 XME and a SBIG ST-10 XME CCD cameras. The exposures were unfiltered and unguided for all targets. Both cameras were operated in 2×2 binning mode, which produces image scales of 1.66 arcsec/pixel and 1.25 arcsec/pixel for ST-8 XME and ST-10 XME cameras, respectively. Prior to measurements, all images were corrected using dark and flat field frames.

Photometric reduction was conducted using *MPO Canopus* (Warner, 2018). Differential photometry with up to five comparison stars of near solar color (0.5 ≤ B-V ≤ 0.9) was performed using the Comparison Star Selector (CSS) utility. This helped ensure a satisfactory quality level of night-to-night zero-point calibrations and correlation of the measurements within the standard magnitude framework. Field comparison stars were calibrated using standard Cousins R magnitudes derived from the Carlsberg Meridian Catalog 15 (VizieR, 2022) Sloan r' magnitudes using the formula: R = r' - 0.22 in all cases presented in this paper. In some instances, small zero-point adjustments were necessary in order to achieve the best match between individual data sets in terms of achieving the most favorable statistical indicators of Fourier fit goodness.

Lightcurve construction and period analysis was performed using *Perfindia* custom-made software developed in the R statistical programming language (R Core Team, 2020) by the author of this paper. The essence of its algorithm is reflected in finding the most favorable solution for rotational period by minimizing the *residual standard error* of the lightcurve Fourier fit.

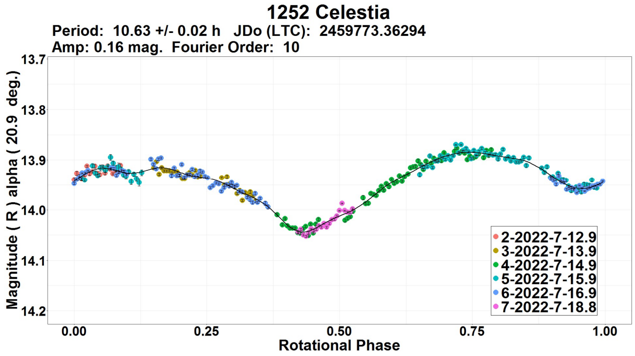
The lightcurve plots presented in this paper show so-called 2% error for rotational periods, i.e., an error that would cause the last data point in a combined data set by date order to be shifted by 2% (Warner, 2012) and represented by the following formula:

$$\Delta P = (0.02 \cdot P^2) / T$$

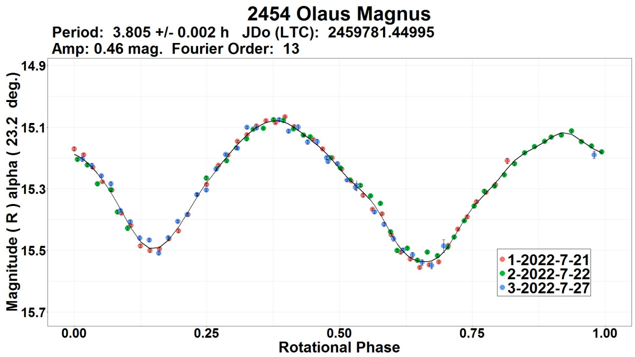
where P and T are the rotational period and the total time span of observations, respectively. Both of these quantities must be expressed in the same units. Table I gives the observing circumstances and results.

Observations and Results

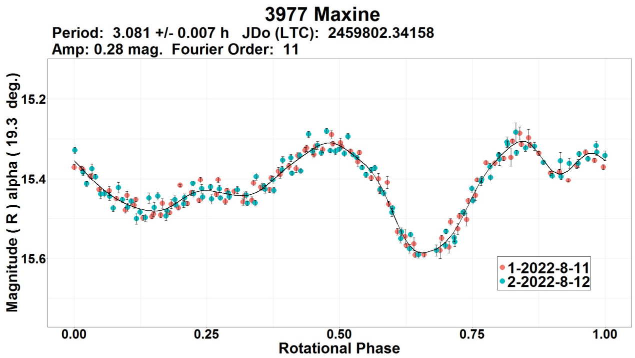
1252 Celestia. There is an apparent match between the only previous rotation period determination by Worman (1995, 10.636 h) and the bimodal period (P = 10.63 ± 0.02 h) derived from the SAO data obtained in 2022 July over 6 nights.



