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ROTATION PERIODS AND LIGHTCURVES FOR SIX NEAR-EARTH ASTEROIDS

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(Received: 15 July)

The lightcurves and synodic rotation periods for six near-Earth asteroids observed in the period 2013 October to 2014 June are presented.

Photometric observations of six near-Earth asteroids were carried out in the period 2013 October through 2014 June using an SBIG ST-8XME CCD camera mounted on a 0.35-m LX200 GPS Schmidt-Cassegrain (SCT) that operated at focal ratios of *f*/6.3 (2014 observations) and *f*/10 (2013 observations). The exposures were unguided. No filters were used in order to maximize signal-to-noise. To further increase the sensitivity, the camera was operated in a 2x2 binning mode, which produced an image scale of 1.66 arcsec/pixel at *f*/6.3 and 1.04 arcsec/pixel at *f*/10. The exposure times were customized depending on the brightness and apparent motions of the particular targets.

All photometric measurements, lightcurve constructions, and period analyses were performed in *MPO Canopus* software (2012). The Comparison Star Selector (CSS) utility in *MPO Canopus* was employed for differential photometry. This allowed using up to five comparison stars of near solar color. The V-band magnitudes were taken from the hybrid MPOSC3 catalog, where BVRI magnitudes were derived from J and K 2MASS catalog magnitudes by applying formulae developed by Warner (2007). As a result, the magnitude zero-points for individual data sets are generally consistent within a few hundredths of a magnitude. However, in some cases, more significant misfits between the individual data sets on the order of a few tenths of a magnitude have been noticed. Most likely such discrepancies could be a consequence of catalog magnitude errors.

Due to the very rapid movement of the observed targets in a relatively small field of view and consequent changes of surrounding stellar configurations, it was necessary to change comparison star selections for the observations made during a single night, which resulted in a number of individual data sets for that night. Elliptical apertures with the long axis oriented along an object's path were used in these rapid motion cases.

<u>(154275) 2002 SR41</u>. This asteroid was observed from 2014 June 9–11. The observations resulted in 16 individual photometric sessions with a total of 794 data points. Since the asteroid was fairly faint (V ~ 16.4–17.0), a quite noisy lightcurve was obtained, even with a relatively long exposure time of 240 seconds. Period analysis suggests many possible solutions (see the period spectrum). The most likely is the bimodal solution of 2.75 ± 0.01 hours that, while having the lowest RMS residual, only slightly stands out among other solutions. The Fourier fit amplitude of the corresponding lightcurve is 0.16 mag.

<u>(275677) 2000 RS11</u>. The target was observed from 2014 March 19–23. A bimodal period of P = 4.444 ± 0.001 h can be clearly distinguished among all other solutions in the period spectrum. A large amplitude lightcurve was obtained for this solution. The calculated amplitude for the 15th order Fourier fit is 1.15 ± 0.01

mag., but the real amplitude is even higher than this value. The recently published result of 4.444 ± 0.001 h by Warner (2014a) is fully consistent with the result presented here.

(387733) 2003 GS. The combined data set obtained from 2014 April 06-09 shows an unambiguous bimodal solution for period of P = 2.467 ± 0.001 h and amplitude A = 0.13 ± 0.02 mag. The period is consistent with the one of 2.469 ± 0.001 h reported by Hicks *et al*. (2014).

2011 JR13. Analysis of the photometric data gathered for this asteroid from 2014 May 18–21 indicates a bimodal solution with a period of P = 3.96 ± 0.01 h as the most favorable one. The lightcurve amplitude is 0.35 ± 0.02 mag.

