

Application of the spectral subtraction technique to the Ca II H & K and H ϵ lines in a sample of chromospherically active binaries ^{*}

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Abstract. We present new spectroscopic observations in the Ca II H & K line region for a sample of 28 chromospherically active binary systems (RS CVn and BY Dra classes), with different activity levels. By using the spectral subtraction technique (subtraction of a synthesized stellar spectrum constructed from reference stars of similar spectral type and luminosity class) we obtain the active-chromosphere contribution to the Ca II H & K lines and to the H ϵ line when it is present. We have compared the emission equivalent widths obtained with this technique with those obtained by reconstruction of the absorption line profile below the emission peak(s).

The emissions arising from each individual star were obtained when it was possible to deblend the contribution of both components. The Ca II line profiles corresponding to different seasons and orbital phases are analysed in order to determine the contribution of each component and to study the chromospheric activity variations.

Key words: stars: activity – stars: binaries: close – stars: chromospheres – stars: late-type – stars: rotation

1. Introduction

The chromospherically active binaries, RS Canum Venaticorum (RS CVn) systems and BY Draconis (BY Dra) stars, defined by Hall (1976) and Bopp & Fekel (1977) respectively, are detached binary systems with cool components characterized by strong chromospheric, transition region, and coronal activity. The RS CVn systems have at least one cool evolved component whereas both components of the BY Dra binaries are main sequence stars (Fekel et al. 1986).

The core emission in the Ca II H & K resonance lines are the most widely used optical indicators of chromospheric activity, their source functions are collisionally controlled and hence are important diagnostics of stellar chromospheres. The chromospheric activity levels can be also inferred by the presence of emission or filled-in absorption in the core of the H α line and the UV emission lines. However, in chromospherically active binaries the excess emission equivalent widths (EW) of these chromospheric activity indicators were rarely determined because of the complication in the analysis due to the binary nature of these stars. The reason for this complication is that the emission of the active component is contaminated by the non active component which in many cases is the main contributor to the total observed flux. In addition, if both components are active their emissions can be blended.

The calculation of the active-chromosphere contribution to the Ca II H & K lines involves the subtraction of a photospheric flux. The methods normally used to estimate this underlying photospheric contribution are the reconstruction of the absorption line profile below the emission peak(s) by extrapolating the line wings to the line centre (Fernández-Figueroa et al. 1994 (hereafter FFMCC) and references therein) or the subtraction of a photospheric contribution obtained from a pure radiative equilibrium calculation (Linsky et al. 1979). However, a more suitable method, that eliminates the complications introduced by

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the binary nature of these systems in the observed absorption line profile, is the spectral subtraction technique (described by Montes et al. (1995a) for the case of the H α line). This method is based on the subtraction of a synthesized stellar spectrum constructed from reference stars of similar spectral type and luminosity class than the components of the active system under consideration.

In this paper we study the behaviour of the Ca II H & K lines in a sample of 28 active binary systems of different activity levels selected from "A Catalog of Chromospherically Active Binary Stars (second edition)" (Strassmeier et al. 1993, hereafter CABS). By using both, the reconstruction of the absorption line profile and the spectral subtraction technique, we determine the excess Ca II H & K emissions for each active star. The dependence of the excess Ca II H & K emission EW on stellar parameters and the relation with the excess H ϵ emission EW and other activity indicators are studied in a separate paper (Montes et al. 1995c) in a sample of 73 chromospherically active binaries where the 53 stars analysed by FFMCC have been included.

In § 2 we give the details of our observations and data reduction and we describe the two methods to obtain the active-chromosphere contribution to the Ca II H & K lines. In § 3 we describe the individual results of the Ca II H & K line observations of our sample.

2. Observations and Data Reduction

Observations of the Ca II H & K lines for 28 chromospherically active binary systems and several inactive stars of similar spectral types and luminosity classes have been obtained during two observing runs in December 1992 and March 1993. Two different instrumental configurations were used:

1. The Isaac Newton Telescope (INT) at the Observatorio del Roque de Los Muchachos (La Palma, Spain) in 1992 December, using the Intermediate Dispersion Spectrograph (IDS) with grating H2400B, camera 500 and a 1280 x 1180 pixel EEV5 CCD as detector. The reciprocal dispersion achieved is 0.18 Å/pixel which yields a spectral resolution of 0.36 Å and a useful wavelength range of 215 Å centered at 3945Å.

2. The 2.2 m Telescope at the German Spanish Astronomical Observatory (CAHA) in Calar Alto (Almería, Spain) in 1993 March, using a Coudé spectrograph with the f/3 camera, grating #1 and a 1080 x 1030 pixel TEK #6 CCD as detector. The reciprocal dispersion achieved is 0.21 Å/pixel which yields a spectral resolution of 0.42 Å and a useful wavelength range of 190 Å centered at 3920Å.

The spectra have been extracted using the standard reduction procedures in the MIDAS package (bias subtraction, flat-field division, and optimal extraction of the spectrum). The wavelength calibration was obtained by taking spectra of a Th-Ar lamp. Finally, the spectra have

been normalized to the measured flux in 1 Å window centered at 3950.5 Å. This reference point at 3950.5 Å is not a real continuum, but it is a relatively line-free region that could be used as a pseudo-continuum to normalize all the Ca II H & K spectra and that has been used by Pasquini et al. (1988) to develop a calibration procedure for converting the observed line fluxes into absolute surface fluxes.

In this paper we also analyse the spectra of other single inactive stars, used as reference stars, and other active single stars and active components of visual binaries taken by us in previous observational seasons with a similar instrumental configuration (described by FFMCC).

Following our previous paper on Ca II H & K emissions in active binaries (FFMCC) the 28 stars of the sample are arranged in three groups according to the assigned luminosity class of the active component. Group 1 contains the systems whose active component is a main-sequence star (luminosity class V), group 2 includes the systems whose active component is an evolved star (luminosity class IV) and group 3 contains systems whose active component is a giant or supergiant (luminosity classes III and II)

In Table 1 we list the HD number, name, spectral type and luminosity class (T_{sp}), the binary nature (SB), and the adopted stellar parameters (from CABS) for the 28 chromospherically active binary systems studied. In Table 2 we give the HD number, name, spectral type and luminosity class (T_{sp}), the V-R color, rotational period (P_{rot}), and $V\sin i$ (from the Bright Star Catalogue (Hoffleit & Jaschek 1982), Noyes et al. 1984; and Donahue 1993) of the reference stars used for the construction of the synthesized spectrum and some other active single stars and active components of visual binaries which are also studied in this paper. In the last column A and R mean active and reference star respectively, based on our Ca II H & K observations.

2.1. Reconstruction of the absorption line profile

In all our papers where the chromospheric emission has been analyzed (FFMCC, and references therein) the chromospheric emission fluxes of the Ca II H & K lines, $F_{obs}(H;K)$, were obtained by reconstruction of the absorption line profile below the emission peak(s), following the method given by Blanco et al. (1974). In this method the wing profiles are extrapolated smoothly toward the line center in order to define the upper photospheric level.

For the cases in which there is only one emission component, the profile reconstruction is easily performed. However, when the two components of the binary system are active the observed profile is the result of the emission from both components and to deblend the two contributions it is necessary to perform a Gaussian fit of the two emission lines and the absorption profile. In some of the examined systems the Balmer H ϵ line (3970.07 Å) is an emission feature. Since H ϵ is very near to the Ca II H line (3968.47 Å) it is also necessary to carry out another

Gaussian fit to deblend these two emissions. The problem is still more complicated when both components present Ca II H emission and also one or both components show H ϵ in emission, in this case it is necessary to perform three or four Gaussian fits.

Following this method, we have determined the excess Ca II H & K emission EW in the spectra normalized to the pseudo-continuum at 3950.5 Å. We have also measured the parameter C(K) defined by FFMCC as:

$$C(K) = \frac{F_{\text{obs}}(K)}{F_{\text{T}}(K) - F_{\text{obs}}(K)}$$

where $F_{\text{T}}(K)$ is the total Ca II K emission line flux measured above the zero-flux level, whereas $F_{\text{obs}}(K)$ is the flux measured above the reconstructed absorption line profile. This parameter indicates the relative flux of the emission above the absorption feature.

2.2. Spectral subtraction technique

Another approach to estimate the underlying photospheric contribution is the subtraction of a synthesized stellar spectrum constructed from reference stars of similar spectral type and luminosity class.

