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H-ALPHA AND LiI OBSERVATIONS OF THE RS CVn TYPE BINARIES : σ Gem, α Aur, 93 Leo and HR 6469

Variations in the H-alpha line profiles of RS CVn binaries have been reported by numerous authors, but only a few objects are known where the H-alpha variations are correlated with orbital phase. Weiler et al. (1978) suggested such a correlation for V711 Tau (P=2.838 days) whereas Bopp and Talcott (1978) do not. On the other hand Bopp and Talcott report coherent Hα variations with orbital phase in UX Ari (P=6.438days). Vogt (1981) monitored the Hα region of II Peg ($P=6^{d}.724$) and found a correlation between enhanced Hα emission and spot visibility in this well-studied RS CVn star.

The evidence of a LiI 6707.8 line is a qualitative indicator of stellar age. Lithium abundances have been used to estimate rough ages of solar-type stars, but deriving quantitative ages is much more difficult (Soderblom,1983). The main reason is that the depletion time scale is extremely sensitive to stellar mass. Consequently, we only give equivalent widths. Because of RS CVn's are post-main sequence binaries (Popper and Ulrich,1977) the amount of LiI should be very small.

The observations were obtained on 1985 Feb. 5, 7 and 8, May 10, 11 and 14 and Oct. 28 with the Cassegrain echelle spectrograph (Weiss et al., 1981) of the 1.5 m Vienna RC telescope. The detector used was a dual,liquid nitrogen cooled, Reticon CP-1001 array with 936 pixel each row (Schalk et al., 1985). The 79 g/mm echelle grating used with the 900 lines/mm cross disperser gave a reciprocal dispersion of 10 Å/mm at Hα in the 34th order which covered a spectral range of ∼ 250 Å centered at 6602 Å.

The mean FWHM of the Neon comparison lines covers about 2 pixels, corresponding to a resolution of $\sim$0.65 Å. In our averaged observing conditions (seeing $\sim$ 3", slit width 300µm) the integration times varied from 20-60 minutes for a uniform signal-to-noise ratio of typically $\sim$ 200 (except of α Aur, where SNR $\sim$ 400 with 2min).

Table I

Hα data

	$EW^{(a)}$ [mÅ]	$\frac{counts(\lambda_c)}{counts(cont.)}$	FWHM [km/s]
σ Gem (S1)	-1022	0.53	91
σ Gem (S2)	- 943	0.51	82
σ Gem (S3)	- 950	0.51	76
α Aur	-1445	0.36	91
93 Leo	-1249	0.48	87
HR 6469	-1360	0.38	74
V 711 Tau	+ 685	1.24	132
HR 5110 (H1)	- 780	0.77	100
HR 5110 (H2)	- 650	0.75	87
ψ UMa	-1069	0.32	59

(a) Note that these are actually measured equivalent widths from the composite spectrum.

σ Gem (= HR 2973 = HD 62044): The single-line spectrum shows rotationally broadened lines. The Hα feature is clearly filled in by chromospheric emission as was mentioned by Smith and Bopp (1982). These emission is present during our February run as well as in the May-data, five epochs later. But there are still not enough data to look for season-to-season changes of these emissions. All H-alpha data are summarized in Table I.
The LiIλ6707.8 line seems to be present in all spectra but is strongly blended ($W_\lambda \sim$ 31 $\pm$ 10 mÅ).

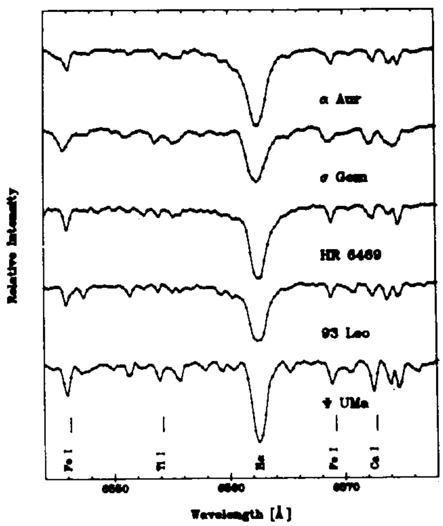

Fig. 1: Enlarged view of the Hα region for our program stars along with the nonactive single star ψUMa. The spectra were shifted to be in accordance with the ψUMa spectrum. σGem, HR6469 and 93 Leo show chromospherically filled in absorption cores.

