The DACs and SACs Effects From Stars to Quasars. Some First General Notices

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Abstract. The spectra of Hot Emission Stars and AGNs present peculiar profiles that result from dynamical processes such as accretion and/or ejection of matter from these objects. In this paper we explain the idea of DACs and SACs phenomena, as a reason of spectral lines peculiarity in Hot Emission Stars and AGNs. We present the line function of a kinematical model enabling to study the physical parameters of the density regions in the plasma surrounding the considered objects, where DACs and SACs of a spectral line are created, producing the observed peculiar profiles. We also present some first general conclusions, deriving from the proposed model, including the relations among the physical parameters of the density regions of the plasma surrounding the Oe stars, where DACs and SACs are created, producing the observed peculiar profiles.

Keywords: stars: line profiles – absorption components, early-type, emission-line, AGN
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INTRODUCTION

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

In the case of hot emission stars, DACs or SACs arise from spherical density regions surrounding the star or lying far away from it, that present spherical (or apparent spherical) symmetry around the star or their own center [3]. In the case of AGNs, accretion, wind (jets, ejection of matter etc.), BLR (Broad Line Regions) and NLR (Narrow Line Regions) are, perhaps, the density regions that construct peculiar profiles of the spectral lines [4].

Similar phenomena can be detected as an effect of the ejected plasma around peculiar stars. For example around Wolf-Rayet stars (e.g. WR 104) one can detect density regions of matter, quite away from the stellar object, able to produce peculiar profiles [4].

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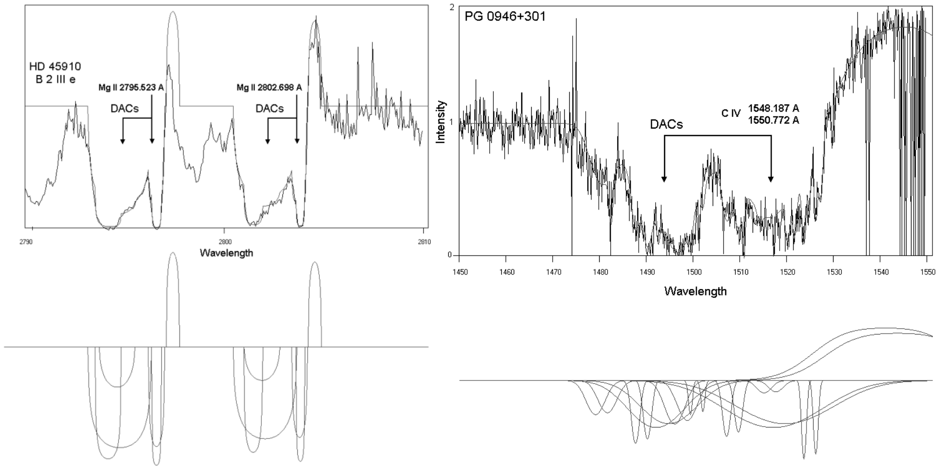

FIGURE 1. DACs in the spectra of Hot Emission Stars (left) and AGNs (right). Below the fit one can see the decomposition of the observed profile to its SACs.

