FLARE STARS AMONG K DWARFS MEMBERS OF YOUNG STELLAR KINEMATIC GROUPS

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Abstract

During the last years (1999 - 2004), our group has been studying the spectroscopic properties of a large sample of stars members of the young stellar kinematic groups: Local Association (Pleiades moving group, 20 - 150 Myr), IC 2391 supercluster (35 Myr), Ursa Major group (Sirius supercluster, 300 Myr), Hyades supercluster (600 Myr) and Castor moving group (200 Myr). The high resolution spectroscopic observations used in this study allow us to better determine radial velocities, chromospheric activity and lithium abundance of these objects. The chromospheric activity level of these stars has been analysed using the information provided for several optical spectroscopic features (from the Ca II H & K to Ca II IRT lines). Here we report the detection of flare and flare-like events in some of the K dwarfs of the sample such as PW And, BD+17 232, BD+20 1790, DK Leo, and FP Cnc.

Key words: Stars: Chromospheres – Stars: Flares – Stars: Activity

1. Introduction

Stellar kinematic groups (SKG), (Superclusters (SC) and Moving groups (MG)) are kinematic coherent groups of stars (Eggen 1994) that could share a common origin. In our previous work (Montes et al. 2001a) we have compiled a sample of late-type stars possible members of the youngest and best documented MG: Local Association (Pleiades moving group, 20 - 150 Myrs), IC 2391 supercluster (35 Myrs), Castor moving group (200 Myrs), Ursa Major group (Sirius supercluster, 300 Myrs) Hyades supercluster (600 Myrs).

1.1. Spectroscopic survey

Stars have been selected from previously established members of SKG 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 Fig. 1 we represent the Galactic coordinates (l, b) for this sample of stars. In order to better establish the membership of these candidate stars in the different young SKG we have carried out a program of high resolution echelle spectroscopic observations.

The spectroscopic analysis of these stars allow us to obtain a better determination of their radial velocity, lithium (λ6707.8 Å line) equivalent width, rotational velocity and the level of chromospheric activity. We will use all these new data to study in detail the kinematic (Galactic space motion (U, V, W)) of these stars, apply age-dating methods for late-type stars, and in this way analyse in more detail the membership of these stars in the different SKG. For more details and results of this survey see Montes et al. (2001b, 2003), López- Santiago et al. (2004).

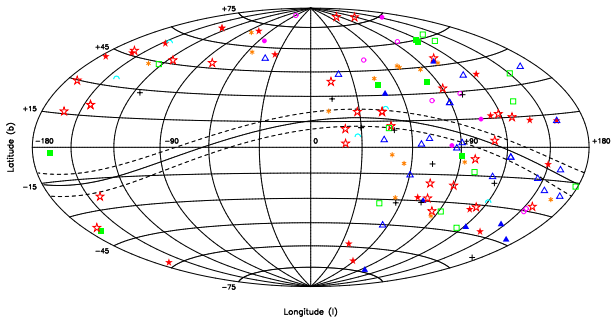

Figure 1. Galactic coordinates (l, b) for the stars of the sample

1.2. Flare stars

Flares are believed to result from the release of magnetic energy stored in the corona through reconnection. Many types of cool stars produce flares, sometimes at levels several orders of magnitude more energetic than their solar counterparts. In the dMe stars (or UV Cet type stars) optical flares are a common phenomenon (see contribution by Crespo-Chacón et al. in this book). In more luminous stars, flares are usually only detected through UV or X-ray observations, although optical flares have been detected in young early K dwarfs like LQ Hya (Montes et al. 1999) and PW And (López-Santiago et al. 2003). Here we report the detection of optical flares in several K dwarfs included in our high resolution spectroscopic survey of late-type stars member of young moving groups.

Table 1. Observing runs carried out from 1999 to 2002.

