Rotation periods of the asteroids 55 Pandora, 78 Diana and 815 Coppelia

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Abstract. This paper presents new photometric CCD observations of the asteroids 55 Pandora, 78 Diana and 815 Coppelia with the 50/70 cm Schmidt telescope at Rozhen National Astronomical Observatory during October-November 2010. The rotation periods and amplitudes of light variations of the observed asteroids were determined from the light curves.
Key words: asteroid, light curve, rotation period

Ротационни периоди на астероидите 55 Pandora, 78 Diana и 815 Coppelia

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Статията представя нови фотометрични наблюдения на астероидите 55 Pandora, 78 Diana и 815 Coppelia, получени с 50/70 cm Schmidt телескоп на НАО-Рожен през октомври-ноември 2010 г. От получените криви на блясъка определихме ротационните периоди и амплитудите на изменения на блясъка на наблюдаваните астероиди.

Introduction

The light curves of the asteroids allow to determine their rotation periods and amplitudes of light variations. By modeling of these light curves one can obtain the global parameters of the asteroids (inclination of the rotation axis, absolute magnitude, shape, size, reflection, etc.). These parameters are the basis to create models for the internal structure and composition of the asteroids.

The long-term photometric observations allow to search for the relations "rotation velocity - size", "rotation velocity - shape", "rotation velocity - composition", which are important to study the origin and evolution of the asteroids and thus, the origin, dynamics and evolution of the Solar System.

In this paper we present the results of the photometric observations of 3 asteroids. They were chosen by the following criteria: a) to be brighter than 15^m in order to get qualitative observations with the Schmidt telescope at the Rozhen National Astronomical Observatory ; b) to be close to oppositions in the range November-December 2010; c) to have a rotation periods below 8 hours. As a result, we chose the targets: 55 Pandora, 78 Diana and 815 Coppelia.

1 Observations and data reduction

The photometric observations of the asteroids were made with the 50/70 cm Schmidt telescope and CCD camera FLI PL 16803 during October-November 2010. The frames were taken in R filter with exposure times of 180 sec.

Table 1 presents information about the locations of the asteroids during the observational runs: ecliptic longitude λ; ecliptic latitude β; distance Δ from the Earth in AU; distance r from the Sun in AU; phase angle α (the angle between the Sun, asteroid, and Earth).

Table 1. Positions of the observed asteroids

Object	Date	λ	β	Δ	r	α
55 Pandora	22.10.2010	106.2038739	8.2138136	2.161	2.574	22.1353
	23.10.2010	106.2398052	8.2287793	2.158	2.575	22.1107
78 Diana	20.11.2010	80.4892287	14.8270177	1.597	2.307	11.2978
815 Coppelia	16.11.2010	84.4281052	5.5318156	1.596	2.509	10.8829
	18.11.2010	82.0799553	5.5760081	1.584	2.508	10.0771

The reduction of the images as well as differential photometry were made by the software *MaxImDL*. For transition from instrumental system to standard photometric system we used standard stars from the GSC catalogue (Fig. 1-3). They were chosen by the criterion to be constant within 0.01 mag during the all observations and in all filters. The coordinates and magnitudes of the standard stars are given in Tables 2-4.

Table 2. Standards for 55 Pandora

Standard	GSC ID	RA (2000)	DEC (2000)	R
C1	2451-1965	07 14 26.90	+30 38 40.05	11.34
C2	2451-2227	07 14 07.33	+30 41 26.95	11.36
C3	2451-1871	07 14 33.33	+30 33 30.20	11.50
C4	2451-2115	07 14 46.13	+30 28 47.38	11.80
C5	2451-1837	07 14 21.50	+30 29 52.18	12.13
C6	2451-1801	07 14 23.39	+30 29 29.54	11.71
C7	2451-1845	07 13 58.38	+30 25 25.10	12.24
C8	2451-1839	07 13 40.59	+30 27 08.31	12.42
C9	2451-2037	07 13 41.16	+30 28 46.30	12.20

The periodogram analysis of our photometric data was made by the software *PerSea* Version 2.6 (written by Maciejewski on the *ANOVA* technique, Schwaezenberg−Czerny 1996).

