COOL STARS: CHROMOSPHERIC ACTIVITY, ROTATION, KINEMATIC AND AGE

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Abstract: We summarize here our ongoing project of multiwavelength high and medium resolution optical observations aimed at studying the chromosphere of different kinds of late-type stars including pre-main sequence stars (weak-lined T Tauri stars), chromospherically active binaries, flare stars, and young single stars members of stellar kinematic groups. We quantify the phenomenology of chromospheric activity using the information provided by several optical spectroscopic features (from the Ca II H & K to the Ca II IRT lines) that are formed at different heights in the chromosphere. In addition, we obtain a better determination of the stellar parameters, spectral type, and possible binarity. With all these information we study the flux-flux and rotation-activity relationships in order to get insights into the mechanisms which drive the solar-like stellar activity.

1 Introduction

Cool stars (stars with spectral type later than F2) have an outer differentially rotating convection zone. As in the Sun, a positive temperature gradient have been found in the outer atmosphere of these stars. Above the photosphere the temperature increases through the chromosphere (where it reaches $\approx 10^4$ K) and transition region and into the corona, where it is $\approx 10^6$ K. This heating is thought to be due to the dissipation of energy carried by magnetohydrodynamic waves, and/or from reconnection of stressed magnetic field lines, but the precise physics involved is not yet understood. It is believed that convection coupled with high stellar rotation results in a dynamo mechanism which converts the mechanical energy of rotation and convection into magnetic energy. On the one hand the rotation rate in late-type stars moderates the dynamo mechanism which generates and amplifies the magnetic field in the convection zone, but there is a further relationship between rotation and age. Rotation rate declines with age because stars lose angular momentum through the coupling of magnetic field and stellar mass loss, and thus there is an indirect trend of decreasing magnetic activity with increasing age.

The stars that are rapidly rotating by virtue of their youth or presence in a close-binary system, are orders of magnitude more active than the Sun. The observations of these extremely active stars have revealed some very non-solar-like characteristics as confined cool material at large distances, infalling matter, and high latitude magnetic flux emergence.

Our group have been working during the last years in the analysis of high and medium resolution spectroscopic observations that allow us to quantify the phenomenology of the chromospheric activity of different kinds of cool stars. We include in our studies stars with different levels of activity and rotation rate, from very young stars (pre-main sequence stars of weak-lined T Tauri type) to evolved stars in chromospherically active binaries (RS CVn type). Late-type stars members of young stellar kinematic groups (age from 20 to 600 Myr) are being also analysed. In addition, we are studying the behaviour of very frequent flares and microflares that take place in dMe dwarfs of UV Cet type (flare stars).

In the next sections we describe the methods used in our analysis, the results from our previous studies as well as the most recent results we have obtained for all these cool stars.

2 Observations

High and medium optical spectroscopic observations of different kinds of cool stars, covering the most of the spectral lines widely used as chromospheric activity indicators, have been obtained during several observing runs using different telescopes and instrumental configurations: the 2.5 m Isaac Newton Telescope (INT) with the Intermediate Dispersion Spectrograph (IDS) and the ESA-MUSICOS Echelle spectrograph, the 4.2 m William Herschel Telescope (WHT) with the Utrecht Echelle Spectrograph (UES), the 2.56 m Nordic Optical Telescope (NOT) using the Soviet Finish High Resolution Echelle Spectrograph (SOFIN) and the 3.5 m Telescopio Nazionale Galileo (TNG) using the Spectrografo di Alta Resoluzione (SARG) at the Observatorio del Roque de Los Muchachos (La Palma, Spain); the 2.2 m telescope at the German-Spanish Observatory (CAHA) in Calar Alto (Almería, Spain), using a Coudé spectrograph and the Fibre Optics Cassegrain Echelle Spectrograph (FOCES); the 2.1 m telescope using the Sandiford Cassegrain Echelle Spectrograph and the 9.2 m Hobby-Eberly Telescope (HET) with the High Resolution Spectrograph (HRS) at the McDonald Observatory (Texas, USA). The spectral resolution achieved range from 0.05 to 0.5 Å.

