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UBVR-PHOTOMETRY OF THE ECLIPSING BINARY SZ Cam

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The early-type eclipsing binary system SZ Cam is the northern component of the visual double star ADS 2984(B). Both components of this visual double system of almost equal brightness ($V \sim 7^{\rm m}$) and spectral type (O9 IV and B0 III) are the brightest members of the open cluster NGC 1502. The first photoelectric light curves in UBV were obtained in 1970–1971 by Kitamura & Yamasaki (1970) and by Polushina (1977). Two more light curves were got later by Chochol (1980) in two non-standard intermediate passband filters and by Gorda & Polushina (1987) in $UBVR$ with the use of the area scanning technique in 1984/85 years. As it is given by Mayer et al. (1994) the small fragments of the light curves were obtained by Delgado in 1983 and by Irsmambetova in 1992.

The small spatial separation (approximately $18''$) between two stars of very similar brightness posed particular difficulties for realization of a conventional photometry of this eclipsing binary. As a consequence in some light curves of SZ Cam (see, e.g., Polushina 1977) depths of the minima achieve only 2/3 of their usual values. The fluctuations of brightness, especially in the vicinity of the secondary minimum and distortions of its shape are observed also. Distortions of the light curves can be borne by the nature of this eclipsing binary, however, they can be caused by observational effects as well.

Recently Mayer et al. (1994), Lorenz et al. (1998) and other authors (see, e.g., Harries et al. 1998), using the new spectral data, have explained the triple structure of composite absorption spectral lines of SZ Cam by existence of a third body in the system. Mass ratio had been redefined also ($q = 0.7$ against early $q = 0.2$) and now SZ Cam belongs to the type of completely detached systems instead of semi-detached.

For a long time no full light curve of SZ Cam has been obtained, that is why we have begun new investigation of this system. SZ Cam was observed photoelectrically at Astronomical Observatory of Ural State University, with a 45-cm Cassegrain telescope in $UBVR$ filters during 25 nights from October 1996 to November 1999. Bulk of the data was obtained in 1999. In order to eliminate influence of close visual companion ADS 2984A, we used the area scanning technique for our investigations. Thus the visual component was used as the comparison star automatically, because in this case the single-channel photometer worked as a two-channel one. This circumstance allowed us to use the data obtained during nights when the sky conditions were not so good.

More than 700 measurements of the magnitude difference in each colour with a standard error of $\pm0\overset{\rm m}{.}006$ in B, V and $\pm0\overset{\rm m}{.}008$ in U and R filters were obtained. For computation of the photometric phases we used ephemeris suggested by Mayer et al. (1994):

$$\mathrm{JD}_{\odot}\,\mathrm{Min\,I} = 2448932.3474 + 2.698393 \times \mathrm{E}. \qquad (1)$$

