Hyper ionisation phenomena in the N V 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 N V 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 N V 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 N V resonance lines (λλ 1238.81, 1242.804 Å) are formed.

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 Δλ, 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 N V 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 N V 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 N V resonance lines (λλ 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 lines consists of one component in 2 stars, two components in 7 stars, three in 9 stars and four in 2 star. In Fig. 1 we present the λλ 1238.821, 1242.804 Å N V resonance lines' best fit of one of the studied stars (HD 34656), using the proposed model. The graph bellow the fit indicates the 3 absorption satellite components and one emission which construct the complex structure of the line above. The thick line presents the observed spectral line profiles and the thin one the best fit. The differences between the observed spectrum and its fit are some times hard to see, as we have accomplished the best fit.

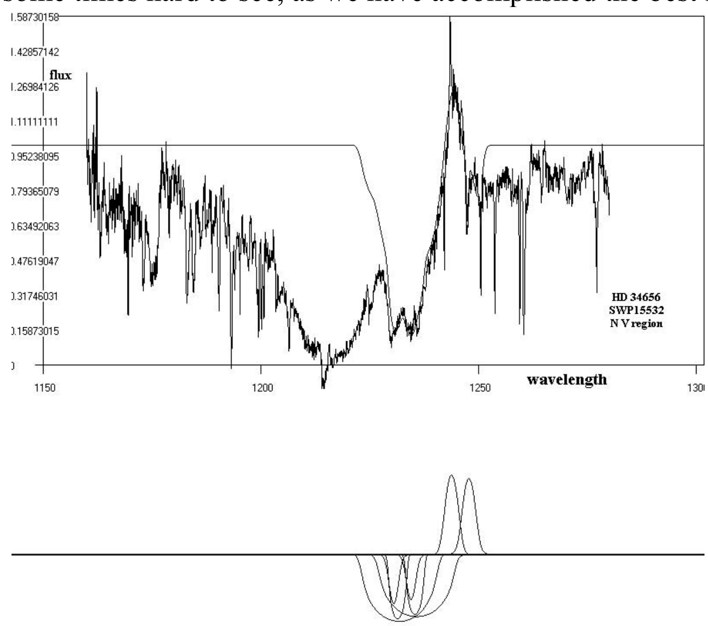

Fig. 1. The N V λλ 1238.821, 1242.804 Å resonance lines in the spectrum SWP 15532 of HD 34656. Each of N V spectral lines consists of 3 SACs and one emission component.The graph bellow the fit indicates the components which construct the complex structure of the line above.

In Fig. 2, we present the N V doublet 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.

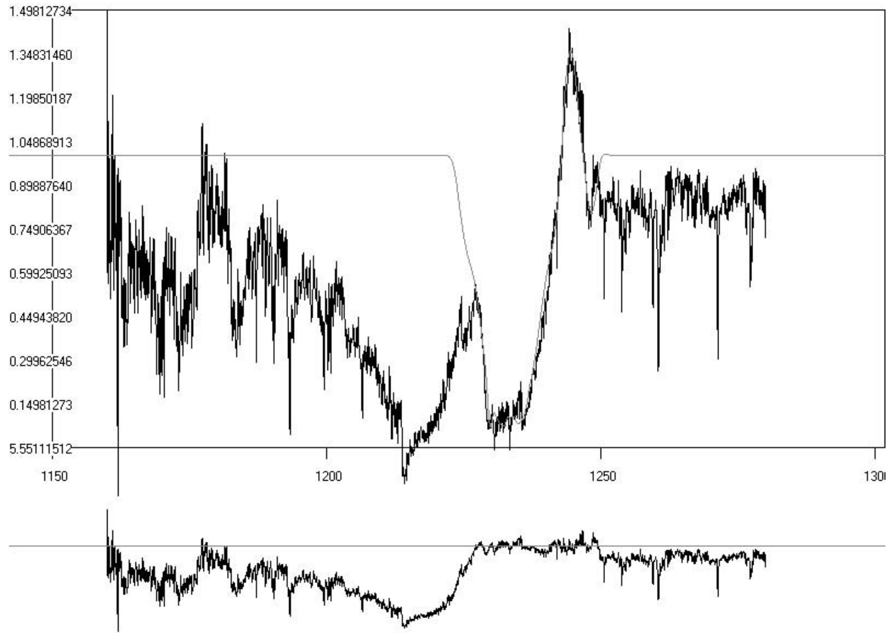

Fig. 2. The N V λλ 1238.821, 1242.804 Å resonance lines the spectrum SWP18941 of HD 24912. Each of N V spectral lines consists of three SACs.