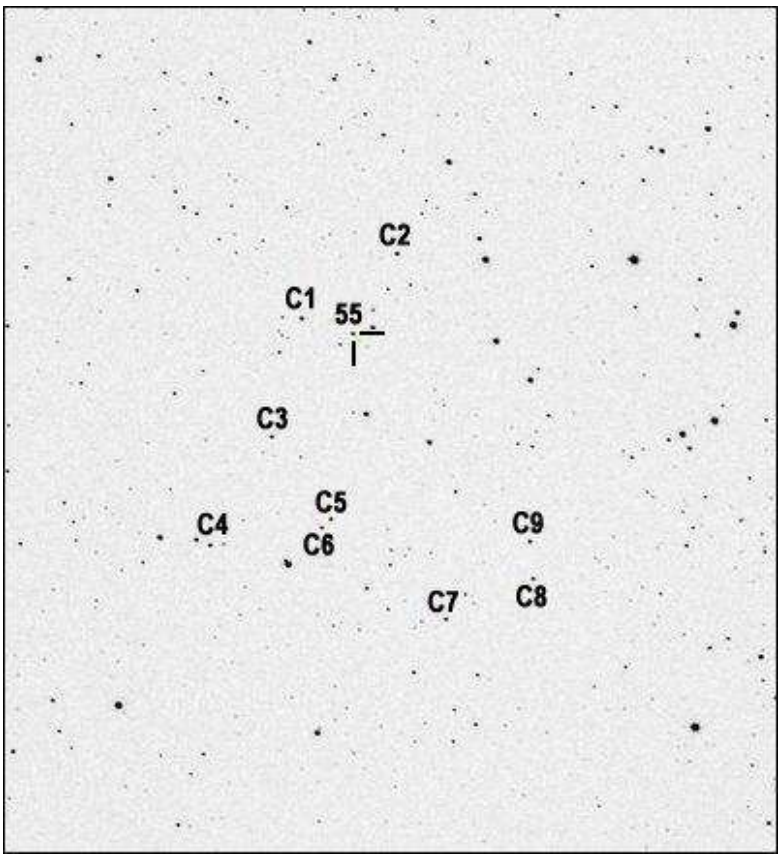

Fig. 1. The field of 55 Pandora

2 Results

2.1 The Asteroid 55 Pandora

Firstly Shober (1977) determined the rotation period of 55 Pandora as P=4.804 hours and the amplitude of light variability 0.24^m. Further the global parameters of the target have been determined by ground-based observations and observations with the IRAS satellite (http://ssd.jpl.nasa.gov/sbdb.cgi): diameter 66.7 km and absolute magnitude 7.8^m. 55 Pandora was classified as E-type asteroid (metallic with a big albedo) according to the spectral classification of Tholen (1984).

Our photometric data covering 2 consecutive nights (Fig. 4) show cyclic light variability with repeating unequal maxima and minima. There is a weak tendency of an increase of the brightness and the light amplitude during the second night.

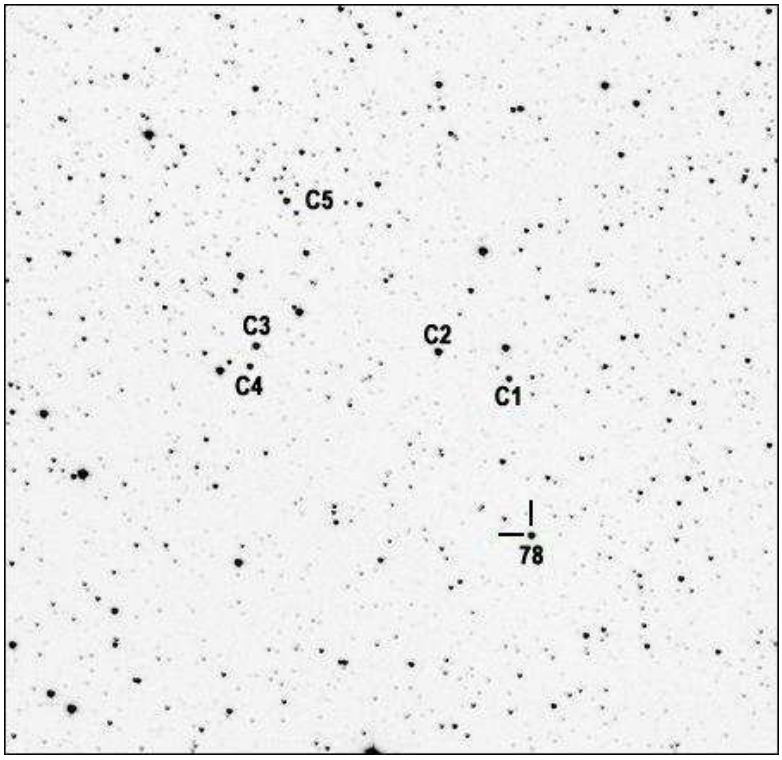

Fig. 2. The field of 78 Diana

By periodogram analysis of our data we determined a rotation period of P=4.7992 hours and light amplitude of 0.22^m. These values are close to those obtained by Shober (1977). Hence, the rotation period and the light amplitude of 55 Pandora are stable.

