

Hyper ionisation phenomena in the C IV region in 20 Oe stars

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ABSTRACT

Spectral lines of Oe and Be stars present DACs or SACs

In this paper we study the C IV line profiles of a sample of 20 Oe stars (from O4 to O7 spectral subtype). Using the model given by Danezis et al. (2003, 2005a,b) we found that the line shapes are very complex and that they can be fitted by a multi-component C IV region. In the sample the region may be divided into two to five subregions which show different kinematical and physical parameters. We give the kinematical parameters of subregions where the C IV resonance lines ($\lambda\lambda$ 1548.155, 1550.774 Å) are formed.

Key words: Oe stars, DACs, SACs, rotational velocity, Gaussian contribution, random velocities.

1. Introduction

As it is already known, some of the spectral lines of many Oe and Be stars present Discrete Absorption Components (DACs) which, due to their profiles' width, as well as the values of the radial velocities, create a complicated profile of the main spectral lines (Bates & Halliwell, 1986). The DACs are not unknown absorption spectral lines, but spectral lines of the same ion and the same wavelength as a main spectral line, shifted at different $\Delta\lambda$, as they are created at different density regions which rotate and move radially with different velocity (Danezis et al. 2003a). However, if the

regions that give rise to such lines rotate with large velocities and move radially with small velocities, the produced lines have large widths and small shifts. As a result they are blended among themselves as well as with the main spectral line and thus they are not discrete. In such a case the name Discrete Absorption Component is inappropriate and we use only the name Satellite Absorption Components (SACs).

In this paper, using the method that Danezis et al. (2003, 2005a,b) and Nikolaidis et al. (2006) proposed, and using I.U.E - spectra we detect the presence of this phenomenon (DACs or SACs) in the C IV resonance lines of 20 Oe stars of different spectral subtypes. We calculate, for each component, the variations of the mean values of the apparent rotational velocities, the Gaussian contribution to the line broadening, and the ions' random velocities as a function of the spectral subtype.

2. The Gaussian - Rotational model (GR-model)

With the proposed model (Danezis et al. 2003, 2005a,b, Nikolaidis et al. 2006) we can calculate many parameters of the regions that construct spectral lines which present DACs or SACs, as the apparent rotational and radial velocities, the Gaussian deviation of the ions' random motions, the random velocities of these motions, as well as the optical depth, the Full Width at Half Maximum (FWHM) and the absorbed or emitted energy of the independent regions of matter which produce the main and the discrete or satellite components (DACs, SACs) of the studied spectral lines.

3. The variation of the physical parameters in the C IV region in 20 Oe stars as a function of the spectral subtype

This study is based on the analysis of 20 Oe stellar spectra taken with the IUE - satellite (IUE Database <http://archive.stsci.edu/iue>) and we examine the complex structure of the C IV resonance lines ($\lambda\lambda$ 1548.155, 1550.774 Å). Our sample includes the subtypes O4 (one star), O6 (four stars), O7 (five stars) O8 (three stars) and O9 (seven stars). In our sample we detect that the C IV spectral lines consists of two components in 9 stars, three in 7 stars, four in 3 stars and five in 1 star.

In Fig. 1 we present the C IV resonance lines' best fit of one of the studied stars (HD 93521), using the proposed model. The graph below the fit indicates the 5 satellite components which construct the complex structure of the line above. The thick line presents the observed spectral line profiles and the thin one the best fits. The differences between the observed spectrum and its fit are some times hard to see, as we have accomplished the best fit.

In Fig. 2, we present the C IV doublet of the O9 star HD 209975, and its best fit. The best fit has been obtained with 2 SACs. The graph below the profile indicates the difference between the fit and the real spectral line.

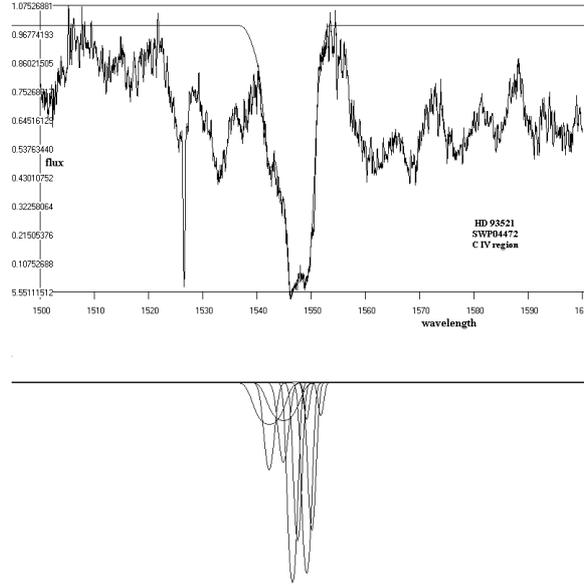


Figure 1: The C IV $\lambda\lambda$ 1548.155, 1550.774 Å resonance lines in the spectrum SWP 04478 of HD 93521. Each of C IV spectral lines consists of 5 SACs. The graph below the fit indicates the 5 satellite components which construct the complex structure of the line above.

3.1. The Rotational Velocities

In Fig. 3 we present the variation of the mean values for each component and of each spectral subtype of the apparent rotational velocities for the C IV independent density regions of matter, which create the 2, 3, 4 or 5 satellite components in each of the $\lambda\lambda$ 1548.155, 1550.774 Å C IV resonance lines, as a function of the spectral subtype.