This spectral subtraction technique has been extensively used in the literature for the case of the H α line (Montes et al. 1994; 1995a; b, and references therein) however for the case of the Ca II H & K lines some attempts have been made: Catalano (1979) for single active stars, Thatcher & Robinson (1993) for a sample of late-G to early-K single and binary stars using only one reference star of spectral type G6V, Strassmeier (1994b) for one binary system and finally the work about composite spectrum subtraction (Griffin et al. 1994 and references therein).

In this paper we apply to the Ca II H & K lines the spectral subtraction technique described in detail for the case of the H α line by Montes et al. (1995a). In this method the synthesized spectra were constructed from artificially rotationally broadened, radial-velocity shifted, and weighted spectra of inactive stars (i.e., stars with negligible Ca II H & K emission) chosen to match the spectral types of both components of the active system under consideration. The contribution of each component to the total continuum (S_{H} and S_{C}) has been obtained using the luminosity ratio in the Ca II H & K line region, calculated with the radii and the Planck functions of the hot and cool components.

By subtracting the synthesized spectrum from the observed one, we obtain a residual spectrum that contains only the active-chromosphere contribution to the Ca II H & K lines. The excess Ca II H & K emission EW, EW(H;K), is then defined to be the EW measured in the subtracted spectrum additively offset to have a continuum of unity. The contribution to the profile from each stellar component in the subtracted spectrum was then measured

by a fit of two Gaussians to the blended profile. Finally, the measured EW is corrected for the contribution of the components to the total continuum multiplying by a factor ($1/S_{\text{C}}$) for the cool component and by ($1/S_{\text{H}}$) for the hot component.

The $F_{\text{S}}(\text{Ca II K})$ flux has been obtained using the linear relationship between the absolute surface flux at 3950 Å (in $\text{erg cm}^{-2} \text{s}^{-1} \text{Å}^{-1}$) and the colour index (V-R) by Pasquini et al. (1988).

2.3. Measured parameters

The excess Ca II H & K and H ϵ emissions EW has been measured following the two above mentioned methods.

In Fig. ?? we compare the EW obtained from both methods. As we can see in this figure the EW obtained with both methods are similar, however the EW measured using the spectral subtraction technique are always rather larger than the one measured by reconstruction of the absorption line profile and the difference tends to be larger for larger EW. This result was expected since the observed inner wings of the Ca II H & K absorption lines used for reconstruction of the absorption line profile of the active star, are brighter than the one of the inactive stars used to the construction of the synthesized spectrum.

The spectral subtraction technique provides better results when the profile reconstruction is not easily performed, as is the case of systems that present Ca II H & K emissions from both components and systems in which the absorption line profile have important contribution from both components. Furthermore, in some cases, the application of the spectral subtraction technique allow us to detect a small H ϵ emission line that it is not noticeable in the observed spectrum.

The Ca II H & K and H ϵ line parameters, measured in the observed and subtracted spectra of the active stars, are given in Tables 3, 4 and 5 for the groups 1, 2, and 3 respectively. Column (3) gives the orbital phase (φ) for each measured spectrum, and in column (4), H and C mean emission belonging to hot and cool component respectively, and T means that at these phases the spectral features can not be deblended. Column (5) gives the weights for the hot and cool component (S_{H} and S_{C}). In columns (6) to (9) we list the EW and the C parameter for the K and H lines respectively, obtained by reconstruction of the absorption line profile, and in columns (10) to (15) we give the EW and the peak emission intensity (I) for the K, H and H ϵ lines respectively, measured in he subtracted spectrum. Finally, in Table 6 the Ca II H & K and H ϵ line parameters for the reference stars, the active single stars and the active components of visual binaries are given. In columns (3) and (4) we list the core flux, $F(1.0\text{Å})$, for the H and K lines, measured as the residual area below the central 1.0 Å passband. In the following columns we give for the stars with measurable level of activity the same parameters that in the last columns of Table 3, 4 and 5.

3. Individual results

In the following we describe the Ca II H & K spectra of the stars of this sample and we compare our results, obtained with the spectral subtraction technique, with the ones reported by other authors. When observations of these systems in the region of the H α line are also available (Montes et al. 1995a, b) we briefly describe the behaviour of this emission.

The Ca II H & K line profiles of each chromospherically active binary system are displayed in Fig. 2 to 29. The name of the star, the orbital phase, and the expected positions of the H & K features for the hot (1) and cool (2) components are given in each figure. For each system we plot the observed spectrum (solid-line), the synthesized spectrum (dashed-line), the subtracted spectrum, additively offset for better display (dotted line) and the Gaussian fit to the subtracted spectrum (dotted-dashed line). The Ca II H & K line profiles for the active single stars and the active components of visual binaries are displayed in Fig. 30 to 42. The orbital ephemeris used for the phase computation are taken from CABS apart from the cases explicitly mentioned in the text.

3.1. Group 1 (Active component of luminosity class V)

3.1.1. VY Ari (HD 17433)

This system is a single-lined spectroscopic binary (K3-4 V-IV). Bopp et al. (1989) found the H α line varying from a pure emission profile to an absorption profile with occasionally enhanced H α emission presumably related to flare events. Our observation in the H α line region (Montes et al. 1995a, b) shows a weak H α emission superimposed to the blue wing of a weak absorption.

We have taken one spectrum of this system in Dec-92 at orbital phase 0.17 (Fig. ??). The spectrum is well matched using a reference star of spectral type G8IV. The subtracted spectrum presents strong Ca II H & K emission lines and the He line in emission.

3.1.2. OU Gem (HD 45088)

OU Gem is a double-lined spectroscopic binary composed of two K dwarf stars (K3V/K5V) with strong Ca II H & K emission from both components and filled-in absorption of the H α line in the cool component (Bopp et al. 1981a, b).

Our observation in the H α line region (Montes et al. 1995a, b) reveals a strong excess emission but it is not possible to know whether the emission belongs to the cool component or to both components.

We took one spectrum in the Ca II H & K line region in Mar-93 at orbital phase 0.47 (Fig. ??). In this spectrum we can see strong emission in the Ca II H & K lines and a small He emission line. At this orbital phase the difference in radial velocity between the components is very small

and it is not possible to know whether the emission arises from the cool component or rather it is a composite of the two components as was observed by Bopp et al. (1981a), further taking into account that the spectral type of both components is similar. We have constructed a synthesized spectrum with two K1V stars and a relative contribution of 0.7/0.3. We have obtained a satisfactory fit between observed and synthesized spectra in the absorption lines. However in the inner wings of the Ca II H & K absorption lines a significant excess is present (see Fig. ??), which can be interpreted as a result of noradiative heating of the upper photosphere.

3.1.3. YY Gem (BD +32 1582)

YY Gem is a doubled-lined partial eclipsing binary and one of the most active flare stars. CABS assigns dM1e/dM1e spectral types to the system. Our H α observation (Montes et al. 1995a, b) at orbital phase 0.49 shows a strong emission with contributions from both components.

Our spectrum in the Ca II H & K line region at orbital phase 0.44 (Fig. ??, upper panel) shows very strong emission from both components. In the case of the K line the intensity of the emission arising from the blue component is rather lower than one from the red component. In the case of H line, three emissions are clearly seen, that is, in order of increasing wavelength: Ca II H of the primary, Ca II H of the secondary overlapped with He emission of the primary and finally the He of the secondary. In the same spectrum we can also see that H ζ , and H η Balmer lines from both components appear in emission (see Fig. ??, lower panel).

3.1.4. BF Lyn (HD 80715)

Double-lined spectroscopic binary with spectral types K2V/[dK] and strong Ca II H & K and H α emissions from both components (Strassmeier et al. 1989; Barden & Nations 1985).

We have taken one spectrum of this system in the Ca II H & K line region at orbital phase 0.21 (Fig. ??). This spectrum shows a clear and strong emission in the H & K lines from both components with very similar intensities. The He line from the red-shifted component is in emission, the blue-shifted component also present He emission but is overlapped with the Ca II H emission of the red-shifted component. The synthesized spectrum has been constructed with two K1V stars and with the same contribution to the total continuum.

3.1.5. DH Leo (HD 86590)

This is a triple system whose primary and secondary components are active.

Our spectra in the H α line region (Montes et al. 1995a, b), clearly show the H α emission line from the secondary

and an absorption feature from the primary. The subtracted spectra allow us to obtain the emission EW of both components. We found that the hot component presents the strongest excess H α emission.

