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CONFIRMATION OF A DOUBLE NATURE OF THE THIRD BODY IN SZ Cam

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The eclipsing binary system SZ Cam is the brightest object of the open cluster NGC 1502. The primary was classified as O9.5V by Budding (1975). Using high-resolution spectroscopy, Mayer et al. (1994) identified the system as triple, composed of a close binary orbiting a massive companion. Lorenz et al. (1998) estimated the minimum mass of the tertiary component as 19.7 $M_{\odot}$ and proposed that the third body is a close binary.

In this message the preliminary results of a new spectral investigation of this eclipsing binary are presented. In total 26 CCD spectra of SZ Cam close to quadrature phases were taken with the Coude-echelle spectrometer (Musaev, 1996) of the Zeiss-1000 (D = 1m) telescope at the Special Astrophysical Observatory by Russian Academy of Sciences (SAO RAS) during three nights in December 2000. In order to provide wavelength calibration, one spectrum of α CMa was taken in the same fashion as those of SZ Cam.

The CCD TDK1024 (1242 × 1152 pixels, 22.5 × 22.5 microns) cooled by liquid nitrogen was used for registration of the spectral orders. The linear dispersion was 3 Å mm^{-1}, and the resolving power was in the range of 39000 to 40000. Useful wavelength interval in each order was ∼60 Å, and all orders covered the range from 3600 Å to 9000 Å. The exposure time of 30 minutes yielded signal-to-noise ratios of about 40 to 60. Data reduction was performed with echelle spectra processing program package DECH20T (Galazutdinov, 1992).

The most prominent lines besides H_{α} and H_{β} were $HeI(4922, 5016, 5876)$; other lines were much weaker. In all of the spectra HeI lines from the primary and secondary components of the close binary as well as those from the third body can easily be recognized. The line features were fitted with individual Gaussian profiles for each stellar component using the Marquardt nonlinear least squares method for the optimization of the following parameters: central wavelength, full width at half maximum, and amplitudes of the Gaussian function. The simultaneous fit with three Gaussian functions was required.

Typical line features and Gaussian fits of helium lines are shown in Figure 1. Using this set of three different Gaussian profiles, it was possible to derive the radial velocity curves of the eclipsing binary components and the third body. Radial velocities were calculated including the barycentric correction for the mass center of the solar system.

The radial velocity curves of the primary and secondary components were fitted separately with functions $V_i + K_i \sin(2\pi\varphi)$ ($i = 1, 2$ for the primary and secondary components, respectively) using the linear least squares method to optimize the free parameters K_i with fixed systemic velocities $V_i = V_0 = -15.3 \pm 2.5$ km/s; here φ denotes the orbital phase. The value of V_0 is the arithmetic mean of V_1 and V_2 which correspond to the best fits of the radial velocity curves when V_i and K_i are regarded as free parameters.

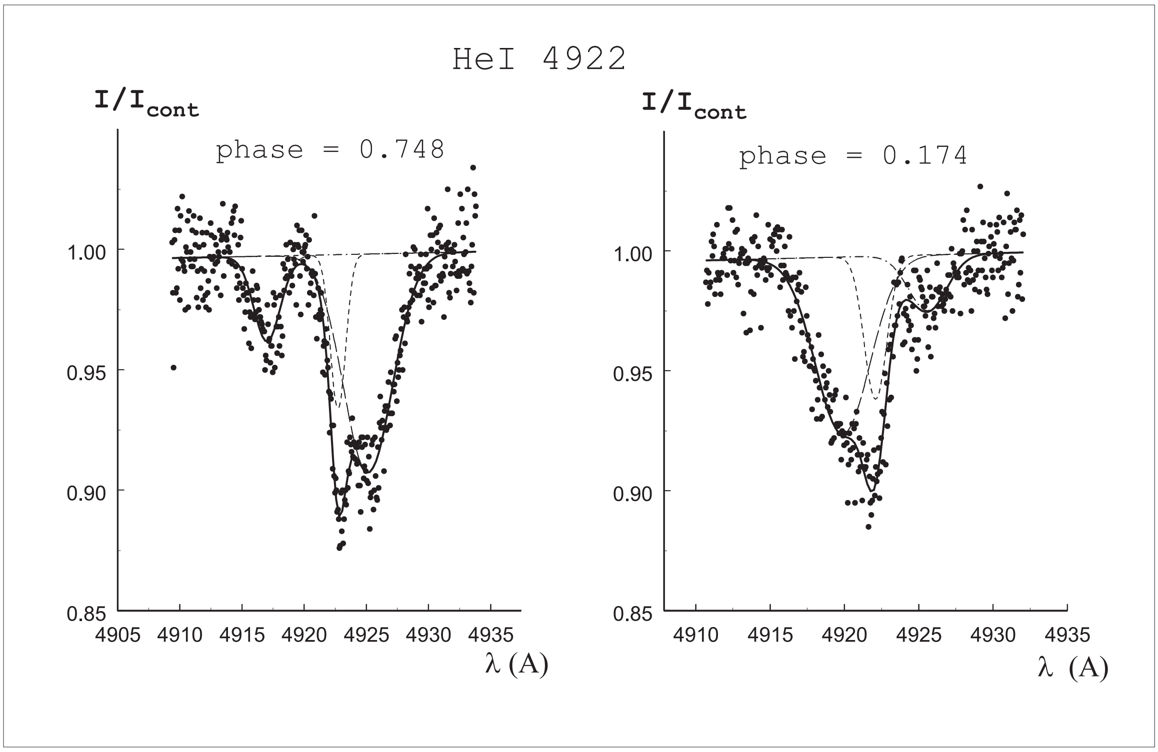

Figure 1. Typical profile of *HeI* 4922 spectral line around both quadrature phase. References: The fitted Gaussian functions are drawn as long-dashed, dash-dotted and dashed lines for the primary and secondary component and the third body, respectively. The resulting fit is shown as solid line; • – the spectral data.

