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SARG observations of 40 stars with different activity level: test for the $R_{\rm IRT}$ chromospheric activity indicator

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Abstract. We report on preliminary analysis of high resolution spectra (R≈86,000) of a sample of 42 late-type active stars (with $\log R'_{\rm HK}$spanning from ≈ -3 to ≈ -5) acquired with the Italian 3.6m Telescopio Nazionale Galileo (TNG) by using the SARG spectrometer in th e 4960 - 10110 Å range.
The high quality of the spectra and the good activity level coverage allow us to test and calibrate the new chromospheric indicator $R_{\rm IRT}$ given by the difference between the calculated NLTE photospheric central intensity and the observed one (Busa et al. 2003; Andretta et al. 2005).
This analysis indicate that Ca II IRT lines are good chromospheric diagnostic, in particular in the low-activity level range.

Key words. Stars: atmospheres – Stars: radiative transfer – Stars: line formation – Stars: chromosphere – Stars: magnetic activity

1. Introduction

Several authors have underscored the diagnostic power of the Ca II IRT lines as magnetic activity indicator. In particular, Chmielewski (2000) finds an average relation between the central depth of the observed λ8542 Å line and the $\log R'_{\rm HK}$ indicator. However, as Chmielewski stresses, the observed CD cannot be considered a pure chromospheric indicator because no correction for the photospheric contribution is made. Busa et al. (2003) suggest, as a better estimator of the chromospheric contribution to the Ca II IRT lines, the $R_{\rm IRT}$ index which take into account the proper subtraction of the photospheric quiescent contribution. We report here a preliminary analysis to test and calibrate this pure chromospheric indicator with respect to the $\log R'_{\rm HK}$ using an homogenous sample of observations (42 stars of known $\log R'_{\rm HK}$) obtained with the SARG spectrograph at TNG.

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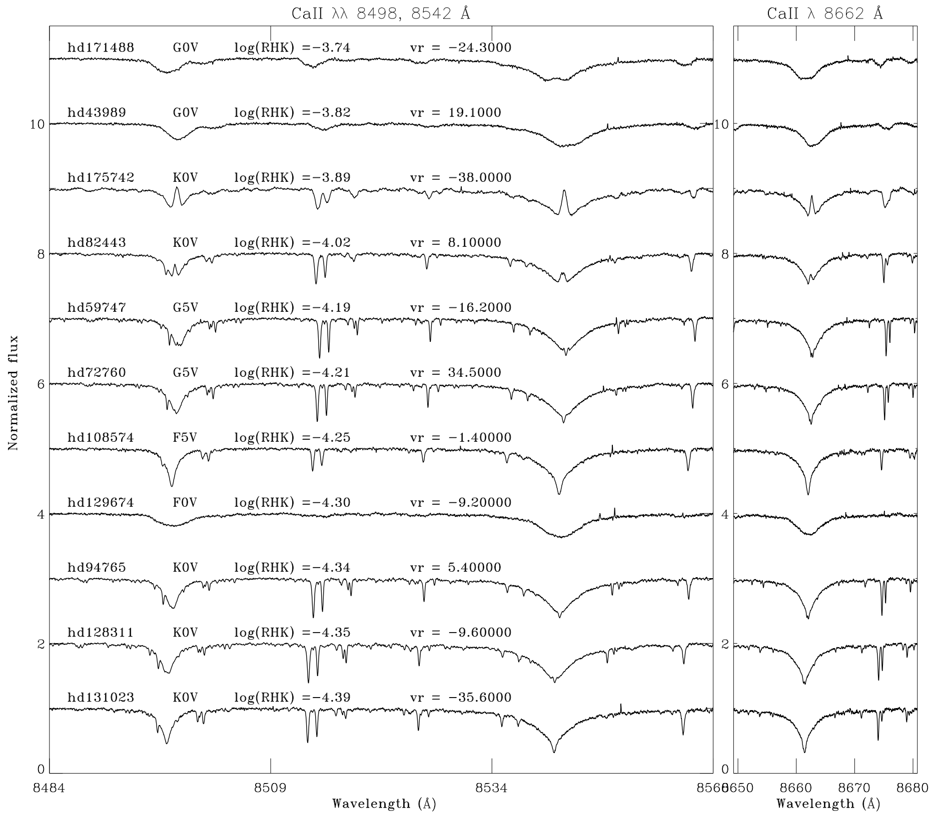

Fig. 1. SARG spectra in the region of the Ca II infrared triplet ordered according to increasing values of $\log R'_{\mathrm{HK}}$. Correction for radial velocities has been applied.