Id.	Date	Telescope	Instrument	CCD chip	Spectral range (Å)	orders	dispersion (Å)	FWHM (Å)
1	24-29 07/1999	2.2m[a]	FOCES[1]	2048x2048 15μm LORAL#11	3910 - 9075	84	0.03 - 0.07	0.09 - 0.15
2	26-27 11/1999	NOT[b]	SOFIN[2]	1152x770 EEV P88200	3525 - 10425	44	0.06 - 0.17	0.14 - 0.32
3	18-22 01/2000	INT[c]	MUSICOS[3]	1024x1024 24μm TEK5	4430 - 10225	73	0.07 - 0.15	0.16 - 0.30
4	05-11 08/2000	INT[c]	MUSICOS[3]	1024x1024 24μm TEK5	4430 - 10225	73	0.07 - 0.15	0.16 - 0.30
5	10-13 11/2000	NOT[b]	SOFIN[2]	1152x770 EEV P88200	3525 - 10425	44	0.06 - 0.17	0.14 - 0.32
6	02-05 04/2001	INT[c]	IDS[4]	2148x4200 13.5μm EEV10a	3554 - 7137	1	0.48	1.22
7	21-24 09/2001	2.2m[a]	FOCES[1]	2048x2048 24μm Site#1d	3510 - 10700	112	0.04 - 0.13	0.08 - 0.35
8	10-11 10/2001	TNG[d]	SARG[5]	2(2048x4096) 13.5μm EEV 4280	4960 - 10110	62	0.02 - 0.04	0.08 - 0.17
9	19 12/2001 - 28 02/2002	HET[e]	HRS[6]	2(2048x4096) 15μm Marconi	5040 - 8775	52	0.06 - 0.11	0.15 - 0.28
10	22-25 04/2002	2.2m[a]	FOCES[1]	2048x2048 24μm Site#1d	3510 - 10700	112	0.04 - 0.13	0.08 - 0.35
11	01-06 07/2002	2.2m[a]	FOCES[1]	2048x2048 24μm Site#1d	3510 - 10700	112	0.04 - 0.13	0.08 - 0.35
12	21-29 08/2002	NOT[b]	SOFIN[2]	2048x2048 2K3EB PISKUNOV1	3525 - 10200	42	0.02 - 0.05	0.05 - 0.15

[a] 2.2 m telescope at German Spanish Astronomical Observatory (CAHA) (Almería, Spain). [b] 2.56 m Nordic Optical Telescope (NOT) at Observatorio del Roque de los Muchachos (La Palma, Spain). [c] 2.5 m Isaac Newton Telescope (INT) at Observatorio del Roque de los Muchachos (La Palma, Spain). [d] 3.5 m Telescopio Nazionale Galileo (TNG) at Observatorio del Roque de los Muchachos (La Palma, Spain). [e] 9.2 m Hobby-Everly Telescope (HET) at McDonald Observatory (Texas, USA).

[1] FOCES: Fiber Optics Cassegrain Echelle Spectrograph. [2] SOFIN: Soviet Finnish High Resolution Echelle Spectrograph. [3] MUSICOS: spectrograph developed as part of MUlti-SIte COntinuous Spectroscopy project. [4] IDS: Intermediate Dispersion Spectrograph. [5] SARG: Spectrografo di Alta Resoluzione Galileo. [6] HRS: High Resolution Spectrograph.