3 Spectroscopic analysis

3.1 Chromospheric activity indicators

The simultaneous analysis of the different optical chromospheric activity indicators using the spectral subtraction technique (see below), allow us to study in detail the chromosphere, discriminating between the different structures: plages, prominences, flares and microflares. The most relevant optical spectroscopic features that can be used as chromospheric activity indicators are:

The Ca II H & K lines: the emission reversals above these two strong absorption resonance lines (see Figure 1) are the most widely used optical indicators of chromospheric activity, since their source functions are collisionally controlled and represent an extremely important cooling mechanism.

The Ca II infrared triplet (IRT) lines: these lines share the upper levels of the Ca II H & K transitions and are formed in the lower chromosphere. The ratio of excess emission equivalent width, E_{8542}/E_{8498}, is an indicator of the type of chromospheric structure (plages, prominences) that produces the observed emission.

The Hα and other Balmer lines: these lines are formed at the middle chromosphere, but are only in emission above the continuum in very active stars, and in less active stars only a filled-in absorption line (see Figure 2) is observed. The $\mathrm{E_{H\alpha}/E_{H\beta}}$ ratio can be used as a diagnostic for discriminating between the presence of plages and prominences in the stellar surface.

The Na I D_1, D_2 and Mg I b triplet: The Na I doublet lines are collisionally dominated and are good indicators of changes in the upper photosphere and lower chromosphere. The Mg I b triplet lines originate in the same region. Both Na I and Mg I lines are detected during flares as emission reversal or as filling-in.

The He I D_3 line: it originates in the upper chromosphere and the observation of this line in emission supports the detection of flare like events. This line could be also filling-in due to frequent low-level flaring activity.

The spectral subtraction technique

We determine the chromospheric contribution in these features subtracting the underlying photospheric contribution by using the spectral subtraction technique (see [21, 22, 23, 26, 27, 34]). This technique consists of the subtraction of a synthesized stellar spectrum constructed from artificially rotationally broadened, radial-velocity shifted, and weighted spectra of inactive stars chosen to match the spectral types and luminosity classes of the components of the active system under consideration (see Figs. 1, 2, 7). The synthesized spectrum is constructed using the program STARMOD developed at Penn State [1]. The inactive stars that we have used as reference stars in the spectral subtraction have been observed during the same observing run as the active stars, or taken from our libraries of late-type stars (see [32]).

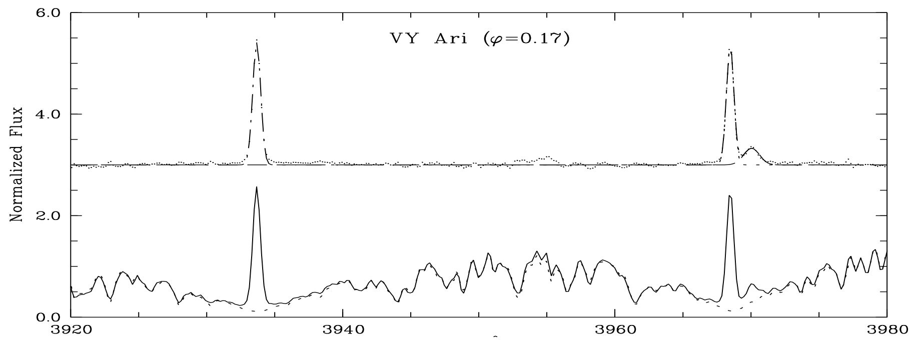

Figure 1: Ca II H & K observed and subtracted spectra of the chromospherically active binary VY Ari.

3.2 Radial and rotational velocities

Heliocentric radial velocities have been determined by using the cross-correlation technique. The spectra of the program stars were cross-correlated order by order, using the routine FXCOR in IRAF, against spectra of radial velocity standards of similar spectral types. We have used these heliocentric radial velocities together with precise measurements of proper motions and parallaxes taken from Hipparcos and Tycho-2 Catalogues, to calculate Galactic space-velocity components (U, V, W) (see [35]). In the case of binary systems [12]) we have used these radial velocities to determine the radial velocity curve and obtain a minimum χ^2 fit orbit solution (see Figure 3).

