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Line profile variations in δ Scuti stars from high S/N ratio profiles

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Abstract. Line profile variations in some δ Scuti stars were presented and discussed in the poster. Here we describe the results for HD 88824 only. Average line profiles have been derived with the Least Squares Deconvolution technique from spectrograms covering a very long wavelength range. The typical resulting S/N ratios of the deconvolved mean profiles are about of a few thousands and allow us to detect very small variations in profile's shape. In some cases periods of the order of a few tens of minutes were detected by means of the Fourier–Doppler Imaging technique.

Key words. Stars: variables: δ Sct – Stars: oscillations – techniques: spectroscopic

1. Introduction

Modern spectrographs allow us to obtain high S/N ratio spectrograms which cover very long spectral ranges, thus covering a lot of lines which can be used to study the line profile variations (LPV) in non-radial pulsating stars. This approach is much more sensitive than photometry to study pulsation of high non-radial degree, because the rotationally broadened profiles supplies a one-dimensional Doppler map of the stellar disk. Moreover with the Least-Squares Deconvolution technique (LSD, Donati et al., 1997) is possible to derive from the many spectral lines a single average profile of very high S/N ratio (from our data we get typical values of a few thousands), which allows us to detect very small variations in its shape. Aiming to detect the shortest periods of non-radial pulsation that can be seen in δ Scuti stars, we observed some of these objects at La Silla Observatory (ESO) with the FEROS spectrograph. This very efficient instrument allowed us to collect with exposure times of few minutes high S/N ratio spectrograms with a resolution of 48000 and a spectral range of about 6000 Å. Mantegazza & Poretti (2005) got some evidences that pulsations with periods around ten minutes were present in the δ Scuti star AV Ceti, but these findings are based on the study of two lines only with a S/N ratio of a few hundredths, i.e. at the limits for such a detections. In the poster the cases of HD 88824, HD101158, and HD111786 were presented. Here, for space problems, we shall limit ourselves to discuss HD 88824 only.

2. LPV in HD 88824

The light variability of this star was discovered by Lampens & Rufener (1990), who suggested the presence of two frequencies of 7.98 and 10.76 c/d. No spectroscopic studies of this

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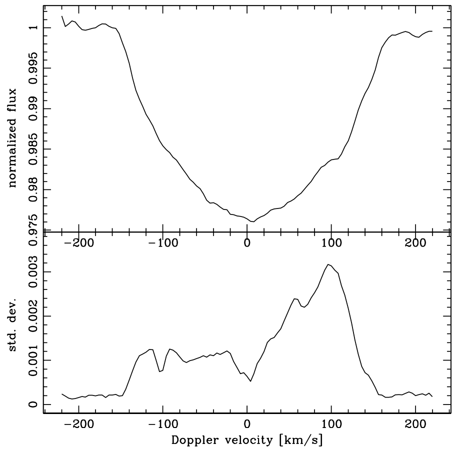

Fig. 1. Average of the LSD mean profiles (upper panel). Their pixel by pixel standard deviations (lower panel).

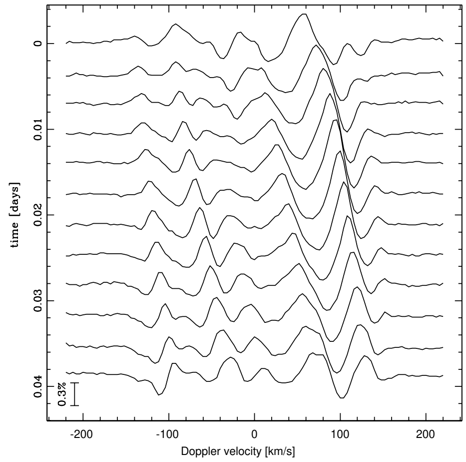

Fig. 2. Differences among individual LSD mean profiles and their average.The small bar gives the scale of the fluxes normalized to the continuum.

object have been performed up to now. Figure 1 shows in the upper panel the average of the LSD mean profiles derived from our 12 spectrograms observed on January 17, 2003 and spaced in time by about 5 minutes. From the first zeroes of the Fourier transform of this profile we obtain $v \sin i = 154 \pm 1 km/s$. The lower panel shows the pixel by pixel standard deviations across the line profile. These values in the continuum pixels show that the typical S/N ratio of the individual LSD mean profiles is about 4000. In Figure 2 we show the behaviour of the perturbations propagating across the line profile obtained by subtracting to each LSD mean profile their average. We see that the dominant pulsation modes propagates in the same direction as the stellar rotation (i.e. they are progrades, as it is usual in δ Scuti stars). Figure 3 shows the Fourier-Doppler Image (FDI: Kennelly et al., 1998; Hao, 1998) derived from the data shown in Figure 2. We see that the pulsation pattern is very complex with several modes both of low and high non-radial degree, and that there are also modes with period as short as about 12 minutes. The peak at the bottom on the left corner corresponds to the photometrically detected modes.

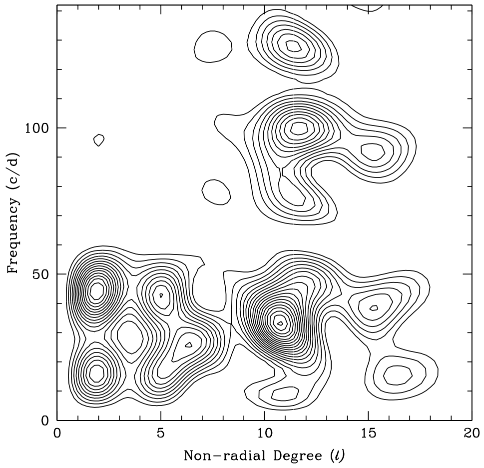

Fig. 3. Fourier-Doppler Image. Abscissae: spatial frequencies; ordinates: time frequencies.

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