Application of a new model of density shells of matter to the expanding gaseous envelope of the star HD 45910 (AXMon).

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Introduction

AX Monocerotis (HD45910 = BD+5°,1267 = SAO13974, $\alpha=6^h27^m52^s$, $\delta=+5°,54',1$ (1950), V=6,59 - 6,88 mag) is a binary system (Merrill 1952) with an orbital period of 232.5 days (Magalashvili & Kumsishvili 1969, Papousek 1979) and a variable spectrum (Merrill 1923, Plaskett 1923, 1927).

In this paper we present a coronal model for the structure of the envelope of Oe and Be stars (Doazan 1982, Danezis 1984, Danezis et al. 1991, 1995, 2000, 2001), which allows the existence of many absorption shells or many independent density regions and concludes to a function for the spectral line, able to reproduce all the spectral lines, as well as the results deriving from its application to the star of HD 45910 (AX Mon).

The UV data

Our data are the ten UV spectra (table) of HD 45910 (AX Mon) taken with IUE satellite.

Spectra	Spectrum Width	Date
SWP 03774	1098 Å - 2099 Å	1/1/1979
LWR 03353	1810 Å - 3457 Å	1/1/1979
SWP 04762	1098 Å - 2099 Å	27/3/1979
LWR 04131	1810 Å - 3457 Å	27/3/1979
SWP 07225	1098 Å - 2099 Å	26/11/1979
LWR 06234	1810 Å - 3457 Å	26/11/1979
SWP 15733	1098 Å - 2099 Å	13/12/1981
LWR 12138	1810 Å - 3457 Å	13/12/1981
SWP 29415	1098 Å - 2099 Å	10/10/1986
LWP 09251	1808 Å - 3360 Å	5/10/1986

The atmospherical model

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 conclude to the function:

$$I_\lambda = \left[I_{\lambda 0} \exp\left\{-L_{\lambda e}\xi_e\right\} \prod_i \exp\left\{-L_i \xi_i\right\} + \Theta_0 \left(1 - \exp\left\{-L_{\lambda e}\xi_e\right\}\right) \right] \exp\left\{-L_{\lambda g}\xi_g\right\}$$

where: $\mathbf{I_{\lambda 0}}$**:** the initial radiation intensity, $\mathbf{L_i}$, $\mathbf{L_{\lambda e}}$, $\mathbf{L_{\lambda g}}$: functions of the rotational and the expansion/contraction velocities (vsini, $v_{ex/c}$),

$\xi = \int_0^s \Omega \rho ds$ where $\mathbf{\Omega}$: an expression of k_λ, $\mathbf{\Theta_0}$: the source function $S_{\lambda e}$, which, at the moment when the spectrum is taken, is constant and

$L = \sqrt{1-\cos^2\theta}$, if $\cos\theta_0 < 1$, or

$L = 0$, if $\cos\theta_0 \geq 1$

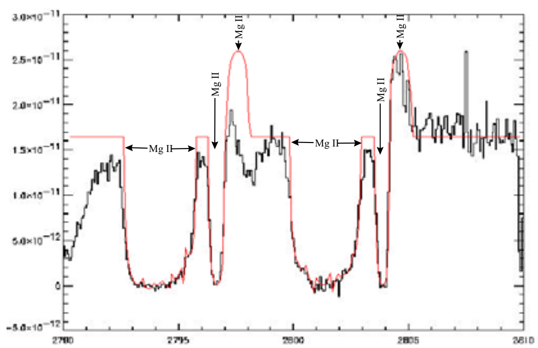
where: $\cos\theta_0 = \dfrac{-\lambda_0 + \sqrt{\lambda_0^2 + 4\Delta\lambda^2}}{2\Delta\lambda z_0} < 1$

where: λ_0 is the wavelength of the center of the spectral line and $\lambda_0 = \lambda_{lab} + \Delta\lambda_{\exp}$, where λ_{lab} is the laboratory wavelength of the spectral line and $\Delta\lambda_{exp}$ is the radial Doppler shift and $\dfrac{\Delta\lambda_{\exp}}{\lambda_{lab}} = \dfrac{v_{\exp}}{c}$

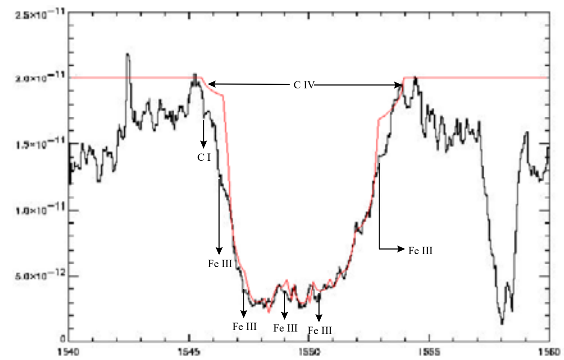
$z_0 = \dfrac{v_{\exp}}{c}$, where v_{exp} is the apparent rotational velocity of the i density shell of matter.