We have determined the rotational velocities ($v \sin i$) of our star sample by using the cross-correlation technique. The spectrum of the program star is cross-correlated against the spectrum of a template star (a slowly rotating star of similar spectral type) and the width of the cross-correlation function is determined (see [36, 12]). The calibration of this width, to yield an estimate of $v \sin i$, is determined by cross-correlating artificially broadened spectra of the template star for a range of $v \sin i$ with the original template star spectrum.

3.3 Age from the Li I 6708 Å line

In order to obtain an estimate of the age of our stars we have used the resonance doublet of Li I at λ6707.8 Å which is an important diagnostic of age in late-type stars, since it is destroyed easily by thermonuclear reactions in the stellar interior. The measured equivalent width of this line, EW(Li I), (corrected from the blended Fe I λ6707.41) is compared with the one of stars in well-known young open clusters of different ages (see [36]).

4 Results

4.1 WTTS, weak-lined T Tauri stars

The weak-lined T Tauri stars (WTTS) are low mass pre-main sequence stars (PMS) with Hα equivalent widths $\leq$ 10 Å in which no signs of accretion are observed. The emission spectrum of these stars is not affected by the complications of star-disk interaction which often masks the underlying absorption lines as well as extincts the stellar light in classical T Tauri stars (CTTS). The WTTS are thus ideal targets to study the behaviour of surface activity in the PMS stage of the stellar evolution. A large number of WTTS have been recently discovered by the ROSAT All-Sky Survey. Many of them have been found far away from the star formation clouds and whether these stars are really WTTS, or post TTS, or even young main sequence stars is a matter of ongoing debate.

We have started a high and medium resolution optical observational program dedicated to study the chromospheric activity of late-type pre-main sequence stars. We include in our study both bona-fide WTTS in Taurus with known rotational period, and WTTS recently discovered by the ROSAT All-Sky Survey, which have been very little studied until now. Simultaneous Hα and Ca II H & K INT/IDS spectroscopic observations of a sample of 20 bona-fide WTTS in Taurus-Auriga molecular clouds, with well determined photometric rotational periods, have been analysed [43, 38]. The results of high resolution echelle spectroscopic observations of six ROSAT discovered WTTS, located in and around the Taurus-Auriga molecular clouds, can be found in [31].

4.2 Chromospherically active binaries

The chromospherically active binaries (CABS) 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 [9].

In previous work [10, 21, 22] we have studied the Ca II H & K and Hα lines in a large sample of CABS. The activity-rotation and flux-flux relations for these systems have been analysed [21, 23, 24].

Multiwavelength optical observations of well known CABS

We analyzed, using the spectral subtraction technique, IDS/INT simultaneous Hα, Na I D_1, D_2, and He I D_3 spectroscopic observations of 18 CABS [25, 26]. High

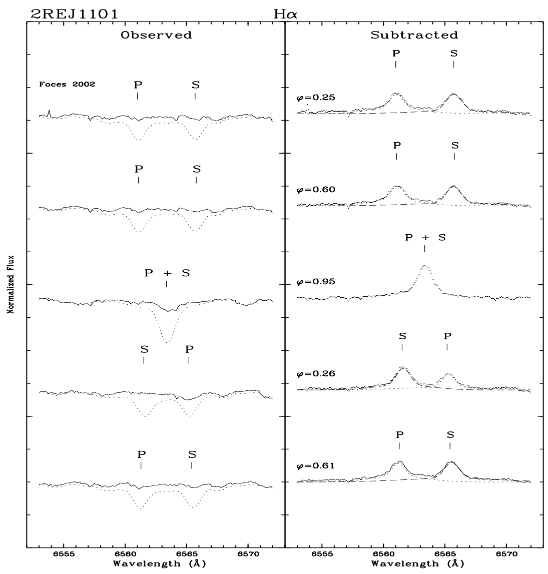

Figure 2: Spectra of 2RE J1101+223 (HD 95559) in the Hα line region. The observed spectrum (solid-line) and the synthesized spectrum (dashed-line) are plotted in the left panel and the subtracted spectrum (dotted line) in the right panel. The positions of the Hα line for the primary (P) and secondary (S) components are marked

