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# Spectral observations and photometry of the near-Earth object (25916) 2001 CP44

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**Abstract.** During the demonstrational experiment on quasi-simultaneous observation of asteroid 2001 CP44 with meter-class telescopes the variations of the colour indices of the object with the period $P{=}0^d.19165(9)$ were discovered. This value is close to the previously defined rotation period of the asteroid. We elaborated methods for the rapid measurement of a large number of physical and mineralogical characteristics.

**Key words:** Minor planets, asteroids: individual:2001 CP44 – techniques: photometric – techniques: spectroscopic

## 1. Introduction

We present the spectral and photometrical quasi-simultaneous observations of 2001 CP44 = 25916 NEO asteroid which were conducted with the help of the 2-m Zeiss telescope situated on the peak Terskol (Caucasus, Mt. Elbrus) and the 1-m Zeiss Mt. Koshka (Crimea) Cassegrain. We obtained a new value of the period of the optical variations, colour indices, the taxonomic class and some other characteristics of the object. We present the methods and the results of data processing, the comparison analysis of light curves in different pass-bands. The taxonomic class is obtained from the spectral observations and mean colour indices analysis. Some recommendations on the methods of simultaneous spectral and photometric observations are given. The first demonstrational experiment using several telescopes, the so-called observation network of INASAN, was first conducted by us in Ibragimov et al. (2013).

## 2. Observations and data reduction

The continuous photometric runs were obtained in June 11-13, 2018 in the $BV(RI)c$ - system with the 1-m reflector and FLI PL0900 CCD at Mt. Koshka

(Crimea). The magnitudes of comparison stars were obtained by special observations of the 1081491 standard star from Landolt (2009) with the Zeiss-600 telescope and the VersArray 512UV CCD at Mt. Koshka on August 23, 2018. The details of our photometric system and instrumentation one can find in Volkov et al. (2011).

Spectroscopic observations were fulfilled on June 12, 13 and 15, 2018 on the peak Terskol with the 2-m reflector and a Multi Mode Cassegrain Spectrometer (MMCS). MMCS was designed for spectroscopic observations of faint objects at the
Cassegrain focus ($f/8$) of the telescope Zeiss-2000. It has a modular design which allows quick transformation from its echelle to prism mode. The collimator is a parabolic mirror with a diameter of 75 mm and a focal length of $f = 600$ mm. The spectrometer has a wide range of resolutions from $R = 100$ to $R = 15000$ and the spectral range 3700 - 8000Å. We used a 45° crown glass prism in combination with a $f = 150$ mm Schmidt-Cassegrain camera, which provided $R = 100$ at the hydrogen line $H\gamma$. The limiting magnitude of our spectroscopy and photometry comes up to 17 mag in $V$.

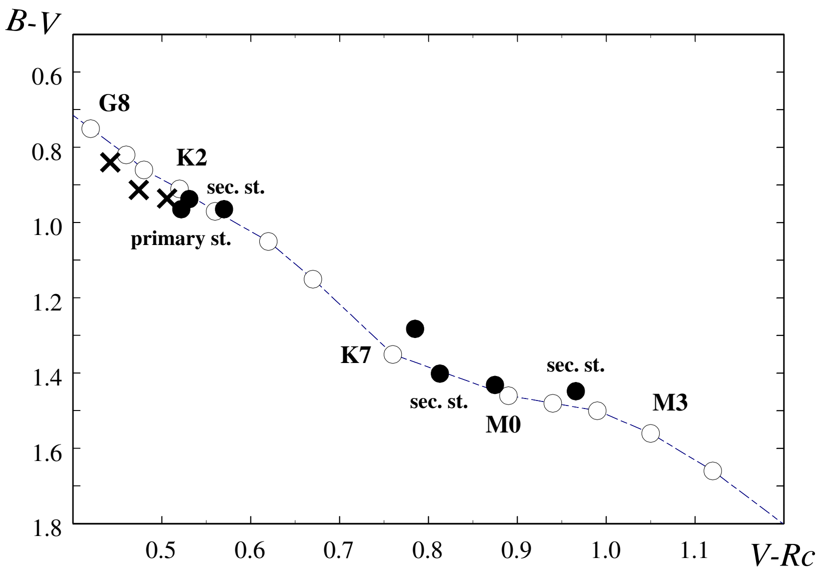


**Figure 1.** The $B-V, V-Rc$ diagram for the asteroid and the stars in the field. Crosses - mean colour indices of the asteroid for three consecutive nights. Black circles point stars position. Unsigned black circles - the position of check stars. The dashed line connecting empty circles - normal colour indices sequence for fifth-luminosity class stars.