Five spectra of this system in the Ca II H & K line region are available. Two observations taken in Feb-88 at orbital phases 0.32 and 0.55 (FFMCC) and three new observations taken in Mar-93 at orbital phases 0.07, 0.87 and 0.70 (Fig. ??). All these spectra show that both components present Ca II H and K emission. The strongest emission, always centered in the absorption, correspond to the hot component, which also presents H ϵ in emission. The weak emission blue- or red-shifted depending on the orbital phase belongs to the cool component. In the spectra at phases 0.07 and 0.32 the Ca II H of the cool component is overlapped with H ϵ emission of the hot component. The bump between the Ca II emissions in Fig. ??, (best seen in the second and the fourth panel) could arise, taken into account data given by Barden (1984), from the third component of the system.

The synthesized spectra have been constructed with a contribution of each component to the total continuum of 0.9/0.1, calculated with the radii and spectral types of the components, and in agreement with the observed spectrum.

We have not found considerable temporal or orbital phase variations of the emission.

3.1.6. AS Dra (HD 107760)

This is a double-lined spectroscopic binary composed of two main sequence stars of similar spectral type (G4V/G9V). Previous observations carried out by us (Fernández-Figueroa et al. 1986) showed that the Ca II H & K emissions arise from both components and the hot star was the more active component of the system.

Two new observations of this system taken in Mar-93 at orbital phases 0.49 and 0.85 confirm that both components are active. In the spectrum at orbital phase 0.85 (Fig. ??, lower panel) the Ca II H & K emission lines from both components are clearly seen with intensities very similar with the red component (corresponding to the hot star) being something larger than the one arising for the cool star. This difference is a little larger in the case of the Ca II H line, because the H ϵ emission line of the cool component is overlapped with the Ca II H emission of the hot component. In the observation at orbital phase 0.49 (Fig. ??, upper panel) is not possible to separate the contribution from each component, but the subtracted spectrum points out the presence of the H ϵ emission line. A synthesized spectrum has been constructed with G2V and G8V reference stars and with a relative contribution of each component of 0.66 and 0.34.

3.1.7. IL Com (HD 108102)

A double-lined spectroscopic binary with F8V+F8V spectral types. Xuefu & Huisong (1987) and Eker et al. (1995) reported strong H α absorption. Our spectrum of the H α line (Montes et al. 1995a, b) shows absorption lines from both components and the subtracted spectrum, points out an excess emission from both components with very similar EW.

We have observed this system in the Ca II H & K line region in three different epochs. Two spectra taken in Jun-85 (Fernández-Figueroa et al. 1986), two spectra taken in Feb-88 (FFMCC) and a new spectrum taken in Mar-93 (Fig. ??). In all spectra we can see Ca II H and K emissions arising from both components. We have constructed a synthesized spectrum with two F8V stars and with the same contribution to the total continuum. For this star, the Doppler shifts used have been obtained measuring the shifts of several absorption lines in the observed spectra. The Doppler shifts estimated in this way have never agreed with those extracted from the corresponding orbital phases (see our comments on this star in Fernández-Figueroa et al. 1986). Using this synthesized spectrum, we have not found a good fit with the observed spectrum. This result indicates a possible misleading spectral classification of this system.

In the subtracted spectra of Feb-88 the blue-shifted component have a little larger intensity than the red-shifted component, however, in Mar-93 we observed the opposite, and the difference between the two emissions is lower.

3.1.8. HD 131511 (HR 5553)

Single-lined spectroscopic binary classified as K2V and not included in the first edition of CABS (Strassmeier et al. 1988). Moderate Ca II H & K emission lines were noted by Heintz (1981), Basri et al. (1989) and Strassmeier et al. (1990), who also found variable H α absorption.

We present one observation of this system in the Ca II H & K line region taken in Mar-93 at orbital phase 0.75 (Fig. ??). A moderate emission, centered at the absorption line, is observed. The spectral subtraction using a K1V reference star yields a good fit in the absorption spectral lines except in the inner wing of the Ca II H & K absorption lines.

3.1.9. MS Ser (HD 143313)

Double-lined spectroscopic binary composed by two K dwarfs stars (K2V/K6V). This system presents strong Ca II H & K emission (Strassmeier et al. 1990) and the H α line in emission (Bopp et al. 1981b).

We have taken one spectrum of this system in the Ca II H & K line region in Mar-93 at orbital phase 0.16 (Fig. ??). This spectrum shows strong emission in the H & K lines and the H ϵ line also in emission. The observed

spectrum exhibits absorption lines from both components, the blue-shifted lines –which according to the orbital phase correspond to the hot component– being deeper than the red-shifted ones. This is in agreement with the calculated contribution of each component to the total continuum (0.88/0.2). On the other hand the wavelength position of the observed H & K emission lines corresponds to the more intense and blue-shifted absorption lines, therefore, we can conclude that the emission arise from the hot component of the system.

The spectral subtraction yield a satisfactory fit and the subtracted spectra allow us to obtain the emission EW of the H, K and H ϵ lines.

3.1.10. KZ And (A and B) (HD 218738)

KZ And is the component B of the visual pair ADS 16557, and is a double-lined spectroscopic binary with spectral types dK2/dK2.

This system has been observed at orbital phase 0.33 in Jul-89 (FFMCC) and at phase 0.39 in Dec-92 (Fig. ??, upper panel). Both spectra present Ca II H & K emissions from both components. In the case of K line the intensities of both emissions are nearly equal and in the H line region, three emissions are clearly seen, that is, in order of increasing wavelength: Ca II H of the primary, Ca II H of the secondary overlapped with H ϵ emission of the primary and finally the H ϵ of the secondary. We have constructed a synthesized spectrum with two K1V stars with the same contribution to the observed spectrum. The excess Ca II emission obtained are larger in the 1989 observation than in 1992.

We have also observed, (in Dec-92) the component A of the visual pair ADS 16557 (HD 218739) that is only 15" away and of spectral type G0V. This spectrum (Fig. ??, lower panel) shows a small emission in the Ca II H & K lines with an intensity of $I_{K_3}=0.38$.

3.1.11. KT Peg (HD 222317)

KT Peg is a double-lined spectroscopic binary with spectral types G5V and K6V. CABS only indicates the presence of emission in the Ca II H & K lines in this system and the behaviour of the H α line is not reported.

One spectrum of this system taken in Dec-92 at orbital phase 0.27 (Fig. ??) shows Ca II H & K emissions from both components. The stronger emission, centered at the absorption line, arise from the hot component, which is the component with the larger contribution to the continuum (0.9/0.1 according to the radii and T_{eff} of the components). The red-shifted and less intense emission corresponds to the cool component. The computed orbital velocity agrees with the observed shift. We have constructed the synthesized spectrum with two reference stars of spectral types G2V and K1V and taking into account the different contribution of both components to the

observed continuum above mentioned. The emission EW of each component have been determined in the subtracted spectrum with two Gaussian fits.

3.2. Group 2 (Active component of luminosity class IV)

3.2.1. UX Ari (HD 21242)

This double-lined spectroscopic binary (G5V/K0IV) is a well known RS CVn system and extensively studied in the literature (Carlos & Popper 1971; Bopp & Talcott 1978; Huenemoerder et al. 1989; Raveendran & Mohin 1995). Our H α observation (Montes et al. 1995a, b) shows clear H α emission above the continuum from the cool component which is superimposed to a weak absorption from the hot component.

Our spectrum in the Ca II H & K line region at phase 0.92 (Fig. ??) shows strong emission from the cool component and a weak H ϵ emission line. The spectral subtraction using G2V and G8IV as reference stars yielded a satisfactory fit if we take a relative contribution of 0.60/0.40 that is very different to that obtained with the spectral types and radii given in CABS. This result is in agreement with the observed spectrum since the emission peak, coming from the cool component, appear blue-shifted –in agreement with the orbital phase– with respect to absorption of the hotter component, which indicates that the contribution to the observed continuum of the hot component is larger than that of the cool one.

3.2.2. HU Vir (HD 106225)

HU Vir is a K0 subgiant in a close binary system with an unseen secondary component. It shows strong Ca II H & K emission and the H α line filled by emission (Bidelman 1981; Fekel et al. 1986). Strassmeier (1994a), found in this system a big, cool polar spot from Doppler imaging and two hot plages 180 $^{\circ}$ apart, from H α and Ca II H & K line-profile analysis.

We have observed this system in the Ca II H & K line region in Mar-93 at orbital phase 0.71 (Fig. ??). This spectrum shows very strong Ca II H & K emission and an important H ϵ emission line superimposed to the wide Ca II H line. The observed intensity of the emission ($I_{K_3}=2.4$) is similar to the maximum emission of the spectra reported by Strassmeier (1994a). A good fit between observed and synthesized spectra has been obtained. To deblend the contribution of the H and H ϵ lines we have used a two-Gaussian fit.

