
Active regions in a sample of late-type rotator stars: spectroscopic analysis

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Summary. High-resolution spectral and temporal echelle observations of late-type rapid rotator stars have been carried out along several runs using: SOFIN spectrograph at 2.56m Nordic Optical Telescope (NOT, La Palma), FOCES spectrograph in 2.2m Telescope at Calar Alto Observatory and SARG spectrograph at 3.58m Telescopio Nazionale Galileo (TNG, La Palma).

The detailed analysis of spectra with high S/N can be used to detect the presence of active regions in different layers: spots on photosphere, plages and prominences on chromosphere and flares. In essence we search temporal variations on equivalent width and profile line asymmetry of different magnetic indicators (mainly H α (6562.9 Å) and H β (4861 Å)). Heliocentric radial velocity variations have been also determined.

In this contribution the applied method and main results are presented for BD+20 1790 .

1 An overview of BD+201790

Stellar parameters of BD+201790 are not well known. The rotational and photometric periods are very much uncertain, the photometry is incomplete and there is not a preliminary spectroscopic study to typify the chromospheric and photospheric activity.

BD +20 1790 was classified by Jeffries [4] as a KVe star with V=9.9. Montes [9] and López-Santiago [6] proposed its membership in the Local Association moving group.

We have detected strong chromospheric activity in several observing runs (Hernán-Obispo [5]). In spite of the fact that BD+201790 rotational velocity is not very high (~ 10 km/s), the H α and H β emission lines are very strong which can allow us to study the existence of chromospheric structures like plages or prominences. We present the study of chromospheric and photospheric activity as an example of the working method for all of the stars of the sample.

2 Chromospheric activity

We study the H α line variation to infer the kind of structure present in the chromosphere. The chromospheric contribution has been determined using the spectral subtraction technique with STARMOD developed at Penn State University [1]. In order to control the errors and minimize the uncertainties of the subtracted spectra some routines of the astronomical data reduction package REDUCEME, developed at Universidad Complutense de Madrid [2] has been used. Prominence-like clouds can be detected as transient absorption features moving across the H α line profile. To study asymmetry variations in the profile line we have used the bisectors technique, by determining a bisector for each profile line [5]. Any feature moving across the H α profile must disturb the bisector. Variations in the asymmetry are related with the presence of transient of prominences. To quantify the changes in the bisector, the difference from the average values at the top and the bottom zones of bisector, $\Delta\lambda_{bis}$ were used. Two completed transient could be detected in different observing runs: NOT03B and TNG04B. They are marked in Fig. 1 (left) and Fig. 1 (right) with a dashed ellipse. The time of the transient was about ~ 2 h in both cases, smaller than rotational period, and in agreement with typical transient times. So we concluded that the feature we are detecting it is not a superficial feature.

3 Photospheric activity

Heliocentric radial velocities were determined using the cross-correlation technique. The spectra of the star were correlated order by order, against spectra of several radial velocity standards. Orders with chromospheric features and telluric lines were excluded of the correlation. The radial velocities (RV) calculated for each order were weighted by their errors. Every point in the Fig. 2 (left) represents an observation of these star. Differences up to ~ 1 km/s are detected. These variations are larger than the individual measurement error (~ 0.10 km/s).

The RV variations induced by stellar activity are due to changes in the profile of spectral lines caused by the presence of spots [11]. The relationship of bisectors of the cross-correlation function and RV is a powerful method to discriminate if the RV variation may be due stellar activity or light contamination from an unseen stellar companion or mechanical motion around the barycentre of a star-planet system [10], [7].

The cross-correlation function (CCF) determined was limited to regions ranging from 6300 to 6465 Å and 6670 to 6760 Å, which includes lines commonly used in Doppler imaging. The bisector of CCF was calculated. To quantify the changes in the CCF bisector, was determined the difference of the average values of the top and the bottom zones of bisector, $\Delta\lambda_{bis}$. [3], [6].

If a correlation appears between RV and $\Delta\lambda_{bis}$, with negative slope, the variations in RV may be due to stellar activity, like spots. A lack of correlation supports the mechanical nature of RV variations. The case of BD +201790, for the TNG04B run is presented in Fig. 2 (right).

Due to the high chromospheric activity of the star a high photospheric activity was expected, but the lack of correlation indicates us that the RV variations are not due to variations in the asymmetry of the photospheric profile lines. The presence of a sub-stellar companion may be an explanation. In any case more observations and the use of another techniques, like Doppler Imaging, are necessary to study photospheric activity.

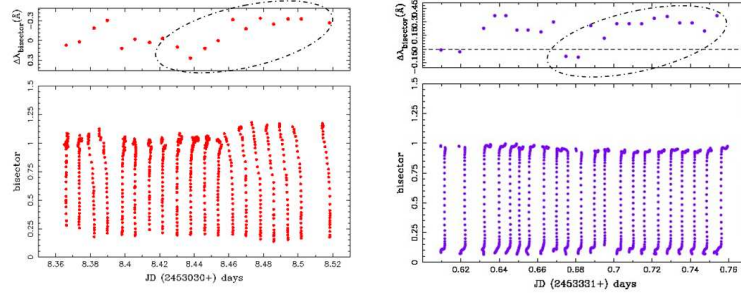


Fig. 1. Bisector of the subtracted spectra of H α line. **Left:** 02/02/2004. **Right:** 22/11/2004

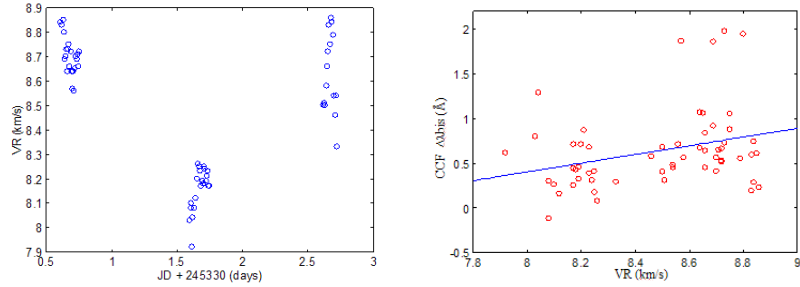


Fig. 2. **Left:** Radial velocities for TNG04B run. **Right:** RV vs. $\Delta\lambda_{bis}$ for TNG04B run and the best fit to a linear regression. The linear Pearson correlation coefficient is $r=0.3041$

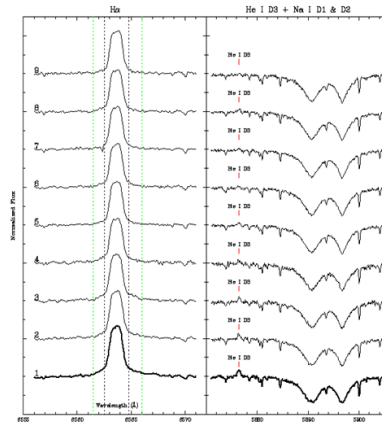


Fig. 3. Sequence of consecutive H α (left) and He I D_3 (right) line profile FOCES 04A

4 Flare event

In FOCES 04A and TNG04B run flare event was observed. Fig. 3 shows the sequence of consecutive (down to up) line profiles of H α and He I D_3 and gradual decay of the flare for the FOCES 04A run. The flare maximum is marked with bold line. Minimum H α width is marked with black spotted line and maximum width is marked with green spotted line. Every observation has a time of integration of 10 minutes. We observed the gradual decay of the flare about ~ 2 h 40m for the FOCES04A flare and ~ 4 h for TNG04B.

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