

DETERMINING LIGHTCURVES AND ROTATIONAL PERIODS OF FOUR MAIN BELT ASTEROIDS

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Lightcurves and rotational periods were determined for the following four asteroids: 2394 Nadeev: 6.539 ± 0.001 h; 3717 Thorenia: 4.365 ± 0.001 h; 4700 Carusi: 10.798 ± 0.002 h; and (29032) 2059 T-1: 5.238 ± 0.001 h.

Introduction

This research was performed to determine the rotational period of four main belt asteroids: 2394 Nadeev, 3717 Thorenia, 4700 Carusi, and (29032) 2059 T-1. Data was taken over several nights of observations to produce photometric lightcurves that were then analyzed to determine rotational periods. For an optimal signal to noise ratio, these asteroids needed to have a brightness of 16 mag or less. The telescope used, residing in the northern hemisphere, dictated that these asteroids have a positive declination.

Asteroid 2394 Nadeev was discovered in 1973 by N. Chernykh at Nauchnyj. This asteroid has an orbital eccentricity of 0.214 and a semi-major axis of 3.175 AU (JPL). Asteroid 3717 Thorenia was discovered in 1964 by the Indiana Asteroid Program at the Goeth Link Observatory in Brooklyn, Indiana. It has an orbital eccentricity of 0.171 and a semi-major axis of 3.159 AU (JPL). Asteroid 4700 Carusi was discovered in 1986 by E. Bowell at Flagstaff. It has an orbital eccentricity of 0.201 and a semi-major axis of 2.563 AU (JPL). Asteroid (29032) 2059 T-1 was discovered in 1971 by C.J. Houten, I. van Houten-Groeneveld, and T. Gehrels at Palomar. It has an orbital eccentricity of 0.206 and a semi-major axis of 2.347 AU (JPL).

Method

The telescope used is a 0.7-m CDK 700 Planewave corrected Dall-Kirkham design telescope with an Andor Technologies CCD camera at Texas A&M University-Commerce Observatory (TAMUC) in Commerce, Texas. The camera was thermoelectrically cooled to between -60°C and -100°C to reduce background noise in the images.

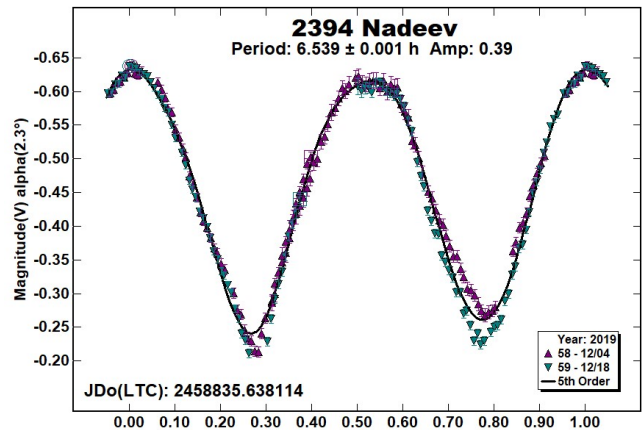
In order to reduce the images, flats, bias, and dark calibration images were taken each night. The flat field images were taken against the twilight sky. The darks were exposed for the same time as the respective light images, three minutes. A Luminance filter that allowed the visible portion of the spectrum to be recorded while blocking the infrared was used in front of the CCD camera.

The software *MaxImDL* was used to calibrate and align the asteroid images. Afterward, the program *MPO Canopus* v10.4.0.8 (Warner, 2011) was used to perform differential photometry on the reduced data. For each data set, five stars within an image were used for

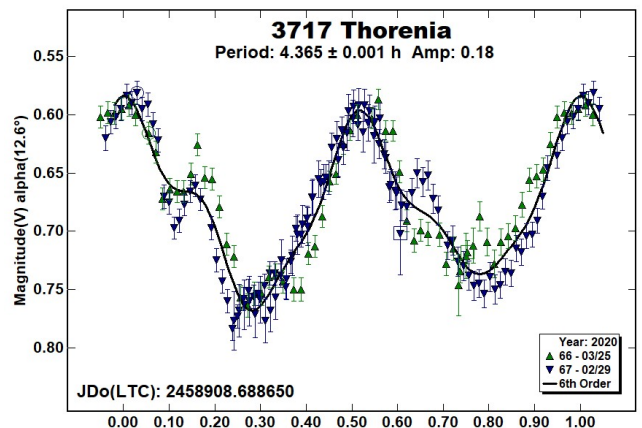
brightness comparison to the asteroid. Aperture photometry was used to determine the brightness of these comparison stars and the asteroid. The average of the difference in mag. between the stars and the asteroid was found for each image and then plotted in a phased plot, mag. versus time, to create a lightcurve. A Fourier transform was then applied to the lightcurve to determine the rotational period and error in the period.