resolution echelle spectra including all the optical chromospheric activity indicators from the Ca II H & K to Ca II IRT lines are analysed in the binary EZ Peg [27] and in other 16 CABS [34]. The subtracted Hα profile of the more active stars of the sample (Hα in emission above the continuum) has very broad wings, and is well matched using a two-components Gaussian fit (narrow and broad). The broad component is primarily responsible for the observed variations of the profile, and its contribution to the total equivalent width (EW) increases with the degree of activity. So we have interpreted this broad component emission as arising from microflaring activity that take place in the chromosphere of these very active stars (see also [28]). Prominence-like extended material has been detected in a near-eclipse Hα observation of the system AR Lac. The excess emission found in the Na I D_1 and D_2 lines by application of the spectral subtraction technique, and the behaviour of the Hα line in the corresponding simultaneous observations indicate that the filling-in of the core of these lines is a chromospheric activity indicator. In giant stars of the sample the He I D_3 line has been detected in absorption in the subtracted spectra.

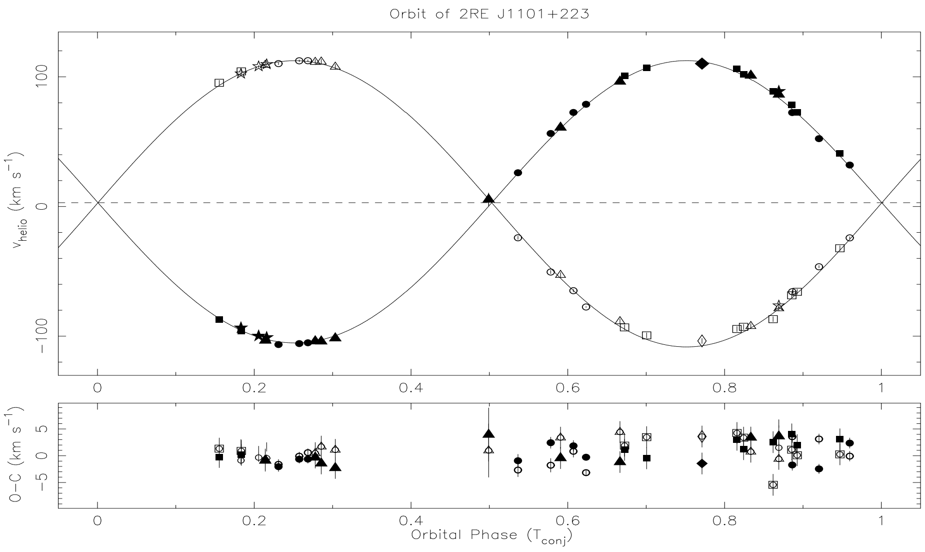

Figure 3: Radial velocity data and fit vs the orbital phase of 2RE J1101+223 (HD 95559). Solid symbols represent the primary and open symbols represent the secondary. Squares for [17], triangles for [9], rhombus for [44], and circles and stars are our data [13]

Multiwavelength optical observations of X-ray/EUV selected CABS

As an extension of our study of well known CABS we have started to observe also CABS recently discovered by their X-ray and EUV emission detected by the ROSAT satellite. We have analysed the Hα and Ca II IRT lines of the binary system 2RE J0743+224. We have found that this star, previously classified as single-lined spectroscopic binary, is a double-lined spectroscopic binary (SB2) with a K1 III primary and an orbital period of 10 days. During the observations an unusual long-duration flare took place [30]. A Li I λ6708 Å line enhancement was detected during the flare, which we suggest is produced by spallation reactions during the flare [29, 30]. Our observations during four observing runs from 1999 to 2001 of BK Psc (2RE J0039+103) [12] confirm the single-lined spectroscopic binary (SB1) nature of this system and allow us to obtain, for the first time, the orbital solution of the system as in the case of a SB2 system. The minimum masses ($Msin^3i$) resulting from the orbital solution are compatible with the observed K5V primary and an unseen M3V secondary. Both components of the binary system show high levels of chromospheric activity. Hα emission above the continuum from both components is a persistent feature of this system. Finally the SB2 binaries 2RE J0725-002 (V789 Mon) and 2RE J1101+223 (HD 95559) [13] are analysed in detail (see the Hα emission of HD 95559 in Figure 2) and an improved orbital solution has been obtained (see Figure 3).