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 N V independent density regions of matter, which create the 1, 2, 3 or 4 satellite components in each of the λλ 1238.821, 1242.804 Å N V resonance lines, as a function of the spectral subtype.

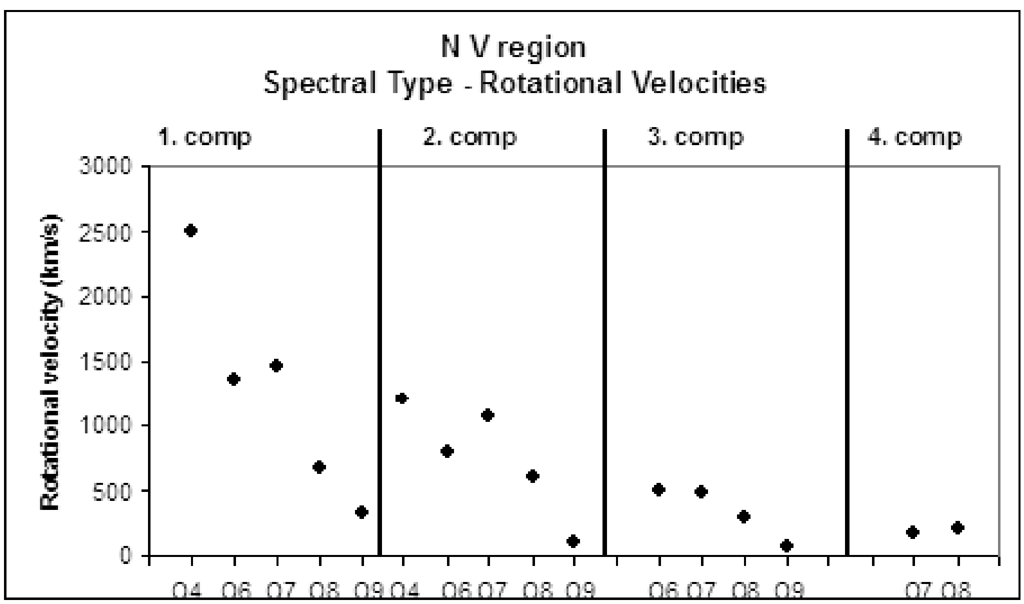

Fig. 3. Variation of the rotational velocities' mean values of the N V resonance lines (λλ 1238.821, 1242.804 Å) for the independent density regions of matter which create the 1, 2, 3 and 4 SACs as a function of the spectral subtype.

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 N V satellite components in each of the λλ 1238.821, 1242.804 Å N V resonance lines, as a function of the spectral subtype.