2013 SU24. The target was observed for astrometric purposes on 2013 October 6 over a span of ~40 minutes. Subsequently, having noticed large multiple changes in the target's brightness during the short time interval, the author decided to try to perform photometric measurements using the available images. This resulted in 3 data sets and a total of 76 data points. The period analysis showed that it is indeed a fast rotator and produced two characteristic harmonically related solutions of 0.11 h (monomodal) and 0.22 h (bimodal). On the basis of the data gathered by Warner (2014a), Pravec conducted a more detailed analysis and found that this NEA is a non-principal axis rotator with two periods of 0.23335 h and 0.19894 h (Warner, 2014a). It is interesting to note that the rough bimodal solution obtained by the author of this paper (P = 0.22 ± 0.01 h) from the routine photometric measurements of the images obtained in a very short period of time lies between the two periods found by Pravec. The value found for amplitude of the bimodal lightcurve is extremely large: 1.67 mag.

2013 WT44. This NEA target was observed from 2014 March 29 until April 4. The observations resulted in 9 sessions with a total of 393 data points. The period analysis shows two almost equally dominant solutions in the period spectrum: 3.29 hours (monomodal) and 6.58 hours (bimodal). Taking into account radar observations that showed a nearly pole-on viewing aspect and revealed a nearly spherical shape of this asteroid as stated by Warner (2014b), the shorter period should be considered as the more likely solution. The value for period recently published by Warner (2014b) of 2.8849 h is significantly different from that presented in this paper (3.29 ± 0.01 h). It would be of importance to check why there is such a difference in the period values independently obtained by two authors. The value found for amplitude is 0.06 ± 0.02 mag.

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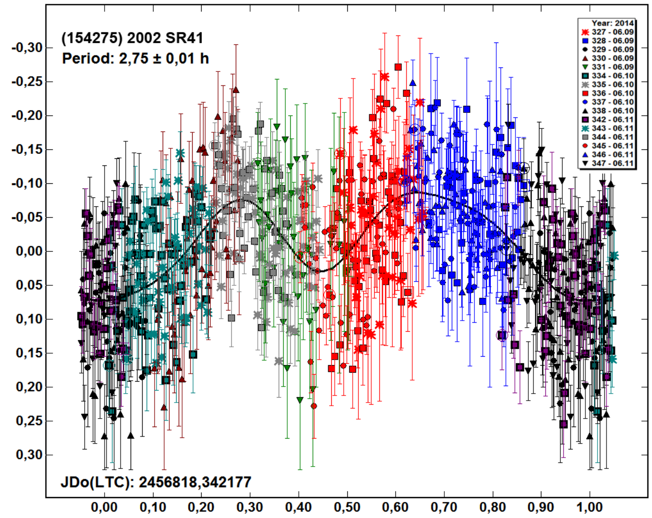

