LIGHTCURVE ANALYSIS OF ASTEROIDS 1939 LORETTA, 2099 OPIK, 2699 KALININ, 2779 MARY, 3108 LYUBOV, 5182 BRAY, AND 9098 TOSHIHIKO

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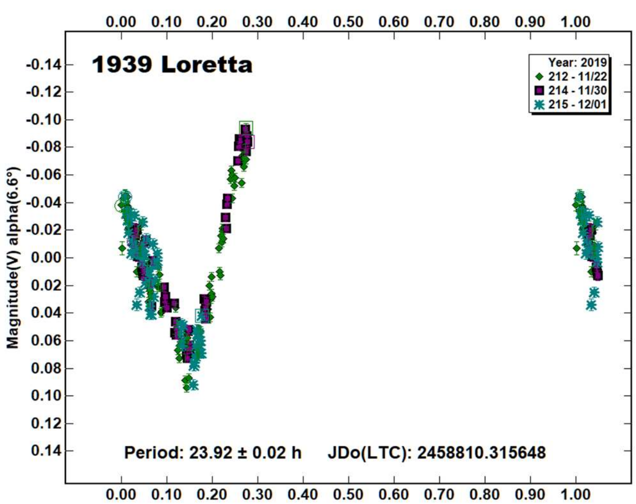
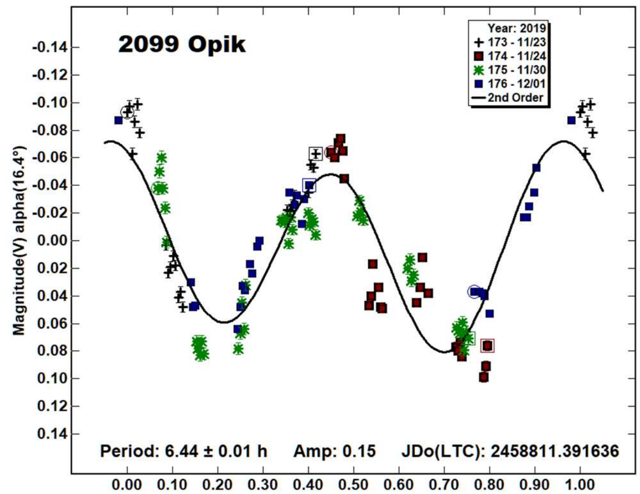
Photometric observations of seven main-belt asteroids were obtained on five nights between 2019 November 22 and 2019 December 28. The following rotational periods were determined: 1939 Loretta, 23.92 ± 0.02 h; 2099 Opik, 6.44 ± 0.01 h; 2699 Kalinin, 2.928 ± 0.001 h; 2779 Mary, 3.62 ± 0.01 h; 3108 Lyubov, 4.83 ± 0.01 h; 5182 Bray, 2.88 ± 0.01 h; 9098 Toshihiko, 3.46 ± 0.01 h.

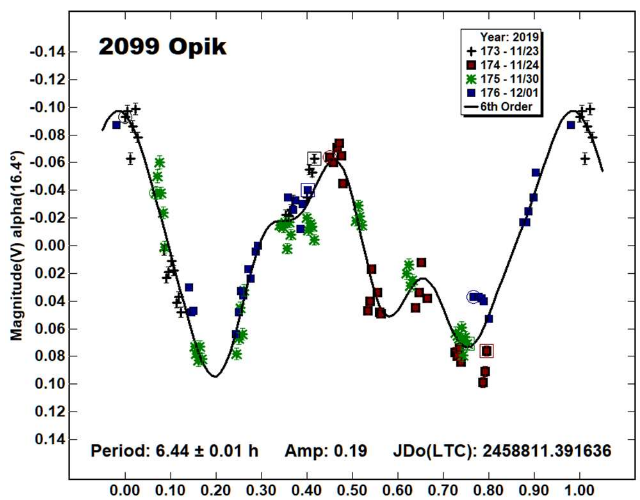
Photometric observations obtained with the Southeastern Association for Research in Astronomy (SARA) consortium 1-m Jacobus Kapteyn Telescope at the Observatorio del Roque de los Muchachos on the Spanish island of La Palma are presented. The telescope is coupled with an Andor iKon-L series CCD. A detailed description of the instrumentation and setup can be found in Keel et al. (2017). The data was calibrated using *MaximDL* and photometric analysis was performed using *MPO Canopus* (Warner, 2017).