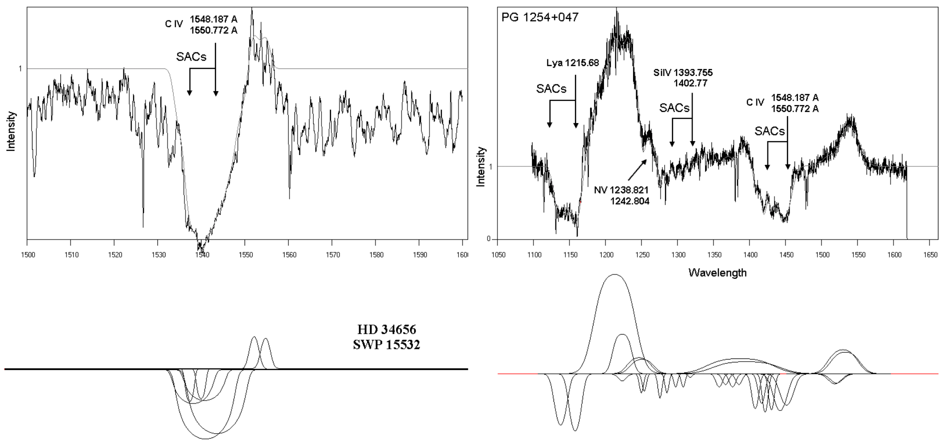

FIGURE 2. SACs in the spectra of Hot Emission Stars (left) and AGNs (right). Below the fit one can see the decomposition of the observed profile to its SACs.

In the case of DACs or SACs phenomenon we need to calculate the line function of the complex line profile. Recently, our group proposed a model in order to explain the complex structure of the density regions of hot emission stars and some AGNs, where the spectral lines that present SACs or DACs are created [2, 5].

In order to find the mechanism responsible for the structure of DACs or SACs density regions we need to calculate the values of a group of 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, as well as the relation among them.

Directly from the model we can calculate the apparent radial velocities (V_{rad}) of the absorbing or emitting density regions, the Gaussian standard deviation (σ) of the random thermal motions distribution, the apparent rotational velocities (V_{rot}) of the absorbing or emitting density region and the optical depth (ξ) in the center of the spectral line.

From the above parameters we can calculate, the percentage contribution (G%) of the random velocities to the broadening of the spectral line, the Full Width at Half Maximum (FWHM), the random velocities of the ions (V_{rand}) that produce the spectral lines, the absorbed or emitted energy (Ea, Ee) and the column density (CD).

We point out that with the proposed model we can study and reproduce specific spectral lines. This means that we can study specific density regions in the plasma surrounding the studied object.

In this paper we present a statistical study of C IV, N IV and N V regions in the spectra of 20 Oe stars. Here, we calculate the values of the above parameters and the relation among them, as well as the time scale variations of the C IV, N IV, N V and Si IV density regions in the HD 93521 stellar atmosphere.

OBSERVATIONAL DATA

For this analysis we took 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).

In Figs. 1 and 2 we present spectra of Hot Emission Stars and AGNs that present DACs or SACs, respectively.

A STATISTICAL STUDY OF C IV, N IV AND N V REGIONS IN THE SPECTRA OF 20 Oe STARS

In Table 1 we present the studied stars. As it is known, it is not possible to find stars between O0 and O3 spectral subtypes. In Figs. 3-7 we present the relations among some physical parameters of the C IV, N IV and N V regions.

TABLE 1. The Studied Stars

Star	Spectral subtype	Star	Spectral subtype
HD24534	O9.5 III	HD57061	O9.0I
HD24912	O7.5 III ((f))	HD60848	O8.0Vpe
HD34656	O7 II (f)	HD91824	O7V((f))
HD36486	O9.5 II	HD93521	O9.5II
HD37022	O6 Vp	HD112244	O8.5Iab
HD47129	O7.5 III	HD149757	O9V(e)
HD47839	O7 III	HD164794	O4V((f))
HD48099	O6.5 V	HD203064	O8V
HD49798	O6p	HD209975	O9.5I
HD57060	O8.5If	HD210839	O6.0I

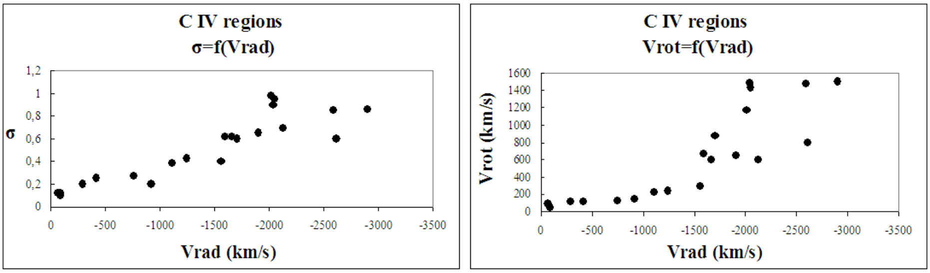

FIGURE 3. Relation of the Gaussian standard deviation (σ) (left) and the rotational velocity (V_{rot}) (right) with the radial velocity (V_{rad}) of the density regions which create the C IV resonance lines.