3.2.3. HD 113816 (BD-04 3419)

This system is a single-lined spectroscopic binary classified as K2IV-III and with strong Ca II H & K emission lines (Buckley et al. 1987; Strassmeier 1994b). The behaviour of the H α line is not reported in CABS.

We have taken one spectrum of this system in the Ca II H & K line region in Mar-93 at orbital phase 0.68 (Fig. ??). In spite of the lower S/N ratio of this spectrum we can see that this system presents a strong emission in the H & K lines with intensities well above the continuum at 3950 Å, but lower than reported by Strassmeier (1994b). We have not found evidence of H ϵ in emission. The synthesized spectrum has been constructed with a K1IV reference star.

3.3. Group 3 (Active component of luminosity class III)

3.3.1. 5 Cet (AP Psc, HD 352, HR 14)

Single-lined spectroscopic binary composed of a K3III star nearly filling its Roche lobe and a small hot companion best studied in the ultraviolet (Eaton & Barden 1988). Classified as \approx F/K1III by Bildelman (1981). CABS reported strong emission from the cool component, based in the photometric index S given by Middelkoop (1982). The behaviour of the H α line is not reported in CABS.

In our observation in the Ca II H & K line region taken in Dec-92 at orbital phase 0.32 (Fig. ??) we can see a weak emission centered at the absorption line that contrasts with the strong emission reported in CABS.

We have not found a satisfactory fit between the observed spectrum and the synthesized spectra constructed with a K1III reference star. This effect could be due to the lower S/N ratio of this spectrum or to the influence of the hot component to the observed spectrum.

3.3.2. BD Cet (HD 1833)

This system is a single-lined spectroscopic binary classified as K1III + F by Bildelman & MacConnell (1973). It presents Ca II H & K emission of Class B from the cool component (Bopp et al. 1983; Fekel et al. 1986) and the H α line as moderate absorption (Fekel et al. 1986).

We present here one spectrum of this system in the Ca II H & K line region taken in Dec-92 at orbital phase 0.90 (Fig. ??). This spectrum shows strong H & K emission lines centered at the absorption line. The spectral subtraction using a K1IV reference star yields a good fit.

3.3.3. ζ And (34 And, HD 4502, HR 215)

This single-lined RS CVn binary system is classified as K1 II in CABS, however, Mewe et al. (1981) give type K1 III. This system have been previously studied by us in the Ca II H & K and H α lines (FFMCC; Montes et al. 1995a).

Two observations in the Ca II H & K line region of this systems are available. One spectrum taken in Oct-1991 at orbital phase 0.29 (FFMCC) and a new spectrum taken in Dec-1992. at orbital phase 0.69 (Fig. ??). Both spectra show strong H & K emissions centered at the absorption.

We have obtain a good fit between observed and synthesized spectra. More observations of the Ca II H line of this systems can be found in Shcherbakov et al. (1995).

3.3.4. η And (38 And HD 5516, HR 271)

Double-lined spectroscopic binary composed by two G8IV-III stars, listed in the first edition of CABS (Strassmeier et al. 1988) as having weak Ca II H & K emission lines ($I_K=3$, Wilson 1976). However it is not included in the second edition of CABS due to insufficient evidence for chromospheric activity. Strassmeier & Hron (1990) reported a nondetection of Ca II H & K emission and found a normal H α absorption line. Xuefu et al. (1993) neither found any H α emission trace.

However, we have found in one spectrum in the Ca II H & K line region taken in Dec-1992 at orbital phase 0.62 (Fig. ??) a weak emission in these lines. This emission is also pointed out by application of the spectral subtraction technique.

3.3.5. AY Cet (39 Cet, HD 7672, HR 373)

AY Cet is a single-line binary composed of a spotted G5III primary and a white dwarf secondary. It presents strong Ca II H & K emission lines (Bopp 1984; Strassmeier et al. 1990), radio flares (Simon et al. 1985) and a filled in absorption H α line (Fekel et al. 1986; Strassmeier et al. 1990).

Our observation of this system in the Ca II H & K line region taken in Dec-92 at orbital phase 0.32 (Fig. ??) shows a strong emission centered at the absorption line. The observed emission intensity does not reach the surrounding continuum and it is very similar to that found by Bopp (1984). We have used a G6IV reference star to perform the spectral subtraction.

3.3.6. HD 12545 (XX Tri, BD +34 363)

HD 12545 is a single-lined spectroscopic binary of spectral type K0III and an extremely active RS CVn binary. It possess very strong Ca II H & K emission lines and the H α line in emission above the continuum (Strassmeier et al. 1990; Bopp et al. 1993) and a photometric amplitude of 0.6 mag in V, which implies that nearly half the hemisphere of the star was covered by cool spots (Bopp et al. 1993).

We have observed this system in the Ca II H & K line region in Dec-92 (Fig. ??). The orbital phase calculated with the ephemerides given by Bopp et al. (1993) is 0.55. This spectrum shows very strong H & K emissions and the H ϵ line also in emission. The emission intensity observed in our spectrum ($I_{K_3}=4.6$) is larger than the emission intensity observed by Strassmeier et al. (1990) (2-3 times that of the local continuum). The synthesized spectrum has been constructed with a reference star of spectral type K1IV obtaining a satisfactory fit. We have performed a two-Gaussian fit of the subtracted spectrum in order to

obtain the emission equivalent widths of the Ca II H and H ϵ lines.

3.3.7. 6 Tri (TZ Tri, ι Tri, HD 13480, HR 642, ADS 1697 A)

This system is the A component of the visual binary ADS 1697, and it is a double-lined spectroscopic binary classified as F5/K0III. CABS reported moderate Ca II H & K emission and the H α line in absorption.

Our spectrum in the Ca II H & K line region taken in Dec-92 at orbital phase 0.87 (Fig. ??) shows a moderate H & K emission from the cool component. The emission peaks are blue-shifted in agreement with the computed orbital velocity at orbital phase 0.87. The synthesized spectrum has been constructed with F7V and K0III reference stars and with a relative contribution of each component to the observed continuum of 0.2 and 0.8, however we have not found a satisfactory fit between observed and synthesized spectra.

We have also observed, (in Dec-92) the component B of the visual pair ADS 1697 (HD 13480B) that is only 4" distant and is another double-lined spectroscopic binary, with an orbital period of 2.236 days and spectral type F6V. This spectrum does not show appreciable emission in the Ca II H & K lines.

3.3.8. V1149 Ori (HD 37824)

A single-lined spectroscopic binary classified as K1III + F by Bidelman & MacConnell (1973), although Hirshfeld & Sinnott (1982) list this star as a G5IV. Our observation in the H α line region (Montes et al. 1995a, b) reveals a clear excess H α emission.

We have taken two spectra of this system in the Ca II H & K line region in Mar-93 at orbital phase 0.19 (Fig. ??). These spectra exhibit strong Ca II H & K emission lines with an intensity larger than observed by Bopp (1984).

The synthesized spectrum has been constructed with a G6IV as reference stars because we obtained a better fit than using a K giant star. We have also needed to use a large rotational velocity than the given in CABS to obtain a good fit between observed and synthesized spectra. The subtracted spectrum reveals that the H ϵ line is also in emission.

3.3.9. RZ Cnc (HD 73343)

This system is a double-lined eclipsing binary classified as K1III/K3-4III by Popper (1976), the cooler component filled its Roche lobe and it is in the late phase of mass transfer (Demircan 1990). Eker et al. (1995) found weak H α features from both components and concluded that both stars have filling in the H α core.

The application of the spectral subtraction to the H α line (Montes et al. 1995a, b) reveals the presence of three

emission features; two of which correspond to both components of the system with the stronger coming from the hotter star. The third emission component is blue-shifted by 3.4 Å with respect to the hotter emission component and could be related with the mass transfer from the cool component to the hot one.

We have observed this system in the Ca II H & K line region in two epochs. One spectrum taken in Feb-88 at orbital phase 0.36 (FFMCC) and a new observation taken in Mar-93 at orbital phase 0.44. Both spectra show strong emission which is normally attributed to the hotter component, since this one has the main contribution to the observed spectrum. However the spectral subtraction technique reveals that the cool component also contributes to this emission (in the spectrum at phase 0.36, Fig. ??, upper panel) and that the hot and more active star shows a small H ϵ emission line. In the spectrum at phase 0.44 (Fig. ??, lower panel) the difference in radial velocity between the components is very small and it is not possible to separate both contributions.

3.3.10. DM UMa (BD +61 1211)

DM UMa is a single-lined spectroscopic binary and one of the few RS CVn binaries which show H α emission above the continuum at all times (Mohin & Raveendran 1992, 1994; Hatzes 1995).

