Hyper ionisation phenomena in the N V region in 20 Oe stars

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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 Gaussian standard deviation, which contributes to the line broadening, the ions' random velocities, the Full Width at Half Maximum (FWHM), the absorbed energy and the column density, as a function of the spectral subtype.

THE GAUSSIAN - ROTATIONAL MODEL (GR-MODEL)

With Danezis et al. (2003, 2005a,b) and Nikolaidis et al. (2006) GR model we can calculate many parameters of the regions that construct spectral lines which present DACs or SACs, such 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), the absorbed and the emitted energy and the product of the Source function S and the optical depth ξ of the independent regions of matter which produce the main and the discrete or satellite components (DACs, SACs) of the studied spectral lines.

THE VARIATION OF THE PHYSICAL PARAMETERS IN THE N V REGIONS 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 N V spectral line ($\lambda\lambda$ 1238.821, 1242.804 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 N V spectral line consists of one component in 2 stars two components in 7 stars, three in 9 stars and four in 2 stars.

In Fig. 1, we present the N V spectral line of the O7 star HD 24912, and its best fit. The best fit has been obtained with 3 SACs. The graph below the profile indicates the difference between the fit and the real spectral line.

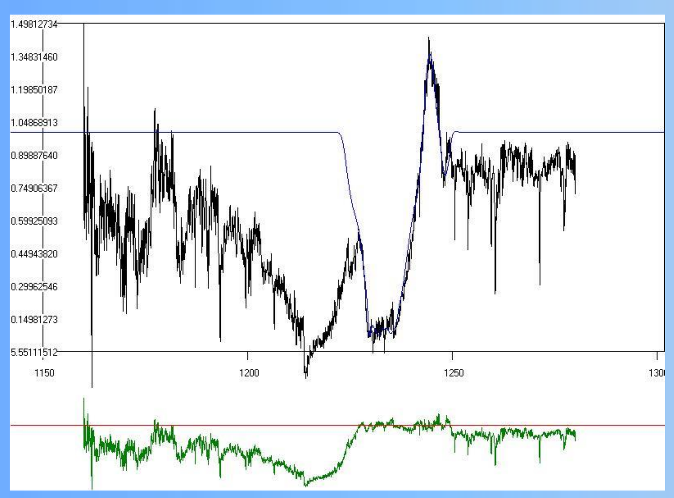

FIGURE 1: The N V $\lambda\lambda$ 1238.821 Å, 1242.804 Å resonance lines in the spectrum SWP18941 of HD 23912. Each of N V spectral lines consists of three SACs.

The Rotational Velocities

In Fig. 2 we present the variation of the mean values for each component and of each spectral subtype of the apparent rotational velocities for the N V independent density regions of matter (SACs), which create the 1, 2, 3 or 4 satellite components in each of the $\lambda\lambda$ 1238.821 Å, 1242.804 Å N V resonance lines, as a function of the spectral subtype.

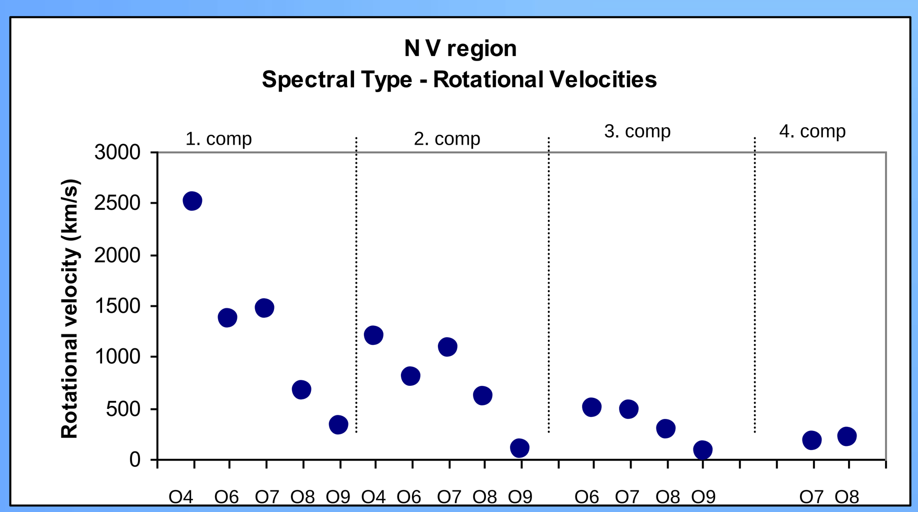

FIGURE 2. Variation of the rotational velocities' mean values of the N V resonance lines ($\lambda\lambda$ 1238.821, 1242.804 Å) for the independent density regions of matter which create the 1, 2, 3 and 4 SACs as a function of the spectral subtype.

