

## Asteroid Lightcurves for Shape Modeling Obtained at the NAO Rozhen

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**Abstract.** The lightcurve photometric observations of two main belt asteroids and one Mars crosser asteroid obtained at the NAO Rozhen during several apparitions and various longitudes and phase angles are presented. These lightcurves with the lightcurve inversion method will be used to determine preliminary poles and triaxial ellipsoid models for the observed asteroids.

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### 1 Introduction

Photometric investigations of the small bodies of the Solar system are gradually an enlargement of the first systematic observational program established at NAO Rozhen: Astrometric observations of asteroids and comets. In the frame of this program many new minor planets were discovered and some of them were named by the discoverers.

The photometric study of asteroids and comets started with the participation of the NAO-Rozhen in the International Halley Watch. The analysis of the lightcurves of asteroids, obtained by photometric observations, is especially important for determination of their rotation and physical characteristics, which are crucial for the understanding of the conditions during the creation of our planetary system. All the four telescopes (2m RCC, 50/70 Schmidt and two 60cm Cassegrain) of the Institute of Astronomy, BAS, admittedly to a different extent, are in use for observations of asteroids, comets, and natural satellites of the planets.

## 2 Observations and Results

In the preliminary reduction, CCD images of asteroids were dark and flat field subtracted. Aperture photometry was performed using the software program *CCDPHOT* [1]. For lightcurve analysis, we used the software package *MPO Canopus* (developed by Brian Warner), that produces composite lightcurves, calculates rotational periods, and provides the Fourier analysis fitting procedure. Differential photometry was used in all cases, and all measurements were light time corrected.

The brightness variations exhibited by a nonspheroidal asteroid mostly are caused by the changes in the illuminated cross-sectional area presented to the observer as the object rotates. The shape of the asteroid, as a dominant factor in the shape and amplitude of a lightcurve, made the lightcurve inversion method [2] a standard tool for asteroid modeling and spin state determination.

The determination of an asteroid's global shape and its rotational state requires a set of lightcurves measured at various observing geometries. For the main belt asteroid, if few lightcurves are observed at different ecliptic latitudes and longitudes, three or four apparitions are usually sufficient. Frequently weather conditions and observing telescope schedule limit the possibility of the observing the asteroid. Sometimes after missing the chance we have to wait one or two more years to "catch" the asteroid in the sky.

Table 1. Asteroid parameters

Asteroid	D (km)	Albedo	Type	Family
698 Ernestina	27.03	0.1269	S	MB-O
1011 Laodamia	7.39	0.259	S	Mars-crosser
1019 Strackea	8.37	0.2236	S2	Hungary

The basic parameters of the asteroids are summarized in Table 1. Their *IRAS* diameters (D), albedos, and taxonomic types are taken from *The Small Bodies Node of the NASA Planetary Data System* (<http://pdssbn.astro.umd.edu/>).

**698 Ernestina** orbits the Sun at the inner edge of the main outer belt.

The synodic period determined from observations in 2001 at the NAO Rozhen was for the first time reported for this asteroid [3].

**1011 Laodamia** is a Mars crosser asteroid. Using observations from its last apparition in 2008 and Fourier analysis we constructed a composite lightcurve with a non-symmetric form of the height and the humps of the maxima, which indicates an irregular shape of the asteroid (Figure 3).

**1019 Strackea** is an inner main belt asteroid and a member of the Hungaria family. The synodic period determined from observations in 2001 at the NAO Rozhen was for the first time reported for this asteroid [3]. During next ap-

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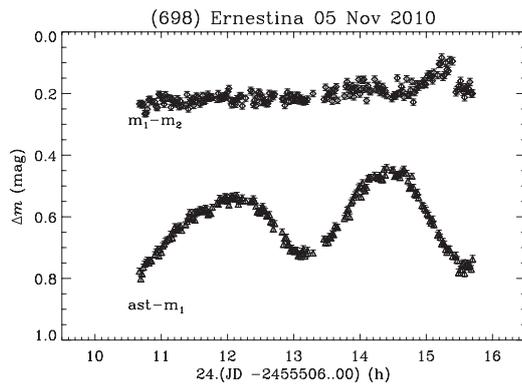


Figure 1. One night observation was enough to cover the whole lightcurve which indicates an asymmetric shape of the asteroid.

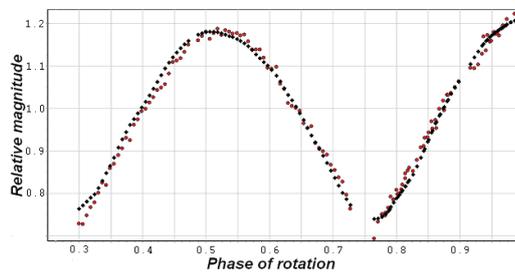


Figure 2. During the modeling of asteroid 698 Ernestina we compared original lightcurve data (represented by red circles) and model lightcurve data (represented by darker black diamonds) and we found out their matching.

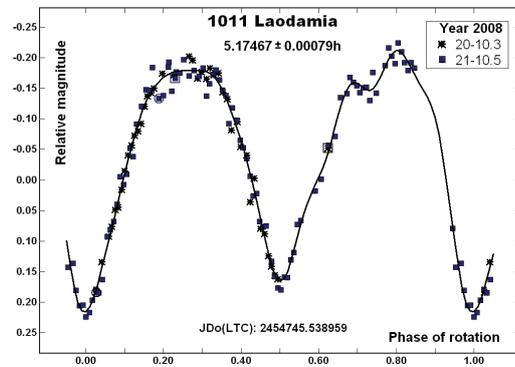


Figure 3. The composite lightcurve of 1011 Laodamia from two night's observations on 3rd and 5th October, 2008.

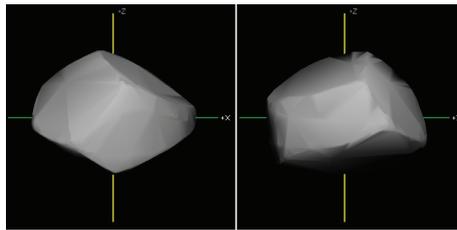


Figure 4. Preliminary shape model of 1019 Strackea, viewed from equatorial level at two longitudes  $90^\circ$  apart.

partitions it was observed at large phase angles which are in favor of the used method for shape modeling. Using lightcurves from 5 apparitions we obtained retrograde sense of rotation and a rough estimate of the shape (Figure 4).

### 3 Conclusion

We think about enlarging and continuing our work connected with shape modeling of already observed asteroids as well as with one special class known as Near Earth Asteroids (NEAs). Increasing the number of asteroids, especially of NEAs with known physical and dynamical properties, will help to choose the most appropriate candidates for a crewed asteroid mission planned by 2025. The lightcurves for few more asteroids observed at NAO Rozhen during only one or two apparitions could be used for shape modeling in combination with lightcurves in long-term observations or in combination with data from photometric asteroid surveys (example Pan STARRS). The obtained spin and shape models will be included into the existing database of spin parameters and used for investigation of the collision processes in the Solar system.

### Acknowledgment

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