Our spectra in the H α line region (Montes et al. 1995a, b) show a strong and asymmetric H α emission above the continuum.

One spectrum in Ca II H & K line region, taken in Mar-93 at 0.85 orbital phase (Fig. ??, upper panel), shows a strong emission and the presence of the H ϵ line also in emission. The synthesized spectrum has been constructed with a K1IV reference star. The subtracted spectrum reveals that H ζ and H η Balmer lines appear also in emission (Fig. ??, lower panel), which indicate that DM UMa is a very active star in agreement with the H α observations.

In the subtracted spectrum we can see that the excess Ca II H & K emission line profiles present pronounced wings and are not well matches with Gaussian profiles. This result indicates the presence of a broad component in the excess Ca II H & K emission lines similar to that found by us and Hatzes (1995) in the excess H α emission.

3.3.11. DK Dra (HD 106677, HR 4665)

This is a double-lined spectroscopic binary with almost identical components of spectral type K1III and Ca II H & K emissions from both components (Bopp et al. 1979; Fekel et al. 1986; Strassmeier 1994b). Eker et al. (1995) reported a variable nature of H α and, using a subtracted spectrum, found emission of similar intensity from both components.

From one spectrum taken in the H α line region (Montes et al. 1995a, b) we found a broad excess emission feature as a result of the emission from both components.

Our observations in the Ca II H & K line region cover three observing seasons: one observation taken in Nov-86 at orbital phase 0.44 (FFMCC), three observations in Jan-88 at orbital phases 0.10 and 0.13 (FFMCC), and two new observations taken in Mar-93 at phases 0.02 and 0.05. Because our orbital phases are very near to 0.0 and 0.5, it is not possible to separate the contribution from both components. In Fig. ?? we can see that the emission line profile show small variations with the phase and, more important, time variations from Nov-86 to Mar-93.

The spectral subtraction technique points out that the spectra of Mar-93, which present the higher levels of activity, also show the H ϵ line in emission.

3.3.12. GX Lib (HD 136905)

Single-lined spectroscopic binary of spectral type K1III, previously studied by us in the Ca II H & K and H α lines (FFMCC; Montes et al. 1995a).

Two spectra taken in Jul-89 at orbital phases 0.44 and 0.36, (FFMCC) show a wide emission line at the center of the absorption line. A new observation of this system taken in Mar-93 at orbital phase 0.83 (Fig. ??, upper panel) confirms this behaviour. Small variations in the emission fluxes and in the line widths in these three spectra were observed (Fig. ??). The synthesized spectrum has been constructed with a K1IV reference star.

3.3.13. 4 UMi (HD 124547, HR 5321)

Single-lined spectroscopic binary of spectral type K3III and with a long orbital period (605.08 days). This system is listed in the first edition of CABS (Strassmeier et al. 1988) as having weak Ca II H & K emission lines ($I_K=3$, Wilson 1976). However it is not included in the second edition of CABS due to insufficient evidence for chromospheric activity in the Ca II H & K lines (Strassmeier et al. 1990) and in the H α line (Frasca & Catalano 1994). However, Xuefu et al. (1993) considered that this system is a chromospherically active star, because the H α line is filled by emission.

In our spectrum in the Ca II H & K line region taken in Mar-93 at orbital phase 0.86 (Fig. ??) we have found a weak emission in these lines. The application of the spectral subtraction technique also pointed out the presence of this weak emission in the H & K lines.

3.3.14. DR Dra (29 Dra, HD 160538)

Single-lined spectroscopic binary consisting of a hot white dwarf and a K0-2III primary (Fekel & Simon 1985). The K star is a highly asynchronous rotator and has been previously studied by us in the Ca II H & K and H α lines (FFMCC; Montes et al. 1995a).

Two observations in the Ca II H & K line region of this systems are available. One spectrum taken in Jul-89 at orbital phase 0.67 (FFMCC) and a new spectrum taken in Mar-93 at phase 0.09 (Fig. ??). Both spectra show strong H & K emissions above the continuum without considerable variation of the emission line fluxes between these two epochs. By subtracting the synthesized spectrum we found a small excess H ϵ emission.

3.4. Single chromospherically active stars

3.4.1. V2213 Oph (HD 154417, HR 6349)

This is a single star of F8.5IV-V spectral type and with a rotational period of 7.6 days, obtained from modulation of the S index (Noyes et al. 1984).

We have taken one spectrum of this system in Jul-89 which shows weak emission in the Ca II H & K lines with an intensity $I_{K_3}=0.21$ (Fig. ??). The subtraction of a F8V reference star confirms this small emission.

3.4.2. 59 Vir (HD 115383, HR 5011)

59 Vir is a single active G0V star with a 3.33 day rotational period (Noyes et al. 1984) and was also observed in the H α line by Herbig (1985).

Our spectrum in the Ca II H & K line region (Fig. ??), taken in Jul-89, shows a weak emission line ($I_{K_3}=0.31$) similar to that observed by Linsky et al. (1979). The synthesized spectrum has been constructed with a G0V reference star.

3.4.3. HN Peg (HD 206860, HR 8314)

Another G0V single star with a rotational period of 4.7 days (Noyes et al. 1984).

In our spectrum in the Ca II H & K line region, taken in Jul-89, we have found a weak but clear emission in these lines (Fig. ??) with an intensity $I_{K_3}=0.35$. The spectrum is well matched using a reference star of spectral type G0V.

3.4.4. ξ UMa A (53 UMa, HD 98231, HR 4375)

This star is the A-component of the visual binary ADS 8119 AB, whose B-component is a RS CVn system already studied by us (FFMCC). ξ UMa A, is a SB with an orbital period of 669.17 days and a G0V spectral type. Wilson (1963) noted the Ca II H & K lines in ξ UMa B, while the A component shows no detectable emission. However, Wooley et al. (1970) found a weak emission in this component.

Our spectrum of this star, in the Ca II H & K line region, taken in Jul-89, shows a very weak emission (Fig. ??), which is possible to measure using the reconstruction of the absorption line profile and the spectral subtraction technique.

3.4.5. σ^1 CrB (HD 146362, HR 6364)

σ^1 CrB is the fainter member of the visual binary ADS 9979. The brighter visual companion σ^2 CrB is a chromospherically active binary previously studied by us (FFMCC).

Our spectrum of this G1V star, in the Ca II H & K line region, taken in Feb-88, seems not to present any indication of chromospheric activity (Fig. ??), however, by subtraction of the synthesized spectrum, constructed with a G1V reference star we have found a weak emission in these lines.

3.4.6. κ^1 Cet (HD 20630, HR 996)

κ^1 Cet is a single active G5V star with a 9.4 day rotational period and extensively studied in the Ca II H & K lines in the literature (Pasquini et al. (1988), Pasquini (1992) y García López et al. (1990, 1992).

Our spectrum in the Ca II H & K line region (Fig. ??), taken in Dec-92, shows a moderate emission in these lines ($I_{K_3}=0.40$). The synthesized spectrum has been constructed with a G1V reference star.

3.4.7. ξ Boo A and B (HD 131156 A and B, HR 5544 A and B)

Visual binary (ADS 9413) composed of stars of spectral types G8V (component A) and K4V (component B) and rotational periods of 6.2 and 11.5 days, respectively (Noyes et al. 1984). ξ Boo B has the largest amplitude of chromospheric activity in the S index (2.1 to 1.2) (Baliunas et al. 1995)

We have taken individual spectra in the Ca II H & K line region of both components of this visual binary. The H & K emission lines of both components are very different. While ξ Boo A shows weak emission lines ($I_{K_3}=0.63$), ξ Boo B exhibits very strong emissions well above the nearby stellar continuum ($I_{K_3}=2.51$) and also presents the H ϵ line in emission. The spectrum of ξ Boo A is well matched using a reference star of spectral type G8IV (Fig. ??, upper panel). However for the spectrum of ξ Boo B (Fig. ??, lower panel) we have not found a satisfactory fit with the synthesized spectra constructed with a K3V reference star.

3.4.8. 61 UMa (HD 101501, HR 4496)

Single active star of spectral type G8V, which is included in the list of standards of Taylor (1984). It presents modulation of the Ca II S index and a rotational period of 17.1 days (Noyes et al. 1984).

Seven spectra of this star in the Ca II H & K line region, taken in Mar-93, are available. In these spectra (Fig. ??) we observe a weak emission ($I_{K_3}=0.30$) very similar to that observed by Linsky et al. (1979) and Strass-

meier et al. (1990). The synthesized spectrum has been constructed with a G8V reference star.