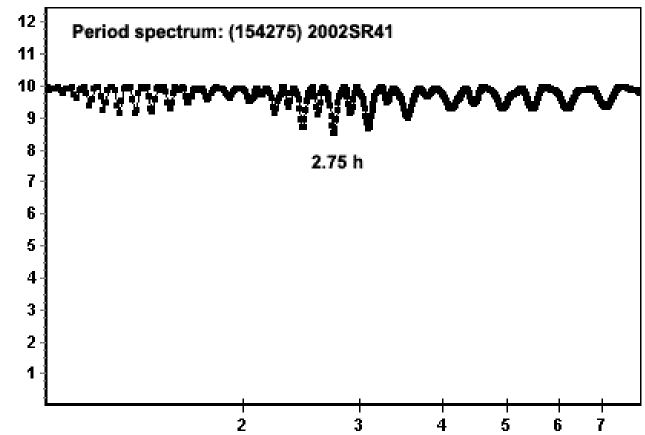

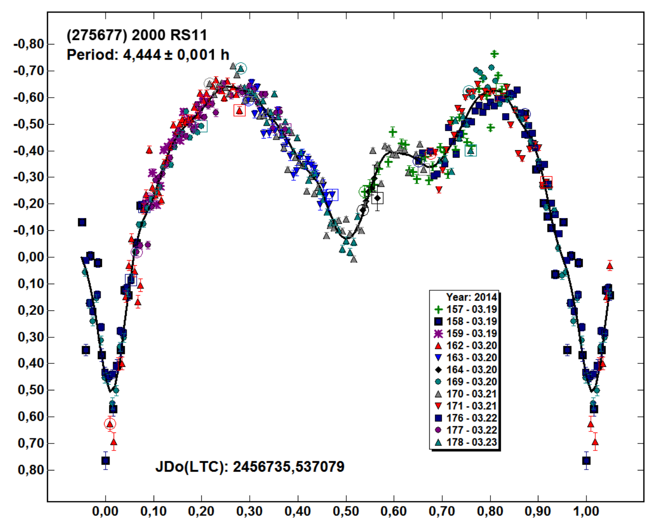

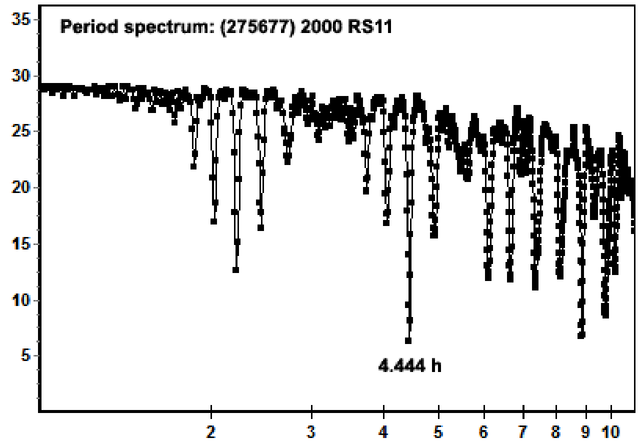
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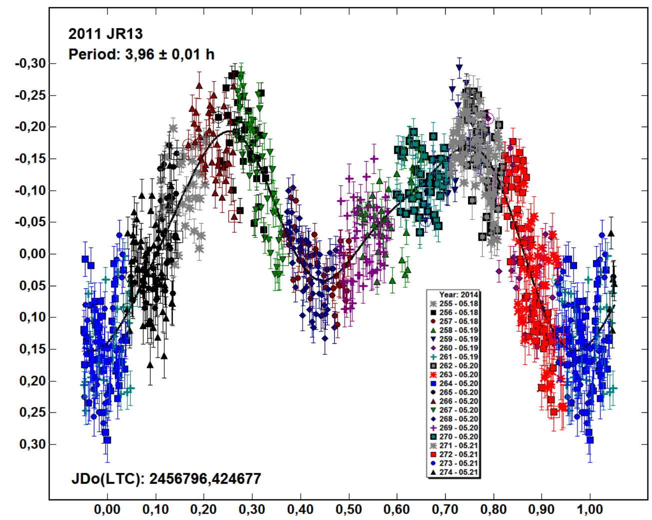
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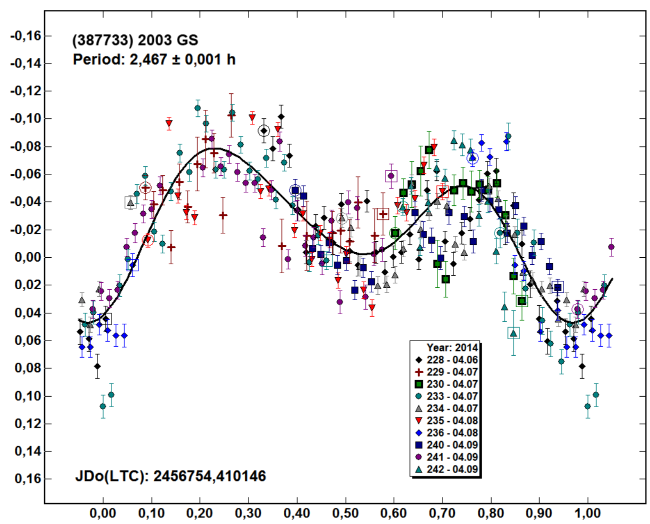
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229 - 04.07