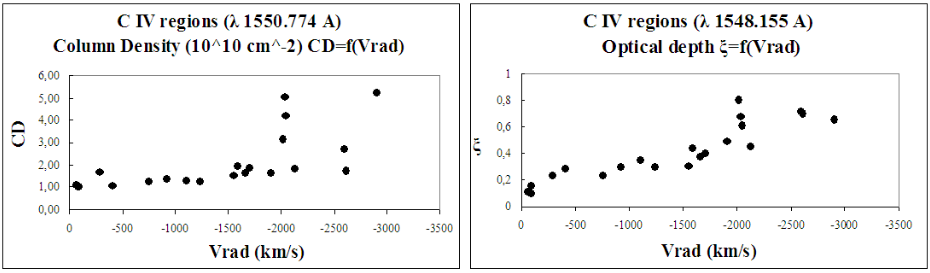

FIGURE 4. Relation of the Column Density (CD) (left) and the optical depth in the center of the line (ξ) (right) with the radial velocity (V_{rad}) of the density regions which create the C IV resonance lines.

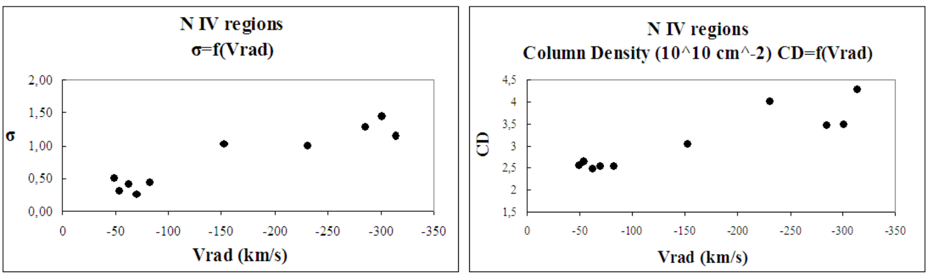

FIGURE 5. Relation of the Gaussian standard deviation (σ) (left) and the Column Density (CD) (right) with the radial velocity (V_{rad}) of the density regions which create the N IV spectral line.

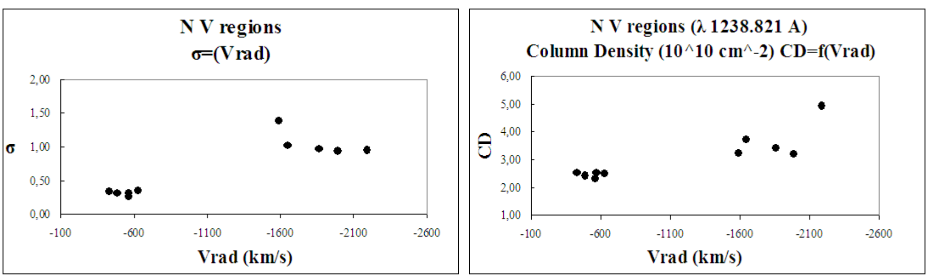

FIGURE 6. Relation of the Gaussian standard deviation (σ) (left) and the Column Density (CD) (right) with the radial velocity (V_{rad}) of the density regions which create the N V resonance lines.

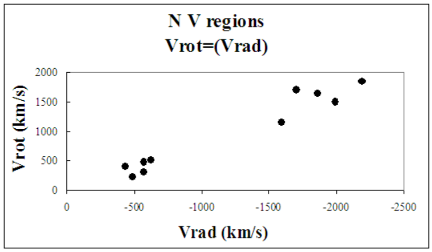

FIGURE 7. Relation between the rotational velocity (V_{rot}) and the radial velocity (V_{rad}) of the density regions which create the N V resonance lines.