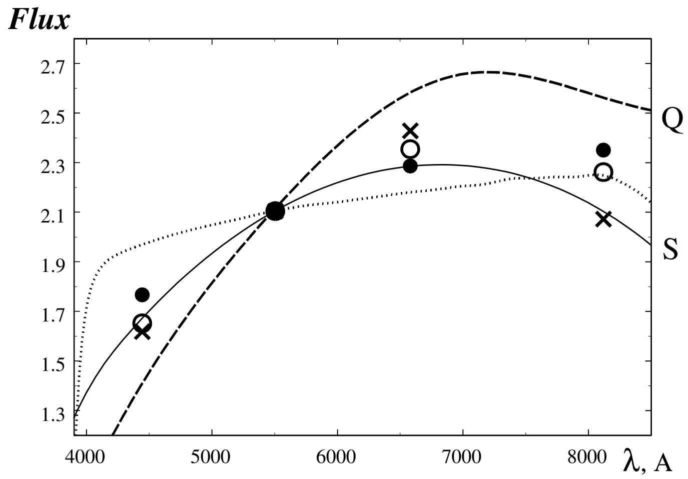


**Figure 2.** Frequent points - smoothed spectrum of the asteroid in relative units normalized on Sun's spectrum. Empty, full circles and crosses - photometrical measurements in $BVRcIc$ in three consecutive nights. The reasons for the discrepancy between spectroscopy and photometry are not fully understood. The taxonomic S-class presents photometric measurements by the best way.

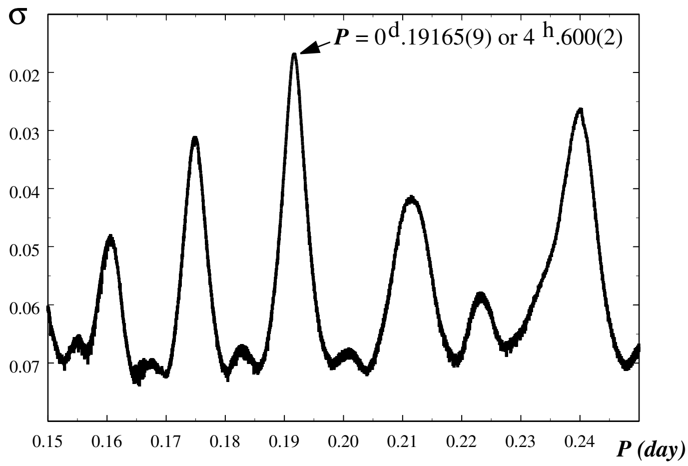


**Figure 3.** A periodogram for all of asteroid observations constructed by a moving average method. The ordinate $\sigma$ characterizes the mean deviation of the observation points relative to the center of mass of the phase curve. The curves were constructed for all period values from the interval indicated on the abscissa axis with a step of 0.00001 day. Aliases are smaller in amplitude than the true period. The value of $\sigma$ in the maximum characterizes the scatter of the mean curve in Fig. 4.