We phased the photometric data with the new period and obtained the folded light curve (Fig. 5) consisting of two similar, but not identical, waves with almost equal duration. The second (higher) maximum is symmetric while the first maximum is asymmetric with steeper increasing branch.

2.2 The asteroid 78 Diana

The first value of the period of 78 Diana was 8 hours (Taylor et al. 1976), but it was corrected to 7.2991 hours on the basis of observations in 1989, 2006, 2007 and 2008. The amplitude of the light variability changes in the range 0.02-0.104^m.

The global parameters of 78 Diana are estimated as: diameter 120.6 km; absolute magnitude 8.09^m (*http* : *//ssd.jpl.nasa.gov/sbdb.cgi*). Tholen &

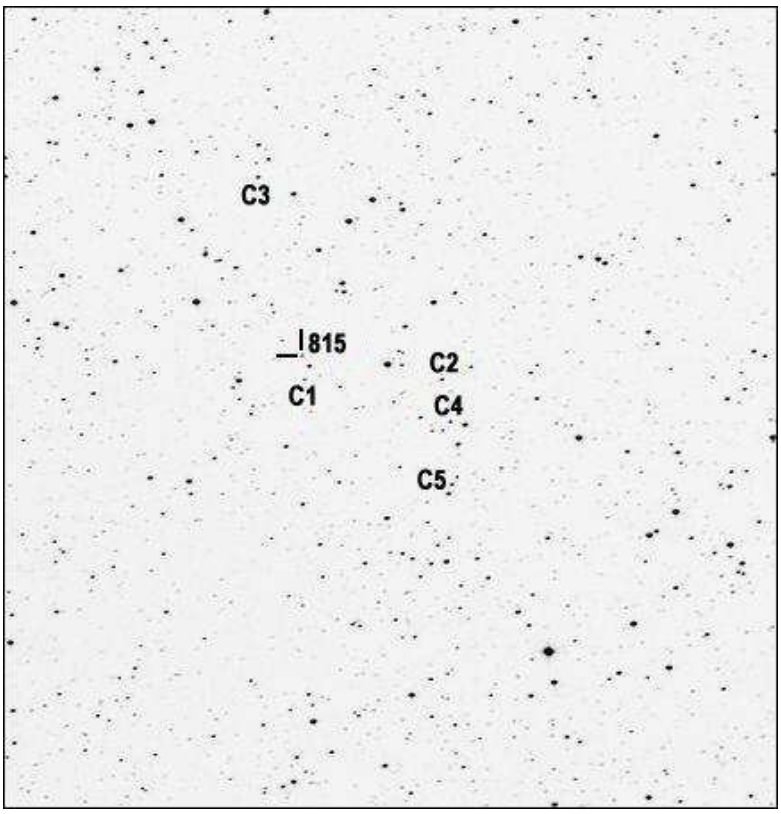

Fig. 3. The field of 815 Coppelia

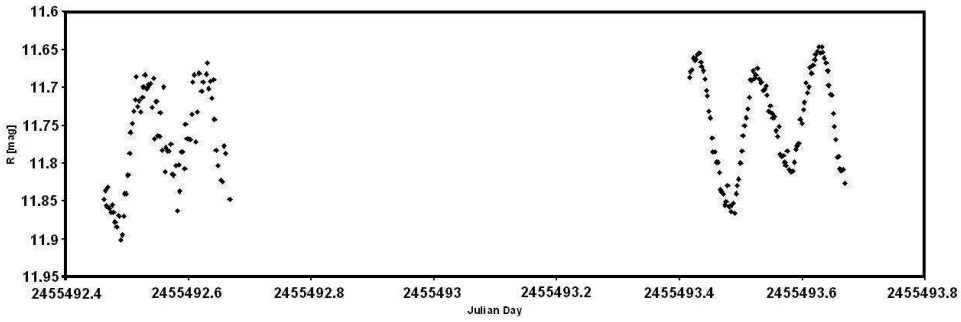

Fig. 4. The light variability of the asteroid 55 Pandora on Oct 22-23 2010

Barucci (1988) classified 78 Diana as a T-type (metallic asteroid with low albedo).

