The Evolution Of Some Physical Parameters In The DACs/SACs Regions In Be Stellar Atmospheres

E. Lyratzi[1], E. Danezis[1], M. S. Dimitrijević[2], L. Č. Popović[2], D. Nikolaidis[1]and A. Antoniou[1]

1. University of Athens, Faculty of Physics, Department of Astrophysics, Astronomy and Mechanics, Panepistimioupoli, Zographou 157 84, Athnes – Greece
2. Astronomical Observatory, Volgina 7, 11160 Belgrade, Serbia

Abstract. In this study we present the evolution of the kinematic parameters from the photosphere to the extreme cool envelope. In order to analyse the stellar spectra we use the method proposed by Danezis et al. (2003) and we conclude that the SACs/DACs phenomena are able to explain, in a unique way, the complex and peculiar observed profiles. These results arise from the study of the Mg II (λλ 2795.523, 2802.698 Å), SiIV (λλ 1393.755, 1402.77 Å), and Hα (λ 6562,817 Å) region of a great number of Be stars of all spectral subtypes and luminosity classes (64 in the case of Mg II resonance lines and 70 in the case of Si IV resonance limes). For the study of the regions which create the complex Hα line profiles we analyzed the OHP (Observatory of Haute Provence) spectrographs of 120 Be stars of all spectral subtypes and luminosity classes.

Keywords: Be stars, DACs, SACs radial, rotational, velocities.
PACS: 97.10.Ex, 97.10.Fy, 97.20.Ec, 97.30.Eh

INTRODUCTION

The spectra of Hot Emission Stars (Oe and Be stars) present peculiar line profiles. In order to explain this peculiarity, we proposed and used the DACs [1] and SACs [2] theory.

In order to find the mechanisms which are responsible for the DACs/SACs formation we should calculate some physical parameters, such as: the rotational, the random and the radial velocities, the FWHM, the optical depth, the absorbed or emitted Energy, the Column Density, and the Gaussian Standard Deviation, in many atmospherical regions, that correspond to different temperatures (ionization potentials) and study the relation among these parameters. A theory for the mechanisms which are responsible for the DACs/SACs formation should be able to explain the values of the above parameters and their relations. Finally, in order to conclude to a consistent mechanism for the mass ejection from Be stars, one should have in mind that a mass ejection theory should agree with the above results and justify and explain the appearance of complex profiles in the spectra of Hot Emission Stars, i.e the existence of DACs/SACs.

Recently, our group proposed a model in order to explain the complex structure of the density regions of hot emission stars, where the spectral lines that present SACs or DACs are created [2, 3, 4]. With this model we can calculate the above mentioned parameters.

In this study we present some general statistical conclusions concerning the structure of Si IV, Mg II and Ha regions in the stellar plasma around Be stars. We calculate the values of the rotational and radial velocities, as well as the FWHM and we examine their variation as a function of the spectral subtype and the relation among them (Lyratzi et al. 2005, 2006, 2007).

OBSERVATIONAL DATA

In our study we used the optical spectra taken by Andrillat & Fehrenbach (1982) and Andrillat (1983) (resolution 5.5 and 27 Å) (for Hα) and the high resolution spectra (0.1 to 0.3 Å) taken with International Ultraviolet Explorer (IUE) found at the VILSPA database (http://archive.stsci.edu/cgi-bin/iue) (for Si IV and Mg II).

We studied i) the Si IV resonance lines at λλ 1393.755, 1402.77 Å in the spectra of 70 Be type stars of all the spectral subtypes and luminosity classes, ii) the Mg II resonance lines at λλ 2795.523, 2802.698 Å in the spectra of 64 Be type stars of all the spectral subtypes and luminosity classes and the Hα spectral line at λ 6562.817 Å in the spectra of 120 Be type stars of all the spectral subtypes and luminosity classes.

In Figure 1 we present the best fit of the Si IV, Mg II and Hα spectral lines.