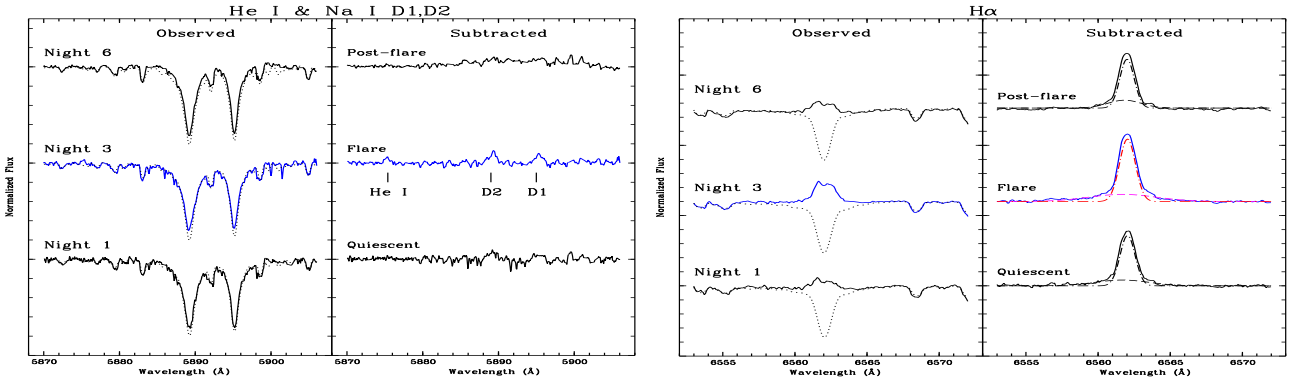

Figure 2. Observed and synthetic spectra (left panel) and subtracted (observed - shyntetic) spectra (right panel) of PW and in the HeI D_3; NaI D_1, D_2; and Hα lines during the HET-HRS 2001/12 observing run

2. Observations

The spectroscopic observations (high resolution echelle spectra) of the stars analysed in this work were obtained during twelve observing runs (from 1999 to 2002). In Table 1 we give the details of the observations: date, telescope, spectrograph, CCD chip, spectral range covered, number of orders included in each echelle spectrum, range of reciprocal dispersion and range of spectral resolution, determined as the full width at half maximum (FWHM) of the arc comparison lines. We have used similar high resolution (resolving power, $\lambda/\Delta\lambda$, ranging from 30000 to 60000 at 6500 Å) echelle spectrographs in all cases except in observing run 6 where a few stars have been observed with the Intermediate Dispersion Spectrograph (IDS).

The spectra have been extracted using the standard reduction procedures in the IRAF package (bias subtraction, flat-field division and optimal extraction of the spectra). The wavelength calibration was obtained by taking spectra of a Th-Ar lamp. Finally, the spectra were normalized by a polynomial fit to the observed continuum.

3. Individual results

3.1. PW And

This K2 dwarf is a young single star member of the Local Association (see López-Santiago et al. 2003). We have observed this star during nine different observing runs from 1999 to 2002. The spectra at different epoch always show strong emission in Hα, CaII H&K and CaII IRT lines, and excess emission in the other Balmer lines in the subtracted spectra.

During three of these observing runs we have detected variations from one day to the other in the optical chromospheric lines typical of flare like events (increase of the

