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CCD Observations of the Minor Planet (73) Klytia

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Abstract

We present unfiltered CCD observations of the minor planet (73) Klytia carried out between 20th February and 2nd March 1997. These measurements allowed us to perform a detailed study regarding the asteroid's light variation. The period of the light curve, found in the 21 hours long data series obtained on 4 nights is 8.275 hours (0.3448 ± 0.0003 day). The amplitude of the light variation is 0.28 mag. Assuming that the light variation is due to the rotation of the non-spherical minor planets, we have fitted a rotating ellipsoid to the observed light curve and derived its minimal a/b axis ratio equal to 1.28. The fitting method was quite approximate, therefore its results should be considered as rough estimates of the real shape.

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1. Introduction

Minor planets play an important role in the deeper understanding of the solar system. Their parameters tell us about the creation of the whole solar system, about different kind of physical processes which happened in the last few billions of years. Various statistical methods need a large number of observations, photometric and astrometric ones as well. Although there are more than 35000 asteroids with at least preliminary orbital elements known [1], they are rarely observed photometrically. Although light variations are well determined for some minor planets, this field of observations is an unexploited one.

Many important parameters describing the minor planet are hidden in the observed light curves. The synodical rotational period can be determined with high accuracy. Long-term observations may reveal different processes resulting in intrinsic light curve variations, i.e. changes of the aspect or (without any approved example) asteroid collision.

Another aspect of the continuous photometry is the shape modelling. With help of sophisticated mathematical methods and high precision light curves, it is possible to derive a theoretical shape for the minor planet which fits the light curve well.

The main aim of this paper is to present our CCD observations of the minor planet (73) Klytia. The next section contains basic data about (73) Klytia, while in Sec. 3 the observations are discussed. Data reduction and analysis are presented in Sec. 4.

2. The target: (73) Klytia

The asteroid (73) Klytia was chosen as the target object because of its moderately high brightness (about 13.5 mag). Klytia was near to the opposition point during our observing run therefore it could be observed high above the horizon.

(73) Klytia was discovered in 1862 and its IRAS diameter is 44.4 ± 3.4 km. The average albedo is estimated to be around 0.22 ± 0.04 [2]. Its distance from the Earth was 1.96 A.U. (2.94×10^8 km) on 22th February and 1.88 A.U. (2.82×10^8 km) on 2nd March [3].

Previous observations were made by Weidenschilling et al. (observations 1984, determined amplitude 0.8, period approximately 13 hours) [4] and Hainaut-Rouelle et al. (observations 1995, determined amplitude 0.28, period 8.29 hours) [5]. While these observations are quite different, we should accept Hainaut-Rouelle et al.'s results as they observed during 3 nights and made 137 measurements while in 1984 only 11 measurements were made.

3. Observations

Observations were carried out using a Celestron-11 Schmidt-Cassegrain type telescope and an SBIG ST-6 CCD camera belonging to JATE University, Szeged, Hungary. Observing log is summarized in Table.

Table Observing log.

Date	Between (UT)	Number of points	Remarks
20/21.02.1997	23:02–02:45	60	wind, clouds
22/23.02.1997	22:30–03:29	44	wind
23/24.02.1997	00:16–04:39	55	bright Moon, wind
02/03.03.1997	21:26–04:12	58	good conditions

The measurements were made from one of the main buildings of the University where the telescope is mounted. Finder charts were made using *Hubble Guide Star Catalogue* and *Uranometria 2000* [6].

During the first 3 nights the maximum exposure time could not be more than 40 seconds because of the strong wind. On 23rd February the nearly full Moon was only 10 degrees far, therefore it was very difficult even to find Klytia. The fourth observing run was conducted under a relatively dark sky without any wind so 80 seconds exposure times were available. The shorter exposures on the first 3 nights have lower signal-to-noise ratio and the spread in the light curves is above 0.1 magnitude (see below). Light curve obtained on the last night (2nd March) has the smallest noise because of the higher exposure time and the darker sky.

In Fig. 1 we show the motion of Klytia during a 5 hour-long observing session to illustrate the quality of our images.