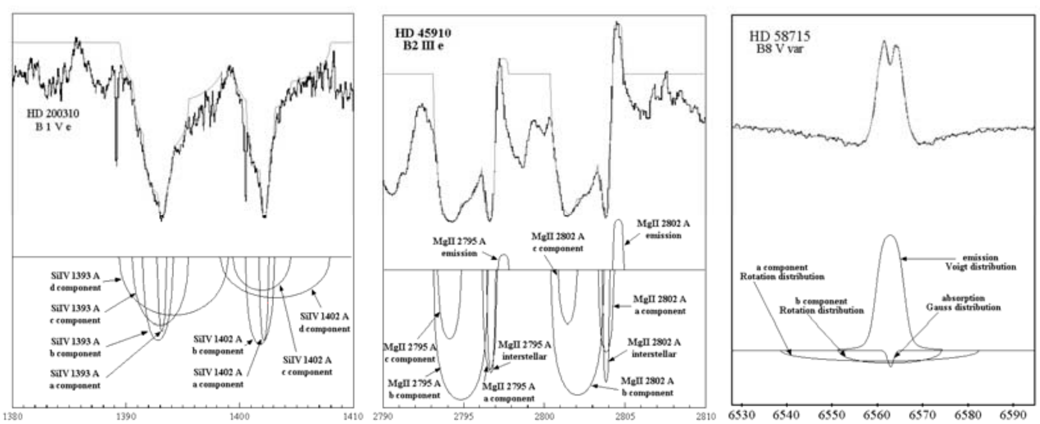

FIGURE 1. Best fit of the Si IV, Mg II and Hα spectral lines. Below the fit one can see the analysis of the observed profile to its SACs.

RESULTS

The Si IV Regions

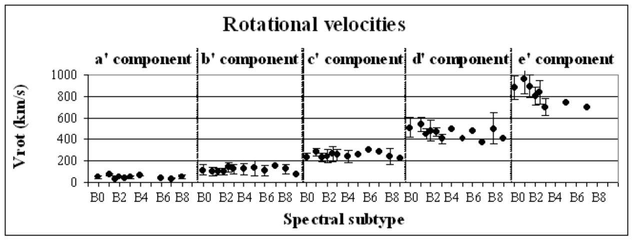

FIGURE 2. Mean rotational velocities of the independent density regions of matter which create the SACs of the Si IV resonance lines (λλ 1393.755, 1402.77 Å) as a function of the spectral subtype.

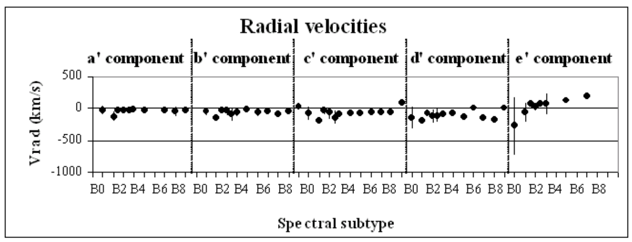

FIGURE 3. Mean radial velocities of the independent density regions of matter which create the SACs of the Si IV resonance lines (λλ 1393.755, 1402.77 Å) as a function of the spectral subtype.

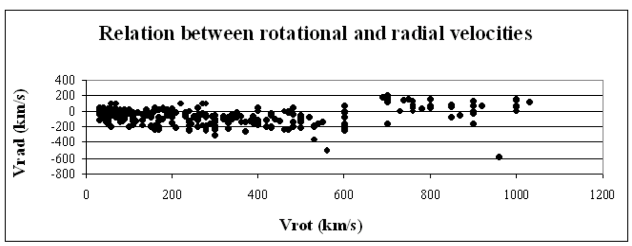

FIGURE 4. Relation between the mean radial (V_{rad}) and rotational (V_{rot}) velocities of the independent density regions of matter which create the SACs of the Si IV resonance lines (λλ 1393.755, 1402.77 Å).

The Mg II Regions

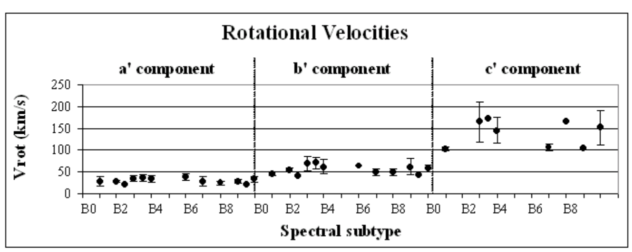

FIGURE 5. Mean rotational velocities of the independent density regions of matter which create the SACs of the Mg II resonance lines (λλ 2795.523, 2802.698 Å) as a function of the spectral subtype.

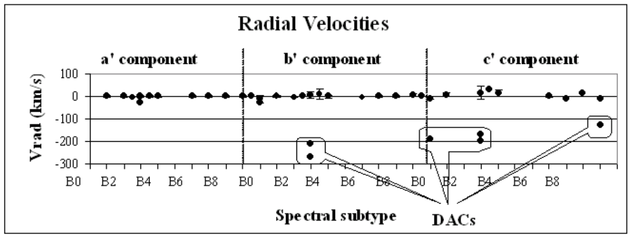

FIGURE 6. Mean radial velocities of the independent density regions of matter which create the SACs of the Mg II resonance lines (λλ 2795.523, 2802.698 Å) as a function of the spectral subtype. The existence of DACs is clearly indicated.