4.3 Flare stars

Flares are events in which a large amount of energy is released in a short interval of time, taking place changes at almost all frequencies in the electromagnetic spectrum.

The first flare ever detected was discovered in the Sun on 1 September 1859 when Carrington [4] observed a large sunspot group looking at the solar photosphere. Since then, flares have been observed in many types of cool stars [42], sometimes radiating at levels several orders of magnitude more energetic than solar flares [14]. In UV Cet type stars (late Ke or Me dwarfs) optical flares are a common phenomenon. On the other hand, flares produced by more luminous stars are usually only detected through UV or X-ray observations. Flares from UV Cet type stars present the greatest analogy to solar flares, in contrast to other stellar sources (e.g. Algol type and RS CVn binary systems and pre-main sequence objects) [40, 2] whose flares have probably got more differences than similarities with respect to the solar case. Even though flares of UV Cet type stars present many analogies with solar flares, there are also significant differences, such as the amount of energy released [41]. The question is: are these differences only due to the different physical conditions of the atmosphere of these stars and the solar one, or are the environments so different that even the basic flare mechanisms may be different?

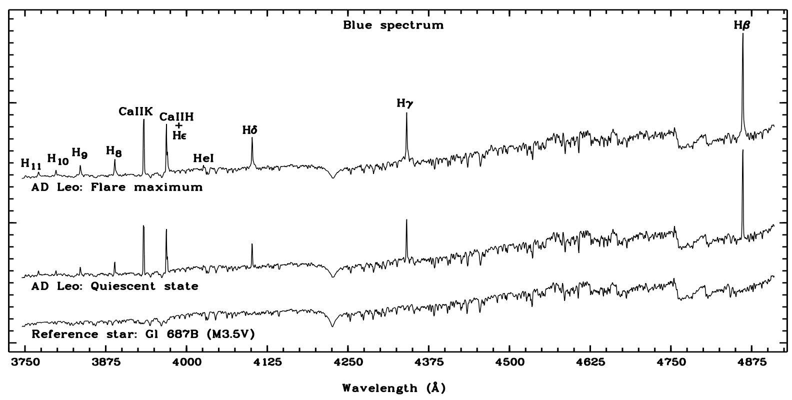

Figure 4: Flare and quiescent spectra of AD Leo, compared with the spectrum of the reference star Gl 687B (M3.5V).

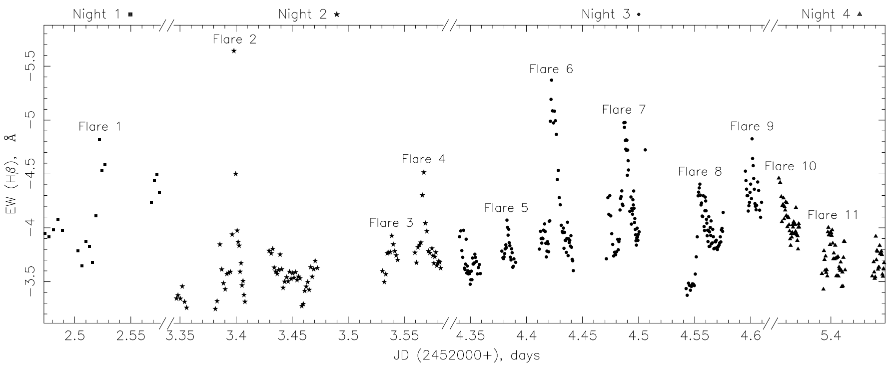

Figure 5: EW($H\beta$) of AD Leo versus time (JD) (MUSICOS 2001 observing run).

As in the Sun, stellar flares are believed to result from the release of free magnetic energy stored in the corona due to reconnection of magnetic field lines [11, 16]. Generally, there are two different kinds of flares [39]: *confined flares*, in which loops in an active region suddenly brighten and slowly decay, and *eruptive flares*, in which the whole configuration of magnetic loops is disrupted and must be newly rebuilt. In eruptive flares the originally closed magnetic field suddenly opens, flowing plasma upward to the corona [18]. Then, magnetic pressure begins to prevail, leading to sequential reconnections of the open field lines which create new loops. The reconnection process produces intense heating which is conducted downwards to the chromosphere and it also accelerates particles that flow along the loop. Then, the gas at the chromospheric loop footpoints is strongly heated and evaporated, making it visible in X-rays and high-temperature lines [3]. Afterwards, the loop cools, making it visible at higher wavelengths. Meanwhile, other new loops are formed above it. The problem concerning the energy release and the overall spectral distribution in stellar flares has recently been discussed in view of new theoretical models and multi-line observations, but the exact physical mechanisms involved in flares remain poorly understood.

