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UNUSUAL FAST SPECTRAL VARIABILITY of γ Cas

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Abstract. An unusual fast variations in the spectra of Be star γ Cas are analysed. Regular line profile variations (LPVs) with periods from 4 to 37 minutes are found.

Introduction

The most important problems of stellar spectroscopy is the study of the structure and mechanisms of the expanding atmospheres of massive stars formation. Such studies are based on an analysis of regular and stochastic variations in the line profiles in the stellar spectrum. In the present paper the observations of the B0.5IVpe star γ Cas at the 1.25-m telescope in the Crimean station of Sternberg Astronomical Institute, Moscow University are analysed.

Observations and data reduction

B0.5IVpe star γ Cas is the prototypical classical Be star and is recently best known for its variable extremely hard X-ray emission. That is the binary system with the primary mass of $15\,M_\odot$ and low mass secondary $0.8\,M_\odot$ [1].

The observations of γ Cas were made with the 1.25-m telescope on the night of September 17/18, 2020. All spectra were obtained with an exposure time 2 s and the time resolution ~ 5 s including SSD reading-out time. Totally 1575 spectra were obtained. The duration of observation is 128.3 min. All our spectra were obtained in the range $\lambda\lambda\,4421 - 6860$ Å with a spectral resolution $\sim$1000 and signal to noise ratio S/N$\sim$400.

The data reduction was made using the code CCDops[1]. One-dimensional spectra were obtained by summing the counts within a 40-pixel (79″) aperture, at a mean FWHM of 26 pixels, with the subtraction of the sky background taken over a region of $60-120$ pixels from the center of the stellar spectrum. The wavelength calibration was made using a Ne-Ar lamp. The spectra are normalized to the continuum. The normalization procedure is described by Kholtygin et al. [2].

[1]http://company7.com/library/sbig/sbwhtmls/ccdopsv5.html

Fast LPVs

Analyzing the difference profiles we will use the Doppler shifts V from the laboratory wavelength λ_0 of the line instead of the wavelength λ. The difference line profile

$$d(V,t) = F(V,t) - \overline{F}(V). \tag{1}$$

Here $\overline{F}(V)$ is the mean flux in the line at the velocity V

$$\overline{F}(V) = \frac{1}{N}\sum_{i=0}^{N} F(V,t_i). \tag{2}$$

where N is the total number of the analysed spectra, $F(V,t_i)$ is the continuum normalized line flux for the spectrum obtained at time t_i. Dynamical spectra $d(V,t)$ for H_β and HeI 5876 lines are given in Fig. 1.

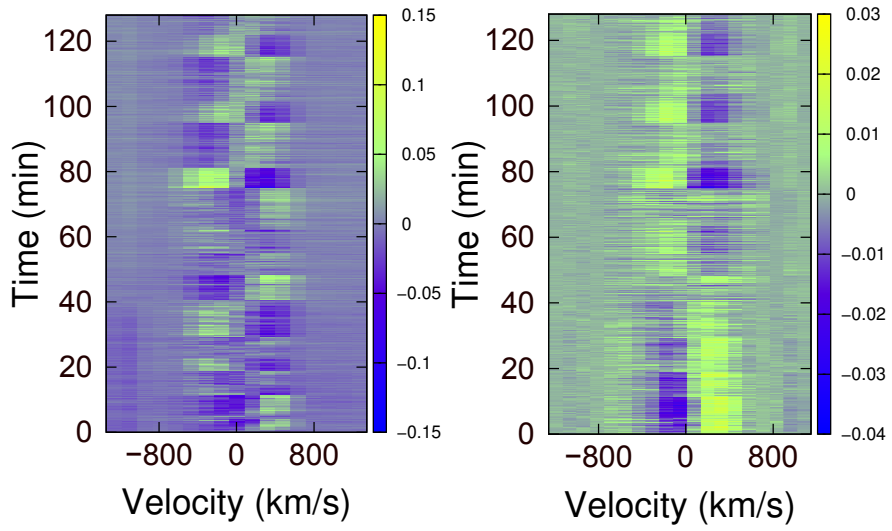

Figure 1: Dynamical spectra of lines H_β (top panel) and HeI 5876 (bottom panel)

Inspecting this figure one can see the similarity of LPVs for H_β and HeI 5876 lines. Such similarity holds also for lines H_α and HeI 6678. Fast variations at the time scale of $\sim 4 \div 20$ minutes are seen in Fig. 1.