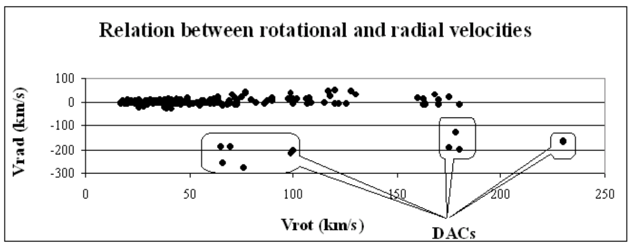

FIGURE 7. Relation between the mean radial (V_{rad}) and rotational (V_{rot}) velocities of the independent density regions of matter which create the SACs of the Mg II resonance lines (λλ 2795.523, 2802.698 Å).

The Hα Regions

In most of the Be stellar spectra the Ha line presents peculiar and complex profiles. Usually the Ha line's profile consists of i) a very broad absorption component (created in the chromosphere), ii) an emission component (created in the cool extended envelope) and iii) a narrow absorption component (created in the cool extended envelope).

We concluded that the best fit is accomplished when we fit i) the very broad absorption component with Rotation distribution (the broad absorption line is composed by one to five components), ii) the emission component with Voigt distribution (in 7 of the 120 stars there exist two emission components) and iii) the narrow absorption component with Gauss distribution.

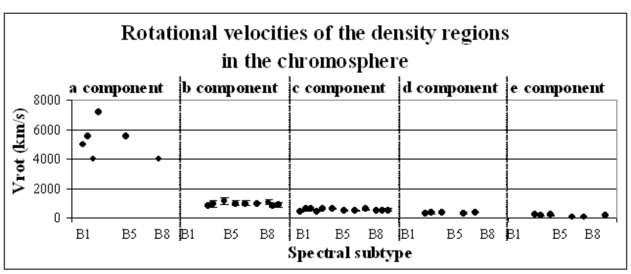

FIGURE 8. Mean rotational velocities of the independent density regions of matter which create the very broad SACs of the Hα spectral line, as a function of the spectral subtype.

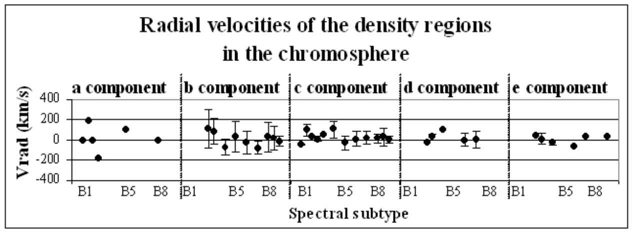

FIGURE 9. Mean radial velocities of the independent density regions of matter which create the very broad SACs of the Hα spectral line, as a function of the spectral subtype.

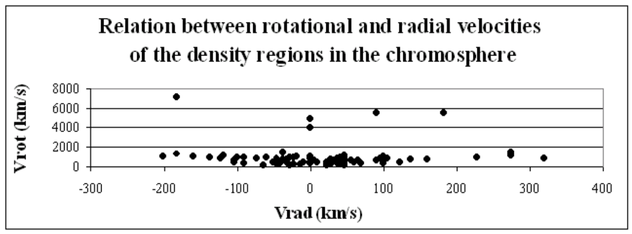

FIGURE 10. Relation between the mean radial (V_{rad}) and rotational (V_{rot}) velocities of the independent density regions of matter which create the very broad SACs of the Hα spectral line.

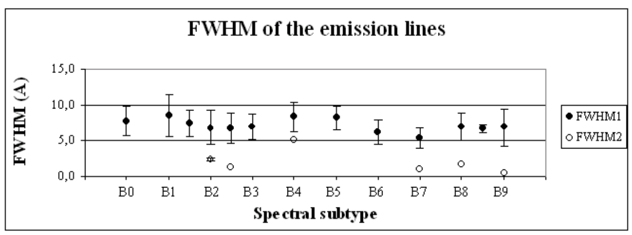

FIGURE 11. Mean values of FWHM of the emission component of the Hα spectral line, as a function of the spectral subtype.

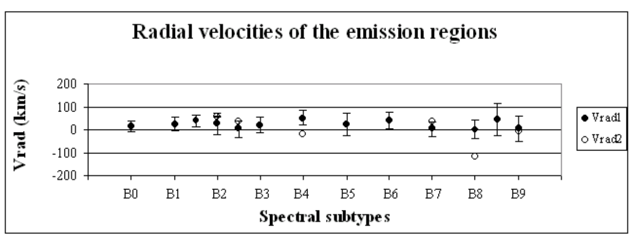

FIGURE 12. Mean radial velocities of the independent density regions of matter which create the emission component of the Hα spectral line, as a function of the spectral subtype.

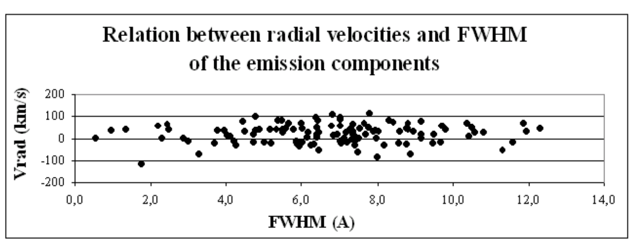

FIGURE 13. Relation between the mean radial (V_{rad}) and the FWHM of the emission component of the Hα spectral line.