High spectroscopic resolution observations of different flare stars

In our previous work high resolution spectroscopic observations of several flare events have been analysed in different kinds of active stars. In the RS CVn systems UX Ari and II Peg flares have been detected in the Hα, Na I D_1 & D_2 and He I D_3 lines [25, 26]. A long-duration (>8 days) optical flare has been found in the recently discovered, X-ray/EUV selected, chromospherically active binary 2RE J0743+224 [29]. During this flare we have also detected a Li I λ6708 Å line enhancement probably produced by spallation reactions during the flare. We have analysed high resolution optical echelle spectra and IUE observations during a strong flare on 22 December 1993 in the very active, young, fast rotator, single K2 dwarf LQ Hya [33]. We have estimated the total energy of this flare, and discussed the broad components, asymmetries, and Doppler shifts seen in some of the emission lines. During the MUSICOS (MUlti-SIte COntinuous Spectroscopy) 1998 campaign we have observed almost continuously the RS CVn system HR 1099 for more than 3 weeks in which two flares were monitored [15].

High temporal resolution observations of Me dwarfs

The purpose of our present work is to study dMe flare stars with high temporal resolution to analyse the evolution of the observed emission lines, that are formed from the upper photosphere to the upper chromosphere, during the different phases of the detected flares. Results will be used to test different flare models. We have already studied in detail the dM3.5e flare stars AD Leo and V1054 Oph [37, 5, 6]. Both stars were monitored with high temporal resolution during the MUSICOS 2001 observing run (2–5 April 2001) using the Isaac Newton Telescope (INT) of the El Roque de Los Muchachos Observatory (La Palma, Spain). We have not detected strong flares (see e.g. Figure 4, where the spectrum of AD Leo in the maximum of the strongest flare has been plotted in comparison to its quiescent spectrum and the one of the reference star Gl 687B) but we have found interesting short and weak variations with properties very similar to flares (microflares) that are produced with high temporal frequency (see e.g. Figure 5, where the detected flares of AD Leo have been identified). These flares last from 14±1 to 31±3 min in the case of AD Leo and from 21±2 to 96±6 min in V1054 Oph. The *EW* rise of the Balmer lines is larger

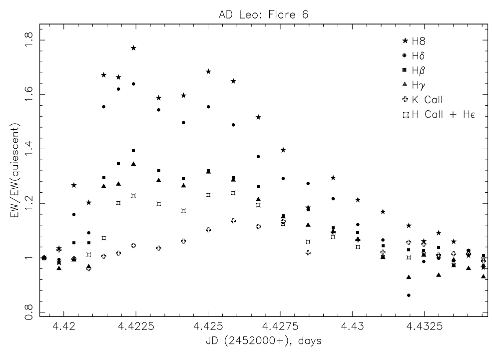

Figure 6: EW ratio (relative to the quiescent state) of different lines during the best monitored flare of AD Leo in our observations.

at shorter wavelengths (e.g. Figure 6), but their temporal evolution is quite similar. It also seems that the Ca II H & K lines are less affected by flares, suffering a lower increase than the Hydrogen lines and reaching the maximum at a different time. The Balmer lines show a red-asymmetry that becomes larger in the flare maxima (despite the broadening of the blue wing during flares).