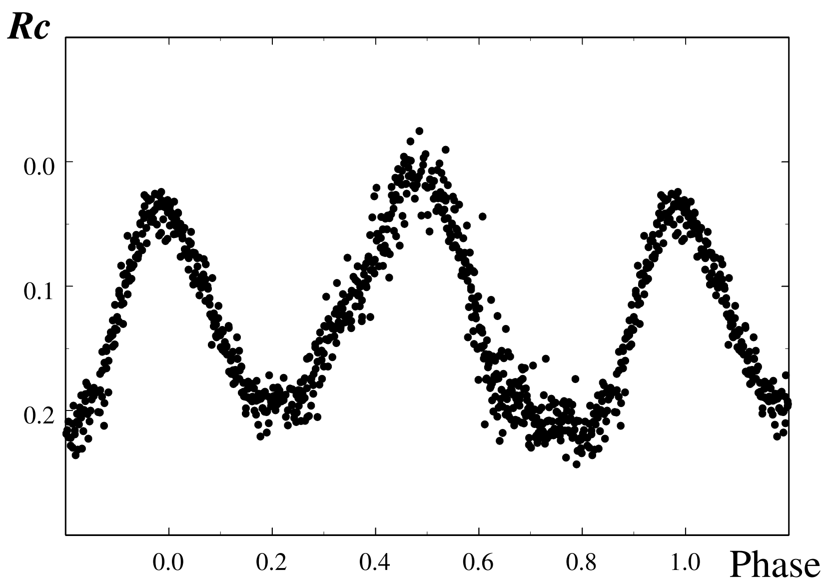


**Figure 4.** All our *Rc* observations phased with a 4.6 hour period.

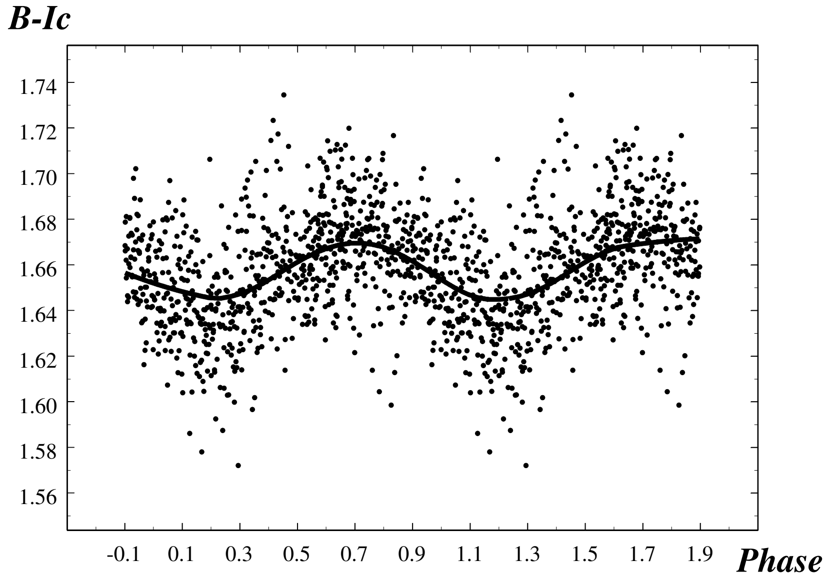


**Figure 5.** Phased with 4.6 hour period $B - Ic$ observations.

## 3. Comparison of photometry and spectrometry

We present the results of our multicolour photometry in Fig. 1. It seems that the colour indices change a little from night to night. Fig. 2 demonstrates the comparison of our photometric and spectral observations with each other and with two taxonomic classes - S and Q, Tholen (1989). All data are normalized on the Sun spectrum. The magnitudes in different pass-bands were normalized on Sun's magnitudes and on the $V$ magnitudes of the asteroid. The scatter of measurements at different nights reflects both the errors of the observations of standard stars and the real changes in the colour indices. Our photometry shows that 2001 CP44 belongs to the S taxonomic class. This result coincides well with Ieva et al. (2014).

Measurable changes in the colour indices were revealed, which correlate well with the period of the rotation of the asteroid found in present investigation, $P{=}0^d.19165(9)$, see Fig. 4 and Fig. 5. Note that the light curve of the asteroid is characterized by two humps in a period and the colour index wave has only one hump in a period. The $B-Ic$ index was chosen for demonstration as it changes much more than other colour indices. A full amplitude of the variations is $0.^m02$. In our opinion, the explanation of this phenomenon lies in the heterogeneity of the substance of the reflectivity of the surface of the asteroid associated with the collision history of this small body. Perhaps there was a collision with another asteroid, part of the substance of which initially formed a cloud of dust and then settled on the surface of the asteroid. So in the place of impact the concentration of the substance of the impactor is maximal and it gradually decreases outwards. However, it is likely that there may be other explanations that will be considered by us in a more detailed study of this unusual phenomenon in the future.

The albedo of 2001 CP44 was determined earlier and has a value of 0.177 (ssd.jpl.nasa.gov). This value corresponds well to the S class derived from our photometry, which means it consists of ordinary chondrites. In the case of an unknown albedo, it can be estimated using, for example, a polarimeter. Now we are preparing one in order to start such observations with the 1-m telescope on Mt. Koshka. It is important to note that iron-nickel asteroids can be used in the future as a source of minerals.

## 4. Conclusions

In this paper, we proposed a configuration of three one-meter class telescopes to determine all the basic physical and mineralogical features of the asteroids that are brighter than 17 mag. We demonstrate its applicability for the study of asteroid 25916, whose visibility was favorable in June 2018. The variability of colour indices was found. This phenomenon seems to be quite rare and requires a separate study.

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