

# PHOTOMETRY AND LIGHTCURVE ANALYSIS OF FOUR MARS-CROSSING ASTEROIDS

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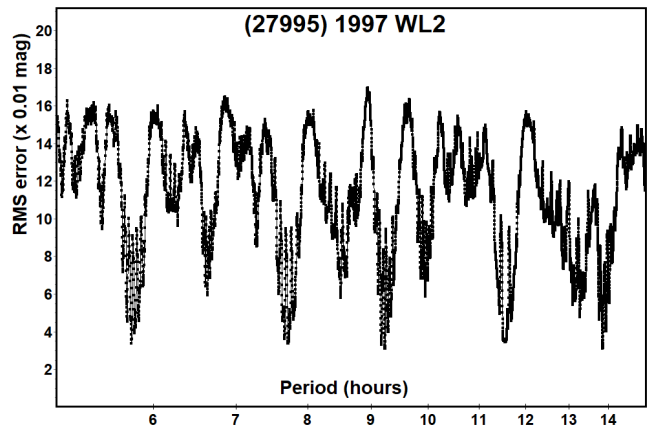
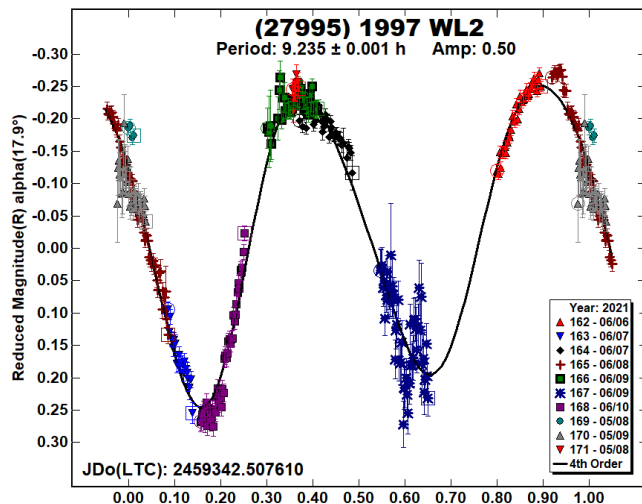
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Rotational periods of four Mars-crossing asteroids (MCs) were determined from lightcurves acquired at the Observatório Astronômico do Sertão de Itaparica (MPC Y28, OASI) between 2020 July to 2021 October.

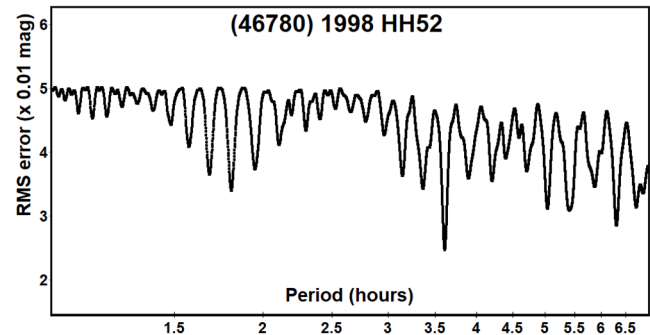
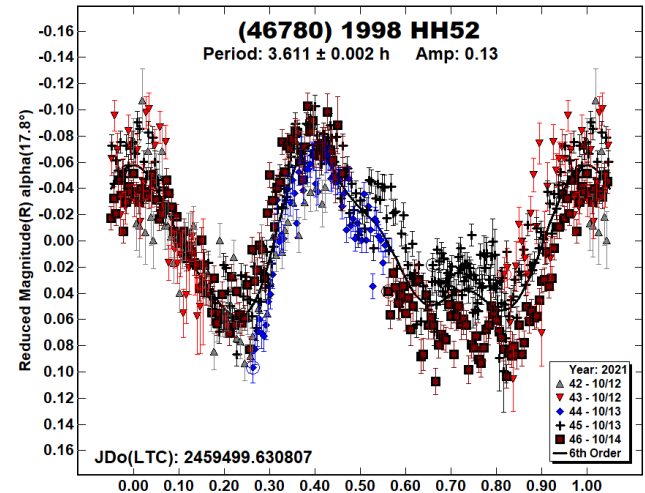
CCD photometric observations of four Mars-crossers were made at the Observatório Astronômico do Sertão de Itaparica (MPC code Y28) between 2020 July and 2021 October. Images were obtained with the 1.0-m f/8 telescope of the IMPACTON project and an FLI PL424 CCD camera (2048×2048 pixels) set to 2×2 binning (Rondón et al., 2020) and Johnson-Cousins R filter. The raw images were calibrated with dark and flat frames. *MPO Canopus* (Warner, 2017) was used for magnitude measurement, Fourier analysis (Harris et al., 1989), and to produce the final lightcurve.