2. Data acquisition and reduction

High resolution spectra (R≈86,000) of 42 late-type active stars covering the spectral types from F5 to K3 have been obtained on the 22nd 23rd February 2002 using the high-dispersion spectrograph SARG at the 3.5 m TNG. The observations were made using the RED cross-dispersed grism, which provides a spectral coverage from 5500 to 10110 Å, a slit width of 100μm, corresponding to 0.53 arcsec projected on the sky, yielding to a spectral resolution ($\lambda/\Delta\lambda$) of 86 000, and the red filter. The data reduction was performed by using the ECHELLE task of IRAF package following the standard steps: bias subtraction, background subtraction, flat field correction. Several thorium lamp exposures were obtained during each night and then used to provide a wavelength calibration of the observations. Each spectral order was normalized by a polynomial fit to the local continuum.

A set of the reduced spectra, in the wavelength range of the Ca II IRT, are plotted in Fig.1. The spectra are ordered according to increasing values of $\log R'_{\mathrm{HK}}$. We can see from the figure that the Ca II IRT lines at 8498, 8542, 8662 Å are quite prominent features in the spectrum of late-type stars. Furthermore, Andretta et al. (2005) show that their extended wings probe a wide range of photospheric layers and are sensitivity to metalicity and temper-

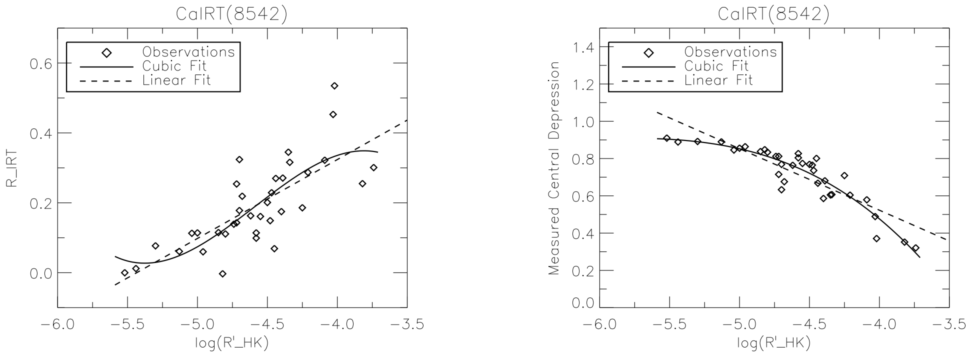

Fig. 2. The R_{IRT} index (left panel) and Central Depression (right panel) versus $\log R'_{\mathrm{HK}}$.

ature distribution while the cores are formed in the uppermost atmospheric layers (chromosphere). This means that the line cores are sensitive to the degree of chromospheric activity as can be seen in Fig.1. It is worthwhile to notice, infact, that, raising the activity level, the lines show intense filled-in absorption which become strong reversal emission in the cores of very active stars such as HD 82443 and HD175742 ($\log R'_{\mathrm{HK}}$=-4.02, $\log R'_{\mathrm{HK}}$=-3.89 respectively). HD 128311 is a planet host star.

3. Calibration of the R_{IRT}

The behavior of the R_{IRT} index (calculated for the λ8542 Ca II IRT line as $CD_{calculated}$ - $CD_{observed}$) versus $\log R'_{\mathrm{HK}}$ has been investigated. We find that a linear fit well represent the data (CHI-SQUARE = 0.2) obtaining the following relation:

$$R_{\mathrm{IRT}} = 0.23 * \log R'_{\mathrm{HK}} + 1.23 \qquad (1)$$

We find that the cubic fit better follow the observed CD (CHI-SQUARE = 0.11) with respect to the linear fit (CHI-SQUARE =0.19). It is worthwhile to notice that the observed CD is not a good chromospheric indicator in the low activity range. Diamonds in the range of $\log R'_{\mathrm{HK}}$ between -5.5 and -4.8 show a CD which is approximal constant while the R_{IRT} vary linearly.

4. Conclusions

The results presented here come from a preliminary study in which the calculation of R_{IRT} could be affected by errors due to the use of non-precise $v \sin \hat{\imath}$ measures, guessed values of stellar parameters, application of a semi-empirical relation for the R_{IRT} calculation and other more. A more detailed analysis is now in progress.

Nevertheless, according to this approximate study we find that both CD and R_{IRT} seem to be good chromospheric activity indicators. Furthermore, the R_{IRT} purely chromospheric index is found to be a good probe for stellar activity also in the range of low activity level where the CD is not. Moreover, we want to stress that the effects of $v \sin \hat{\imath}$ on line CD is not negligible; this fact, compounded with the well-known correlation in late-type stars between activity and rotation rates, must be taken into account when attempting any use of the observed CD for studying stellar activity.

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