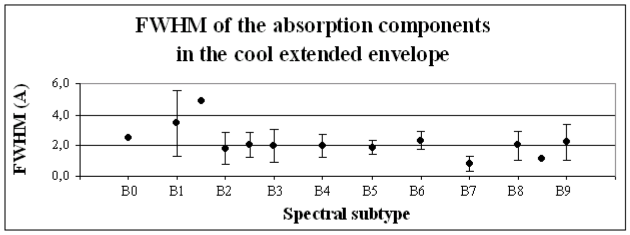

FIGURE 14. Mean values of FWHM of the narrow absorption component of the Hα spectral line, as a function of the spectral subtype.

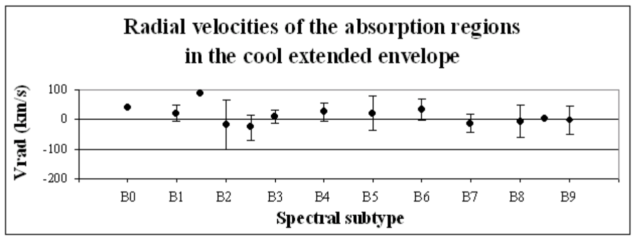

FIGURE 15. Mean radial velocities of the independent density regions of matter which create the emission component of the Hα spectral line, as a function of the spectral subtype.

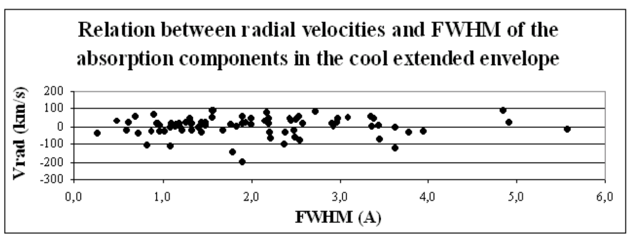

FIGURE 16. Relation between the mean radial (V_{rad}) and the FWHM of the narrow absorption component of the Hα spectral line.

CONCLUSIONS

The results deriving from the study of the Si IV, Mg II and Hα regions in the spectra of many Be stars, are the following:

1. The SACs phenomenon is general in the spectra of Be-type stars and characterizes the studied atmospherical regions (Si IV, Mg II και Hα).
2. The SACs phenomenon is able to explain the peculiar and complex profiles that appear in the spectra of Be stars. The absorption profiles of the studied spectral lines are complex and peculiar, because they do not consist in only one spectral line, but in a group of SACs, which are created in independent density regions, which, of course, do not appear in all the studied stars.
3. We studied the relation among the FWHM and the rotational and radial velocities of the Si IV, Mg II and Hα regions.

ACKNOWLEDGMENTS

This research project is progressing at the University of Athens, Department of Astrophysics - Astronomy and Mechanics, under the financial support of the Special Account for Research Grants, which we thank very much. The project is co-financed within Op. Education by the ESF (European Social Fund) and National Resources, under the "Pythagoras II" project. This work also was supported by Ministry of Science and Environment Protection of Serbia, through the projects: Influence of collisional processes on astrophysical plasma line shapes - P146001 and Astrophysical spectroscopy of extragalactic objects - P146002.

REFERENCES

1. B. Bates and D. R. Halliwell, *Mon. Not. R. Astr. Soc.* **223,** 673-681 (1986).
2. E. Danezis, D. Nikolaidis, E. Lyratzi, A. Antoniou, L.C Popović, and M. S. Dimitriević, *Mem. S. It. Suppl.,* **7**, 107 (2005).
3. E. Danezis, D. Nikolaidis, V. Lyratzi, M. Stathopoulou, E. Theodossiou, A. Kosionidis, C. Drakopoulos, G. Christou and P. Koutsouris, *Ap&SS*, **284**, 1119 (2003).
4. E. Danezis, D. Nikolaidis, E. Lyratzi, L. Č. Popović, M. S. Dimitiević, A. Antoniou and E. Theodosiou, *PASJ,* **59**, in press (2007).
5. E. Lyratzi, E. Danezis, D. Nikolaidis, L. Č. Popović, M. S. Dimitiević, E. Theodosiou and A. Antoniou, *Mem. S. It. Suppl*, **7**, 114 (2005).
6. E. Lyratzi, E. Danezis, A. Antoniou, D. Nikolaidis, L. Č. Popović and M. S. Dimitiević, *IAUJD*, **4**, 10 (2006).
7. E. Lyratzi, E. Danezis, L. Č. Popović and M. S. Dimitiević, D. Nikolaidis and A. Antoniou, *PASJ*, **59**, 357 (2007).