PROCEEDINGS OF SCIENCE

Lightcurve analysis on asteroids from NAO Rozhen observations in 2021

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In the last two decades, part of the observational time at Bulgarian National Astronomical Observatory (BNAO) Rozhen was dedicated to asteroid observations. Even though during 2021, we had limited time, we collected enough information to proceed with differential photometry on many asteroids. Using a combination of asteroid lightcurves, gained from observations at several oppositions, we were able to determine precise synodic periods. Through the analysis of different lightcurves, we can give predictions about their preliminary shape. In this work we will present the process for synodic period determination for 418 Alemannia, 339 Dorothea, 901 Brunsia, and 2650 Elinor. Moreover, using the characteristics of the lightcurves, we will calculate the ratio between the axis of the asteroid and give first assumptions about its shape.

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1. Introduction

Asteroids have minimal changes in their chemical compositions, that makes them important carriers of information about the history of the Solar System. On the other side, during their evolution, they have "suffered" catastrophic collisions that have led to enormous changes in their shape. Asteroids have irregular shapes, usually approximated by triaxial ellipsoids, with three major axes: a, b, and c, where $a > b > c$.

The photometric observation of these objects can give us information mainly about their rotation properties and shapes. When observing the asteroids, we can detect the reflected sunlight from their surface. During the observation, the asteroid is rotating, and we get information from different portions of its surface, which changes the apparent brightness of the asteroid. By measuring the variation of the brightness of the asteroid during a time interval and presenting it graphically, we can construct its lightcurve, revealing its synodic period of rotation and amplitude. The shape of the lightcurve and the value of its amplitude can give us first assumptions about the ratio between asteroid axis and shape.

2. Observations and data reduction

The observations of the four asteroids presented here, were carried out in few nights during several months in 2021. The asteroid 418 Alemannia was observed in August, September, and October, 901 Brunsia was observed in September and October, 339 Dorothea was observed one night in May, and 2650 Elinor during one night in March. We used two telescopes for our observations: a 50/70cm Schmidt telescope with FLI PL16803 CCD camera and a 60cm Cassegrain telescope with FLI PL09000 CCD camera.

Asteroid	Date	r	Δ	α	λ_e	β_e
	(UT)	(AU)	(AU)	(°)	(°)	(°)
339 Dorothea	2021 May 10.929	3.178	2.274	9.63	199.64	8.11
418 Alemannia	2021 August 8.908	2.435	1.444	6.43	304.52	10.04
	2021 September 11.780	2.397	1.622	18.80	309.13	8.04
	2021 October 3.844	2.347	1.833	23.25	301.47	8.57
901 Brunsia	2021 September 11.066	1.810	1.000	25.69	39.47	5.93
	2021 October 4.009	1.852	0.906	14.4	37.78	6.214
2650 Elinor	2021 March 7.950	3.145	2.156	1.67	165.28	-4.79

Table 1: Aspect data for the asteroids' observations.

The aspect data for the observations are given in Table1. The first column gives the date of the observation, referring to the mid-time of the observed lightcurve. The following columns contain: the asteroid distance from the Sun (r), distance from the Earth (Δ), the Sun-asteroid-observer angle (phase angle (α)), the J2000.0 ecliptic longitude (λ_e) and latitude (β_e) of the asteroid, referred to the time in the first column.

For differential aperture photometry, we used CCDPHOT by Buie [1]. Lightcurve analysis (composite lightcurves, synodic rotational period, and estimation of the amplitude of the lightcurve), was performed using MPO Canopus v10.7.7.0 [2]. To calculate the ratio between the smallest and largest observed axis, we used the formula $R = 10^{(A_0/2.5)}$, where A_0 represents the corrected amplitude of the lightcurve. This correction includes the influence of the phase angle and the spectral type of the asteroid [3].

3. Results

The asteroid **339 Dorothea**, with a diameter of 44.329 km, is a large member of the Eos family, located in the outer region of the main belt. According to the SMASS II taxonomy [4], this asteroid is classified as K- type. The officially published rotational period in the JPL data base for this asteroid is 5.974 h [5]. This asteroid was observed only one night, on the 9^{th} of May 2021. The constructed lightcurve of 339 Dorothea, with Fourier fit of order 6, reveals a period of 5.968 ± 0.001 h (Fig.1). Our results are close to the newest published one, which is 5.96881 h [6]. Due to the small amplitude of the lightcurve 0.1^m, and the calculated ratio between the smallest and largest observed axis $a/b \geq 1.1$, we believe this asteroid can be almost spherical in shape.