The Gaussian Contribution

Fig. 3 shows the variation of the mean values of the Gaussian percentage contribution to the line broadening for the N V independent density regions of matter (SACs), which create the 1, 2, 3 or 4 satellite components in each of the $\lambda\lambda$ 1238.821, 1242.804 Å N V resonance lines, as a function of the spectral subtype.

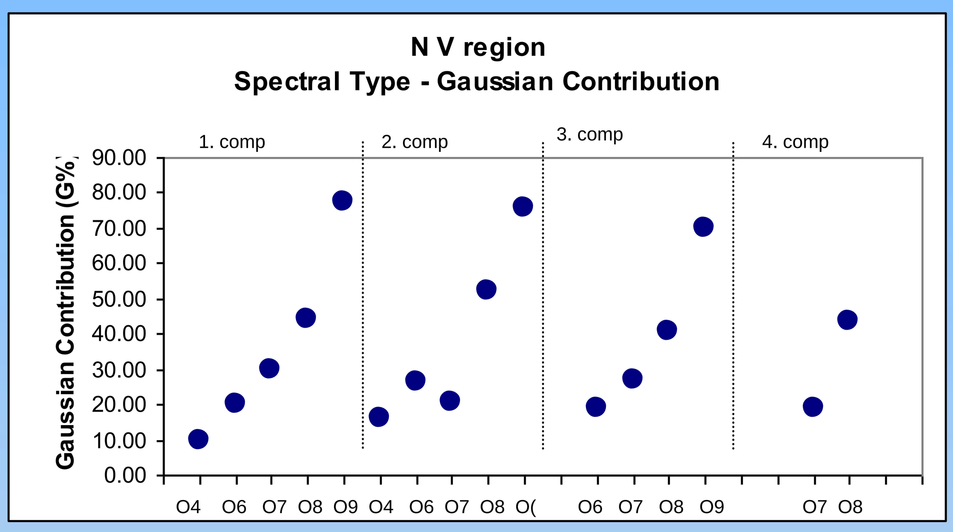

FIGURE 3. Variation of the mean Gaussian contribution to the line broadening of the N V resonance lines ($\lambda\lambda$ 1238.821, 1242.804 Å) for the independent density regions of matter which create the 1, 2, 3 and 4 SACs as a function of the spectral subtype.

The Random Velocities

In Fig. 4 we see the variation of the mean values of the random velocities of the ions for the N V independent density regions of matter (SACs) which create the 1, 2, 3 or 4 satellite components in each of the $\lambda\lambda$ 1238.821, 1242.804 Å N V resonance lines, as a function of the spectral subtype.

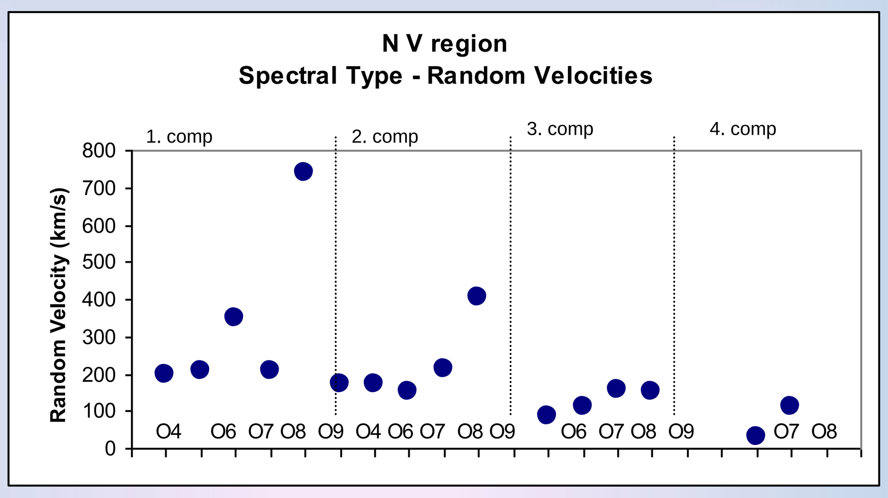

FIGURE 4. Variation of the mean random velocities of the ions of the N V resonance lines ($\lambda\lambda$ 1238.821, 1242.804 Å) for the independent density regions of matter which create the 1, 2, 3 and 4 SACs as a function of the spectral subtype.

Full Width At Half Maximum (FWHM)

Fig. 5 indicates the variation of the mean value of the Full Width at Half Maximum (FWHM) for all the N V independent density regions of matter which create the 1, 2, 3 or 4 satellite components in all the stars of our sample, as a function of the spectral subtype.