3.2. The Gaussian contribution to the line broadening

Fig. 4 shows the variation of the mean values of the Gaussian percentage contribution to the line broadening for the C IV satellite components in each of the $\lambda\lambda$ 1548.155, 1550.774 Å C IV resonance lines, as a function of the spectral subtype.

3.3. The random velocities of the ions

In Fig. 5 we see the variation of the mean values of the random velocities of the ions for the C IV independent density regions of matter, which create the 2, 3, 4 or 5

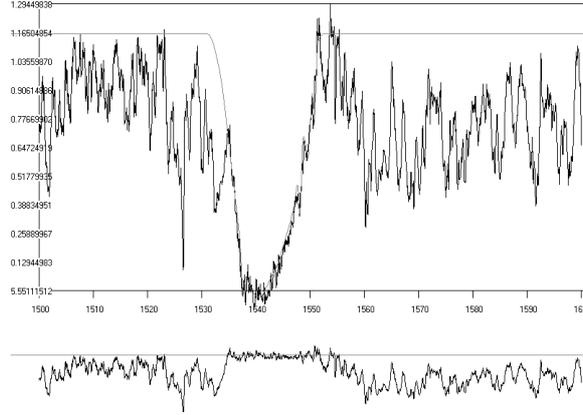


Figure 2: The C IV $\lambda\lambda$ 1548.155, 1550.774 Å resonance lines in the spectrum SWP 24188 of HD 209975. Each of C IV spectral lines consists of two SACs.

satellite components in each of the $\lambda\lambda$ 1548.155, 1550.774 Å C IV resonance lines, as a function of the spectral subtype.

4. Conclusions

Using the model given by Danezis et al.(2003, 2005a,b), here we investigated the line shapes of high-ionized C IV regions with aim to investigate hyper-ionization phenomena in the region. We found that high-ionized lines of C IV are formed in several subregions. Here we give some of our conclusions:

Rotational velocities: From the diagram in Fig. 2 we can conclude that the first component in all stars present the highest mean values of the rotational velocity. These values are about 1400 - 1600 km s⁻¹ for the spectral subtypes O4, O7 and O8 and about 1000 km s⁻¹ for the O9 stars. For the rest components we see the same phenomenon with lower rotational velocity values.

Gaussian contribution: In Fig. 3 we can conclude to the reverse situation of the diagram in Fig. 2.

Random velocities: The random velocities present almost the same behavior as the rotational velocities.

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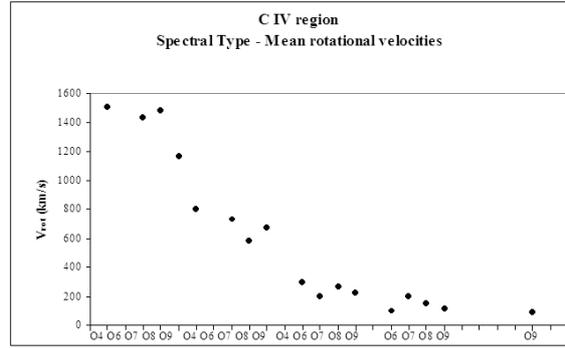


Figure 3: Variation of the rotational velocities' mean values of the C IV resonance lines ($\lambda\lambda$ 1548.155, 1550.774 Å) for the independent density regions of matter which create the 2, 3, 4 and 5 SACs as a function of the spectral subtype.

“Astrophysical spectroscopy of extragalactic objects”.

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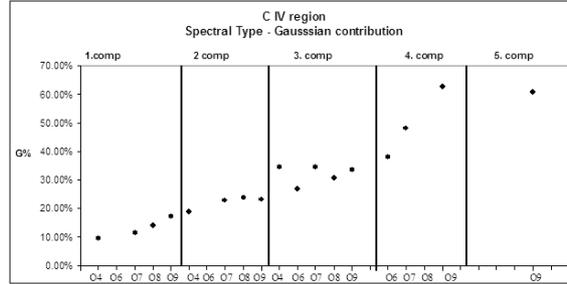


Figure 4: Variation of the mean Gaussian contribution to the line broadening of the C IV resonance lines ($\lambda\lambda$ 1548.155, 1550.774 Å) for the independent density regions of matter which create the 2, 3, 4 and 5 SACs as a function of the spectral subtype.

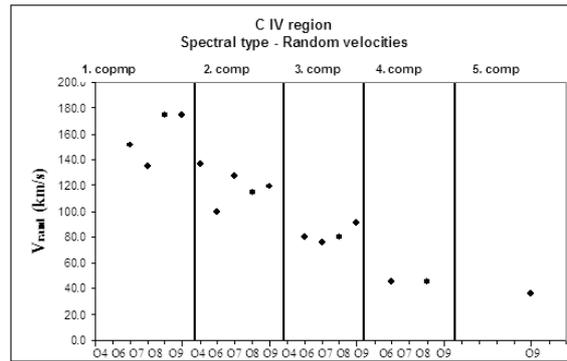


Figure 5: Variation of the mean random velocities of the ions of the C IV resonance lines ($\lambda\lambda$ 1548.155, 1550.774 Å) for the independent density regions of matter which create the 2, 3, 4 and 5 SACs as a function of the spectral subtype.