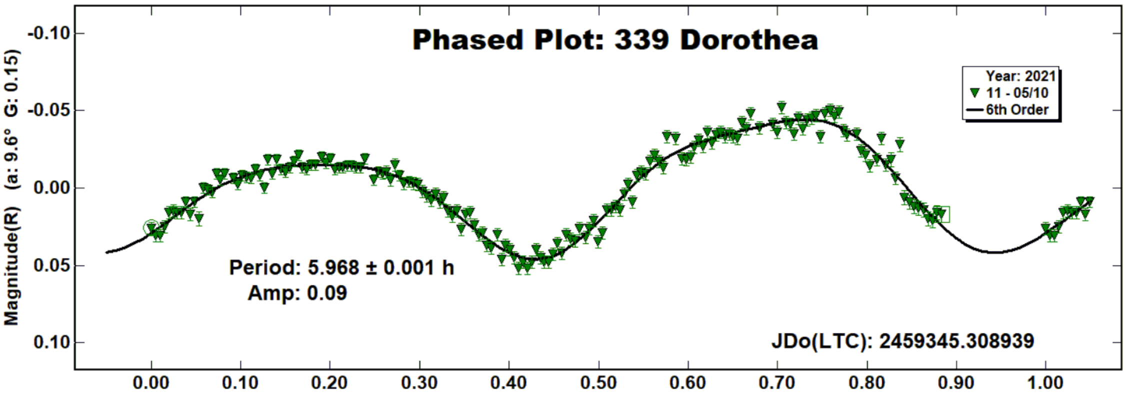

Figure 1: Lightcurve of 339 Dorothea, obtained from observations in May 2021.

418 Alemannia, discovered in 1896, is an M-type asteroid from the central part of the main belt and has a rotational period of 4.671 h [7]. This asteroid was observed in three months: August, September, and October, and the phase angle during these observations changed from 6.43° to 23.25°. In August, we observed this asteroid for 5 hours, covering the time interval of its whole rotational period. The constructed lightcurve (Fig.2), with Fourier fit of order 9, confirms the published period of 4.671 ± 0.001 h and reveals a very asymmetric shape of the lightcurve with an amplitude of 0.17^m . The first assumptions for the shape of this asteroid, based on the shape of the lightcurve, are that it is an irregular asteroid with an axis ratio of $a/b \geq 1.27$.

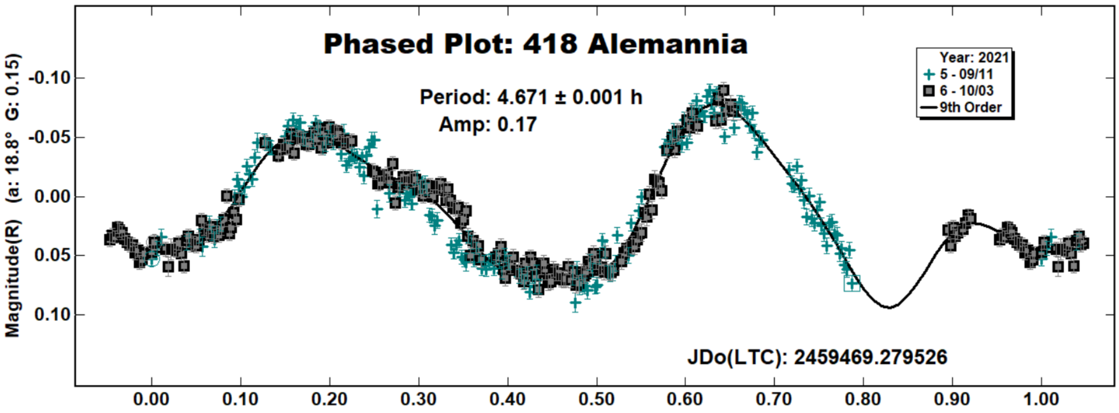

Figure 2: Composite lightcurve of 418 Alemannia, obtained from observations in September and October 2021.

The photometric observations of **901 Brunsia** were carried out for two nights, on the 11^{th} of September and the 3^{rd} of October 2021, and the phase angle during these observations decreased from 25.35° to 14.49°. This S-type asteroid is a member of the Flora family and has a publish rotational period of 3.1363 h [5]. Our constructed composite lightcurve (Fig.3), with a Fourier fit of order 6, reveals a period of 3.136 ± 0.001 h. According to the shape of the lightcurve and the calculations of the axis ratio 1.20, we can expect 901 Brunsia to have a regular triaxial ellipsoid shape, with small irregularities at the poles of the asteroid, due to the depth of the maxima in the lightcurve.