TIME SCALE VARIATIONS OF THE C IV, Si IV, N IV AND N V DENSITY REGIONS IN THE HD 93521 STELLAR ATMOSPHERE

From the study of the hyper-ionization regions in the atmosphere of the Oe star HD 93521, we found that the C IV, N IV, N V and Si IV spectral features are fitted with 5, 1, 1 and 3 SACs, respectively. In the case of N V lines, we also detected one emission component.

In Fig. 8 we present the best fit of the C IV, N IV, N V and Si IV spectral lines. In Figs. 9-17 we present the time scale variation of some physical parameters of the C IV, N IV, N V and Si IV regions in the spectrum of HD 93521.

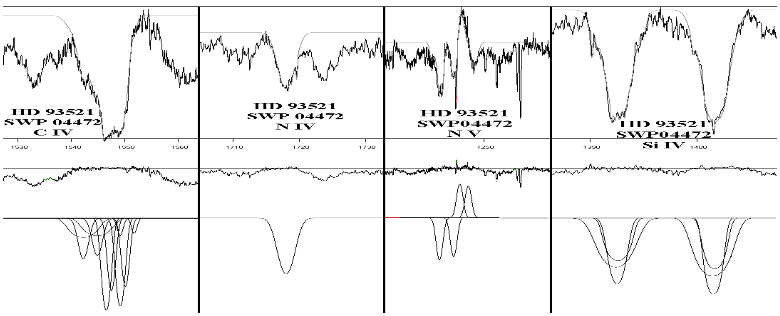

FIGURE 8. Best fit of the C IV, N IV, N V and Si IV spectral lines of the Oe star HD 93521. The graph bellow the fit indicates the differences between the observed spectrum and the fit. Below the fit one can see the decomposition of the observed profile to its SACs.

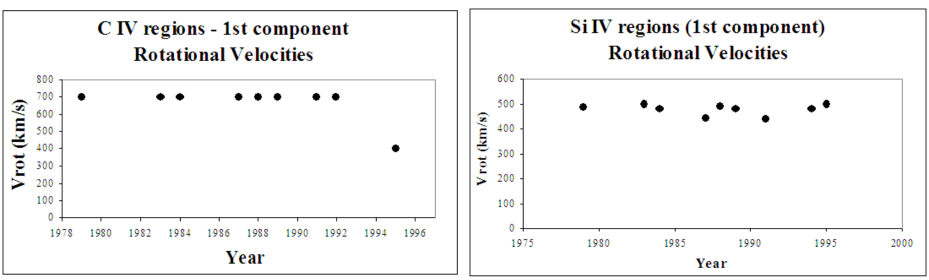

FIGURE 9. Time scale variation of the rotational velocities (V_{rot}) of the C IV (left) and Si IV (right) regions, which create the first SAC in the spectrum of the Oe star HD 93521.

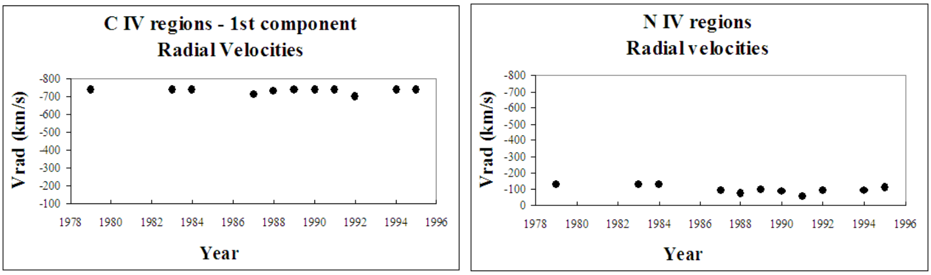

FIGURE 10. Time scale variation of the radial velocities (V_{rad}) of the C IV (left) and N IV (right) regions, which create the first SAC in the spectrum of the Oe star HD 93521.

