

Photometric investigation of the asteroids with the extreme rotation periods

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In 2023–2024, photometric observations of three asteroids during their close approaches to the Earth were carried out using two telescopes of the Pulkovo observatory. The aim of the investigation was to obtain the lightcurves and to determine the rotation periods of the asteroids. The rotation periods were determined based on the analysis of the lightcurves obtained: two of them turned out to be extremely short (2023 BU— 77.69 ± 1.00 s, 2023 DZ2— 376.49 ± 1.00 s), and one was confirmed to be extremely long (1998 XB— 1913040 ± 360 s).

Keywords: Asteroids, photometry, lightcurves.

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Among over 8,300 asteroids [1], whose axial rotation periods are determined at the time of this study and presented in ALCDEF database (Asteroid Lightcurve Data Exchange Format), the asteroids with periods of several minutes or several hundred hours in total are amounting less than a hundred. The study of such objects allows us to understand the nature of their origin. Determining extremely short periods requires high accuracy of observations with short exposures, and determining extremely long periods requires regular series of observations over dozens of nights. During 2023 and early 2024, observations of three asteroids belonging to both of these categories were carried out on two telescopes in Pulkovo Observatory.

This paper presents a photometric study of two asteroids with axial rotation periods of less than 400 s, as well as one asteroid with an axial rotation period of more than $1.9 \cdot 10^6$ s. Photometric processing of the observational data was performed using APEX-II [2] software package with GAIA DR2 as the reference catalog [3]. The Lomb-Scargle method [4] was used to define the periods.

Asteroid 2023 BU belonging to Apollo group was discovered on January 21, 2023 by G. Borisov (vlg. Nauchniy, Crimea) [5]. Its absolute magnitude is $H = 29.70$ [6]. On January 27, 2023 this asteroid passed near Earth at a distance of only 0.00007 AU (10^7 m) [6].

Using MTM-500M telescope, installed at the Mountain Astronomical Station of Pulkovo Observatory (MAS CAO, Kislovodsk) [7], observations of 2023 BU asteroid were carried out (in the period of January 24–27, 2023) during four nights. The obtained light curve is shown in Fig. 1.

The resulting period is 77.69 ± 1.00 s, which is consistent with the estimates of other researchers [8,9]. The light curve amplitude was about 1.40 ± 0.02 mag.

Asteroid 2023 DZ2 belonging to Apollo group was discovered on February 27, 2023 within EURONEAR project (La Palma) [10]. Its absolute magnitude is $H = 24.27$ [11].

On March 25, 2023 approached the Earth at a distance of 0.00117 AU ($1.745 \cdot 10^7$ m) [11].

Observations of 2023 DZ2 were carried out during the night of March 23–24, 2023 using ZA-230M telescope installed in Pulkovo Observatory (CAO RAS). The light curve of asteroid 2023 DZ2 is shown in Fig. 2.

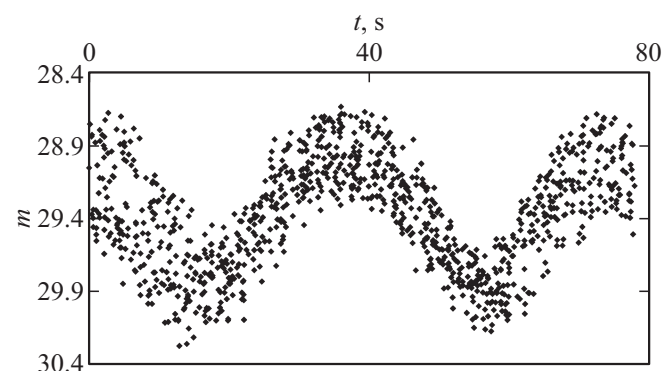


Figure 1. Light curve of asteroid 2023 BU plotted according to the observation data on January 25, 2023

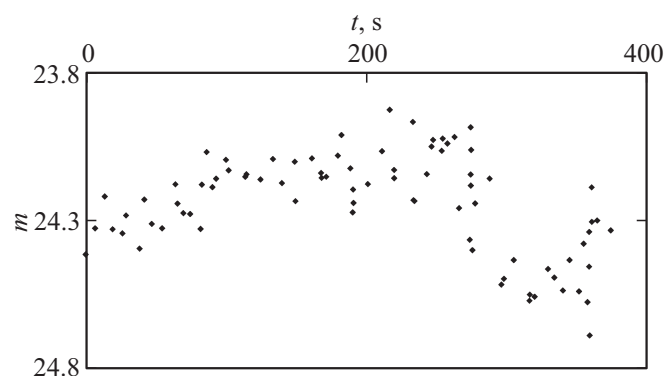


Figure 2. Light curve of asteroid 2023 DZ2.

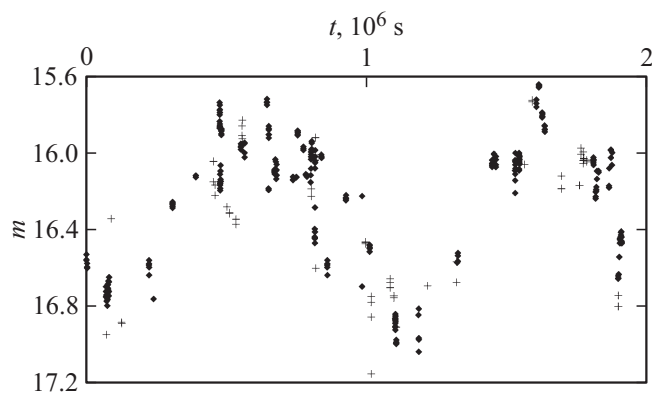


Figure 3. Light curve of asteroid 1998 XB

The resulting period is 376.49 ± 1.00 s which is consistent with the estimates of other researchers [12,13]. The light curve amplitude was about 0.64 ± 0.02 mag.

The Aten asteroid (96590) 1998 XB was discovered on December 01, 1989 within BAO Schmidt CCD Asteroid Program (Xinglong Observatory) [14]. This asteroid was observed with radar in 2012–2016–2018 [15], its absolute magnitude is $H = 16.2$ [16], and its estimated diameter is about 882 m [16]. The estimates of its axial rotation period are given on web-site Pravec 2005web [17], and make $1.8 \cdot 10^6$ s (500 h) and $1.872 \cdot 10^6$ s (520 h). However, they are made using incomplete light curve.

To plot the light curve and specify the period of axial rotation of asteroid 1998 XB, we used observational data obtained from ZA-320M and MTM-500M telescopes of Pulkovo Observatory over several years: 40 observation nights for December 2023, January and February 2024, as well as data for 4 nights 2018, 7 nights 2016, 8 nights 2011 and 5 nights 2010. These observations were performed with approximately the same configuration of the asteroid relative to the Earth and the Sun: the change in the longitude of the phase angle bisector was less than 90° . Taking into account that orientation of the asteroid's rotation axis is unknown, we neglected these changes.

The result is provided in Fig. 3, where data for 2010–2018 are designated as criss-cross. The obtained period is 1913040 ± 360 s (531.4 ± 0.1 h or 22.142 ± 0.004 d), and has the light curve amplitude of about 1.50 ± 0.05 mag.

Thus, within the framework of this study, the periods of axial rotation for the two fast rotators were confirmed, and it was possible to specify the period of axial rotation for one slow rotator.

Conflict of interest

The authors declare that they have no conflict of interest

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