3.4.9. ϵ Eri (HD 22049, HR 1084)

ϵ Eri is a single active star classified as K2V with a rotational period of 11.3 days (Noyes et al. 1984). The Ca II H & K lines have been studied by Linsky et al. (1979), Zarro & Rodgers (1983) and García López et al. (1992).

Our spectrum in the Ca II H & K region, taken in Dec-92, shows a moderate emission ($I_{K_3}=0.80$). The spectrum is well matched using a reference star of spectral type K1V (Fig. ??).

3.4.10. HD 4628 (HR 222)

Single dwarf star classified as K4V by Noyes et al. (1984) and listed as K2V in the Bright Star Catalogue (Hoffleit & Jaschek 1982). Recently, Mathioudakis et al. (1994) reported the detection of EUV emission from this star and suggested the existence of a cool corona.

We have taken one spectrum of HD 4628 in Dec-92 which shows weak emission in the Ca II H & K lines ($I_{K_3}=0.29$). We have used a K1V reference star to perform the spectral subtraction (Fig. ??).

3.4.11. HD 115404

Another K dwarf star with a rotational period of 18.3 days (Noyes et al. 1984) and studied in the Ca II H & K region by Thatcher & Robinson (1993).

Our spectrum in the Ca II H & K line region, taken in Jul-89, shows moderate emission ($I_{K_3}=0.80$) (Fig. ??). The synthesized spectrum has been constructed with a K1V reference star.

3.4.12. ρ Boo (25 Boo, HD 127665, HR 5429)

K3 giant included in the catalog of Keenan & McNeil (1989). Observed in the Ca II H & K line region by Strassmeier et al. (1990) as a non-active chromosphere star.

We have taken one spectrum of this star in Mar-93 in the Ca II H & K line region (Fig. ??). This spectrum shows very weak emissions in these lines ($I_{K_3}=0.10$). This star has not been used as reference star.

3.4.13. 61 Cyg A and B (HD 201091 and 201092, HR 8085 and 8086)

This visual binary has components of spectral type K5V and K7V and rotational periods of 37.9 and 48.0 days, respectively (Noyes et al. 1984). Both components present Ca II H & K emission lines (Linsky et al. 1979; Strassmeier et al. 1990).

In Jul-89 we have taken spectra in the Ca II H & K line region of both components of this visual binary. The H & K emission lines of both components are different, 61

Cyg A presents an emission line with an intensity $I_{K_3}=1.1$, while 61 Cyg B exhibits very strong emissions well above the nearby stellar continuum ($I_{K_3}=2.0$). Both components show also the He line in emission, but it is more difficult to see in the B component.

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Table 1. Stellar parameters, chromospheric active binaries (Groups 1, 2 and 3)

HD	Name	T _{sp}	SB	R (R _☉)	d (pc)	V-R	P _{orb} (days)	P _{rot} (days)	Vsin <i>i</i> (km s ⁻¹)
Group 1.									
17433	VY Ari	K3-4V-IV	1	-	21	0.61	13.198	16.42	6
45088	OU Gem	K3V/K5V	2	-	12	0.82/0.99	6.9919	7.3600	5.6/5.6
-	YY Gem	dM1e/dM1e	2	0.62/	13.7	1.40/1.40	0.8142822	0.8143	40/40
80715	BF Lyn	K2V/[dK]	2	≥0.78/≥0.78	29		3.80406	≈P _{orb}	10/10
86590	DH Leo	{K0V/K7V}/K5V	3	{0.97/0.67}	32	0.64/0.90	1.070354	1.0665	{45/31}/8
107760	AS Dra	G4V/G9V	2	-	29.4	0.60	5.414905	≈P _{orb}	12/8
108102	IL Com	F8V/F8V	2	[1.1/1.1]	86	0.47/0.47	0.9620	0.8200	35/35
131511	HR 5553	K2V	1	-	11.9	0.74	125.369	-	4
143313	MS Ser	K2V/K6V	2	-	30		9.0149	9.60	-
218738	KZ And	dK2/dK2	2	≥0.74/	[≈23]	[0.74/0.74]	3.032867	3.03	12.3/11.6
222317	KT Peg	G5V/K6V	2	0.93/0.72	25		6.20199	6.092	8/5
Group 2.									
21242	UX Ari	G5V/K0IV	2	0.93/≥4.7	50	0.70/0.54	6.43791	≈P _{orb}	6/37
106225	HU Vir	K0IV	1	≥5.7	220		10.3876	10.28	25
113816	BD-04 3419	K2IV-III	1	-	165		> 20	-	6
Group 3.									
352	5 Cet	F/K1III	1	≈41	140	0.81	96.439	48.16 ^a	/22
1833	BD Cet	K1III	1	≥10	71	0.81	35.1	34.46	15
4502	ζ And	/K1III	1	≈0.7/13.4	31	0.84	17.7692	8.917 ^a	41
5516	η And	G8IV-III/G8IV-III	2	-	111	0.94	115.71	-	15
7672	AY Cet	WD/G5III	1	0.012/15	66.7		56.824	77.22	4
12545	BD+34 363	K0III	1	≥8	310		23.9824	24.3	17
13480	6 Tri	F5/K0III	2	13	75	[/0.77]	14.7339	≈P _{orb}	7/34
37824	V1149 Ori	K1III	1	≥11	[164]	0.90	53.58	54.1	11
73343	RZ Cnc	K1III/K3-4III	2	10.2/12.2	395	0.81/0.96	21.6430	≈P _{orb}	25/22
-	DM UMa	K0-1IV-III	1	≥3.8	130	0.80	7.4949	7.478	36
106677	DK Dra	K1III/K1III	2	≥13/≥13	130	0.89/0.89	64.44	63.75	10/10
124547	4 UMi	K3III	1	-	100	0.96	605.8	160.0	15
136905	GX Lib	[G-KV]/K1III	1	/≥7	[219]	0.84	11.1345	11.134	/32
160538	DR Dra	WD/K0-2III	1	0.012/≥5	87.9	[/0.81]	39.	31.5	/8

Table 2. Stellar parameters of reference stars, active single stars and active components of visual binaries.

HD	Name	T _{sp}	V-R	P _{rot} (days)	Vsin <i>i</i> (km s ⁻¹)	A/R*
F						
13480B	ADS 1697 B	F5V	0.40	2.236	-	R
120136	τ Boo	F6IV	0.42	-	10.0	R
124850	ι Vir	F6III	-	-	15.0	R
187013	17 Cyg	F7V	0.45	-	10.0	R
212754	34 Peg	F7V	0.45	-	10.0	R
216385	σ Peg	F7IV	0.45	-	10.0	R
187691	\circ Aql	F8V	0.47	-	5.0	R
142373	χ Her	F8V	0.47	-	10.0	R
194012	HR 7793	F8V	0.47	-	5.0	R
45067	HR 2313	F8V	0.47	-	< 15	R
6920	44 And	F8V	0.47	15.3	< 15	R
107213	9 Com	F8V	0.47	-	10.0	R
136202	5 Ser	F8III-IV	0.48	-	5.0	R
154417	V2213 Oph	F8.5IV-V	0.48	7.78	5.0	A
43587	HR 2251	F9V	0.49	-	5.0	R
G						
115383	59 Vir	G0V	0.50	3.33	5.0	A
152792		G0V	0.50	-	-	R
114710	β Com	G0V	0.50	12.35	10.0	R
206860	HN Peg	G0V	0.50	4.86	10.0	A
29645	HR 1489	G0V	0.50	-	< 15	R
13974	δ Tri	G0V	0.50	-	10.0	R
98231	ξ UMa A	G0V	0.50	-	< 15	A
218739	ADS 16557 A	G0V	0.50	-	-	A
13421	64 Cet	G0IV	0.50	-	< 15	R
190406	15 Sge	G1V	0.52	13.94	5.0	R
146362	σ^1 CrB	G1V	0.52	-	-	R
-	Sun	G2V	0.53	25.72	-	R
143761	ρ CrB	G2V	0.53	0.0	5.0	R
81809	HR 3750	G2V	0.53	40.20	10.0	R
9562	HR 448	G2IV	0.61	-	< 15	R
12235	112 Psc	G2IV	0.61	-	< 15	R
217014	51 Peg	G2.5IV	0.61	-	0	R
20630	κ^1 Cet	G5V	0.54	9.24	< 15	A
115617	61 Vir	G6V	0.55	-	< 15	R
190360	HR 7670	G6IV	0.62	-	-	R
182488	HR 7368	G8V	0.58	-	-	R
131156A	ξ Boo A	G8V	0.58	6.31	3	A
144287		G8V	0.58	-	-	R
101501	61 UMa	G8V	0.58	16.68	< 15	A
182572	31 Aql	G8IV	0.64	-	< 15	R
188512	β Aql	G8IV	0.64	-	15	R
158614	HR 6516	G8IV	0.64	-	-	R
K						
3651	54 Psc	K0V	0.64	48.00	-	R
50082	BD+06 1411	K0III	0.77	-	-	R
190404		K1V	0.69	-	-	A
10476	107 Psc	K1V	0.69	35.2	< 20	R
22072	HR 1085	K1IV	0.75	-	-	R
142091	κ CrB	K1IV	0.75	-	< 15	R
50843	BD+04 1506	K1III	0.81	-	-	R
22049	ϵ Eri	K2V	0.74	11.68	< 15	A
4628	HR 222	K2V	0.74	38.5	-	A
16160	HR 753	K3V	0.82	48.0	-	A
219134	HR 8832	K3V	0.82	-	-	A
115404		K3V	0.82	18.47	-	A
127665	ρ Boo	K3III	0.96	-	< 15	A
131156B	ξ Boo B	K4V	0.91	12.28	20	A
201091	61 Cyg A	K5V	0.99	35.37	10	A
201092	61 Cyg B	K7V	1.15	37.84	< 25	A