αAur (= HR 1708 = HD 34029) is a double-line spectroscopic binary consisting of a G6III primary and an active F9III secondary. Shen et al. (1985) fitted two Gaussians to the line profiles to deconvolve both components from the composite spectrum near conjunction and found for the relative "dip"-strength G6/F9 = 1.7 ± 0.2. In our high SNR, 10 Å/mm-spectrum taken at phase 0.091, the secondary spectrum can be clearly seen, but all lines (except of LiI) were blended by these broad F9-lines in a way which corresponds to a relative "dip"-velocity shift of ∿30 km/s to the blue. The derived relative "dip"-strength is 1.69 ± 0.05 using the NiIλ6643 line.

The composite Hα absorption feature reaches down to ∿0.4 that of the continuum. If any emission occurs it is surely a weak one, not comparable with σGem.

A visual comparison of the LiIλ6707.8 region (Fig.2) with the two spectra given by Boesgaard (1971) in her Figure 2, p.513, showed a remarkable different intensity ratio between the nearby FeI lines from the G-component and the LiIλ6707.8 line from the F-component. But this is probably due to larger blending in our spectrum. No LiI line from the G-star is seen, it is fully blended by the broad F-line and an FeI-line at 6707.44 Å. The measured equivalent widths were corrected for the effect of composite continuum by multiplying with 1.67 for the G-star and 2.50 for the F-star.

93 Leo (= HR 4527 = HD 102509) exhibits a composite spectrum of a A7V and an G5III-IV component, with the presence of moderately strong emission in the H and K lines from the G-star. All lines are sharp and belong to the late-type component which contributes 0.67 of the total light in V. This corresponds to V-magnitudes of $5^{m}.52$ for the A-, and $5^{m}.09$ for the G-star. The actually measured equivalent widths were multiplied by a factor of 1.46 for correction of the composite continuous spectrum.

The $H\alpha$ line of the G-star is fully blended by the broad and shallow $H\alpha$ feature of the A-component. The slight asymmetry of the blue wing is in accordance with a velocity shift of $\sim$25 km/s relative to the G-component at phase 0.060.

We used a $H\alpha$ spectrum of Vega (AOV), also at 10 Å/mm, to substract it from the composite 93 Leo spectrum (after the Vega-spectrum was shifted to be in accordance with the early type component in 93 Leo). From this and from the composite spectrum follows that the high $H\alpha$ core intensity is not due to rotational effects but indicating that the normal absorption line is filled

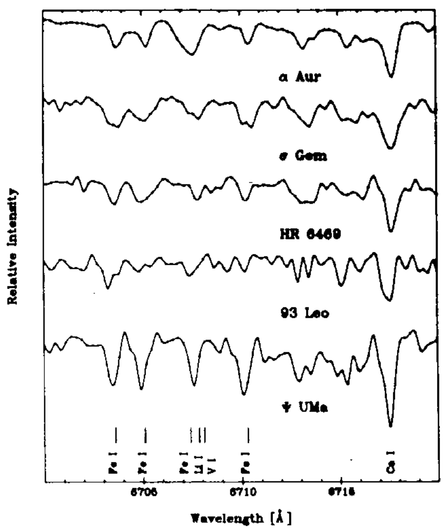

Fig. 2 : Reticon spectra of the LiIλ6707 region (10 Å/mm original dispersion and 0.65 Å resolution). The spectra were shifted to be in accordance with the CaIλ6717 line of ψUMa.

in by emission.

As seen in Figure 2 , a weak blended) LiI line (W_λ = 74 ± 10 mÅ) from the G-star is observable. We derived a ratio EW (Liλ 6707)/EW(Ca λ6717) = 0.44 and a relative abundance of [Li/Ca] = 1.2.

Recently, Walter (1985) reported that the G-component is the X-ray source in the 93 Leonis system.

HR 6469 (= HD 157482) is a double-lined F7V + ? + G5IV binary with a third spectroscopic component. Two components were resolved by McAlister et al. (1983) at 0".04 seperation using speckle interferometry techniques.

We are not able to resolve the second component in our 10 Å/mm-spectrum, although we have a good SNR, we are limited by a spectral resolution of $\sim$25 km/s. The photospheric lines are sharp and similar to the lines of the G-star in 93 Leo. In comparison with the F9III secondary of the α Aurigae system, HR 6469 shows a very weak LiIλ6707.8 feature ($W_\lambda \sim$ 61 $\pm$ 15 mÅ).

Visual inspection of the Hα profile displayed in Figure 1 reveals a weak emission.

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