GASEOUS COMPONENTS OF PROTOPLANETARY DISKS

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EXPORT[†]

Abstract. A set of high resolution echelle spectra is used to find evidences of circumstellar disks around PMS and MS stars. The footprints searched for are Redshifted Absorption Components (RACs), present at the bottom of some metallic lines. The method and an example of application are presented.

1. Motivation

One possible scenario for the formation of planets requires them to be formed in the protostellar disk via the formation of planetesimals (Beckwith et al. 2000). It has been reported extensively that β Pic, the prototype MS star with a disk, has an anomalous spectroscopic behaviour (see for example Beust et al. 1998) that has been explained by some authors in terms of grazing cometesimals falling into the star (Lagrange et al. 2000). It has been called the Falling Evaporating Bodies (FEB) hypothesis. This behaviour consists of RACs superimposed on strong metallic lines. If this point of view holds true, they are direct signatures of the presence of planetesimals around stars. PMS stars also show this kind of variability, even in a stronger way (Grady et al. 2000).

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These spectroscopic events deserve a systematic studio, including visible and infrared observations (e.g. spectroscopy and photopolarimetry). One of the main goals of the EXPORT collaboration (EXo Planetary Observational Research Team) was to collect a large, homogeneous sample of high resolution spectra of PMS and Vega-like stars (MS stars with infrared excesses) in order to start such a studio (Eiroa et al. 2000). Specific goals are the identification, isolation and abundance analysis of the RACs.

2. Observations

The spectra have been obtained with the WHT 4.2m telescope (ORM, La Palma). They are part of the observing time awarded to EXPORT in the context of the 1998 Intenational time programme of the Canary Islands telescopes. The EXPORT observing time also includes true simultaneous UBVRI photopolarimetry, JHK photometry and intemediate resolution spectra.

The high resolution data comprise a set of 198 spectra of 49 stars obtained with the Utrecht Echelle Spectrograph (UES). They were taken during four different campaigns covering a whole year of monitoring (May, July and October 1998, January 1999). The instrument was set to give a wavelength coverage of 3800 - 5900 Å with a spectral resolution of 49000. The width of the slit used was 1.15" projected on the sky. The data is actually completely reduced.

3. Spectral analysis

The analysis is divided into three steps. Identification of RACs and parent lines, generation of synthetic spectra for the selected wavelength intervals and subtraction of the generated spectra.

The RAC search is performed for a series of stars, with known circumstellar activity, in the usual and tedious way: comparing two different spectra obtained at different times and looking for variability. Once the most prominent changing features have been selected, it is needed a synthetic spectrum including the most prominent features (opacity greater than 10% of the continuum) to clearly identify the atomic transition responsible of the variability.

When the library of circumstellar lines is completed, the search will be limited to them for the remaining data, thus reducing the amount of time needed for the identification of FEB events.

The spectra are created using the code developed by Kurucz (http://cfaku5.harvard.edu/programs.html) for VAX computers, adapted to UNIX machines by Lester (http://ccp7.dur.ac.uk/library.html).

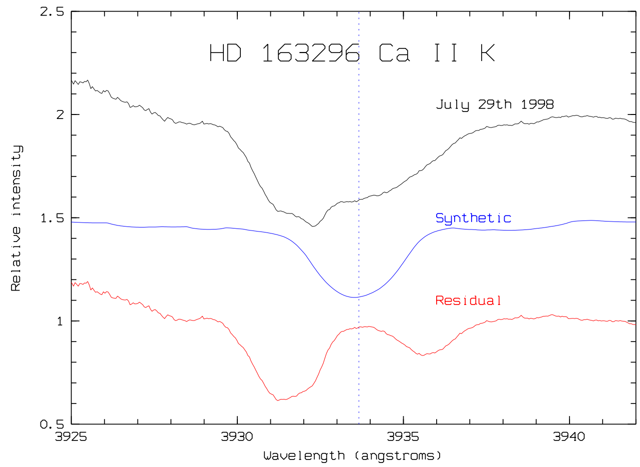

Figure 1. Schematics of the subtraction method. The observed and synthetic spectrum as well as the subtraction residual are shown for HD 163296 in the Ca II K line region.

There is a need of good stellar parameters. There is an effort inside EXPORT to give an independent, self-consistent and complete determination of them for the whole sample. At this moment the rotational velocity *v sini* (Solano et al. 2000) and spectral type (Merín et al. 2000) are already estimated for most of the stars. The effective temperature and gravity are estimated using empirical relations with the spectral type (de Jager & Nieuwenhuijzen 1987, Habets and Heintze 1981).

The model atmospheres are those of the grid calculated by Kurucz and available on the web ((http://cfaku5.harvard.edu/grids.html). The atomic parameters of the electronic transitions involved are extracted from the Vienna Atomic Line Data base VALD (Kupka et al. 1999, Piskunov et al. 1995). The synthetic spectra are generated around the central line within an interval of $\pm$ 1000 km/s and a resolution $\lambda/\Delta\lambda$ of 10000-20000. The convergence threshold applied is 1% of the local continuum.

The basic steps of the spectral subtraction are: radial velocity correction, rotational velocity broadening, continuum fitting and final subtraction. The radial velocities have to be measured carefully in active stars, trying to select pure photospheric lines. The rotational broadening of the synthetic spectra is made according to Gray (1992). The continuum is fit with two points and a linear regression. Once all this work is done, the spectra are subtracted. The residual is the flux absorbed by the CS material. An illustrative example of the process is shown in figure 1.

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