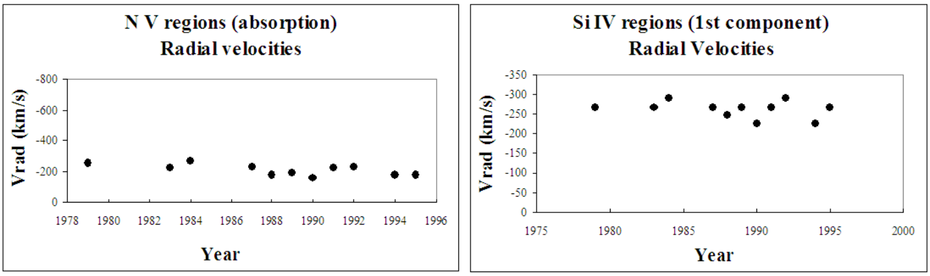

FIGURE 11. Time scale variation of the radial velocities (V_{rad}) of the N V (left) and Si IV (right) regions, which create the first SAC in the spectrum of the Oe star HD 93521.

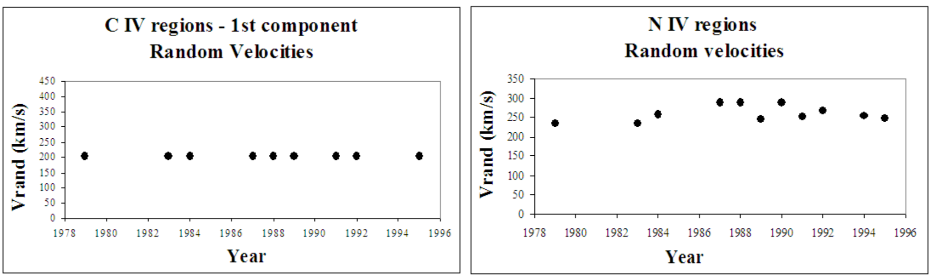

FIGURE 12. Time scale variation of the random velocities (V_{rand}) of the C IV (left) and N IV (right) regions, which create the first SAC in the spectrum of the Oe star HD 93521.

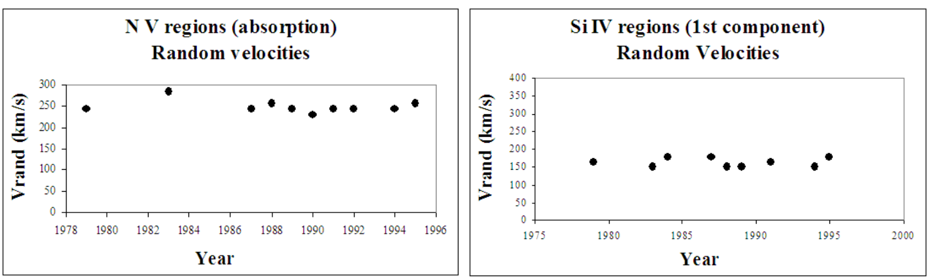

FIGURE 13. Time scale variation of the random velocities (V_{rand}) of the N V (left) and Si IV (right) regions, which create the first SAC in the spectrum of the Oe star HD 93521.

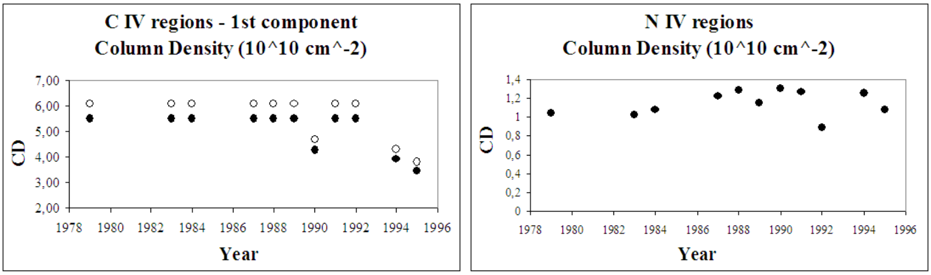

FIGURE 14. Time scale variation of the Column Density (CD) of the C IV (both members of doublet) (left) and N IV (right) regions, which create the first SAC in the spectrum of the Oe star HD 93521.