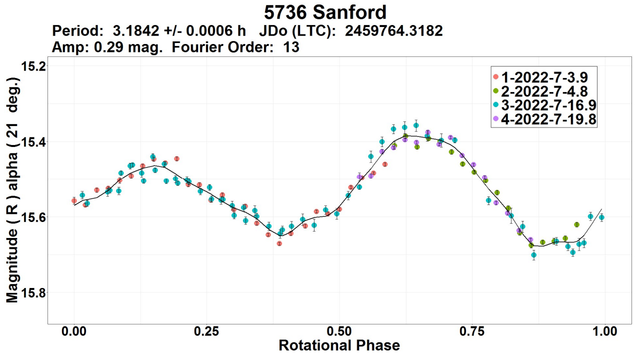
2454 Olaus Magnus. Two previous rotation periods in the Asteroid Lightcurve Database (LCDB; Warner et al., 2009) records are as follows: 3.804 h (Vargas, 2013) and a sidereal one determined by Durech et al. (2020, 3.80436 h). Observations carried out at SAO on 3 nights in 2022 July yielded a bimodal period result (P = 3.805 ± 0.002 h) in complete agreement with previous ones.



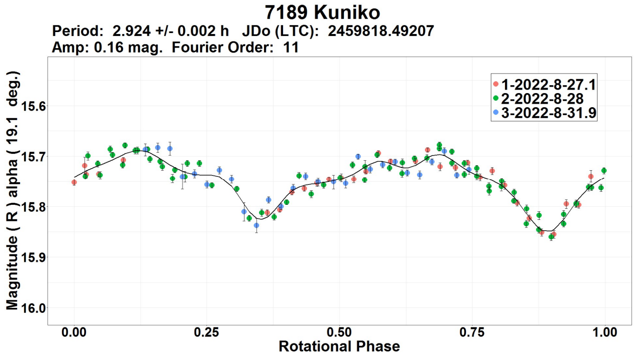
3977 Maxine. The only previously known rotation period determination result by Franco et al. (2014, 3.081 h) is completely identical to the newly determined period of P = 3.081 ± 0.007 h obtained from the SAO data acquired over 2 consecutive nights in 2022 August.



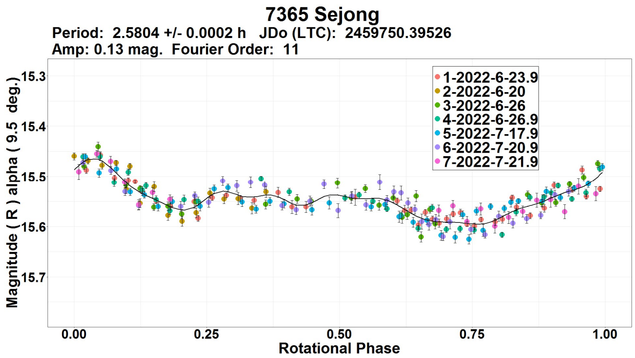
5736 Sanford. A search of the LCDB database found a value of 3.1846 h (Pravec, 2011web) as the only previously determined rotation period. Period analysis carried out upon the 2022 July SAO observations shows a statistically equal rotation period result of P = 3.1842 ± 0.0006 h.



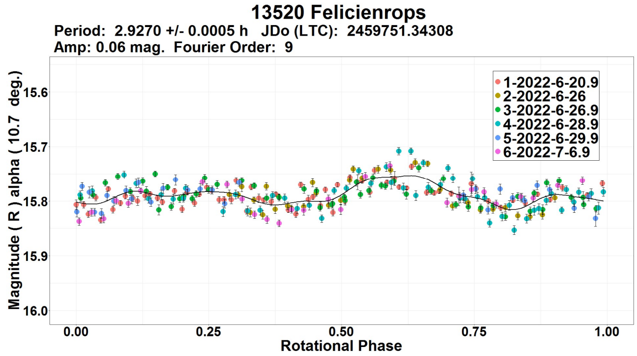
7189 Kuniko. Waszczak et al. (2015) found a rotation period of 2.922 h. SAO data obtained in late 2022 August indicate a concordant result of P = 2.924 ± 0.002 h.



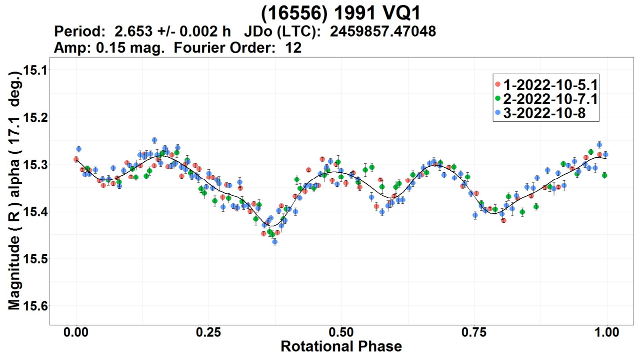
7365 Sejong. Rotation period result of P = 2.5804 ± 0.0002 h found from the SAO data collected over 7 nights in 2022 June - July is fully accordant with the previous period determinations by Pravec (2019web, 2.5802 h), Polakis (2020, 2.579 h) and slightly different from the period obtained by Yeh et al. (2020, 2.59 h).