1939 Loretta. This asteroid is a member of the Themis family of asteroids. The asteroid was observed on three nights for approximately 6 h each night. The rotational period of 1939 Loretta is close to 24 h and therefore only part of the lightcurve could be observed. However, the period is well-defined as the data contains a steep and sharp minimum. As no maximum was observed we cannot determine the amplitude for the lightcurve. The current data yields a rotational period of 23.92 ± 0.02 h. This is in excellent agreement with the two previous measurements by Ďurech and Hanuš (2018, 23.931 ± 0.002 h) and Fauerbach (2019, 23.88 ± 0.02 h).

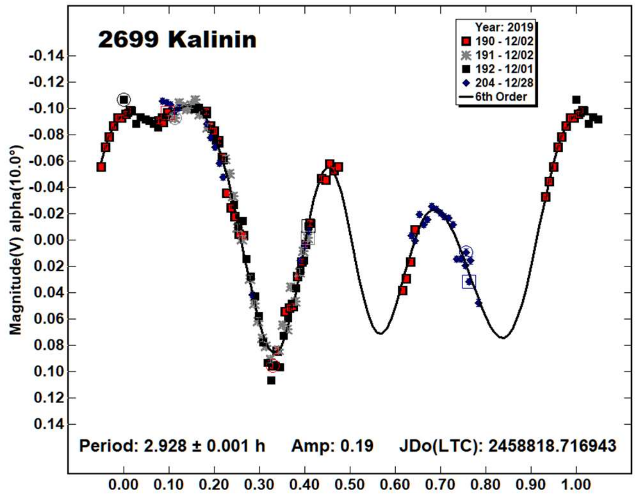


2099 Opik is a Mars-crossing asteroid. Goretti (2000) derived a period of 9.3 ± 0.1 h with an amplitude of 0.7 mag based on sparse data. Behrend (2005) reports a period of 6.4430 ± 0.0002 h with an amplitude of 0.21 mag. The present data yields a period of 6.44 ± 0.01 h with an amplitude of 0.19 mag. This is in excellent agreement with the result by Behrend. As their results indicate a more intricate lightcurve, the current data is presented with both a bimodal, and a 4th-order fit.