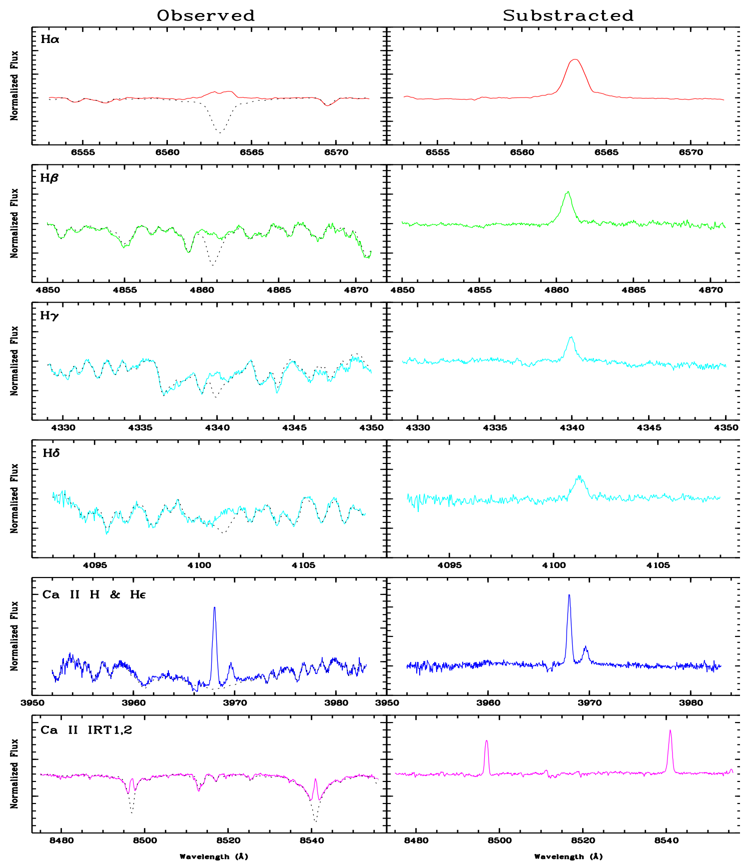

Figure 7: Representative spectra of PW And in the quiescent state in several chromospheric activity indicators.

4.4 Cool stars in young moving groups

Moving groups (MG) are kinematic coherent groups of stars [7] that could share a common origin. In our previous work [35] we have compiled a sample of late-type stars possible members of the youngest and best documented MG: Local Association or Pleiades moving group (20 to 150 Myr); IC 2391 supercluster (35-55 Myr); Castor moving group (200 Myr); Ursa Mayor group or Sirius supercluster (300 Myr); and Hyades supercluster (600 Myr). These stars have been selected from previously established members of MG based on photometric and kinematic properties, as well as from new candidates based on other criteria as their level of chromospheric activity, rotation rate and lithium abundance.

In order to better establish the membership of these candidate stars in the different young MG we have started a program of high resolution echelle spectroscopic observations [36, 20]. The spectroscopic analysis of these stars allow us to obtain a better determination of their radial velocity, lithium (λ6707.8 Å line) EW, rotational velocity and level of chromospheric activity. The high resolution spectroscopic observations (150 stars until now) were taken during 12 observing runs from 1999 to 2002. Our results confirm the membership of several previously established members, but in other cases the kinematic and spectroscopic criteria indicate the membership in a different MG or that the star should be considered only as a young disk star with no clear membership in any MG. Some new spectroscopic binaries have been identified. The rotational modulation of the photospheric and chromospheric activity of the young, single K2-dwarf PW And (member of the Local Association) has been analysed in detail [19].

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References

[1] Barden, S. C. 1985, ApJ, 295, 162

[2] Byrne P. B. 1989, Solar Physics, 121, 61

[3] Cargill P. J., Priest, E. R. 1983, ApJ, 266, 383

[4] Carrington, R. C. 1859, MNRAS, 20, 13

[5] Crespo-Chacón, I., Montes, D., López-Santiago, J. et al. 2003, in: *Highlights of Spanish Astrophysics III*, Kluwer Academic Publishers, 468

[6] Crespo-Chacón, I., Montes, D., Fernández-Figueroa, M.J., et al. 2004, Astr. & Sp. Sc., 291, Vols 1-4