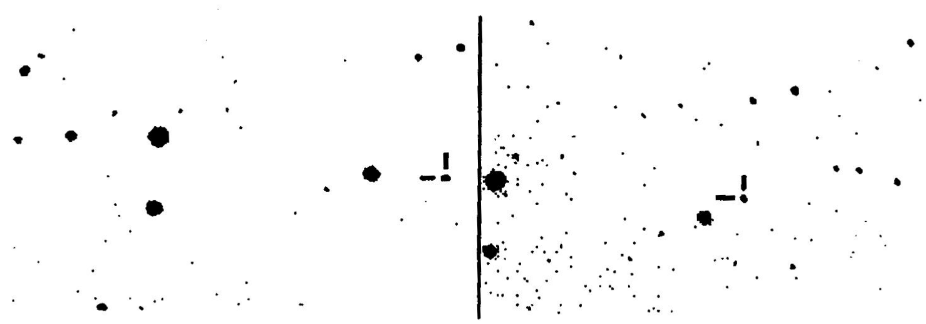

Fig. 1. Klytia's motion during a 5 hour-long observing session (it is marked by the vertical and horizontal dashes).

4. Data reduction and analysis

The CCD pictures were corrected by the standard dark and flat field frames. After the necessary processing aperture photometry was carried out by the handling software of the CCD camera provided by the manufacturer (Santa Barbara Instruments Group). It is a very simple implementation of aperture photometry since rectangular areas (generally 5×5 pixels wide)

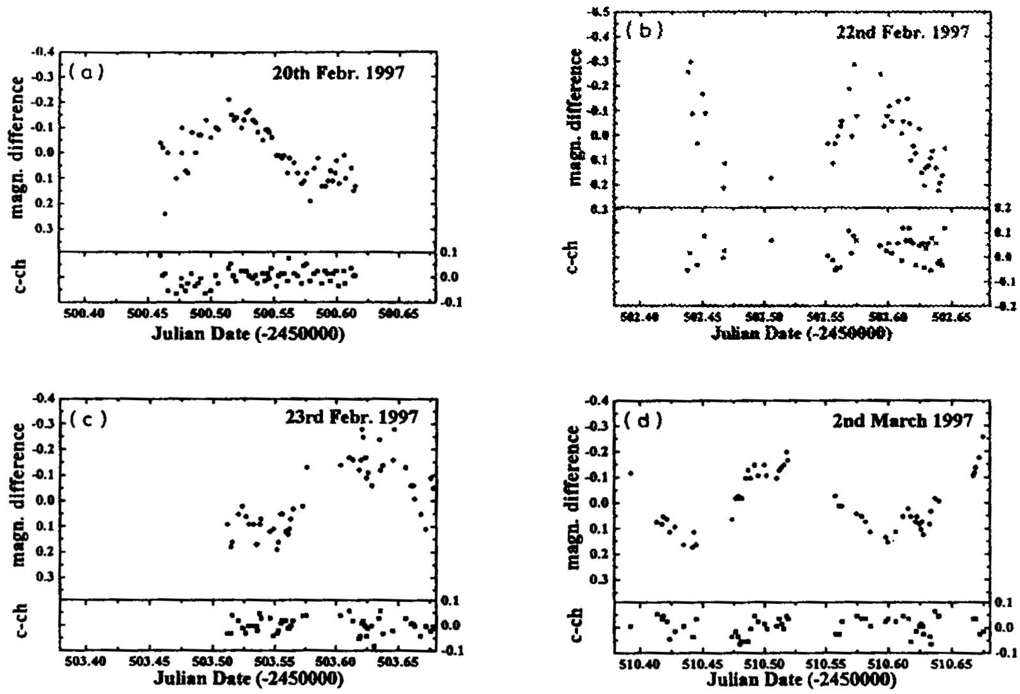

Fig. 2. Differential light curve for: (a) 20th February 1997, (b) 22nd February 1997, (c) 23rd February 1997, (d) 2nd March 1997.

are integrated to get stellar intensities. The sky value was computed with the same method choosing a starless small field on the CCD frame.

