The complex structure of the Si IV $\lambda\lambda$ 1393.755, 1402.77 Å regions of 68 Be-type stars

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ABSTRACT

DACs and SACs phenomena in Si IV resonance lines of 68 Be stars

In our study we apply the method proposed by Danezis et al. (2003) on the spectra of 68 Be stars, taken with I.U.E. and we examine the variations of the physical parameters, stated below, as a function of the spectral subtype.

We found that the absorption atmospherical regions where the Si IV resonance lines originated may be formed of one to five independent density layers of matter which rotate with different velocities, producing one to five Satellite Absorption Components (SACs or DACs). With the above method we calculate the values of the apparent rotational and radial velocities, as well as the optical depth of the independent regions of matter which produce the main and the satellites components of the studied spectral lines.

Key words: UV astronomy, hot emission stars, Si IV, DACs, SACs

1. Introduction

The ultraviolet resonance lines of Si IV ($\lambda\lambda$ 1393.755, 1402.77 Å) arise from the transition $3s^2S - 3p^2P^0$. This doublet is usually an intense feature in the spectra of early type stars and provides us with a useful tool for the study of the stellar atmosphere's structure. Thus, it has been studied by many researchers. The profile of the resonance lines seem to depend on the spectral subtype and the luminosity class (Snow 1977), so it has been proposed that the doublet may be a significant tool for the spectral classification (Walborn & Nichols-Bohlin 1987, Prinja 1990). It has been observed that the lines present decreasing strength from the earliest to the latest spectral subtypes. Panek & Savage (1976) and Henize et al. (1976, 1981) observed that they disappear in the spectra of Be-type stars later than B3. However, according to Marlborough (1982), Marlborough & Peters (1982) and Slettebak (1994) the doublet may be observed in stars as cool as B8. Many researchers have studied the existence of Satellite Absorption Components (SACs or DACs), which accompany the Si IV resonance lines in the spectra of Be-type stars and which are of circumstellar or interstellar origin (Underhill 1975, Snow 1977, Lamers et al. 1982, Marlborough 1977, 1982, Snow et al. 1979, Hubeny et al. 1986, Danezis 1984, 1987, Sahade et al. 1984, Sahade & Brandi 1985, Hutsemékers 1985, Sapar & Sapar 1992).

In this paper we apply the model proposed by Danezis et al. (2003) in order to investigate the presence of SACs or DACs in Si IV resonance lines' regions in Be-type stars and their kinematical characteristics.

2. Application of the model to the Si IV resonance lines $\lambda\lambda$ 1393.755, 1402.77 Å of 68 Be stars

The data we used are the Si IV resonance lines of 68 Be stars taken from the IUE Archive Search database (http://archive.stsci.edu/cgi-bin/iue). The stellar spectra were observed with IUE satellite using the Short Wavelength range Prime camera (SWP) at high resolution (0.1 to 0.3 Å).

We applied the model proposed by Danezis et al. (2003) to the Si IV resonance lines ($\lambda\lambda$ 1393.755, 1402.77 Å) in the spectra of 68 Be stars of all the spectral subtypes and luminosity classes.

Our first step is to identify the spectral lines in the studied wavelength range, in order to find out which lines may be blended with the Si IV doublet and, thus, may contribute to the observed features. The identification has been made by NIST Atomic Spectra Database (http://physics.nist.gov/cgi-bin/AtData/lines form), as well as the catalogues of Moore (1968) and Kelly (1979). In the studied spectral range, we identified some spectral lines, which are blended with those of Si IV. This means that the observed profiles consist of the Si IV resonance lines, as well as some blended lines. Thus, in order to accomplish the best fit, we should have in mind the existence of blends and the studied profiles should present some "badly fitted" features. Moreover, as we deal with resonance lines, we know that if one line of the doublet is well fitted, we should apply the same parameters to the other one, even if the fit is not so good. In this case the unfitted regions correspond to blends.

In Fig. 1 we present the best fit of the Si IV resonance lines in HD 200310, as an example. In Figs. 2 and 3 we present the rotational and radial velocities of the 5 density regions which create the SACs as a function of the spectral subtype, respectively. In Fig. 4 we present the optical depth of the 5 SACs for each line of the doublet as a function of the spectral subtype.

