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SPECTRUM ANALYSIS OF THE BINARY STAR 53 AUR WITH A CP3 COMPONENT

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INTRODUCTION

The CP-star 53 Aur (HD 47152, HR 2425) has been assigned in the literature different types of peculiarity. Bertaud (1959) classified it as A0p-EuCr, Cowley et al. (1969) as B9p-Eu(Cr?), Osawa (1965) as Hg and Zverko (1974) as Mn - type. MacAlister (1978) discovered its binary nature and Tokovinin (1986) first determined its orbit with a period of 13.7 y. Subsequent interferometric observations by Baize (1989) yielded new orbital elements with a period of 25.816 y, total mass of 5.8 $M_{\odot}$ and magnitude difference of two B9 components 0.3 mag. Adelman (1982) performed spectrophotometry and fitted the Balmer jump with $T_{\rm eff}$=10 500 K, while the Paschen continuum with $T_{\rm eff}$=9 500 K, log g=4 in both cases. Palmer (1965) estimated the projected rotational velocity to 325 km s^{-1} from the width of the Ca II-K line, while Wolff and Preston (1975) obtained 33 km s^{-1} from the Mg II 448.1 nm line. In this work we analyze high-dispersion spectra obtained in two distant orbital phases, namely in 1975 and in 1992 to distinguish the components of the system.

OBSERVATIONS AND PROCESSING OF SPECTROGRAMS

All spectrograms were obtained at the coudè focus of two-metre telescope of the Astronomical Institute, Czechoslovak Academy of Sciences, Ondřejov. Eight spectrograms included in the first group, were taken during January and February 1975, four spectrograms in the second group were taken in the period from February to April 1992 with the same instrument, emulsion Kodak IIa-O. The plate factor is 0.85 nm/mm, spectral region $\lambda\lambda$ 380-480 nm. The spectrograms were digitized in the sampling rate of 366.7 px/nm, converted into the intensity units using Baker's densities. Continuum was rectified to unity with INTEP (Hill, 1982) and the highest frequency component of the noise filtered off. Finally, the records were coadded by means of cross-correlation to create two low-noise spectra, for each of the two orbital phases obtaining one coadded record. This coaddition is justified since each set of the spectra was taken no more than during 0.02 of the shorter of the published orbital periods. Since the spectrograms taken in 1992 have the star's spectrum on the plate twice as high as those taken in 1975 the resulting signal-to-noise ratio on both coadded records is the same, approximately 50:1. The resulting spectra are almost identical, offering a possibility to measure lines as faint as approximately 10 mÅ of equivalent width. There is a number of lines in the spectrum, mostly in blends, and two wide features at 448.1 and 393.4 nm. The blending mostly hides the true continuum making thus impossible to measure equivalent widths of individual lines by numerical integration. The W_λ's were measured by planimeter.

ORBITAL PHASES, RADIAL VELOCITIES AND POSITION OF LINES IN THE SPECTRA

The equivalent widths of the wide features are approximately equal to the values of CaII-K and MgII 448.1 nm lines typical for stars of B9-A0 spectral type while their halfwidths correspond to projected rotational velocity 200-300 km s^{-1}. If these features were the spectral lines belonging to the second component of the binary, which should be visible because the magnitude difference of the two B9 components is 0.3, their positions would have to correspond with the relative radial velocities of the components derived from the orbit. To determine the mutual position of the narrow and wide lines we fitted them with two gaussians, by means of the simple method of optimization. The results of this procedure are listed in the following table :

TABLE I Fitting parameters of Mg II and Ca II-K regions

		Position		
	Widths	(0.001 = 0.0027 nm)		
Line:	Mg II (4 plates)	Mg II (8)	Ca II (4)	Ca II (8)
narrow:	530.092	530.118	530.323	530.460
wide:	530.151	530.206	530.315	530.471
narrow:	0.035	0.032	0.034	0.030
wide:	0.213	0.192	0.292	0.321

Note: Entries are serial numbers $\times 10^{-3}$ of pixels in the file.

The positions of MgII 448.1 nm lines on both spectra are the same: the wide gaussian is shifted by amount of approximately 0.15 nm longward relatively to the narrow one. Mutual positions of the gaussians at CaII-K line show however the shift of rather opposite sign. This of course can be explained when one takes into account all spectral lines near CaII-K asymmetrically spoiling its profile due to rotational widening. Removing the blends from the profile we came at the same shift for CaII-K, too. This result, however, agrees neither with the results predicted by the orbital elements given by Baize (1989) nor Tokovinin (1986). There are at least two contradictions between prediction and observations: the first - maximum difference of relative radial velocity of the components computed from orbital elements does not exceed 40 km s^{-1} while the shift derived from the mutual position of the wide and narrow gaussians amounts to 100 km s^{-1}.

Even if we admit that the real observed profile, got rid of blending absorptions, to be as small as 0.1 nm, the corresponding radial velocity is still almost as high as 70 km s^{-1}; the second - the shift corresponding to the orbital phase of the first spectrum should be of an opposite sign as the second one but this is not observed. Thus one comes to the conclusion that either the broad features at the places of lines CaII-K and MgII 448.1 nm belong to some other object projected on the same spot as 53 Aur, which was not confirmed by speckle interferometer observations (Balega and Balega, 1985), or both the published sets of orbital elements are not correct.

MODEL ATMOSPHERE, ABUNDANCE ESTIMATION AND DISCUSSION

The equivalent widths of selected lines of Fe, Ti and Cr were measured under the assumption that the narrow spectral lines belong to the brighter component of the binary. Theoretical equivalent widths for models of $T_{\rm eff}$=10 000 K and $\log g$=4.0 (Kurucz,1979) and $\xi_{\rm turb}$=3.0 km s^{-1} and several values of abundances of the elements were computed using the SYNSPEC code (Hubený, 1987). Under these assumptions we only obtained a weak overabundance of iron namely 0.3 dex relative to solar abundance and moderately strong overabundance of titanium, 1.1 dex and of chromium 1.4 dex relative to solar ones. More computations are needed to get more precise values and better understanding of the nature of 53 Aur but some conclusions can be made now. Although we are not able to find any spectrum changes due to the orbital motion there are some indications of duplicity in the spectrum. Besides the presence of narrow and broad features, the profiles of Balmer lines H_γ and H_δ are strongly affected, too. In Zverko et al. (1992) we derived $T_{\rm eff}$=12 800 K and log g=4.4 by comparing theoretical and observed profiles of these lines. The considerably high value of log$g$ obviously witnesses in favour of a presence of a broadened component in the lines.

THE AUTHORS CALL

everybody who possesses any spectrograms of 53 Aur in his spectro-thèque to measure radial velocities and try to estimate the orbit.

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