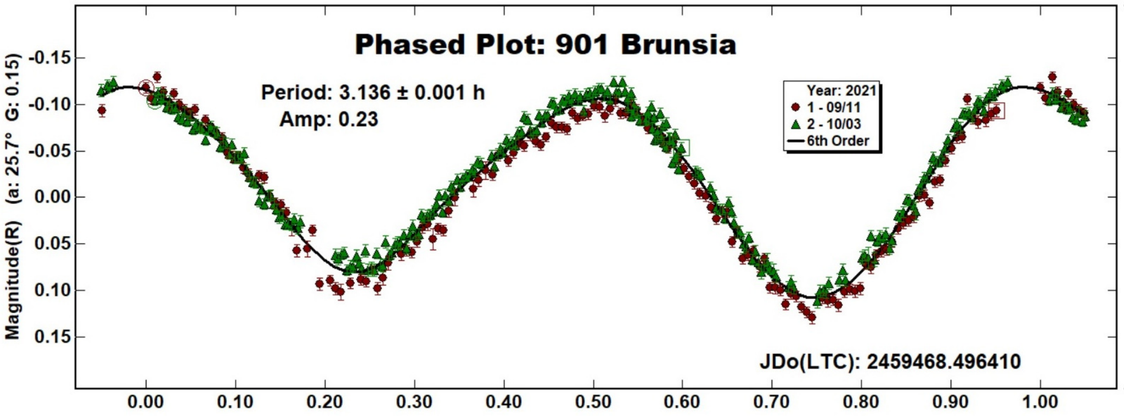

Figure 3: Composite lightcurve of 901 Brunsia, obtained from observations in September and October 2021.

2650 Elinor was observed on the 8^{th} of March 2021. During the observation, the solar phase angle was 1.7°. This main belt asteroid has a published rotational period of 2.762 h [5] and an unknown spectral type. Our constructed composite lightcurve (Fig.4), with Fourier fit of order 6, confirms the already published period of 2.762 ± 0.001 h. The shape of the lightcurve suggests the possibility of an irregular or a binary asteroid shape. The calculated ratio between the smallest and largest observed axis for this asteroid is $a/b \geq 1.15$.

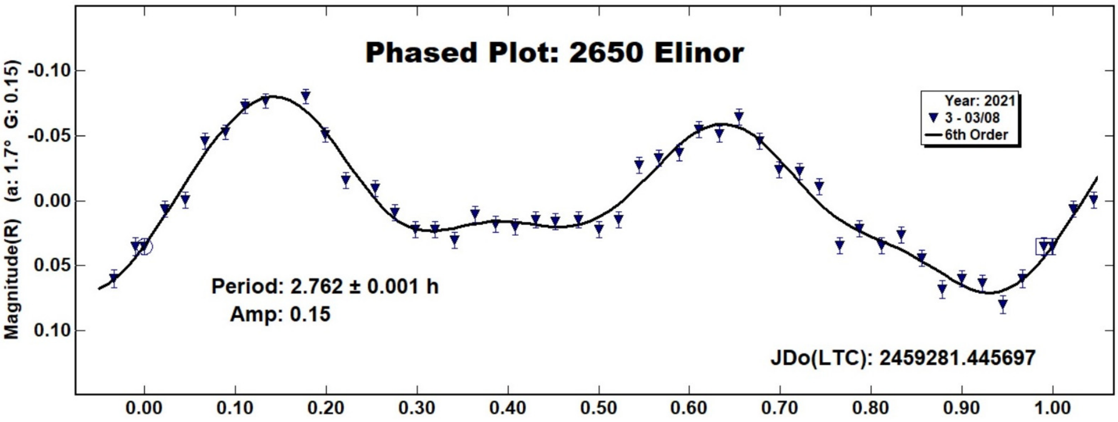

Figure 4: Lightcurve of 2650 Elinor, obtained from observations in March 2021.

4. Conclusions

Most of the asteroids observed in 2021 at NAO Rozhen are a part of our program for long-term studies of asteroids, and the results presented here will help in our future research about the asteroid models. By increasing the number of asteroids with a known model, we get a better understanding of our planetary system evolution. To determine a more precise shape of the asteroid, we need observations at several different observing geometries. Moreover, we need at least 20 lightcurves at 4 or 5 oppositions [8]. In our future work, to decrease the amount of observational time, we plan to combine our dense data from the observations with sparse data from the databases or space missions.

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