[7] Eggen, O. J. 1994, *Galactic and Solar System Optical Astrometry*, Cambridge University Press, 191
[8] Fekel, F. C., Boop, B. W., Africano, J. L., et al. 1986, AJ, 92, 1150
[9] Fekel, F. C., Gregory, W. H. 2000, ApJ, 120, 3265
[10] Fernández-Figueroa, M.J., Montes, D., De Castro, E., Cornide, M. 1994, ApJSS, 90, 433
[11] Foing, B. H. 1989, Solar Physics, 121, 117
[12] Gálvez, M.C., Montes, D., Fernández-Figueroa, M.J., et al. 2002, A&A, 389, 524
[13] Gálvez, M.C., Montes, D., Fernández-Figueroa, M.J., et al. 2004, A&A, in press
[14] García-Alvarez, D., Jevremović, D., Doyle, J. G., Butler, C. J. 2002, A&A, 383, 548
[15] García-Alvarez, D., Foing, B., Montes, D., et al. 2003, A&A, 397, 285
[16] Haisch, B., Strong, K.T., Rodonò, M. 1991, ARA&A, 29, 275
[17] Jeffries, R. D., Bertram, D., Spurgeon, B. R. 1995, MNRAS, 276, 397
[18] Kopp, R. A., Pnewman, G. W. 1976, Solar Physics, 50, 85
[19] López-Santiago, J., Montes, D., Fernández-Figueroa, M. J., Ramsey, L.W. 2003, A&A, 411, 489
[20] López-Santiago, J., Montes, D., et al. 2004, A&A(in press)
[21] Montes, D., Fernández-Figueroa, M.J., De Castro, E., Cornide, M. 1995, A&A, 294, 165
[22] Montes D., Fernández-Figueroa M.J., De Castro E., Cornide, M. 1995, A&A, 109, 135
[23] Montes, D., De Castro, E., Fernández-Figueroa, M.J., Cornide M. 1995, A&ASS, 114, 287,
[24] Montes, D., Fernández-Figueroa, M.J., Cornide, M., De Castro, E. 1996, A&A, 312, 221
[25] Montes, D., Sanz-Forcada, J., Fernández-Figueroa, M.J., Lorente, R. 1996, A&A, 310, L29
[26] Montes, D., Fernández-Figueroa, M. J., de Castro, E., Sanz-Forcada J. 1997, A&A, 125, 263
[27] Montes, D., Sanz-Forcada J., Fernández-Figueroa M.J., et al. 1998, A&A, 330, 155
[28] Montes, D., Fernández-Figueroa, M.J., De Castro, E., et al. 1998, ASP Conf. Ser. 154, CD-1516
[29] Montes, D., Ramsey, L. W., A&A, 340, L5
[30] Montes, D., Ramsey, L. W. 1999, ASP Conf. Ser. , 158, p. 226
[31] Montes, D., Ramsey, L. W. 1999, ASP Conf. Ser., 158, p. 302
[32] Montes, D. 1999, A&ASS, 263, 275 (http://www.ucm.es/info/Astrof/spectra.html)
[33] Montes, D., Saar, S. H., Collier-Cameron, A., Unruh, Y. C. 1999, MNRAS, 305, 45
[34] Montes, D., Fernández-Figueroa, M.J., De Castro, E., et al. 2000, A&ASS, 146, 103

[35] Montes, D., López-Santiago, J., Gálvez, M. C., et al., MNRAS, 328, 45
[36] Montes, D., López-Santiago, J., Fernández-Figueroa, M. J., et al. 2001, A&A, 379, 976
[37] Montes, D., Crespo-Chacón, I., Fernández-Figueroa, M.J., et al. 2004, in: *Proceedings of the IAU Symp.219* (A. Dupree & A. Benz eds.), in press
[38] Montes, D., Miranda, L.F. 2004, A&A, (in preparation)
[39] Pallavicini, R., Serio, S., Vaiana, G. S. 1977, ApJ, 216, 108
[40] Pallavicini, R., Tagliaferri, G. 1989, in: *Solar and Stellar Flares* (B. M. Haisch & M. Rodonò eds.), 17
[41] Pallavicini, R. 1990, IAU Symp.142, 77
[42] Pettersen, B. R. 1989, Solar Physics, 121, 299
[43] Poncet, A., Montes, D., et al. 1998, ASP Conf. Ser., 154, CD-1772
[44] Strassmeier, K., Washuettl, A., Granzer, T., et al. 2000, A&ASS, 142, 275