* A: Active star / R: Reference star

Table 3. Ca II H & K lines measures in the observed and subtracted spectrum (Group 1)

Name	Date	φ	E	S_H/S_C	Reconstruction of the profile				Spectral subtraction					
					EW (K)	C(K)	EW (H)	C(H)	EW (K)	I(K)	EW (H)	I(H)	EW (H ϵ)	I(H ϵ)
VY Ari	16/12/92	0.17	-	-	1.643	3.22	1.412	2.51	1.789	2.46	1.614	2.27	0.477	0.36
OU Gem	04/03/93	0.47	T	0.74/0.26	0.774	1.78	0.715	1.50	0.938	1.09	0.920	1.02	0.232	0.26
YY Gem	04/03/93	0.44	1	0.50	5.049	3.25	4.901	1.91	5.232	5.12	5.378	4.82	-	-
			2	0.50	6.033	3.74	7.613	2.61	6.209	6.32	7.104	7.11	3.199	2.04
BF Lyn	05/03/93	0.21	H	0.50	0.832	1.80	0.717	1.34	0.891	1.25	0.861	1.16	-	-
			C	0.50	0.823	1.86	0.795	1.11	0.881	1.19	0.982	1.27	0.376	0.24
DH Leo	29/01/88	0.55	H	0.94	0.864	1.14	0.788	0.92	1.075	0.93	1.111	0.94	0.268	0.18
			C	0.06	0.203	0.34	0.210	0.29	0.218	0.22	0.183	0.24	-	-
"	01/02/88	0.32	H	0.94	1.469	1.32	1.412	0.90	1.017	0.93	1.008	0.94	0.245	0.21
			C	0.06	0.446	0.40	0.160	0.22	0.243	0.30	0.276	0.30	-	-
"	05/03/93	0.07	H	0.94	0.948	1.13	0.804	0.89	1.098	0.94	0.965	0.85	0.314	0.21
			C	0.06	0.164	0.22	0.325	0.33	0.256	0.28	0.214	0.23	-	-
"	08/03/93	0.70	H	0.94	1.067	0.97	0.823	0.49	1.085	0.88	1.133	0.79	0.213	0.15
			C	0.06	0.283	0.31	0.297	0.23	0.363	0.25	0.406	0.38	-	-
"	07/03/93	0.87	H	0.94	1.052	1.18	0.753	0.57	1.038	0.83	1.074	0.85	0.240	0.19
			C	0.06	0.355	0.46	0.068	0.10	0.256	0.24	0.253	0.21	-	-
AS Dra	07/03/93	0.49	T	0.66/0.34	0.311	0.84	0.281	0.79	0.444	0.54	0.383	0.50	0.208	0.12
			H	0.66	0.174	0.48	0.205	0.53	0.267	0.30	0.272	0.31	-	-
			C	0.34	0.152	0.41	0.137	0.31	0.234	0.24	0.235	0.23	-	-
IL Com	31/01/88	*	1	0.50	0.143	0.21	0.116	0.15	0.315	0.16	0.330	0.17	-	-
			2	0.50	0.108	0.18	0.069	0.11	0.177	0.11	0.184	0.12	-	-
"	01/02/88	*	1	0.50	0.136	0.24	0.087	0.14	0.302	0.18	0.349	0.21	-	-
			2	0.50	0.111	0.19	0.056	0.22	0.181	0.14	0.180	0.14	-	-
"	05/03/93	*	1	0.50	0.115	0.19	0.072	0.11	0.183	0.14	0.154	0.12	-	-
			2	0.50	0.144	0.20	0.095	0.14	0.250	0.17	0.297	0.16	-	-
HD 131511	05/03/93	0.75	-	-	0.259	0.82	0.200	0.58	0.348	0.39	0.317	0.35	-	-
MS Ser	07/03/93	0.16	H	0.82/0.18	1.965	3.00	1.719	2.24	2.004	2.13	1.832	2.03	0.535	0.33
KZ And	07/12/89	0.33	H	0.50	0.600	1.34	0.544	1.15	0.757	1.17	0.709	1.09	-	-
			C	0.50	0.568	1.31	0.609	1.08	0.738	1.16	0.845	1.25	0.329	0.30
			H	0.50	0.631	1.56	0.625	1.49	0.734	1.07	0.631	0.92	-	-
"	15/12/92	0.39	C	0.50	0.605	1.41	0.574	1.07	0.716	1.03	0.695	0.97	0.308	0.23
KT Peg	15/12/92	0.27	H	0.90	0.184	0.62	0.141	0.44	0.243	0.30	0.192	0.24	-	-
			C	0.10	0.095	0.36	0.084	0.33	0.088	0.09	0.169	0.08	-	-

Table 4. Ca II H & K lines measures in the observed and subtracted spectrum (Group 2)

Name	Date	φ	E	S_H/S_C	Reconstruction of the profile				Spectral subtraction					
					EW (K)	C(K)	EW (H)	C(H)	EW (K)	I(K)	EW (H)	I(H)	EW (H ϵ)	I(H ϵ)
UX Ari	16/12/93	0.92	C	0.60/0.40	1.522	1.36	1.332	1.87	1.609	1.29	1.475	1.21	0.292	0.24
HU Vir	09/03/93	0.71	-	-	2.375	3.45	2.608	4.07	2.674	2.39	2.573	2.46	0.794	0.47
HD 113816	07/03/93	0.68	-	-	2.815	6.01	2.461	3.04	2.892	2.49	2.650	2.02	-	-

Table 5. Ca II H & K lines measures in the observed and subtracted spectrum (Group 3)