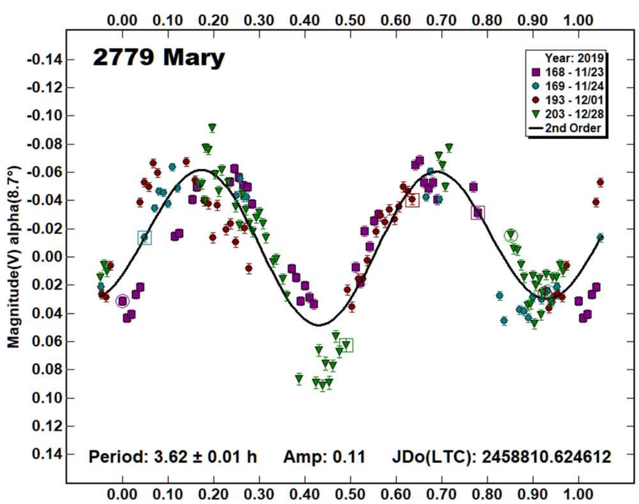




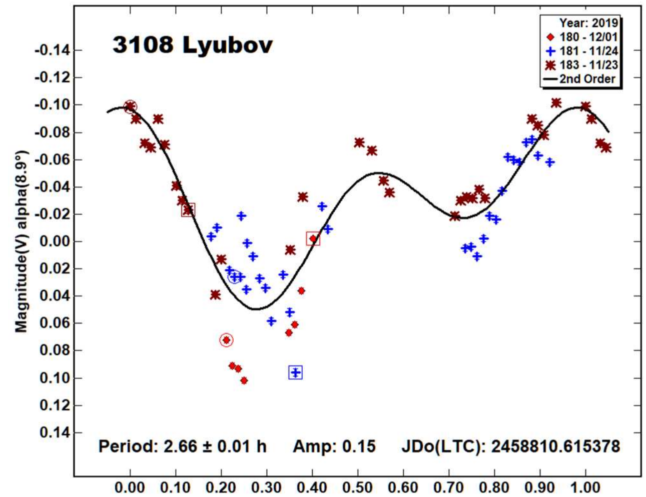
2699 Kalinin. We observed 2699 Kalinin on four nights over a four-week period. A rotational period of 2.928 ± 0.001 h with an amplitude of 0.19 mag was obtained. This is in excellent agreement with the result by Ambrosioni (2011, 2.9279 h) and by our own group (Fauerbach and Zabala, 2019, 2.928 h).

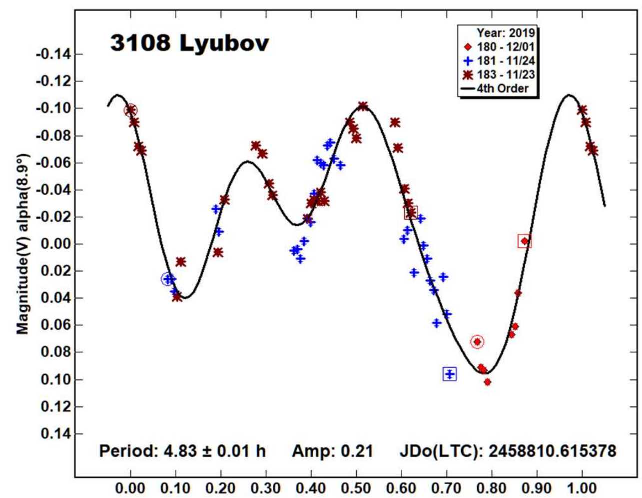


2779 Mary is a member of the Flora group of asteroids. A rotational period of 3.62 ± 0.01 h with an amplitude of 0.11 mag was obtained. The only prior period determination is from Behrend (2006) with a derived period of 3.36 ± 0.05 h. This is in fair agreement with the current measurement.

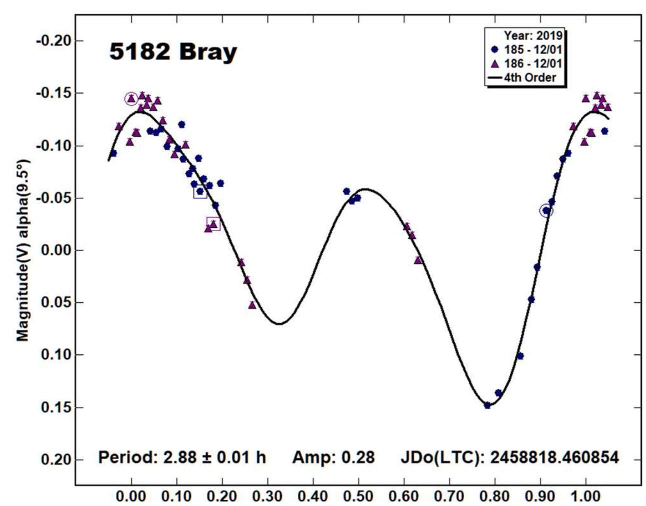


3108 Lyubov is a member of the Flora group/family. The only prior period determination is by Waszczak et al. (2015). They derived a period of 2.658 ± 0.0004 h with an amplitude of 0.18 mag. Our best fit for a bimodal model results in a period of 2.66 ± 0.01 h with an amplitude of 0.15 mag. This seems to be in very good agreement with the period determined by Waszczak, however a closer look at the data shows a rather large scatter of our data. If one takes higher order solutions into consideration a much better fit with a period of 4.83 ± 0.01 h and a magnitude of 0.21 mag appears. For the current publication, the later result is the preferred one.