The observational circumstances for each observed object are given in Table I along with the results, which are discussed individually below. The phased rotational lightcurve and the periodogram are shown for each object.

**(27995) 1997 WL2.** The only previously reported rotational period in the LCDB (Warner et al. 2009) for this small Solar System body is from Behrend et al. (2021web), who reported a period of  $9.229 \pm 0.001$  h with 0.49 mag amplitude. Our results used observations from 2021 May and June and showed a period of  $9.235 \pm 0.001$  h with an amplitude of 0.50 mag. The resulting two-peaked lightcurve is consistent with the previously published value both in period and amplitude.



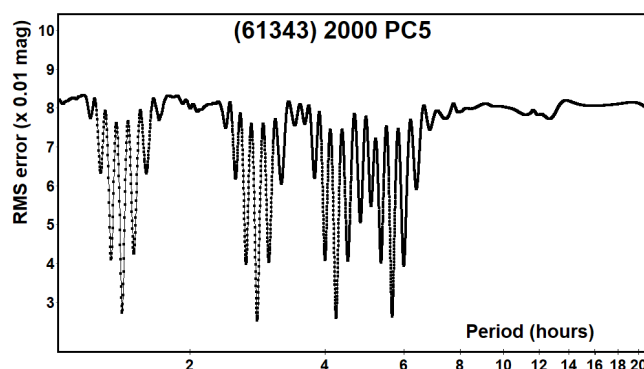
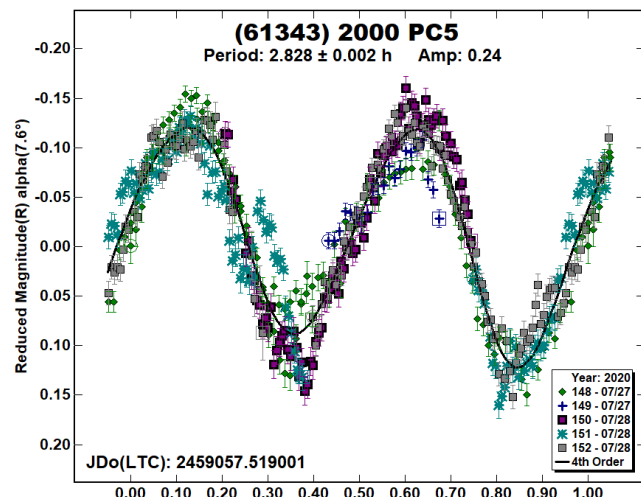
**(46780) 1998 HH52.** One previously reported period in the LCDB for this Mars-crosser (Pravec et al., 2021web) showed  $P = 3.6122 \pm 0.0008$  h and amplitude 0.09 mag. Our observations from 2021 November 12, 13, and 14 best fit a rotational period of  $3.611 \pm 0.002$  h and an amplitude of 0.13 mag. Our result is in concordance with the one previously reported.