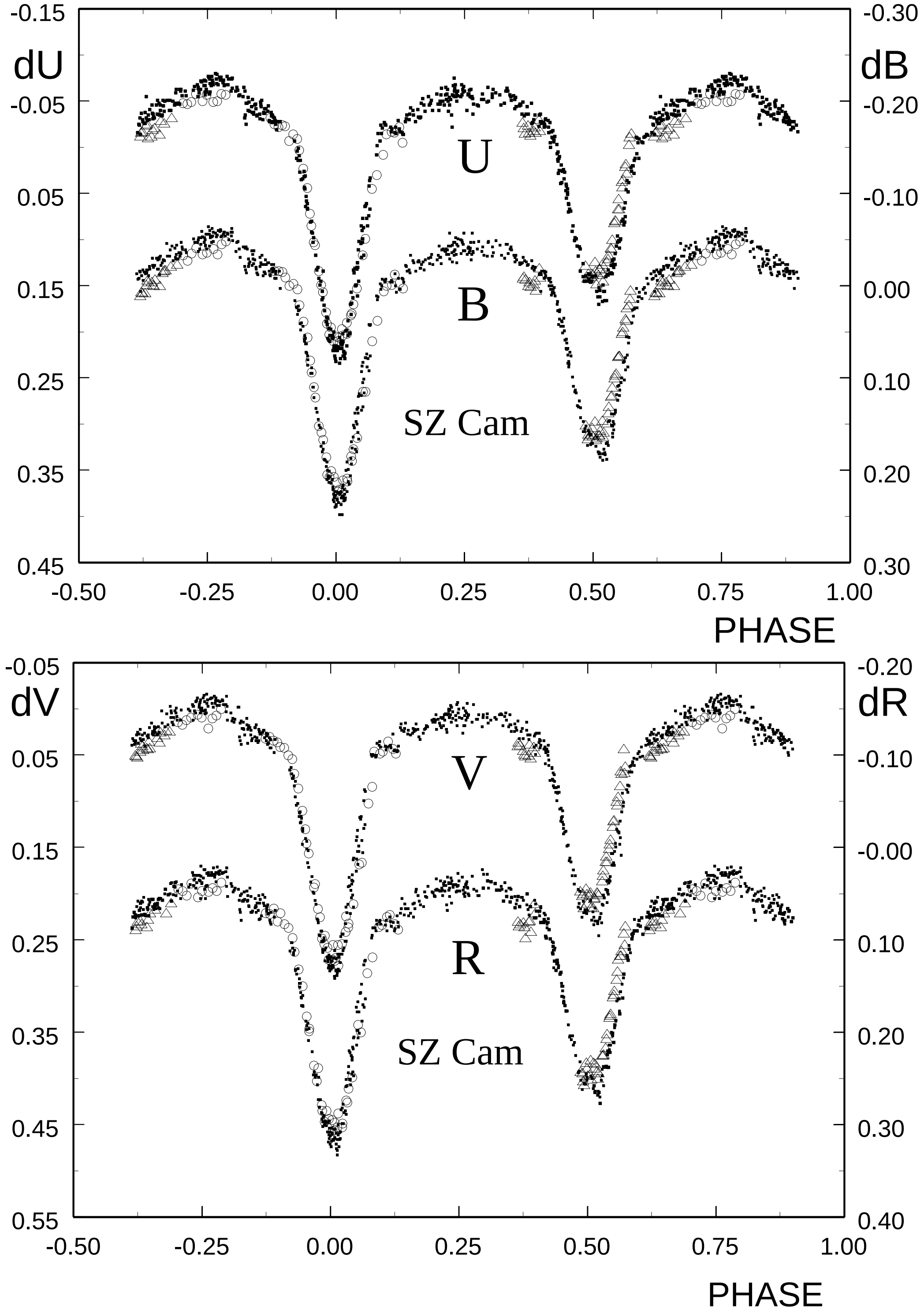

Figure 1. Differential U, B, V, R light curves of SZ Cam. References: • – bulk of the data; △ – the data obtained on 27 November 1996 (phases $0\overset{\text{P}}{.}49$–$0\overset{\text{P}}{.}57$), on 6 January 1997 (phases $0\overset{\text{P}}{.}36$–$0\overset{\text{P}}{.}40$) and on 7 April 1999 (phases $0\overset{\text{P}}{.}62$–$0\overset{\text{P}}{.}70$), which are different from that of other dates; ◯ – the data obtained in autumn 1999: on 5 October (phases $0\overset{\text{P}}{.}69$–$0\overset{\text{P}}{.}79$), on 11 October (phases $0\overset{\text{P}}{.}87$–$0\overset{\text{P}}{.}04$) and on 18 November (phases $0\overset{\text{P}}{.}95$–$0\overset{\text{P}}{.}13$). For detailed explanations see the text.

Table 1: Moments of minima of SZ Cam

$\mathrm{JD}_{\odot} - 2\,400\,000$	Min	E	$O-C$
46127.3300	II	−1039.5	−0.0379
46150.2684	I	−1031.0	−0.0358
51227.3523 ± .0007	II	850.5	+0.0216
51231.3966 ± .0010	I	852.0	+0.0184
51463.4560 ± .0009	I	938.0	+0.0160
51501.2366 ± .0010	I	952.0	+0.0191

The U, B, V and R light curves are shown in Figure 1. The light curves in all filters have similar shape. The mean depths of the minima are the same value for all colours, with the values of $\delta m = (\Delta m_{\max} - \Delta m_{\min}) = 0\overset{\mathrm{m}}{.}275$ and $\delta m = 0\overset{\mathrm{m}}{.}210$ for primary and secondary minima, correspondingly. Nevertheless, the small variations of values in the depths of minima and brightness fluctuations between particular nights do exist.

For example, the data obtained during nights in the autumn 1999 show decrease of depth of the primary minimum in comparison with observations in the spring 1999 by $0\overset{\mathrm{m}}{.}020$. Secondary minimum was less deep in 1996 by the same value. In addition, the existence of small distortions of the shape of the secondary minimum in the region of it bottom and ascending branch is worth noting. Changes of the level of brightness at the vicinity of beginning and final phases of secondary minimum are worth mentioning as well. The average maximum brightness for the phase $0\overset{\mathrm{P}}{.}75$ is brighter than that for the phase $0\overset{\mathrm{P}}{.}25$ by $0\overset{\mathrm{m}}{.}022$. However, in the data obtained in autumn 1999 both maxima are equal in the brightness. In Figure 1 all these peculiarities are marked by empty circles (autumn 1999) and empty triangles (others).

From our measurements we derived 4 new times of minima and their errors, using a method of parabolic approximation. Two additional times of minima were calculated from our early observations (Gorda & Polushina 1987). Moments of minima and $O-C$ values calculated using the light elements by Mayer et al. (1994) are given in Table 1.

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