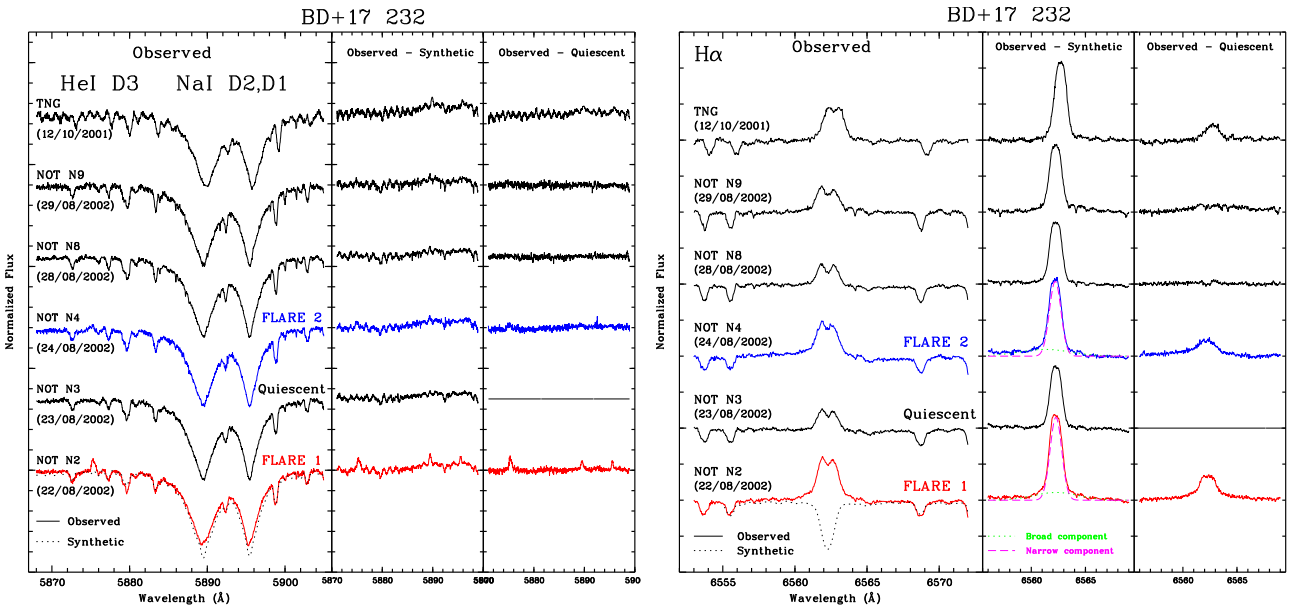

Figure 3. Observed and synthetic spectra (left panel), subtracted (observed - shyntetic) spectra (central panel) and the observed - quiescent spectra (right panel) of BD +17 232 in the HeI D_3; NaI D_1, D_2; and Hα lines during the NOT-2002 observing run

Balmer emission lines broad emission components, HeI D_3 goes in emission, etc.). The more energetic flare was detected during the HET-HRS 2001/12 observing run (see Fig. 2).

3.2. BD +17 232

BD +17 232 is a young single star of spectral type K3Ve and member of the Local Association. We have observed this star at two different epochs. During the NOT-2002 observing run two flares have been detected (see Fig. 3). In the spectrum taken during the TNG-2001 observing run the chromospheric emission is larger than the quiescent state in 2002 but the HeI D_3 is not in emission and we have not classified it as a flare.

FLARE 1: took place during the night 2 of the NOT-2002 run. The EW(Hα) increase in a factor of 1.8. The Hβ line change from complete filled-in absorption line to emission, the HeI D_3 is in emission and a filled-in is detected in the NaI D_1, D_2 lines (see Fig. 3).

FLARE 2: This flare of lower energy that took place during the night 4 of the same observing run. In this case the EW(Hα) changes in a factor 1.4 and the emission in HeI D_3 is smaller.

3.3. BD +20 1790 (2RE J0723+20)

This is a single young star of spectral type K5Ve member of the Local Association. It is a very active star with the Hα and other Balmer lines always in emission and with a variable and asymmetric self-reversal. During our observations in April 2002 we have detected a clear flare event in the night 3 of the observing run (see Fig. 4). In this flare the EW(Hα) increase in a factor of 1.4 and a notable change is also observed in the Hβ and HeI D_3 emission lines. The decay of another strong flare is also observed in other observations (April 2004) of this star.

3.4. DK Leo (GJ 2079)

DK Leo is another member of the Local Association of spectral type K7V. This star shows the Hα line always in emission and it is a known flare star (see the superposition of strong flares and variations at shorter temporal scales we have detected with high temporal resolution spectroscopy, Crespo-Chacón et al. 2004). During our high resolution spectroscopic observations in April 2002 (see Fig. 5) a small flare event has been detected with a change in the EW(Hα) of a factor 1.1, and a small increase of the HeI D_3 line.

3.5. FP Cnc (GJ 1108 A)

FP Cnc is a K5V member of the Local Association. It is a known flare star with strong Hα emission. A low energy flare (or the decay of a strong flare) is detected in our observations in April 2002. The EW(Hα) increase in a factor of 1.1 and the HeI D_3 is clearly in emission (see Fig. 6).