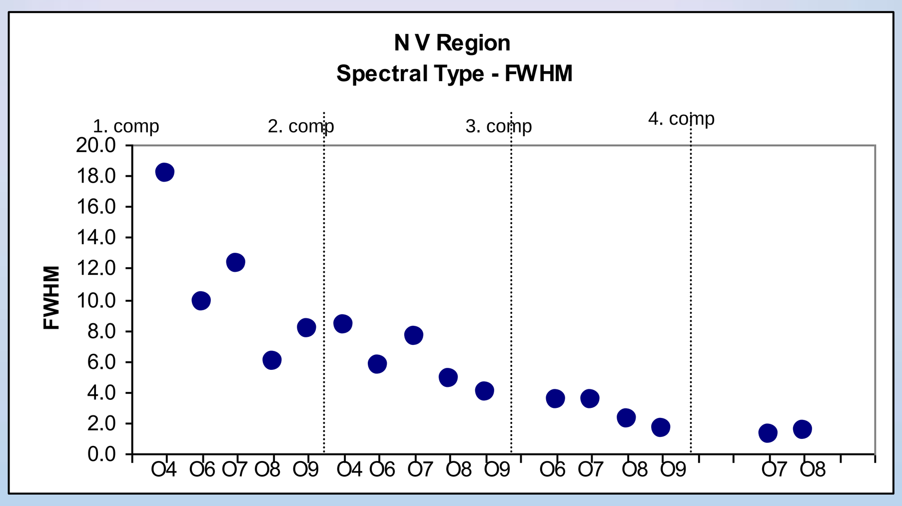

FIGURE 5. Variation of the mean value of the Full Width at Half Maximum (FWHM) for the N V independent density regions of matter which create the 1, 2, 3 or 4 SACs as a function of the spectral subtype.

The Absorbed Energy

In Figs. 6 and 7 we present the variations of the absorbed energy (Ea) in eV, of the $\lambda\lambda$ 1238.821, 1242.804 Å N V resonance lines for all the independent density regions of matter which create the 1, 2, 3 or 4 satellite components in all the stars of our sample as a function of the spectral subtype. We point out that for each component of both of the resonance lines the variations as a function of the spectral subtype are the same.

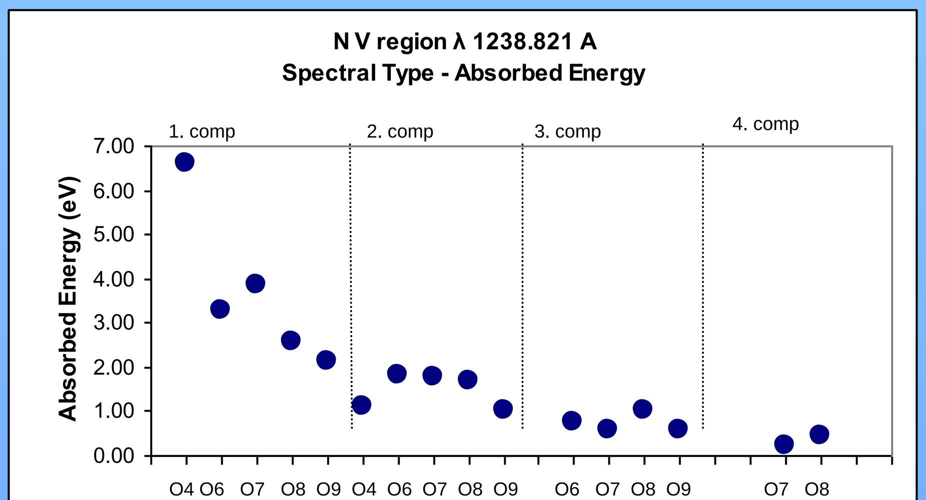

FIGURE 6. Variation of the absorbed energy (Ea) in eV of the N V resonance line λ 1238.821 Å for the independent density regions of matter which create the 1, 2, 3 or 4 satellite components as a function of the spectral subtype.

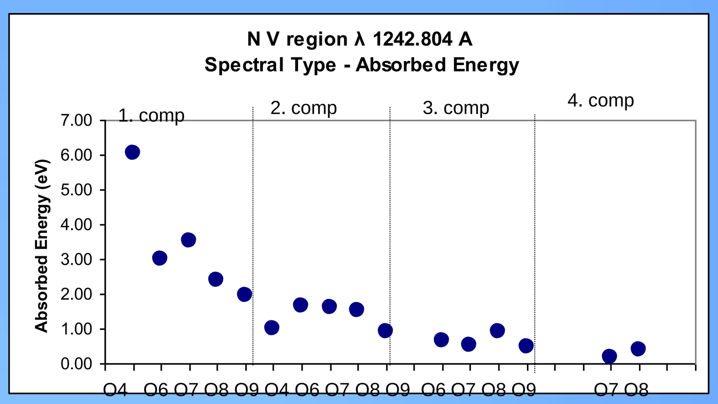

FIGURE 7. Variation of the absorbed energy (Ea) in eV of the N V resonance line λ 1242.804 Å for the independent density regions of matter which create the 1, 2, 3 or 4 satellite components as a function of the spectral subtype.