Table 3. Standards for 78 Diana

Standard	GSC ID	RA (2000)	DEC (2000)	R
C1	2896-1206	05 12 28.19	+37 57 49.21	11.120
C2	2896-2089	05 12 40.76	+37 58 48.46	10.420
C3	2896-2076	05 13 13.38	+37 59 05.74	10.560
C4	2896-2099	05 13 14.57	+37 58 22.00	11.270
C5	2896-1873	05 13 07.66	+38 04 11.42	10.960

Table 4. Standards for 815 Coppelia

Standard	GSC ID	RA (2000)	DEC (2000)	R
C1	1859-1029	05 24 52.77	+28 42 57.99	14.520
C2	1859-1233	05 24 30.14	+28 42 53.46	13.450
C3	1859-767	05 24 59.86	+28 50 18.45	13.380
C4	1859-889	05 24 28.90	+28 41 21.98	13.390
C5	1859-1337	05 42 28.81	+28 39 05.65	13.463

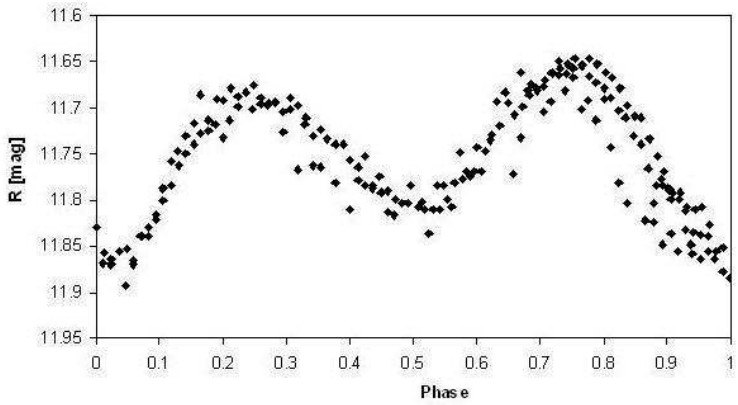

Fig. 5. The folded light curve of the asteroid 55 Pandora

Our photometric data (Fig. 6) show light variations of 78 Diana consisting of two different waves. By periodogram analysis of the data we determined a period P=6.857 hours and light amplitude of 0.10^m. These values are close to those determined by Harris & Young (1989), Licchelli (2006), Fleenor (2007), Fauerbach et al. (2008) and Benishek & Protitch-Benishek (2008). Hence, the rotation period and the light amplitude of the asteroid 78 Diana are stable.

We phased the new data with the derived period and the folded light curve is shown in Fig. 7. It consists of two waves with quite different durations. The shape of the wider wave is more complex with standstills before and after the maximum.