Acknowledgements

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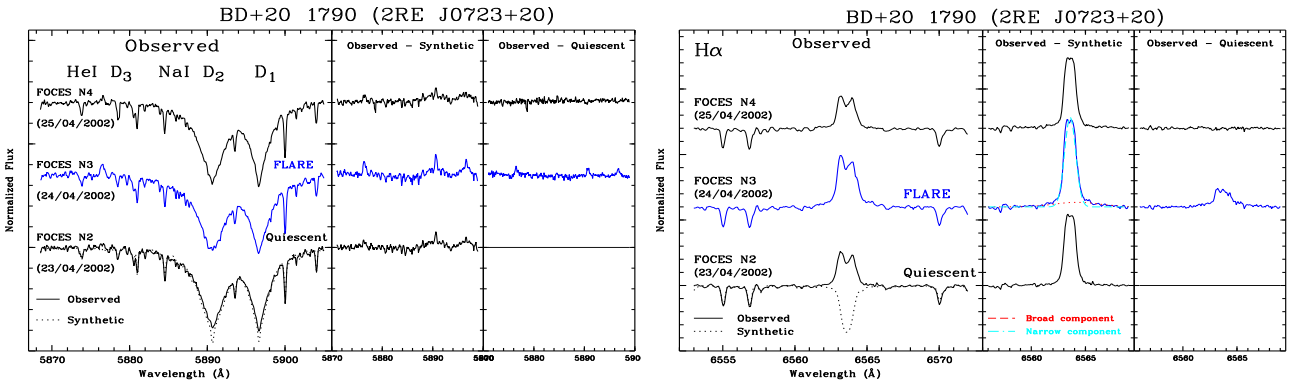

Figure 4. As Fig. 2 for BD +20 1790 during the FOCES-2002/04 observing run

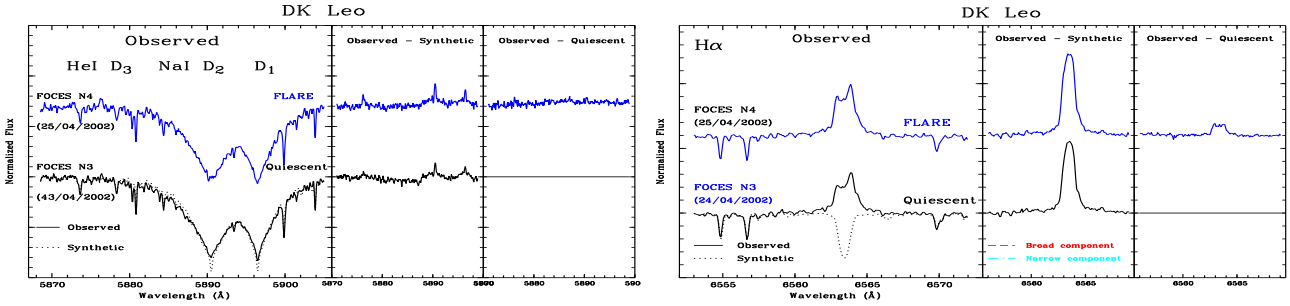

Figure 5. As Fig. 2 for DK Leo during the FOCES-2002/04 observing run

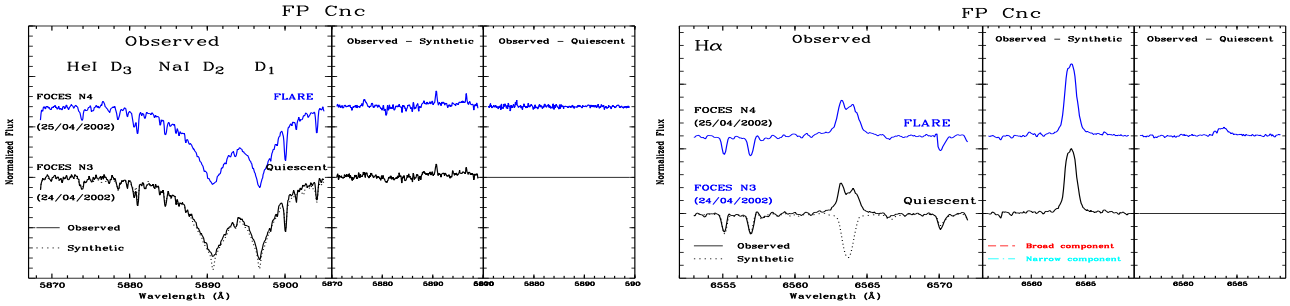

Figure 6. As Fig. 2 for FP Cnc during the FOCES-2002/04 observing run

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