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ON MODELLING SACs REGIONS IN EARLY TYPE ATMOSPHERES

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Abstract. We test the ideas that probably DACs are not unknown absorption spectral lines, but spectral lines (satellite absorption components) of the same ion and the same wavelength as a main spectral line, shifted at different Δλ. In addition, DACs are not always discrete absorption spectral lines, but in most cases lines that are blended among themselves as well as with the main spectral line. This means that when we deal with a significant spectral line, which is accompanied by satellite absorption components, we should not regard them as independent spectral lines, but as a unified formation which must be dealt with as one spectral line splited into a series of components. For these reasons we prefer to name them Satellite Absorption Components (SACs) and not Discrete Absorption Components (DACs).

1. INTRODUCTION

Peton (1974) was the first to point out that, in the visual spectrum of the double system AX Mon (HD 45910), there existed a secondary component of the absorption line FeII λ 4233A, which, depending on the phase, appeared in the violet or in the red side of the main spectral line. For this reason the secondary component was named “satellite component”.

Mullan (1984a,b, 1986) suggested that the satellite components may result from “corotating interaction regions” (CIRs), which may form in stars’ winds depending on asymmetries in the wind velocity or density.

Danezis (1984, 1986) and Danezis *et al.* (1991) studied the UV spectra of AX Mon and noted that the absorption lines of many ionization potential ions, not only of those presenting P Cygni profile, are accompanied by two strong absorption components. This means that the regions where these spectral lines are created are not continuous, but they are formed by a number of independent density layers of matter.

The existence of satellite components in the UV spectrum of AX Mon has been detected by Sahade *et al.* (1984) and Sahade and Brandi (1985). Also, Hutsemekers (1985) noticed the same phenomenon in the UV spectrum of another Be star, HD 50138.

Bates and Halliwell (1986), naming the satellite components as “discrete absorption components” (DACs), constructed a model of ejection of gas parcels from above the star’s photosphere, accelerated by radiation pressure. In order to describe the DACs, many suggestions about the properties of the winds have been made, which propose that the DACs are due to disturbances in the wind such as material that forms spiral streams as a result of the star's rotation (Mullan 1984a, Prinja and Howarth 1988) or to mass ejections constructing "shells", "puffs" or gas "parcels" (Henrichs 1984, Underhill and Fahey 1984, Bates and Halliwell 1986, Grady *et al.* 1987, Lamers *et al.* 1988).

Laskarides *et al.* (1992a) observed one more satellite component in the spectral lines of ions with low ionization potential in the UV spectrum of AX Mon, this in the red side of the main lines. This fact indicates contraction of the outer layers of the gaseous envelope.

Waldron *et al.* (1992) tried to give an explanation to the large-scale ejection phenomena by modelling the full time-dependent hydrodynamic response of a stellar wind to a spherically symmetric propagating density shell, which suggests that a substantial amount of material must be present in front of the stellar disk to reproduce the observations. They concluded that DACs' behaviour in UV P Cygni line profiles was the result of the density shells (Lamers *et al.* 1978, Henrichs *et al.* 1980, 1983).

Cranmer and Owocki (1996) suggested that the DACs originate from "moderate size wind structures such as spatially localized clouds, streams or blobs".

Rivinius *et al.* (1997) proposed that when the "blobs" are in front of the stellar disk they give rise to the DACs appearance, otherwise they only contribute to some extra radiation emitted in all directions (Lamers 1994).

Markova (2000) concluded that the recurrence of DACs is hardly related to the stellar rotation and that the DACs are not due to single mass-conserving features, such as outward moving blobs, but that they may originate from outward moving, large-scale, high-density perturbations, which possibly originate from the photosphere, but develop in the outer wind through which wind material flows. These perturbations may be spherically symmetric density shells or curved structures like kinks.

Danezis *et al.* (1991, 1995, 1998, 2000a,b,c, 2001, 2002,a,b), Laskarides *et al.* (1992a, 1992b), Lyratzi *et al.* (2001) apart from their study of the UV spectrum of Be stars, where they found satellite components, have also studied the UV spectrum of several Oe stars and detected satellite components, not only for the spectral lines of low ionization potential, but also for the resonance lines of NV, CIV, SiIV and the spectral line NIV.

2. THE MAIN IDEA OF OUR RESEARCH

In this paper we test the ideas proposed by Danezis (1984, 1986) and Danezis *et al.* (1991). In these papers they proposed that probably DACs are not unknown absorption spectral lines, but spectral lines (satellite absorption components) of the same ion and the same wavelength as a main spectral line, shifted at different $\Delta\lambda$. In addition, DACs are not always discrete absorption spectral lines, but in most cases lines that are blended among themselves as well as with the main spectral line. In such a case they are not observable, but we can detect them through the analysis of our model (Danezis *et al.* 2002a, 2003). This means that when we deal with a significant spectral line, which is accompanied by satellite absorption components, we should not regard them as independent spectral lines, but as a unified formation which must be dealt with as one spectral line splited into a series of components. For these reasons we prefer to name them Satellite Absorption Components (SACs) and not Discrete Absorption Components (DACs). In the case of absorption spectral lines presenting SACs, as well as a P Cygni profile, the emission spectral line is created in an independent emitting density region.

3. THE MODEL: MATHEMATICAL EXPRESSION

Considering an area of gas consisting of i independent absorbing shells followed by a shell that both absorbs and emits and an outer shell of general absorption, we resort to the function:

$$I_\lambda = \left[I_{\lambda 0} \prod_i \exp\{-L_i \xi_i\} + S_{\lambda e}\left(1 - \exp - L_e \xi_e\right)\right] \exp\{-L_g \xi_g\} \tag{1}$$

where: **$I_{\lambda 0}$:** the initial radiation intensity,

L_i, L_e, L_g: are the distribution functions of $k_{\lambda i}$, $k_{\lambda e}$, $k_{\lambda g}$ respectively. Each L depends on the values of the apparent rotational velocity as well as of the radial expansion or contraction velocity of the density shell, which forms the spectral line

$\xi = \int_0^s \Omega \rho ds$ is an expression of the optical depth τ, where Ω: an expression of k_λ and has the same units as k_λ,

$S_{\lambda e}$: the source function, which, at the moment when the spectrum is taken, is constant and

$L = \sqrt{1 - \cos^2\theta_0}$ if $\cos\theta_0 < 1$ and $L = 0$ if $\cos\theta_0 \geq 1$,

where $\cos\theta_0 = \frac{-\lambda_0 + \sqrt{\lambda_0^2 + 4\Delta\lambda^2}}{2\Delta\lambda z_0}$, where $2\theta_0$ is the angular width of the equatorial disk of matter, λ_0 is the wavelength of the center of the spectral line and $\lambda_0 = \lambda_{lab} + \Delta\lambda_{\exp}$, with λ_{lab} being the laboratory wavelength of the spectral line produced by a particular ion and $\Delta\lambda_{\exp}$ the radial Doppler shift and $\frac{\Delta\lambda_{\exp}}{\lambda_{lab}} = \frac{V_{\exp}}{c}$.

$z_0 = \frac{V_{rot}}{c}$, where V_{rot} is the apparent rotation velocity of the i density shell of matter and

$\Delta\lambda = |\lambda_i - \lambda_0|$, where the values of λ_i are taken in the wavelength range we want to reproduce.

As we can understand from the above, the spectral line's profile, which is formed by the i density shell of matter, must be accurately reproduced by the function $e^{-L_i \xi_i}$ by applying the appropriate values of V_{roti}, V_{expi} and ξ_i.

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