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

The model's fit



Each of Mg II λλ 2795.523, 2802.698 Å resonance lines is formed as a composition of five independent absorption and one emission components

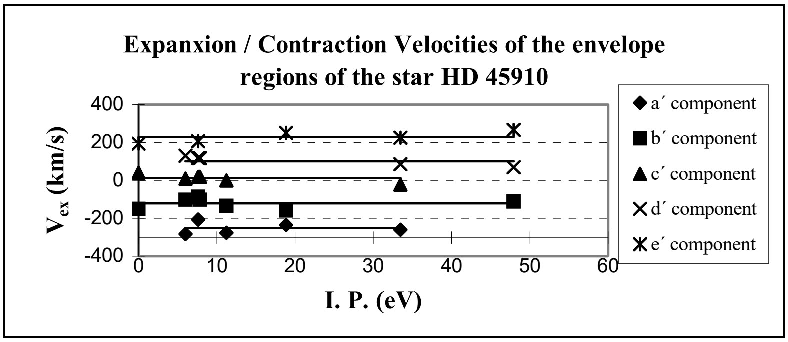


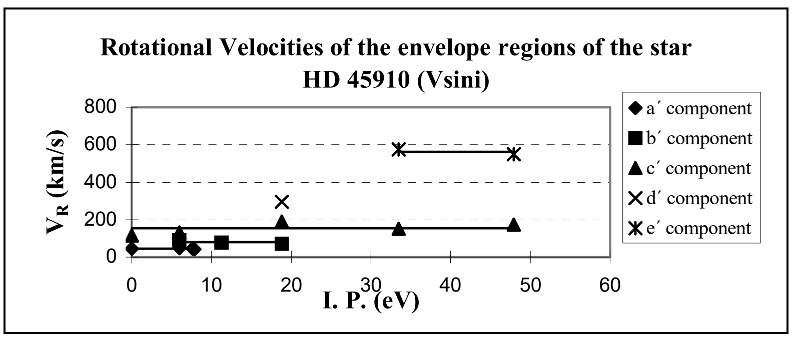
Each of C IV λλ 1548.195, 1550.768 Å resonance lines is formed as a composition of four independent absorption components

The tables of radial velocities and expansion/contraction velocities

Expansion/Contraction velocities of the envelope regions of HD 45910 (kms^{-1})						
Spectral line	**Ionization potential**	**a´ component**	**b´ component**	**c´ component**	**d´ component**	**e´ component**
Lya	**0.000**		-150	+42		+193
Al II	**5.986**	-283	-102	+11	+129	
Mg II	**7.646**	-207	-87	+20	+116	+205
Fe II	**7.870**		-103	+19	+116	
C II	**11.260**	-275	-133	+1		
Al III	**18.828**	-234	-158			+252
Si IV	**33.492**	-261		-21	+86	+225
C IV	**47.887**		-110		+70	+266
Mean		**-252±31**	**-120±27**	**+12±21**	**+103±24**	**+228±31**

Rotational velocities of the envelope regions of HD 45910 (Vsini) (kms^{-1})						
Spectral line	**Ionization potential**	**a΄ component**	**b΄ component**	**c΄ component**	**d΄ component**	**e΄ component**
Lya	**0.000**	45		117		
Al II	**5.986**	47	90	131		
Mg II	**7.646**	46				
Fe II	**7.870**	42				
C II	**11.260**		77			
Al III	**18.828**		71	191	294	
Si IV	**33.492**			150		576
C IV	**47.887**			174		548
Mean		**45±2**	**79±10**	**153±30**	**294±0**	**562±20**





Conclusions

1. By applying the proposed model we are able to reproduce the profiles of all the spectral lines of the star HD 45910 (AXMon) with great accuracy. This means that the coronal model allowing the existence of successive, independent density shells of matter represents accurately the structure of the gaseous envelope of AX Mon.
2. We confirm the existence of the three independent shells of matter, proposed by Danezis (1984, 1986), Laskarides, Danezis & Theodossiou (1992) and Sahade & Brandi (1985) in the envelope of AXMon, with similar expansion velocities. The values that derived by the model's application are –252 ±31 kms^{-1}, -120 ±27 kms^{-1} and +12 ±21 kms^{-1}. We also confirm the existence of the contracting shell, which was proposed by Laskarides, Danezis & Theodossiou (1992), with radial velocity of +103 ±24 kms^{-1}. Additionally, we detected the existence of one more contracting shell of matter moving with +228 ±31 kms^{-1}. It should be underlined that the emitting shell of MgII is a contracting one moving with +205 kms^{-1}, whereas the emitting shell of the Lya region contracts +42 kms^{-1}.

3. The apparent rotational velocities (vsini) of the independent shells of matter fluctuate between 45 kms^{-1} και 562 kms^{-1} and, as it was expected, they decrease as the distance of the shell from the star increases.
4. We have to note that the "dish-shaped" profiles of some spectral absorption lines (for example MgII) do not suggest any special physical feature, but they derive from the composition of a number of components of the same spectral line.
5. Finally, we suggest a mechanism, which leads to the superheating of the corona and the formation of the emission lines. The regions where the superionized spectral lines form consist of expanding and contracting waves of mater. In these regions the large initial opposite radial velocities of these waves seem to be minimized in a short time. According to this fact, we can suppose that the superheating of the coronal region is probably due to the rapid minimization of the initial kinetic energy, happening in a small region, which results to the increase of the kinetic temperature. The same phenomenon is observed in the regions, where the emission spectral lines form. In this case, however, the kinetic energy does not contribute to the increase of the kinetic temperature but it is emitted. In the case of the existence of emission lines in superionized regions (as in the case of Oe stars) the kinetic energy partially contributes to the increase of the kinetic temperature and partially is emitted.

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