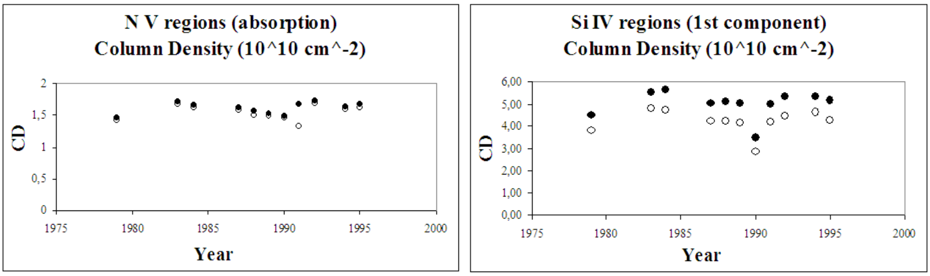

FIGURE 15. Time scale variation of the Column Density (CD) of two resonance lines for the N V (left) and Si IV (right) regions, which create the first SAC in the spectrum of the Oe star HD 93521.

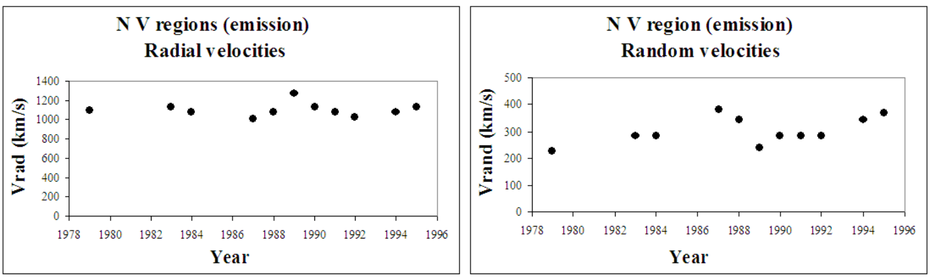

FIGURE 16. Time scale variation of the radial (V_{rad}) (left) and random (V_{rand}) (right) velocities of the N IV regions, which create the emission component in the spectrum of the Oe star HD 93521.

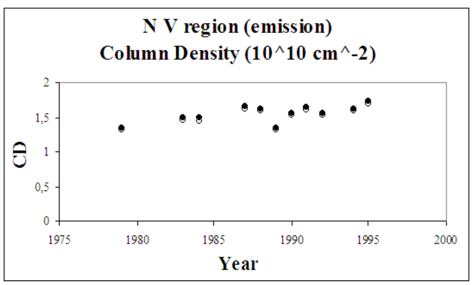

FIGURE 17. Time scale variation of the Column Density (CD) of the N IV region, which creates the emission component in the spectrum of the Oe star HD 93521.

CONCLUSIONS

The results deriving from this study are the following:

1. Using the proposed model, we can calculate the values of some 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, as well as the relation among them. This means that now we can try to understand the mechanism that is responsible for the DACs or SACs phenomenon.
2. The acceptance of SACs and DACs phenomena as the reason of the spectral line complex structure lead us to accept smaller values of the FWHM, optical depths, column densities and different values for the rotational, radial and random velocities, because now the idea is that the complex line profile does non present a single spectral line, but a group of satellite components (DACs or SACs). This idea leads us to a different mechanism for the construction of the density regions that produce the DACs or SACs regions.
3. The detected time scale variation of the parameter values in the C IV, N IV, N V and Si IV density regions in the UV spectrum of the Oe star HD 93521 indicates that the radial, rotational and random velocities, the column densities, and the optical depths present only small variations. This fact leads us to accept that matter which creates DACs or SACs remains practically stable during the studied period of 18 years. An other explanation of this phenomenon is that in the area where we can detect high density regions, matter flows, and only the physical properties (conditions) which lead to high density, remain stable (for example magnetic fields or shocks from a companion in the case of a binary system).

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