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Line profile variability in spectra of hot massive stars

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Abstract. We report the results of our study of the fast line profile variability (LPV) (hours – few days) in the spectra of bright OB and WR stars. All spectra were obtained with 6-m and 1-m telescope of Russian Special Astrophysical Observatory (SAO) and 1.8-m telescope of Bohyunsan Optical Astronomy Observatory, Korea (BOAO). We detected both the stochastic LPV, connected with the formation of small-scale structures in the stellar wind and the regular LPV induced by the large-scale structures in the wind.

Keywords. stars: early-type, line: profiles

1. Observations

Spectral and spectropolarimetric observations of 11 bright OB and 2 WR stars were made in a framework of the program of searching for regular and stochastic LPV in the spectra of OB stars (Kholtygin *et al.* 2003). The observations were obtained in 1997–2011 at SAO and at BOAO. The observations at SAO were made by using 6-m telescope with the Lynx spectrograph (spectral resolution $R = 60000$) and CCD 512 x 512 pixels, with the NES spectrograph ($R = 60000$) and CCD 1024 x 1024 and with the MSS spectrograph ($R = 15000$) and CCD 2k x 2k, while 1-m telescope observations were made with the CEGS spectrograph ($R = 45000$) and CCD 1242 x 1152. The reduction of SAO spectra was made with the MIDAS package. The observations at BOAO were performed by using the 1.8-m telescope equipped with the BOES spectrograph ($R = 45000$) and large CCD (2048 x 4096 pixels). The preliminary reduction of the CCD frames was done with IRAF.

2. Regular LPV

To detect LPV the smTVS analysis (Kholtygin *et al.* 2006) was used. This method allowed us to detect weak variability of the lines of ions SiIII, CIII, OIII, NII, MgII, SiV in the spectra of the program stars that cannot be detected using TVS as it is shown in the Fig. 1 (left panel). We applied smTVS for left and right polarized light separately. We found that pattern of LPV can differ for left (I_L) and right (I_R) polarized components of the lines in the spectra of all program stars (Fig. 1, right panel). For unblended lines with residual intensities less than 0.9, Fourier analysis was made. The obtained periods of regular LPV appeared in the range from hours to days (see, for example Dushin *et al.* 2013).

3. Stochastic LPV

The stochastic LPV is related with small-scale structures in the stellar wind. The expanding winds of WR stars are believed to be strongly clumped. We illustrate in the Fig. 2 (top panel) the clump contribution into the dynamical spectra of HeII λ 5411 Å

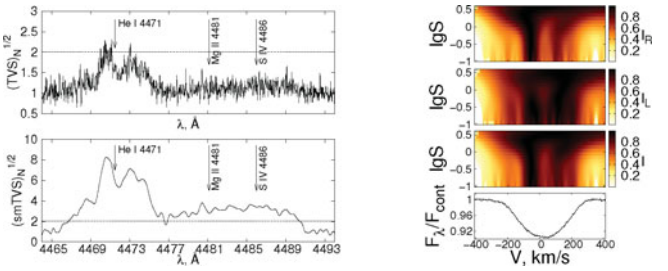

Figure 1. *Left panel*: TVS (top) and smTVS (bottom) normalized by unity of the line HeI λ 4471 Å in the spectra of λ Cep. Filter width S is 0.2 Å. The horizontal line corresponds to the significance level 0.001. *Right panel*: Density plot diagram of smTVS for the I_R, I_L and I components of line profile and the mean profile for the line HeI λ 4471 Å in the spectra of the star λ Cep (from top to bottom). Darker areas correspond to higher smTVS amplitude.

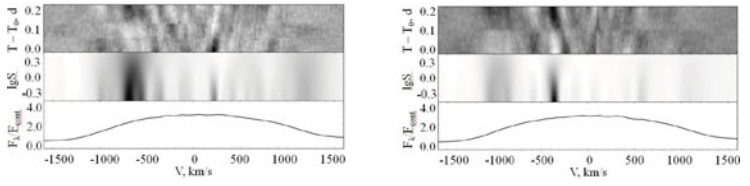

Figure 2. *Left panel*: Dynamical specta of LPV for the line HeII λ 5411 Å in the spectra of WR 136 taken at July 25/26 (top). Grey scale dynamical plot of the smTVS spectrum as a function of the filter width S (middle). Nightly mean HeII λ 5411 Å line profile (bottom). *Right panel*: The same as in the left panel but for the night of July 26/27 (Kholtygin *et al.* 2011).

line. As we can see in the Fig. 2 (middle panel) the regions of the largest amplitude of the smTVS correspond to the moving bumps in the dynamical spectra of LPV. It means that smTVS spectra can be used for detecting stochastic line profile variations of small amplitudes. There is no difference between the pattern of LPV for left and right polarized components of stellar radiation for 2 studied WR stars. It means that the magnetic field in the region of the He II line formation is small.

We also found the evidences of the stochastic LPV in the line profiles in the spectra of O stars using wavelet analysis with MHAT-wavelet as the mother wavelet (e.g. Kholtygin *et al.* 2006).

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