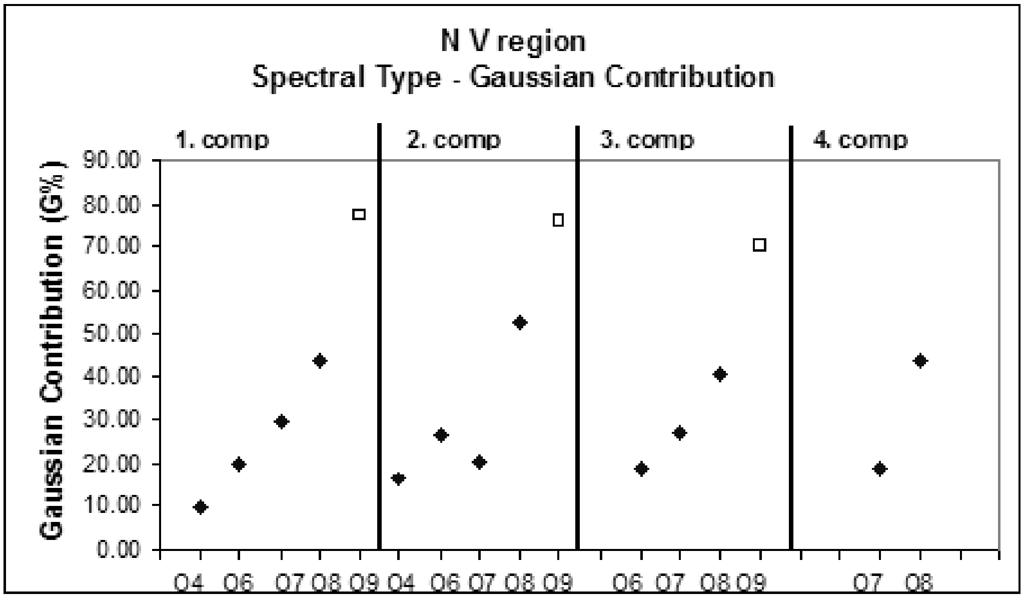

Fig. 4. Variation of the mean Gaussian contribution to the line broadening of the N V resonance lines (λλ 1238.821, 1242.804 Å) for the independent density regions of matter which create the 1, 2, 3 and 4 SACs as a function of the spectral subtype. With white boxes we note the high values of the Gaussian contribution which correspond to the stars where the main reason for the line broadening is the random motions of the ions

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 N V independent density regions of matter, which create the 1, 2, 3 or 4 satellite components in each of the λλ 1238.821, 1242.804 Å N V resonance lines, as a function of the spectral subtype.

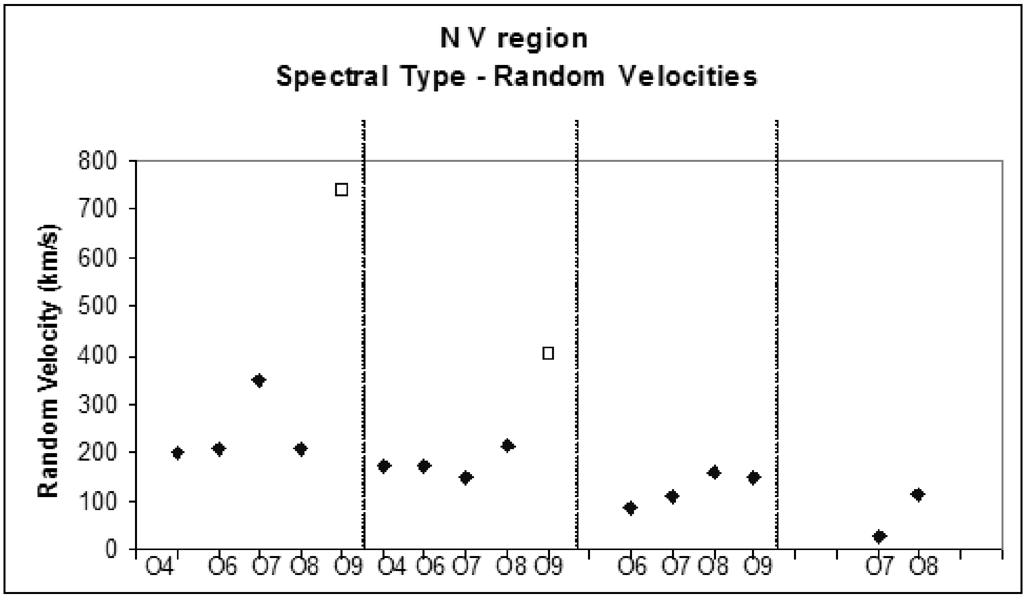

Fig. 5. Variation of the mean random velocities of the ions of the N V resonance lines (λλ 1238.821, 1242.804 Å) for the independent density regions of matter which create the 1, 2, 3 and 4 SACs as a function of the spectral subtype. With white boxes we note the values of the random velocities which correspond to the stars where the main reason for the line broadening is the random motions of the ions

4. Conclusions

Using the model given by Danezis et al.(2003, 2005a,b), here we investigated the line shapes of high-ionized N V regions with aim to investigate hyper-ionization phenomena in the region. We found that high-ionized lines of N V 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 presents 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 rest 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.

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