It was estimated that $K_1 = 196.1 \pm 3.6$ km/s, $K_2 = 269.5 \pm 4.0$ km/s and the spectroscopic mass ratio of SZ Cam $q = K_1/K_2 = M_2/M_1 = 0.73 \pm 0.02$. This value of the mass ratio slightly differs from the value $q = 0.69$ obtained by Lorenz et al. (1998).

The radial velocities of the third body obtained from deconvolution of three blended spectral lines of *HeI* showed variability from night to night. The values of radial velocities and their accuracy for the third body are listed in Table 1. The values of phases and radial velocities of the third body averaged over each night are given in the last two columns of Table 1. The phases were calculated using the elements of the third body given by Lorenz et al. (1998).

Table 1: The radial velocities of the third body

$JD_\odot - 2\,400\,000$	φ	HeI 4922		HeI 5016		HeI 5876			
		V_r	σ	V_r	σ	V_r	σ	$\overline{\varphi}$	$\overline{V_r}$
51886.3710	0.794	32.2	2.1	16.8	9.2	24.2	2.3		
51886.3929	0.801	36.8	3.1	11.4	8.4	27.5	2.3		
51886.4148	0.809	39.8	2.1	18.3	3.2	26.0	2.4		
51886.4370	0.817	35.4	2.0	16.3	5.6	21.2	2.1		
51886.4596	0.825	36.6	1.8	11.1	7.2	24.8	2.4	0.826	26.9
51886.4814	0.833	40.8	2.2	21.1	5.4	29.4	1.8		±2.3
51886.5033	0.841	42.5	1.9	38.2	7.5	25.8	1.8		
51886.5255	0.849	43.0	2.5	27.5	8.5	24.6	1.8		
51886.5478	0.857	38.2	2.4	–	–	28.8	2.7		
51887.4971	0.196	−14.6	6.1	−22.5	6.3	−21.5	2.0		
51887.5193	0.204	−15.3	4.8	−24.3	4.0	−21.3	2.1		
51887.5415	0.212	−15.4	6.1	−31.9	3.5	−26.7	3.1	0.215	−22.7
51887.5641	0.220	−13.0	3.4	−31.3	4.0	−22.7	2.4		±1.3
51887.5867	0.228	−17.0	3.9	−23.1	6.1	−25.8	2.9		
51889.1752	0.796	27.6	3.0	9.2	5.0	18.9	1.5		
51889.1967	0.804	29.4	2.5	12.8	4.7	–	–		
51889.2183	0.812	32.2	2.3	16.2	4.2	23.6	1.8		
51889.2398	0.819	40.0	4.0	17.1	3.2	–	–		
51889.2613	0.827	39.4	4.2	17.7	4.0	24.4	1.9	0.825	27.6
51889.2828	0.835	37.4	3.2	12.4	4.3	–	–		±1.9
51889.3044	0.842	43.5	2.6	19.3	4.2	23.7	1.6		
51889.3259	0.850	46.8	3.2	24.6	5.5	27.5	1.8		

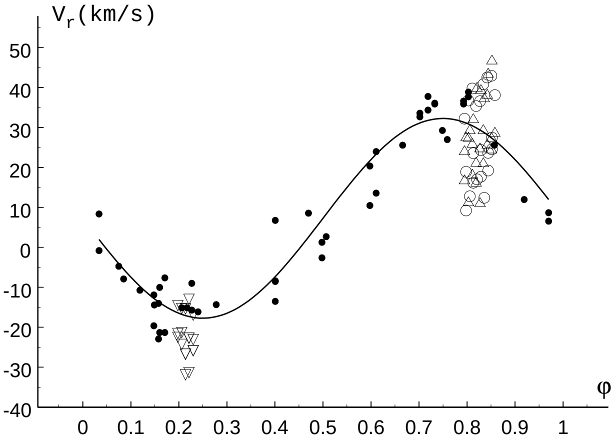

Figure 2. Radial velocity curve of third body. Phase were calculated using ephemeris $JD_\odot = 2448998\overset{d}{.}0608 + 2\overset{d}{.}7966 \cdot E$ (Lorenz et al., 1998). References: The curve $V_r(\varphi)$ (Lorenz et al., 1998) is shown as solid line; • – data by Lorenz et al.(1998); ○ – our data obtained December 7, 2000 ($\varphi = 0\overset{p}{.}79 - 0\overset{p}{.}86$), ▽ – December 8, 2000 ($\varphi = 0\overset{p}{.}20 - 0\overset{p}{.}23$) and △ – December 10, 2000 ($\varphi = 0\overset{p}{.}80 - 0\overset{p}{.}86$).

In Figure 2 our data on radial velocities of the third body is shown along with the data and radial velocity curve of Lorenz et al. (1998). It is seen that (despite the 5 – 7 years epoch difference between our observation and the results of Lorenz et al., 1998) the radial velocities of the third body obtained by us correspond well with the radial velocity curve calculated according to the ephemeris by Lorenz et al. (1998).

It is also necessary to note that the mean values of the radial velocities of the third body obtained by us at the same phases in December 7, 2000 (JD 2451886) and December 10, 2000 (JD 2451889) are practically equal (see Table 1).

Thus, it is possible to make a conclusion that the third component in the system is really a close binary (though we register radial velocity variations of primary component only) and the light elements for the third body obtained by Lorenz et al. (1998) are confirmed.

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