The Column Density

Figs. 8 and 9 show the variation of the Column Density (CD) in 1010 cm-2 of the $\lambda\lambda$ 1238.821, 1242.804 Å N V resonance lines for the independent density regions of matter which create the 1, 2, 3 or 4 satellite components in all the stars of our sample as a function of the spectral subtype. We note again that each component of both of the resonance lines presents the same variation.

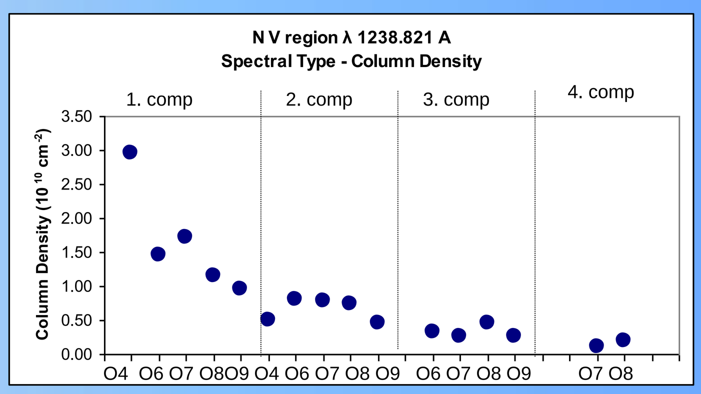

FIGURE 8. Variation of the Column Density (CD) in 1010 cm-2 of the N V resonance line λ 1238.821 Å for the independent density regions of matter which create the 1, 2, 3 or 4 satellite components as a function of the spectral subtype.

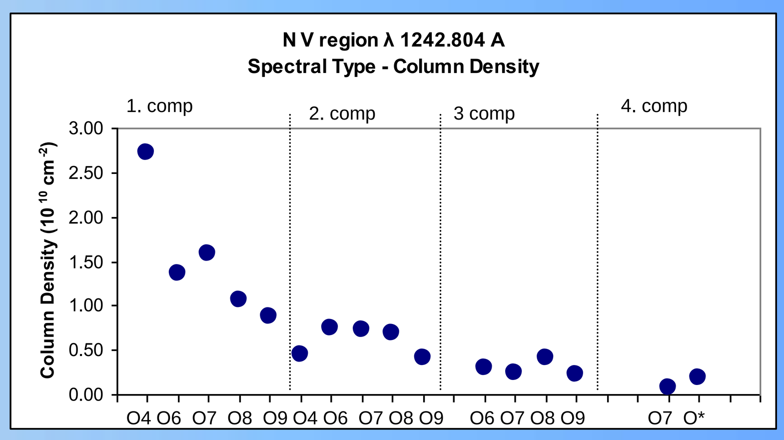

FIGURE 9. Variation of the Column Density (CD) in 1010 cm-2 of the N V resonance line λ 1242.804 Å for the independent density regions of matter which create the 1, 2, 3 or 4 components as a function of the spectral subtype.

RESULTS

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 2500 km/s for the spectral subtype O4, 1500 km/s for the spectral subtypes O6 and O7 and about 300 - 700 km/s for the subtypes O8 and O9 stars. For the other components we see the same phenomenon with lower rotational velocity values. The values about 50 km/s for the second and third component and about 100 km/s for the fourth component correspond to the stars where the main reason for the line broadening is the random motions of the ions.

Gaussian contribution: In Fig. 3 we can conclude to the reverse situation of the diagram in Fig. 2. The Gaussian contribution values are about 70 -80% in the first, second and third component and correspond to the stars where the main reason for the line broadening is the random motions of the ions.

Random velocities: The random velocities are almost constant (about 200 km/s) in each component. High values of random velocities (about 800 km/s in the first and 400 km/s in the second component) correspond to low rotational velocities.

Full Width at Half Maximum (FWHM): The Full Width at Half Maximum (FWHM) (Fig. 5) presents the same image with the respective image of the rotational velocities (Fig. 2).

The absorbed energy: The variation of the absorbed energy (Figs. 6 and 7) present a decreasing trend from the first to the fifth component. We also point out that for each component of both of the resonance lines the variations as a function of the spectral subtype are the same.

The column density: Similarly with the absorbed energy, the column density (Figs. 8 and 9) presents a decreasing trend from the first to the fifth component. It is remarkable that both of these absorption parameters present exactly the same image.

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