Results

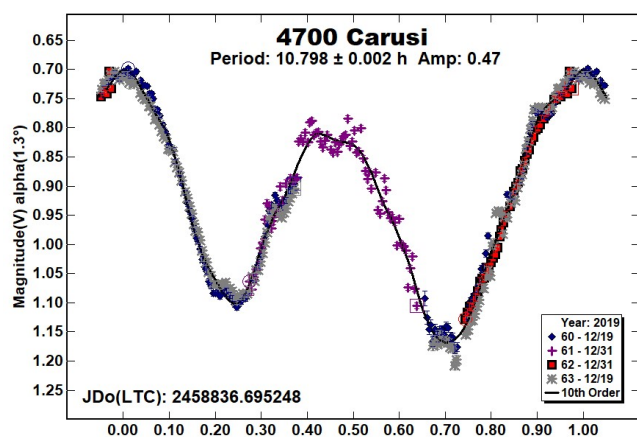
2394 Nadeev was imaged on 2019 December 4, 124 times and on 2019 December 18, 110 times. A rotation period of 6.539 ± 0.001 h with an amplitude variance of 0.05 mag was found. Behrend (2019) found a similar rotation period of 6.54 hours.



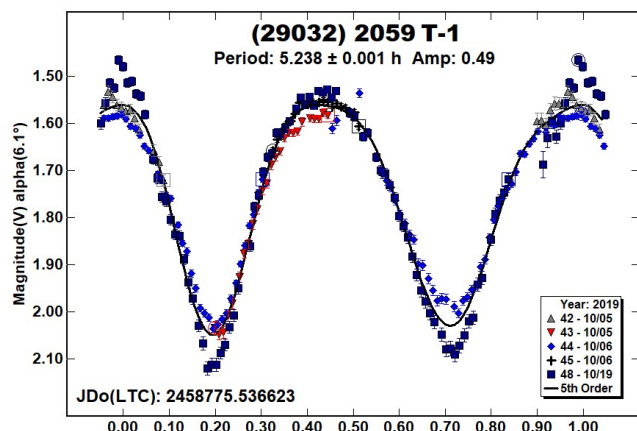
3717 Thorenia was imaged on 2020 February 9, 138 times and on 2020 March 25, 65 times. A rotation period of 4.365 ± 0.001 h with an amplitude variance of 0.02 mag was found. No previous studies regarding the rotation period were found in either the JPL Small-Body Database or the Minor Planet Light Curve Database (MPC).



4700 Carusi was imaged 2019 December 19, 150 times and on 2019 December 31, 139 times. A rotation period of 10.798 ± 0.002 h with an amplitude variance of 0.47 mag was found. Odden et al. (2020) found a period of 11.656 ± 0.001 h with an amplitude of 0.49 ± 0.05 mag. The discrepancy in the two rotation periods is interesting since both studies had well sampled lightcurves.



29032 (2059 T-1) The asteroid 29032 (2059 T-1) was imaged on 2019 October 5, 43 times, 2019 October 6, 110 times, and on 2019 October 19, 90 times. A rotation period of 5.238 ± 0.001 h with an amplitude variance of 0.05 mag was found. Benishek (2020) found a similar rotation period of 5.2393 ± 0.0006 h and an amplitude of 0.41 mag.



Acknowledgments

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Number	Name	yyyy mm/dd	Phase	L _{PAR}	B _{PAR}	Period(h)	P.E.	Amp	A.E.
2394	Nadeev	2019/12/04-2019/12/18	2.1, 8.4	67.6	-1.8	6.539	0.001	0.39	0.05
3717	Thorenia	2020/02/09-2020/03/25	6.9, 12.6	154.8	+2.7	4.365	0.001	0.18	0.02
4700	Carusi	2019/12/19-2019/12/31	1.5, 6.2	88.6	+1.8	10.798	0.002	0.47	0.02
29032	2059 T-1	2019/10/05-2019/10/19	5.9, 14.7	4.0	+4.8	5.238	0.001	0.49	0.05

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).