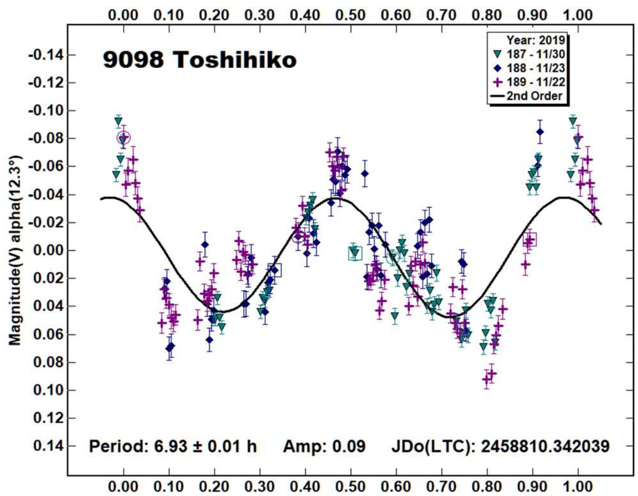


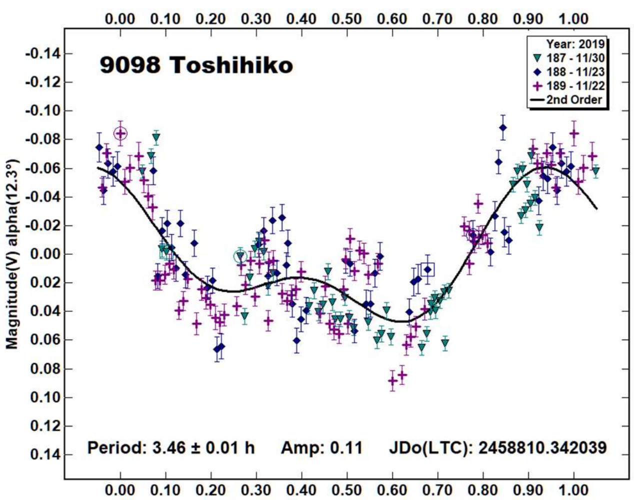


5182 Bray. This is a member of the Eunomia family. We observed 5182 Bray on two successive nights and measured a rotational period of 2.88 ± 0.01 h with an amplitude of 0.28 mag. This is in excellent agreement with previous publications by Klinglesmith (2014, 2.883 h) and Behrend (2018, 2.884 h), as well as our previous result (Fauerbach, 2019, 2.86 h).



9098 Toshihiko. We observed 9098 Toshihiko on three nights for more than 6 h every night. Unfortunately, the data is very noisy and of lower-than-expected quality. The only prior period determination is by Chang et al. (2016). They derived a period of 6.19 ± 0.12 h with an amplitude of 0.13 mag. Our best fit for a bimodal model results in a period of 6.93 ± 0.01 h with an amplitude of 0.09 mag. Due to the noisy nature of the data, the solution is not unique. Many other solutions, including the half-period provide a similar good fit. Looking at the individual nights the half-period of 3.46 ± 0.01 h with an amplitude of 0.11 mag appears to be the preferred solution and will be reported here.





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Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1939	Loretta	2019 11/22-12/01	6.5,9.1	38	0	23.92	0.02			THM
2099	Opik	2019 11/23-12/01	16.4,21.3	48	-14	6.44	0.01	0.19	0.01	MC
2699	Kalinin	2019 12/01-12/28	10.0,5.5	89	8	2.928	0.001	0.19	0.01	MB-M
2779	Mary	2019 11/23-12/28	*8.7,10.1	77	0	3.62	0.01	0.11	0.02	FLOR
3108	Lyubov	2019 11/23-12/01	13.5,8.9	80	-5	1.83	0.01	0.21	0.01	FLOR
5182	Bray	2019 11/30-12/01	9.3,9.5	55	-20	2.88	0.01	0.28	0.03	EUN
9098	Toshihiko	2019 11/22-11/30	8.9,12.2	40	0	3.46	0.01	0.11	0.02	MB-O

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. L_{PAB} and B_{PAB} 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).