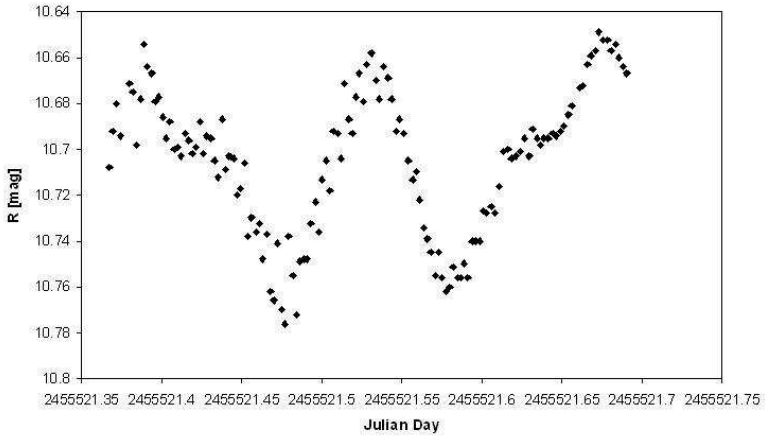

Fig. 6. The light variability of the asteroid 78 Diana on Nov 20 2010

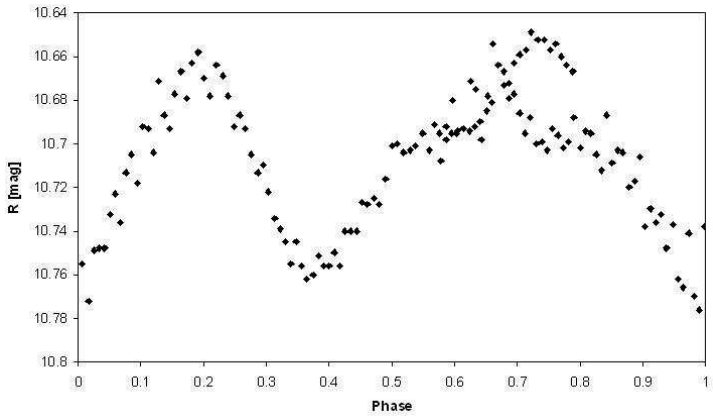

Fig. 7. The folded light curve of the asteroid 78 Diana

2.3 The asteroid 815 Coppelia

Stephens & Robert (2003) and Behrend (2006) determined for the asteroid 815 Coppelia a rotation period of P=4.421 hours and amplitude of light variability of 0.27^m. Its global parameters are: diameter 21.1 km and absolute magnitude 10.7^m (Stephens 2003, Behrend 2010).

Our photometric observations from two nights show light variability consisting of almost sinusoidal waves (Fig. 8). There is a weak tendency for light decrease during the second night.

The periodogam analysis of our data led to a period of P=4.4565 hours and amplitude of 0.27^m. These values are quite near to the previous ones, which means that the rotation period and the light amplitude of the asteroid 815 Coppelia are stable.

We phased the new data with the derived period and the folded light curve is shown in Fig. 9. It consists of two waves with different amplitudes and durations.

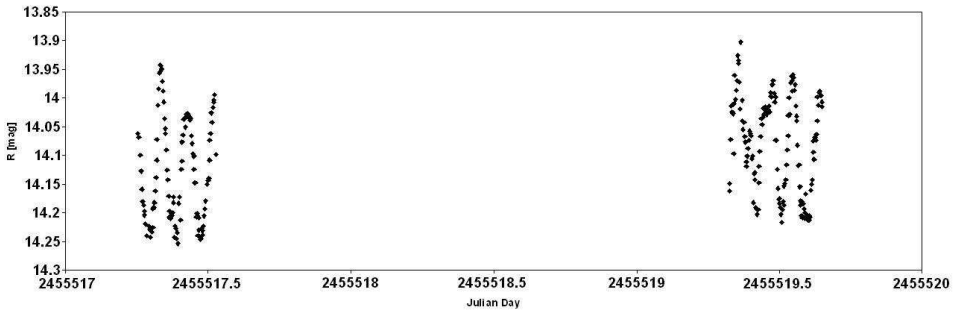

Fig. 8. The light variability of the asteroid 815 Coppelia on Nov 16 and 18 2010

3 Conclusion

The comparison of our values for the periods and light amplitudes of the observed asteroids 55 Pandora, 78 Diana and 815 Coppelia with the values of previous authors revealed that they are close but not equal.

On principle, due to gravitational perturbations and collisions, the rotation axes and rotation periods of the asteroids may change. Light curves from different seasons and years are necessary to determine these changes and to study the dynamic of the interactions and physical consequences of these interactions.

We plan to obtain light curves of 55 Pandora, 78 Diana and 815 Coppelia during the next several seasons in order to build their 3D models.

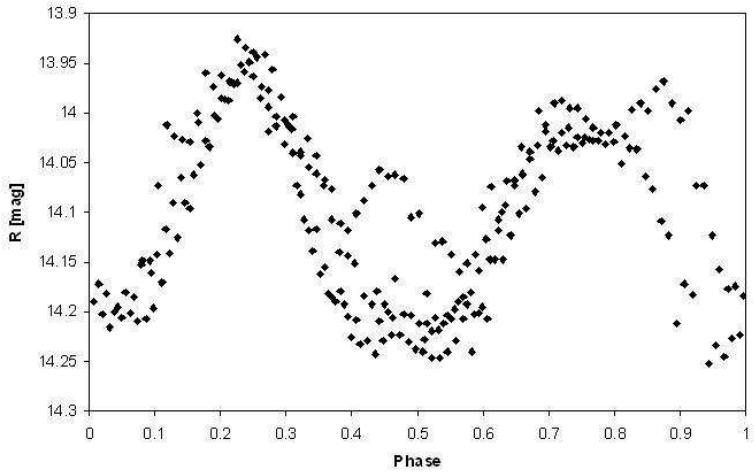

Fig. 9. The folded light curve of the asteroid 815 Coppelia

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