Ca II H and K Spectroscopy of ER Vul

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1. Introduction

ER Vul (HD 200391) is a double-lined spectroscopic binary, at a distance of 45 pc, catalogued as a short-period RS CVn binary, and has been found to present eclipses. The components have spectral types G0V/G5V, masses 1.07/0.98 $M_\odot$, radii 1.23/1.23 $R_\odot$ and M_V 4.8/4.6^m (Strassmeier *et al.*, 1988, and references therein). The system presents emission reversals of the H and K absorption lines (Bond, 1970; Eggen, 1978), but no information on the character of these emissions has been previously reported.

2. Observations and data reduction

We have taken 4 spectra of ER Vul centered at 3950 Å using the INT telescope (2.5 m) at the Observatorio del Roque de los Muchachos (La Palma, Spain) in July 1988. The spectrograph used was the IDS with the 2400B grating and camera 2 mounting the IPCS detector. Three additional spectra were taken in July 1989 at the Centro Astronomico Hispano-Aleman of Calar Alto (Almeria, Spain) using the 2.2 m telescope equipped with the Coude B&C spectrograph and a CCD (RCA) as a detector. The spectral resolution achieved in both instrumental configurations is 0.3 Å/pixel determined by the slit aperture. The journal of observations is given in Table 1. The phase has been computed with the ephemeris from Hall and Kreiner (1980):

$$JD = 2440182.2593 + 0.69809510\,E$$

The wavelength-calibrated spectra have been extracted from the IPCS and CCD images, using standard reduction procedures. The spectra are then corrected from atmospheric extinction by means of the semiempirical method by Hayes and

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Latham (1975). The flux calibration has been performed using 4 standard stars from the compilations of Oke and Gunn (1983). Night to night discrepancies found for the standard star measurements are within 5% of accuracy. After this calibration the flux units are erg cm^{-2} s^{-1} $Å^{-1}$. The spectra are shown in Fig. 1. Using photometric data and the calibration of Catalano *et al.* (1990), the continuum spectrum (above lines) can be synthesized for the components of the system, reproducing very well the expected continuum level over the absorption lines, showing that the flux calibration has been done properly. The emission fluxes for the Ca II H and K lines are obtained by reconstruction of the absorption line profile below the emission peak, as discussed by Armentia *et al.* (1989). Errors in flux measurements are about 25%, in good agreement with similar calculations from Fernández-Figueroa *et al.* (1986) using the same equipment and data reduction techniques. Final results for the emission fluxes are given in Table.

3. Spectroscopic analysis

The spectra obtained at the INT have a lower SNR than those from Calar Alto, a situation increased by the possible eclipse of the hotter star in three of those spectra (labeled a, c and d). As can be easily seen in Fig. 1, the emission reversals of the lines show that both stars are active. In the three above mentioned spectra with phases near 0.0, a gaussian deconvolution of the emission peak has been performed, whose results are presented in Table; for the other cases, the two peaks are separated. The presence of Hε in the neighbourhood of H line made a similar analysis for this line unreliable. To indentify which component is responsible for each peak we have used the orbital parameters from Strassmeier *et al.* (1988) and from new photometric determinations (Arevalo, 1990). The computed radial velocities from Doppler shifts of the peaks lead to similar results. Although this identification is not always certain, possibly due to uncertaintities in the ephemeris available, it seems that the hot star was less active then the cool component during the 1988 July observations, while the emission levels were similar in 1989 July. We have checked the Wilson-Bappu relationship (Rutten, 1984), using the K emission reversals, and the average values for the FWHM in both epochs. The cool star does not fit in any epoch (by an amount of about 4^m), and the hot star fitted in 1988 July, but not in 1989 July, due to the different activity level.

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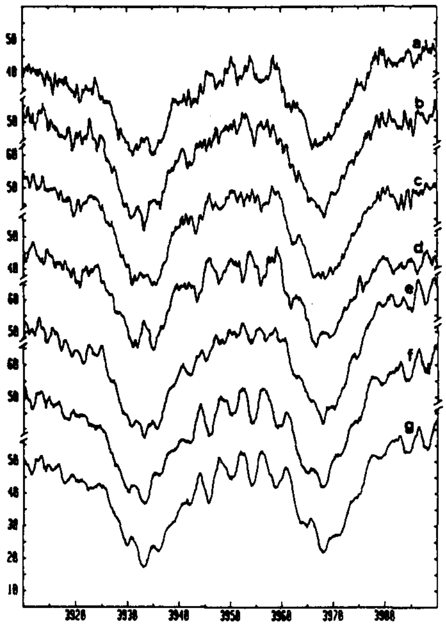

Fig. 1. Spectra of ER Vul. Fluxes in units of 10^{-13} erg cm^{-2} s^{-1}. Phases given in Table

Spec.	JD	Phase	line	λ	F_{obs}	FWHM	Notes
a	244 7370.57	0.04	K	3932.9	3.6	0.7	
	(INT)			3933.9	6.2	1.0	
			H	3968.5	3.4	-	(1)
b	244 7370.61	0.10	K	3932.2	8.2	1.0	
	(INT)			3934.6	13.6	-	(3)
			H	3967.3	1.1	-	(3)
				3969.7	5.3	-	(3)
c	244 7372.58	0.92	K	3932.9	3.7	0.7	
	(INT)			3933.9	6.1	1.0	
			H	3968.7	4.5	-	(1)
d	244 7372.64	0.00	K	3933.1	11.5	1.1	
	(INT)			3934.2	6.2	0.6	
			H	-	-	-	(2)
e	244 7721.59	0.87	K	3931.7	5.2	1.4	
	(CAHA)			3934.8	8.9	1.4	
			H	3966.3	4.3	-	(3)
				3968.8	5.6	-	(3)
f	244 7722.55	0.24	K	3931.2	9.0	1.5	
	(CAHA)			3935.3	9.7	1.6	
			H	3966.0	8.8	-	(3)
				3969.7	12.9	-	(3)
g	244 7723.58	0.71	K	3930.8	11.3	1.3	
	(CAHA)			3935.0	8.1	1.4	
			H	3965.6	8.1	-	(3)
				3969.3	7.2	-	(3)

Notes:

(1) No separation of the components is possible
(2) confuse, no measurements performed
(3) No gaussian fit possible (noisy)
Wavelength and FWHM in A
Fluxes in units of 10^{-13} erg cm^{-2}s^{-1}
INT: 2.5m Isaac Newton Telescope (Roque de los Muchachos)
CAHA: 2.2m Telescope (Calar Alto)

Table: Observations and results

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