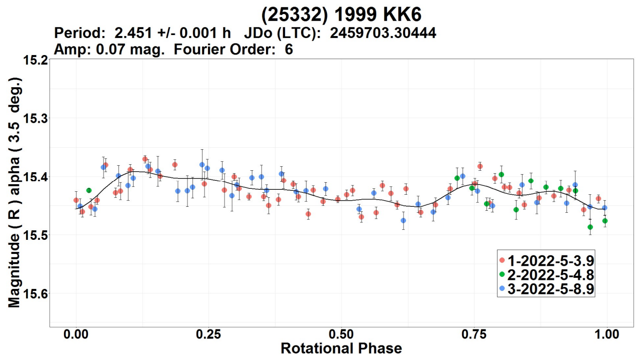
13520 Felicienrops. No clearly defined rotation periods found in the LCDB database. Observations conducted in 2022 June - July point to a fairly plausible low-amplitude lightcurve solution associated with a period of P = 2.9270 ± 0.0005 h.



(16556) 1991 VQ1. According to the LCDB database records the result of this rotation period determination could be considered the first one for this asteroid. Data collected over 3 nights in early 2022 October yield a unique relatively short rotational period of P = 2.653 ± 0.002 h.



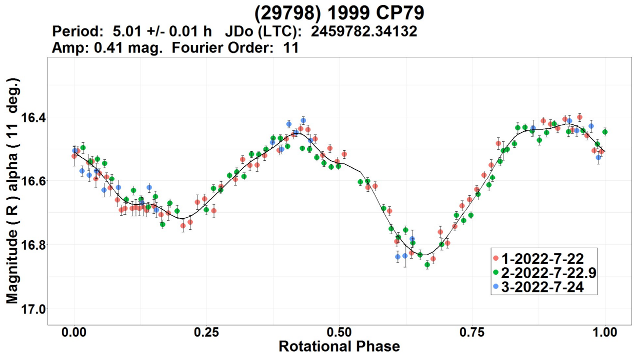
(25332) 1999 KK6. The result for a rotation period of P = 2.451 ± 0.001 h derived from the 2022 May SAO photometric data is consistent with the vast majority of rotation period results previously obtained for this Hungaria family asteroid found in the LCDB, for example: 2.4531 h (Warner, 2008); 2.453 h (Warner, 2013); 2.4531 h (Warner, 2016); 2.452 h (Dose, 2021).



Number	Name	20yy/mm/dd	Phase	L_{PAB}	B_{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
1252	Celestia	22/07/12-22/07/18	22.1,22.6	257	36	10.63	0.02	0.16	0.01	PAL
2454	Olaus Magnus	22/07/20-22/07/27	23.2,20.7	330	7	3.805	0.002	0.46	0.02	MAT
3977	Maxine	22/08/10-22/08/12	19.3,18.9	356	13	3.081	0.007	0.28	0.02	EUN
5736	Sanford	22/07/03-22/07/19	21.0,25.2	276	29	3.1842	0.0006	0.29	0.02	PHO
7189	Kuniko	22/08/26-22/08/31	19.1,16.7	2	-1	2.924	0.002	0.16	0.02	MB-I
7365	Sejong	22/06/19-22/07/21	8.0,22.2	262	10	2.5804	0.0002	0.13	0.02	MB-I
13520	Felicienrops	22/06/20-22/07/07	*10.7,11.2	276	17	2.9270	0.0005	0.06	0.03	MB-I
16556	1991 VQ1	22/10/04-22/10/08	17.1,15.5	34	-8	2.653	0.002	0.15	0.02	MB-I
25332	1999 KK6	22/05/03-22/05/08	3.5,7	218	0	2.451	0.001	0.07	0.03	HUN
29798	1999 CP79	22/07/21-22/07/24	11.0,10.1	319	9	5.01	0.01	0.41	0.03	EUN

Table I. Observing circumstances and results. Phase is the solar phase angle given at the start and end of the date range. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the average phase angle bisector longitude and latitude. Grp is the asteroid family/group (Warner *et al.*, 2009): PAL = Pallas, MAT = Matterania, HUN = Hungaria, MB-I = main-belt inner, PHO = Phocaea, EUN = Eunomia.

(29798) 1999 CP79. No prior rotation period determination results were known. Three datasets obtained in 2022 July reveal an unambiguous bimodal solution for period of $P = 5.01 \pm 0.01$ h.



Acknowledgements

Observational work at Sopot Astronomical Observatory is generously supported by Gene Shoemaker NEO Grants awarded by the Planetary Society in 2018 and 2022.

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