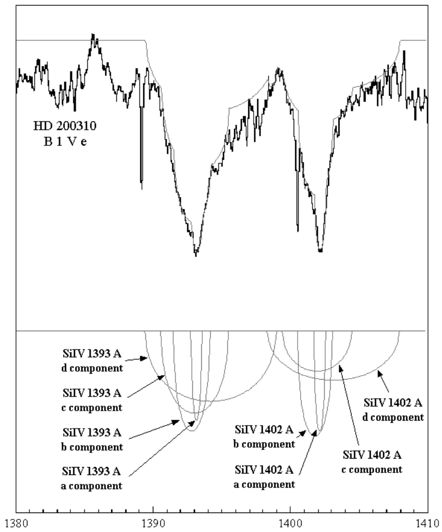

Figure 1: The Si IV resonance line profiles fitted with the proposed model for HD 200310. The thick line present the observed profiles, and the thin line the best fit. The SACs, which compose the observed profile are presented below.

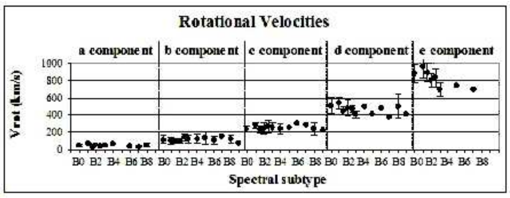

Figure 2: Mean values for each spectral subtype of the rotational velocities of all the SACs as a function of the spectral subtype.

3. Conclusions

We applied the method developed in Danezis et al. (2003) on the Si IV resonance lines of 68 Be stars in order to investigate the kinematical properties of the Si IV resonance lines forming regions. We obtained the rotational and radial velocities which allow us

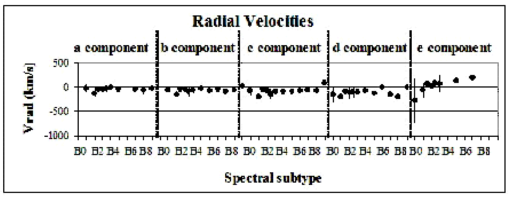

Figure 3: Mean values for each spectral subtype of the radial velocities of all the SACs as a function of the spectral subtype.

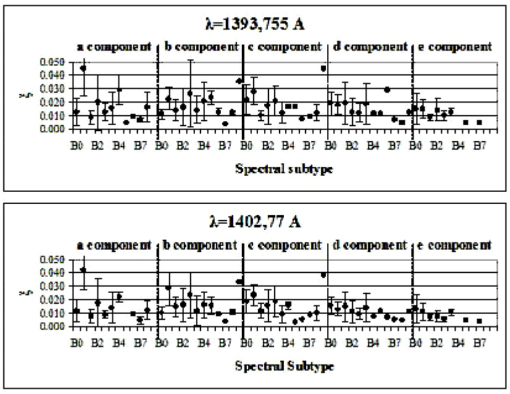

Figure 4: Mean values of the optical depth ξ in the center of the line for all kinematically separated components of each resonance line, as a function of the spectral subtype.

to extract some general physical properties for the Si IV regions of Be stars. Some interesting results inferred from the investigations are the following:

(i) The proposed line function by Danezis et al. (2003) is able to reproduce accurately the complex profiles of the Si IV resonance lines of all the 68 studied Be-type stars. This means that the regions where the Si IV resonance lines are created are not continuous, but they consist of successive independent density regions.

(ii) The absorption atmospherical region where the Si IV resonance lines are created presents a complex structure. It tends to be composed by more than one kinematically independent regions. We found that the kinematically independent regions rotate with different velocities: 40±16 km s^{-1}, 114±38 km s^{-1}, 251±52 km s^{-1}, 469±82 km s^{-1} and 828±119 km s^{-1}. The respective radial velocities are -38±60 km s^{-1}, -53±70 km s^{-1}, -87±89 km s^{-1}, -116±103 km s^{-1} and

$+25\pm145$ km s^{-1}. The rotational velocities of the found independent regions present a uniform fluctuation with the spectral subtype.

(iii) The profiles of the studied Si IV resonance lines appear to be peculiar and complex, as they do not present only one spectral line, but a number of SACs, which are created in independent density regions. This means that the existence of SACs is a general phenomenon in the spectra of Be-type stars. Howevere, all the studied stars do not present the same number of independent density regions.

(iv) The strength of the Si IV resonance lines decreases towards the latest spectral subtypes of the Be-type stars.

(v) We did not detect any emission lines in the studied stellar spectra.

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