

SUPERFAST SPECTRAL VARIATIONS OF OBA STARS

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Abstract. Results of our recent search for superfast line-profile variations (LPVs) in spectra of the bright OBA stars HD 93521 (O9.5III), ρ Leo (B1Iab), α^2 CVn, and γ UMi are presented. The spectra were obtained using the multi-mode focal reducer SCORPIO on the Russian 6-m telescope. Both regular LPVs with periods from 2 to 90 minutes and non-regular LPVs on time-scales of seconds were detected. Such short-term spectral variability in massive OBA stars has not been studied systematically before. These studies can be crucial for understanding the physics of type-II supernova and for improved modelling of stellar evolution.

Keywords: Stars: early-type, variables: general, line profiles

1 Introduction

Regular variations of line profiles with periods ranging from several hours to days in spectra of all types of OBA stars have been well studied. Recent observations by Hubrig et al. (2014) of the A0 supergiant HD 92207 using the focal-reducer, low-dispersion spectrographs FORS2 in spectropolarimetric mode showed moderate line-profile variations (LPVs) of various lines on a time-scale of minutes.

This paper presented the continuation of studies of superfast LPVs in spectra of early-type stars as published by Batrakov et al. (2019); Kholtygin et al. (2018). A log of observations for all the programme stars and their measured *rms* magnetic field strengths \mathcal{B} was taken from a review by Tsiopa et al. (2019) and is listed in the Table.

| Star | Sp.Class | Year, month | N _{sp} | Exp (s) | \mathcal{B} , G |
|------------------------|-----------|-------------|-----------------|-----------|-------------------|
| 6-m telescope, SCORPIO | | | | | |
| ρ Leo | B1Iab | Jan. 2015 | 1271 | 1 | ~ 50 |
| HD 93521 | O9Vp | Jan. 2015 | 529 | 3 | ~ 130 |
| α^2 CVn | A0spe | Jan. 2015 | 387 | 1 | ~ 1100 |
| γ UMi | A2III | Jan. 2015 | 249 | 3 | suspected |
| HD 21389 | A0Ia | Sep. 2016 | 284 | 11 | not detected |
| VLT, FORS2 | | | | | |
| HD 92207 | A0Iae | 2011–2012 | 32 | ~ 60 | ~ 225 |
| λ Eri | B2III(e)p | 2011–2012 | 155 | ~ 3 | ~ 150 |

2 Results and discussion

In spectra of all of the stars observed with the SCORPIO spectrograph at the 6-meter telescope, regular components of LPVs were detected with periods from ~ 30 to ~ 90 min using the CLEAN method by Roberts et al. (1987). These components extend to higher frequencies the sequence of non-radial pulsation (NRP) harmonics already known for these stars, and may be connected with NRP modes $l = 6 - 12$.

In order to reveal any high-frequency components of LPVs, a Fourier transform with Hamming window of width ΔT was applied. Details of this technique are given by Batrakov et al. (2019). The windowed Fourier-transform maps of LPVs for the H γ line in the spectra of the programme OBA stars are shown in Figs. 1-2.

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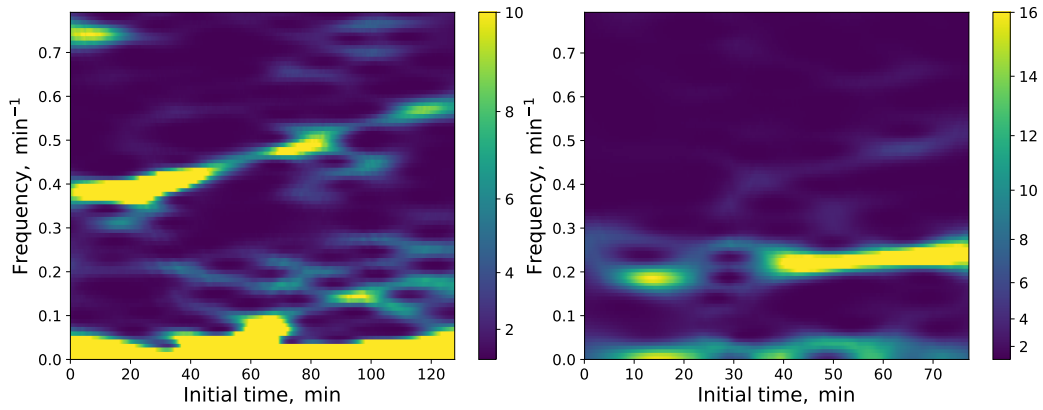


Fig. 1. Left: map of the windowed Fourier transform with Hamming window width $\Delta T = 40$ min for the $H\gamma$ line in the spectra of ρ Leo. **Right:** the same as in the left panel, but for HD 93521 and $\Delta T = 30$ min.

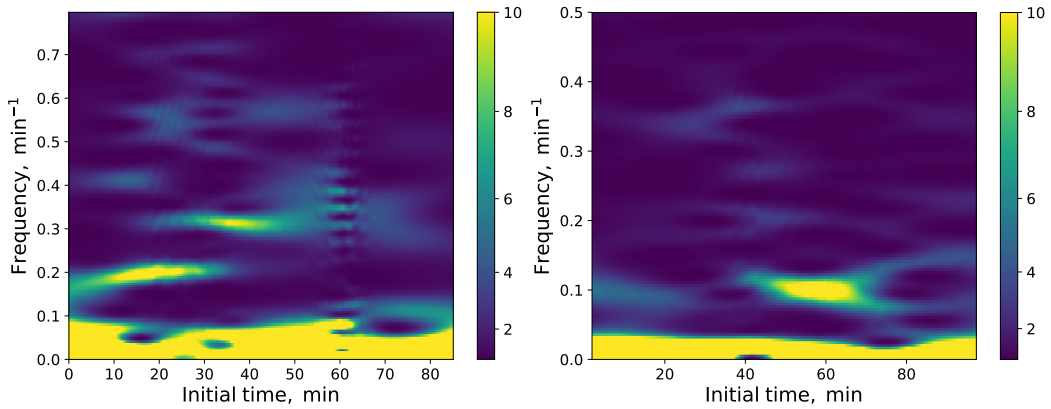


Fig. 2. Left: the same as in Fig. 1 but for α^2 CVn and $\Delta T = 35$ min. **Right:** the same as in the left panel, but for γ UMi and $\Delta T = 50$ min.

Very short period harmonics in the frequency interval $\nu \in [0.1 - 0.7] \text{ min}^{-1}$ were detected. They appear to be unstable on time-scales of tens of minutes. A similar pattern of LPVs was also revealed for other H and He lines. At the same time, such short-scale LPVs were not detected in spectra of HD 21389.

One can presume that the presence of such intriguing components of LPVs can be explained by the instability of high modes of NRPs over short time intervals (10 – 100 min). The stars in which short time-scale LPVs were detected have spectral types from A to O and are of various luminosity classes; they are also magnetic, or suspected to be so. It can indicate that this kind of LPVs can hardly be explained by the properties of the stars themselves, but could be related to their magnetic fields.

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