Name	Date	φ	E	S_H/S_C	Reconstruction of the profile				Spectral subtraction					
					EW (K)	C(K)	EW (H)	C(H)	EW (K)	I(K)	EW (H)	I(H)	EW (H ϵ)	I(H ϵ)
5 Cet	15/12/92	0.32	C	-	0.440	0.67	0.273	0.48	-	-
BD Cet	12/12/92	0.90	C	-	0.984	1.89	0.699	1.16	1.147	0.88	1.005	0.82	-	-
ζ And	24/10/91	0.29	-	-	0.715	0.98	0.568	0.74	0.945	0.58	0.916	0.56	-	-
"	12/12/92	0.69	-	-	0.784	1.39	0.636	0.87	0.980	0.66	0.957	0.61	-	-
η And	12/12/92	0.62	T	0.50/0.50	0.102	0.51	0.065	0.31	0.077	0.08	0.057	0.08	-	-
AY Cet	12/12/92	0.61	C	-	0.589	1.52	0.525	1.38	0.711	0.79	0.657	0.81	-	-
HD 12545	15/12/92	0.55	-	-	4.534	3.80	3.897	3.84	4.874	4.36	4.308	4.34	1.243	0.81
6 Tri	15/12/92	0.87	C	0.20/0.80	0.393	0.76	0.304	0.55	0.566	0.38	0.476	0.36	-	-
V1149 Ori	04/03/93	0.19	C	-	1.697	2.10	1.570	1.72	1.971	1.56	1.915	1.59	0.277	0.23
"	04/03/93	0.19	C	-	1.667	2.00	1.562	1.64	1.963	1.55	1.928	1.64	0.262	0.22
RZ Cnc	31/01/88	0.36	H	0.80	1.302	1.26	1.286	1.05	1.427	1.11	1.323	1.21	0.195	-
"	08/03/93	0.44	C	0.20	1.619	2.12	1.499	1.90	0.302	0.23	0.497	0.32	-	-
"	08/03/93	0.44	H	0.80/0.20	1.619	2.12	1.499	1.90	1.880	1.25	1.734	1.32	0.340	0.24
DM UMa	07/03/93	0.85	-	-	2.733	1.95	2.254	1.69	3.127	2.51	2.890	2.38	0.745	0.61
DK Dra	26/11/86	0.44	T	0.50/0.50	1.253	1.78	1.140	1.38	1.464	1.17	1.388	1.08	-	-
"	29/01/88	0.10	T	0.50/0.50	1.496	2.70	1.377	2.64	1.614	1.41	1.489	1.37	-	-
"	31/01/88	0.13	T	0.50/0.50	1.503	2.56	1.155	1.50	1.640	1.25	1.464	1.17	-	-
"	31/01/88	0.13	T	0.50/0.50	1.298	2.01	1.312	2.05	1.594	1.21	1.493	1.67	-	-
"	07/03/93	0.02	T	0.50/0.50	1.844	2.47	1.700	2.04	2.007	1.72	1.924	1.71	0.208	0.19
"	09/03/93	0.05	T	0.50/0.50	1.730	2.47	1.558	1.87	1.870	1.65	1.783	1.56	0.164	0.14
4 UMi	05/03/93	0.86	-	-	0.100	0.41	0.065	0.28	0.145	0.09	0.107	0.09	-	-
GX Lib	13/07/89	0.36	-	-	0.900	1.40	0.761	0.96	1.047	0.68	1.116	0.72	-	-
"	14/07/89	0.44	-	-	0.619	1.30	0.538	0.81	0.754	0.62	0.849	0.61	-	-
"	05/03/93	0.83	-	-	0.689	1.37	0.555	0.82	0.799	0.61	0.801	0.59	-	-
DR Dra	13/07/89	0.67	C	-	1.164	2.41	1.045	1.85	1.320	1.32	1.296	1.40	0.155	0.15
"	09/03/93	0.09	C	-	1.445	3.11	1.098	1.87	1.553	1.38	1.375	1.36	0.237	0.21

Table 6. Ca II H & K lines measures in the observed and subtracted spectrum (Single stars or components of visual binaries)

HD	Name	Reconstruction of the profile						Spectral subtraction					
		F(1.0 Å)		EW	C(K)	EW	C(H)	EW	I(K)	EW	I(H)	EW	I(H ϵ)
		(K)	(H)	(K)		(H)		(K)		(H)		(H ϵ)	
F													
13480 B	6 Tri B	0.226	0.251	-	-	-	-	-	-	-	-	-	-
120136	τ Boo	0.148	0.181	-	-	-	-	-	-	-	-	-	-
124850	ι Vir	0.229	0.280	-	-	-	-	-	-	-	-	-	-
187013	17 Cyg	0.116	0.139	-	-	-	-	-	-	-	-	-	-
212754	34 Peg	0.099	0.117	-	-	-	-	-	-	-	-	-	-
216385	σ Peg	0.104	0.125	-	-	-	-	-	-	-	-	-	-
187691	\omicron Aql	0.111	0.134	-	-	-	-	-	-	-	-	-	-
142373	χ Her	0.108	0.128	-	-	-	-	-	-	-	-	-	-
194012	HR 7793	0.163	0.184	-	-	-	-	-	-	-	-	-	-
45067	HR 2313	0.112	0.130	-	-	-	-	-	-	-	-	-	-
6920	44 And	0.174	0.183	-	-	-	-	-	-	-	-	-	-
107213	9 Com	0.104	0.122	-	-	-	-	-	-	-	-	-	-
136202	5 Ser	0.122	0.154	-	-	-	-	-	-	-	-	-	-
154417	HR 6349	0.199	0.230	0.049	0.25	0.051	0.23	0.112	0.11	0.164	0.10	-	-
43587	HR 2251	0.119	0.144	-	-	-	-	-	-	-	-	-	-
G													
115383	59 Vir	0.267	0.306	0.099	0.41	0.100	0.39	0.175	0.20	0.198	0.21	-	-
152792		0.111	0.132	-	-	-	-	-	-	-	-	-	-
114710	β Com	0.155	0.186	-	-	-	-	-	-	-	-	-	-
206860	HN Peg	0.280	0.297	0.110	0.49	0.101	0.40	0.262	0.24	0.254	0.23	-	-
29645	HR 1489	0.101	0.127	-	-	-	-	-	-	-	-	-	-
13974	δ Tri	0.184	0.202	-	-	-	-	-	-	-	-	-	-
98231	ξ UMa A	0.188	0.204	0.029	0.17	0.031	0.16	0.046	0.09	0.059	0.08	-	-
218739	ADS 16557 A	0.304	0.301	0.139	0.58	0.120	0.38	0.224	0.26	0.121	0.22	-	-
146362	σ^1 CrB	0.233	0.262	0.037	0.16	0.028	0.12	0.268	0.09	0.361	0.11	-	-
13421	64 Cet	0.083	0.109	-	-	-	-	-	-	-	-	-	-
"	"	0.103	0.124	-	-	-	-	-	-	-	-	-	-
190406	15 Sge	0.145	0.166	-	-	-	-	-	-	-	-	-	-
-	Sol	0.160	0.187	-	-	-	-	-	-	-	-	-	-
143761	ρ CrB	0.117	0.141	-	-	-	-	-	-	-	-	-	-
81809	HR 3750	0.139	0.151	-	-	-	-	-	-	-	-	-	-
9562	HR 448	0.095	0.127	-	-	-	-	-	-	-	-	-	-
12235	112 Psc	0.114	0.136	-	-	-	-	-	-	-	-	-	-
217014	51 Peg	0.110	0.127	-	-	-	-	-	-	-	-	-	-
20630	κ^1 Cet	0.307	0.320	0.143	0.63	0.124	0.46	0.258	0.25	0.307	0.22	-	-
115617	61 Vir	0.126	0.152	-	-	-	-	-	-	-	-	-	-
190360	HR 7670	0.105	0.130	-	-	-	-	-	-	-	-	-	-
182488	HR 7368	0.127	0.144	-	-	-	-	-	-	-	-	-	-
131156 A	ξ Boo A	0.428	0.428	0.233	0.94	0.229	0.88	0.477	0.47	0.463	0.45	-	-
144287		0.129	0.153	-	-	-	-	-	-	-	-	-	-
101501	61 UMa	0.262	0.277	0.087	0.35	0.066	0.24	0.121	0.16	0.098	0.31	-	-
182572	31 Aql	0.118	0.139	-	-	-	-	-	-	-	-	-	-
188512	β Aql	0.106	0.126	-	-	-	-	-	-	-	-	-	-
158614	HR 6516	0.127	0.169	-	-	-	-	-	-	-	-	-	-
K													
3651	54 Psc	0.109	0.122	-	-	-	-	-	-	-	-	-	-
190404		0.141	0.164	0.312	0.16	-	-	-	-	-	-	-	-
10476	107 Psc	0.130	0.155	-	-	-	-	-	-	-	-	-	-
22072	HR 1085	0.109	0.132	-	-	-	-	-	-	-	-	-	-
142091	κ CrB	0.103	0.115	-	-	-	-	-	-	-	-	-	-
22049	ϵ Eri	0.520	0.522	0.344	1.33	0.305	1.07	0.412	0.66	0.390	0.62	-	-
4628	HR 222	0.203	0.233	0.071	0.49	0.056	0.28	0.072	0.14	0.094	0.10	-	-
16160	HR 753	0.216	0.222	0.073	0.46	0.045	0.21	-	-	-	-	-	-
219134	HR8832	0.183	0.206	0.065	0.54	0.052	0.37	-	-	-	-	-	-
115404		0.474	0.489	0.289	1.41	0.270	1.01	0.323	0.58	0.311	0.57	-	-
127665	ρ Boo	0.130	0.131	0.075	0.52	0.059	0.39	-	-	-	-	-	-
131156 B	ξ Boo B	1.337	1.249	1.066	2.13	0.940	1.81	-	-	-	-	0.105	-
201091	61 Cyg A	0.659	0.655	0.453	1.93	0.381	1.38	-	-	-	-	0.041	-
201092	61 Cyg B	1.074	1.002	0.825	2.65	0.691	2.05	-	-	-	-	0.039	-