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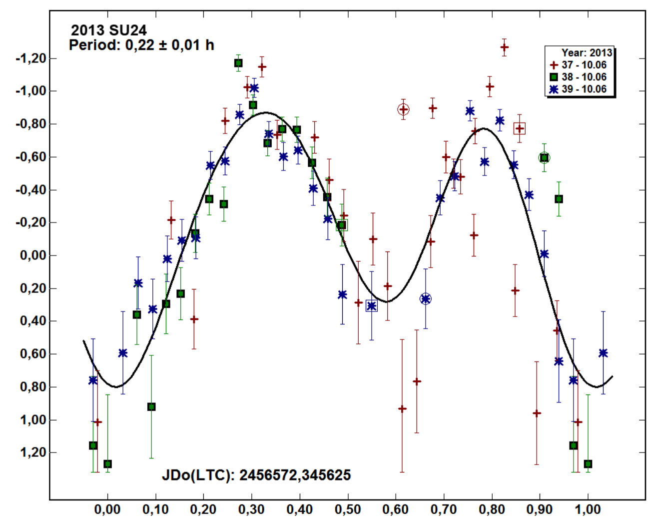
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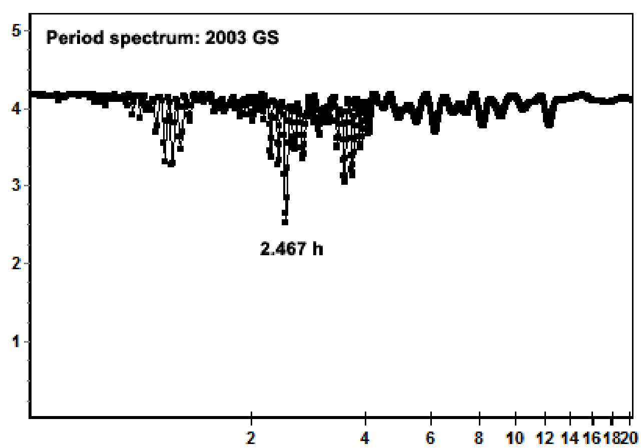
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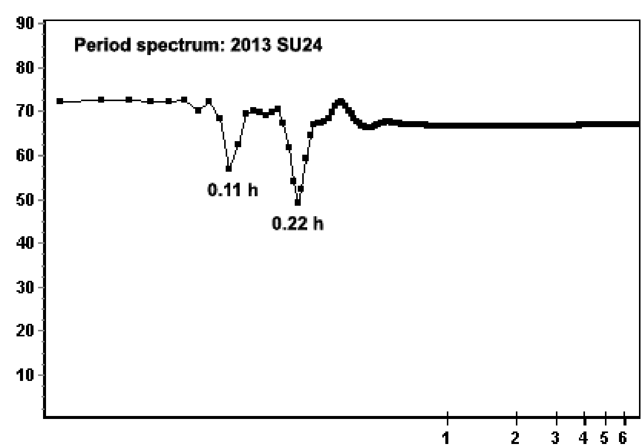
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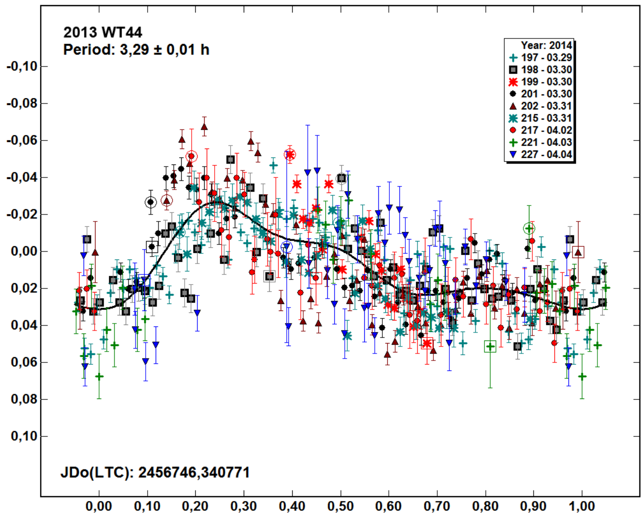