Individual light curves are presented in Figs. 2a–d. The magnitude and time scales are the same in the case of all diagrams. The horizontal axes show the time between 21:20 and 4:40 in Universal Time, while the vertical axes show magnitude differences ($m_{\rm asteroid} - m_{\rm comp.}$ above and $m_{\rm comp.} - m_{\rm check}$ below). The average values were subtracted since different comparison stars were used.

After having the photometric reduction finished, two period searching methods (standard Fourier-analysis by Dr. M. Breger's *PERIOD* programme (free distributed) and phase dispersion minimization by a self-developed code) were applied to the observed light curves.

Two probable rotational periods were found: 0.2940 ± 0.0002 days and 0.3448 ± 0.0003 days. Expressing them in frequency, the difference is exactly 0.5 cycle/day, which means that one of them is the 1-day alias of the other one. Examining the individual light curves 0.2940 days was found to be more acceptable. This was justified by comparing composite light curves constructed from the two lowest noise light curves using these periods. But while the period of 0.2940 is not consistent with observations by Hainaut-Roulle et al. who determined a period of 0.3454 day [5], we have to accept 0.3448 day synodical rotational period for our observations as well. The composite light curve computed with the finally adopted period is shown in Fig. 3.

The amplitude of the light variation is about 0.28 mag, which means 30 percent in intensity. This quite large value can hardly be explained by albedo variations (according to the recent direct images of Gaspra and Ida taken by Galileo, there are no larger albedo differences on minor planet surfaces). The most probable reason is simply the rotation of a non-spherical body.

Modelling Klytia as a rotating ellipsoid, we could derive its minimal a/b axis ratio. We had to assume that the axis of rotation coincides with the shorter axis of the ellipsoid which is perpendicular to the observer's direction.

The ratio of the axes of the ellipsoid was preliminary estimated basing on the light curve's amplitude. As was mentioned above, the amplitude of the light variation is about 30% in intensity which is approximately the ratio of the minimal and the maximal cross-sections of the

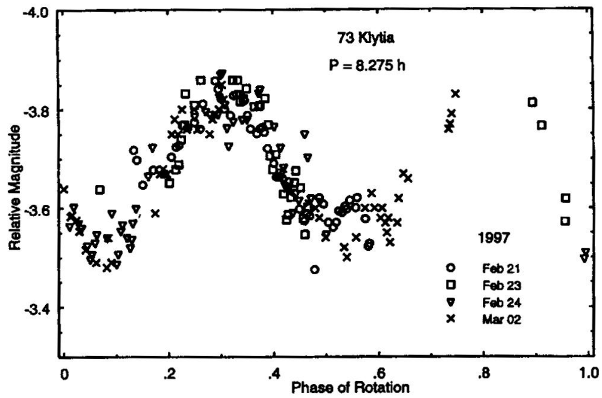

Fig. 3. Composite light curve of (73) Klytia (zero time at 2 March 1997 21.70 UT, corrected for light–time).

ellipsoid. Consequently the ratio of its a/b axes is about 1.30.

The second step was to improve the fit. We modelled the light curve of a rotating ellipsoid by a self-developed computer code which derived the time dependent variations of the ellipsoid's observable cross-section. Adjusting the axis ratio with small amounts we could reach a better fit to the observed light curve. We neglected points in the maxima and minima (as the extrema had higher scatter) and tried to reach the best "general" fit. The final a/b axis ratio turned out to be 1.28.

This theoretical value minimizes the real ratio. If the c axis was not perpendicular to the observer's direction during the measurements, the real a/b ratio may be higher than 1.28. In order to derive the a/b ratio more precisely and to derive the ratio of a/c axes, more observations are required.

5. Summary

Based on the observations discussed in the previous sections we summarize our results:

1. We observed the asteroid (73) Klytia on 4 nights in order to detect its light variation caused by the rotation. The observations show 0.28 mag variations with a period of 0.3448 ± 0.0003 day.

2. Assuming a simple ellipsoidal model for (73) Klytia, we showed that its a/b ratio is to be 1.28 or higher.

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