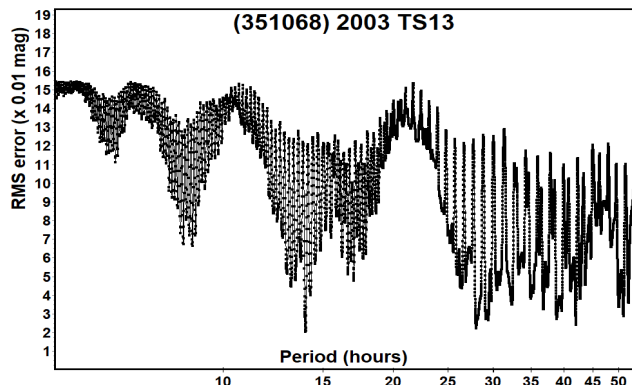
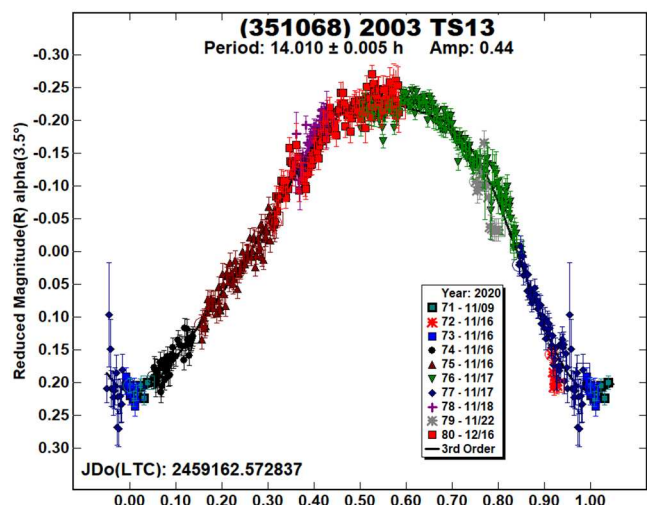
**(61343) 2000 PC5.** A search in the Asteroid Lightcurve Photometry Database did not find any previously reported result for this asteroid. It was possible to derive a rotational period of  $2.828 \pm 0.002$  h from observations acquired on 2020 June 27 and 28. The lightcurve has an amplitude of 0.24 mag and displays two maxima and two minima per rotational cycle.

| Number | Name      | yyyy mm/dd       | Phase      | L <sub>PAB</sub> | B <sub>PAB</sub> | Period(h) | P.E.  | Amp  | A.E. |
|--------|-----------|------------------|------------|------------------|------------------|-----------|-------|------|------|
| 27995  | 1997 WL2  | 2021 05/08-06/10 | *2.0, 20.7 | 229              | 2                | 9.235     | 0.001 | 0.50 | 0.02 |
| 46780  | 1998 HH52 | 2021 10/12-10/14 | 17.0       | 40               | 0                | 3.611     | 0.002 | 0.13 | 0.01 |
| 61343  | 2000 PC5  | 2020 07/27-07/28 | 8.0        | 295              | -1               | 2.828     | 0.002 | 0.24 | 0.01 |
| 351068 | 2003 TS13 | 2020 11/16-12/16 | *3.0, 15.0 | 58               | -1               | 14.010    | 0.005 | 0.44 | 0.02 |

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<sub>PAB</sub> and B<sub>PAB</sub> are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984).



(351068) 2003 TS13. A search in the LCDB (Warner et al., 2009) did not find any previously reported period for this object. Our analysis using the photometric observations carried over several nights in 2020 November and December indicate a possible period of  $14.010 \pm 0.005$  h with an amplitude of 0.44 h.



The true period might be about 28 h, or double our result; the periodogram shows a second RMS minima between 25 and 30 h. It was not possible to follow this Mars-crosser long enough to derive a “full” bimodal lightcurve, so our result is based on the best fit to a monomodal lightcurve.

#### Acknowledgements

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#### References

- Behrend, R. et al. (2021 web). Observatoire de Genève web site. [http://obswww.unige.ch/~behrend/page\\_cou.html](http://obswww.unige.ch/~behrend/page_cou.html)
- 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.; Bowell, E.; Martin, L.J.; Millis, R.L.; Poutanen, M.; Scaltriti, F.; Zappala, V.; Schober, H.J.; Debehogne, H.; Zeigler, K.W. (1989). “Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863.” *Icarus* **77**, 171-186.
- Pravec, P. et al. (2021 web). Photometric Survey for Asynchronous Binary Asteroids web site. <https://www.asu.cas.cz/~asteroid/binastphotosurvey.htm>
- Rondón, E.; Lazzaro, D.; Rodrigues, T.; Carvano, J.M.; Roig, F.; Monteiro, F.; Arcoverde, P.; Medeiros, H.; Silva, J.; Jasmim, F.; de Prá, M.; Hasselmann, P.; Ribeiro, A.; Dávalos, J.; Souza, R. (2020). “OASI: A Brazilian Observatory Dedicated to the Study of Small Solar System Bodies-Some Results of NEOs Physical Properties.” *PASP* **132**, 065001.
- Warner, B.D.; Harris, A.W.; Pravec, P. (2009). “The Asteroid Lightcurve Database.” *Icarus* **202**, 134-146. Updated 2021 Dec. <http://www.minorplanet.info/lightcurvedatabase.html>
- Warner, B.D. (2017). *MPO Canopus* Software, version 10.7.11.1, BDW Publishing. <http://www.bdwpublishing.com>