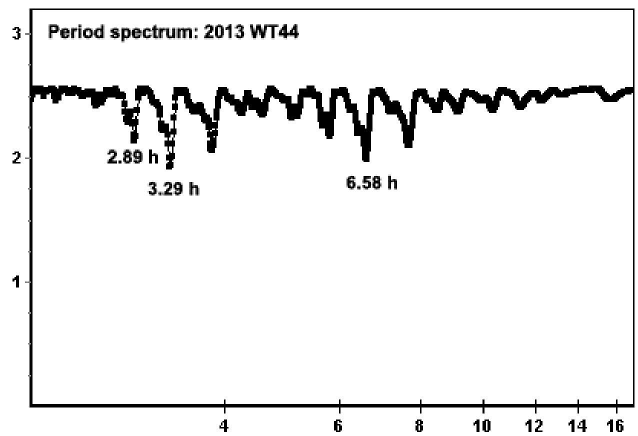

ROTATION PERIOD DETERMINATION FOR THE SLOW ROTATOR 3345 TARKOVSKIJ

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Photometric observations of the main-belt asteroid 3345 Tarkovskij conducted by the authors over more than three months from 2013 December to 2014 March revealed its slow rotation rate and a synodic rotation period of 187.0 ± 0.1 hours. The corresponding bimodal lightcurve has an amplitude of 0.59 ± 0.02 magnitudes.

The main-belt asteroid 3345 Tarkovskij was discovered on 1982 December 23 by L. G. Karachkina at the Crimean Astrophysical Observatory. The asteroid appeared on the list of potential lightcurve targets for 2013 December on the CALL website (Warner, 2013). It reached opposition on 2013 November 27.

Prior to this work there were no published results of the rotation period for this asteroid. Motivated by this fact, in order to determine a synodic rotation period, Benishek began unfiltered photometric observations of 3345 Tarkovskij on 2013 December 10 at the phase angle of 11.0 degrees using a 0.35-m *f*/6.3 Schmidt-Cassegrain (SCT) equipped with SBIG ST-8XME CCD camera. From the beginning it became clear that the asteroid was rotating very slowly and a collaboration with other observers was needed. An invitation for collaboration was extended and Coley kindly offered his participation in the observation campaign. Coley used a 0.35-m *f*/6.6 SCT and a SBIG ST-9XE CCD camera with a clear filter.

As of 2014 March 19, the collaborative observations resulted in 30 data sets, of which 13 were obtained by Coley and 17 were obtained by Benishek. The total interval of phase angles covered by the observations extended from 11.0 to 28.1 degrees. *MPO Canopus* software was used for photometric measurements, period analysis, and data sharing between the authors. Differential photometry with up to five comparison stars of near-solar color was carried out by both authors using the Comparison Star Selector (CSS) feature in *MPO Canopus* by selecting the V-band comparison star magnitudes derived from the hybrid MPOSC3 catalog provided with the program. The individual data sets containing magnitudes obtained using the CSS show a certain misalignment which sometimes can reach up to a few tenths of magnitude. Such discrepancies are most likely to be attributed to catalog magnitude errors. Gradual additional adjustments of the magnitude zero-points for particular data sets were necessary until the best fit in terms of the lowest RMS residual is reached.

The combined data set of 3090 data points was used in the period analysis, which covered a range of 10 to 1000 hours. The synodic period of 187 hours related to a bimodal solution is clearly seen among all the other values in the period spectrum. The Fourier fit amplitude for the corresponding bimodal lightcurve is A = 0.59 ± 0.02 mag. This amplitude, combined with the range of relatively low phase angles, strongly favors a bimodal solution of 187 h over