Regular components of LPVs

For searching the periodic components of the line profile variations in the spectrum of γ Cas the CLEAN method of Fourier analysis [3] was used. Fourier spectra of variations in the difference profiles of HeI 5876, 6678, H_β and H_α lines (periodograms) are calculated. In Fig. 2 (left panel) the fit of the residual values $d(V,t)$ for the line H_β at $\Delta V = -78\,\mathrm{km\,s^{-1}}$ is shown. An example of the full Fourier spectra for H_α line and low FAP (False Alarm Probability) level $\sim 10^{-4}$ is given in Fig. 2 (right panel).

We obtain the upper limits of the regular component frequency errors and the errors of the corresponding periods in the Fourier spectrum using the expression $\Delta\nu \leqslant 1/T$ [4], where

Table 1: Periods of regular LPV's components

Comp. number	1	2	3	4	5
Period, min	4.02 ± 0.13	6.57 ± 0.34	10.35 ± 0.84	20.82 ± 3.38	37.11 ± 10.76

$T = 128.3$ minutes is the total duration of observations. The detected periods together with their errors are given in Table 1.

We have tabulated only those periods P for which the ratio $P/\Delta P > 3$ where ΔP is the period's error. Additionally we revealed 3 components with periods from 50 to 116 minutes. Longer observations are needed to confirm their reality. Given short-time LPVs are firstly detected in spectra of γ Cas was not known before but they are similar to those for bright OB stars [5,6].

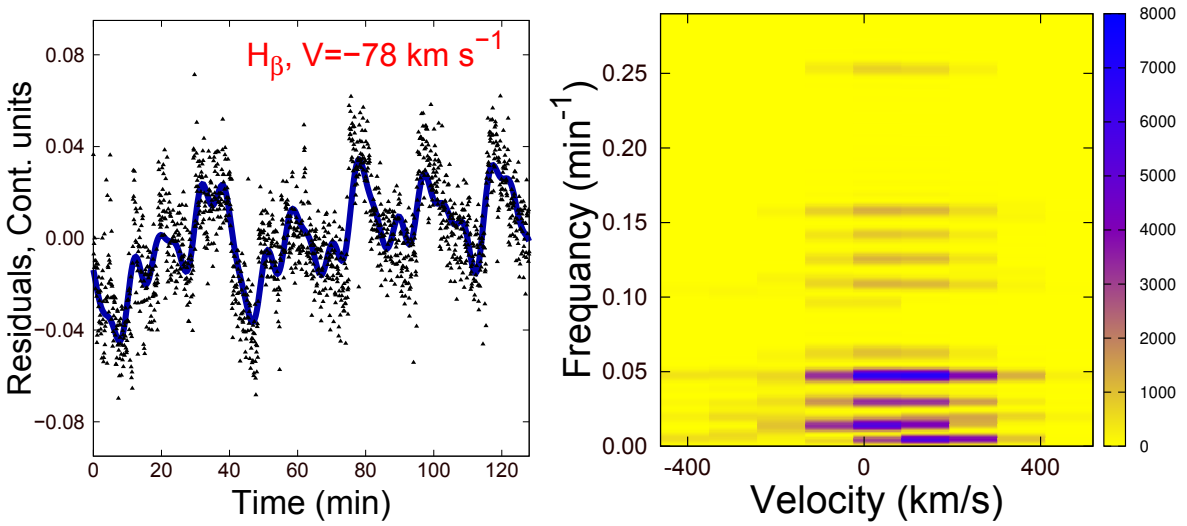

Figure 2: Fit (blue line) for H_β residuals at $V = -78\,\mathrm{km\,s^{-1}}$ (left panel) and Fourier spectra for H_α and FAP=10^{-4} (right panel)

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НЕОБЫЧНО БЫСТРАЯ СПЕКТРАЛЬНАЯ ПЕРЕМЕННОСТЬ γ CAS

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Резюме. Проанализирована быстрая переменность профилей линий в спектре γ Cas. Обнаружены регулярные вариации профилей с периодами от 4 до 37 минут.