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VARIATIONS OF ULTRA-VIOLET LINES FOR C, N, AND O IN THE Ap STARS HD 18296 AND HD 25823†

JEAN-FRANÇOIS GONZALEZ & MARIE-CHRISTINE ARTRU
Ecole Normale Supérieure de Lyon, Laboratoire de Physique, 46, allée d'Italie, F-69364 LYON Cedex 07, FRANCE

ABSTRACT From the rotational variation of UV resonance lines of carbon, nitrogen, and oxygen, we study the irregular distribution of these elements upon the surface of two magnetic Ap stars: HD 18296 (21 Per) and HD 25823 (41 Tau).

1 INTRODUCTION

The localization of anomalous elements over the stellar surfaces of magnetic Ap stars provide important clues to understand the radiative diffusion in presence of a magnetic field which drive the migration of ions. Mappings have already been elaborated for a number of Ap stars and different elements (mostly from the iron-peak sequence) showing spots and rings of accumulation tied to the large-scale magnetic geometry (see for example Landstreet, 1988 or Hatzes, 1991).

In the case of carbon, nitrogen, and oxygen, very few data exist, mainly because their visible lines are weak in the red region. In this work we intend to derive the rotational modulation of C, N, and O from strong ultra-violet resonance lines, using the high-resolution spectra recorded by the IUE satellite for the stars HD 18296 and HD 25823 at different times of their rotational period (10 and 5 spectra).

In a previous investigation of HD 25823, Artru and Freire-Ferrero (1988) have pointed out a variation of carbon lines similar to the one of gallium and titanium, and opposite to the one of silicon and iron. Recently, the star HD 18296 has been studied by Wehlau *et al.* (1991) who obtained maps of Mn, Fe, Cr, Si, and Ti.

2 METHODS

To extract the variations of carbon, nitrogen, and oxygen absorption, we measured the equivalent widths of their lines at each phase. We chose very strong lines (listed in Table 1) to reduce the perturbation of blends, which is severe in the ultra-violet.

†Based on observations by the International Ultraviolet Explorer collected at the Villafranca Satellite Tracking Station of the European Space Agency.

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TABLE I Resonance ultra-violet lines of C, N, and O used for the variation study

	λ (Å)		λ (Å)		λ (Å)		λ (Å)
C I	1560.3	C II	1323.9	N I	1319.0	O I	1302.2
	1560.7		1334.5		1411.9		
	1561.4		1335.7		1492.6		
	1656.9				1492.8		
	1657.4				1494.7		
	1658.0						

We measured equivalent widths by fitting a gaussian curve on the central part of each line and on a given pseudo-continuum. Because of the large density of lines, it is very difficult to choose a continuum. We excluded the visual estimate of a high-peak continuum, which is somewhat arbitrary, and adopted a pseudo-continuum equal to the averaged value of the observed flux over a fixed neighbouring spectral range, containing no strong lines. We checked that the variations of these values over the rotational period are significantly lower than those obtained for the equivalent widths (as shown in Table II).

3 RESULTS

Figure 1 shows the variations of the equivalent widths of C II, N I, and O I lines for HD 18296 and HD 25823 and of their effective magnetic field versus the rotational phase. The dashed curves are least-square fits by a simple sine function. The phases for HD 18296 are computed using the ephemeris given by Preston (1969):

$$JD\ (\text{primary maximum}) = 2439491.77 + 2\overset{\mathrm{d}}{.}88422\,E$$

and those for HD 25823 with the ephemeris of Abt and Snowden (1973):

$$JD\ (\text{periastron}) = 2421944.74 + 7\overset{\mathrm{d}}{.}227424\,E\,.$$

The variation curves obtained from different lines of carbon are in agreement with each other: the maxima of equivalent widths are all located within an interval of 0.1 in phase. For HD 25823, the maxima of carbon absorption occurs near phase 0.55, and coincide with the maximum of the effective magnetic field, according to Wolff (1973).

The maxima found for oxygen are close to the carbon ones. For nitrogen, the agreement between the different lines is not satisfactory and the behaviour appears very different from the other elements.

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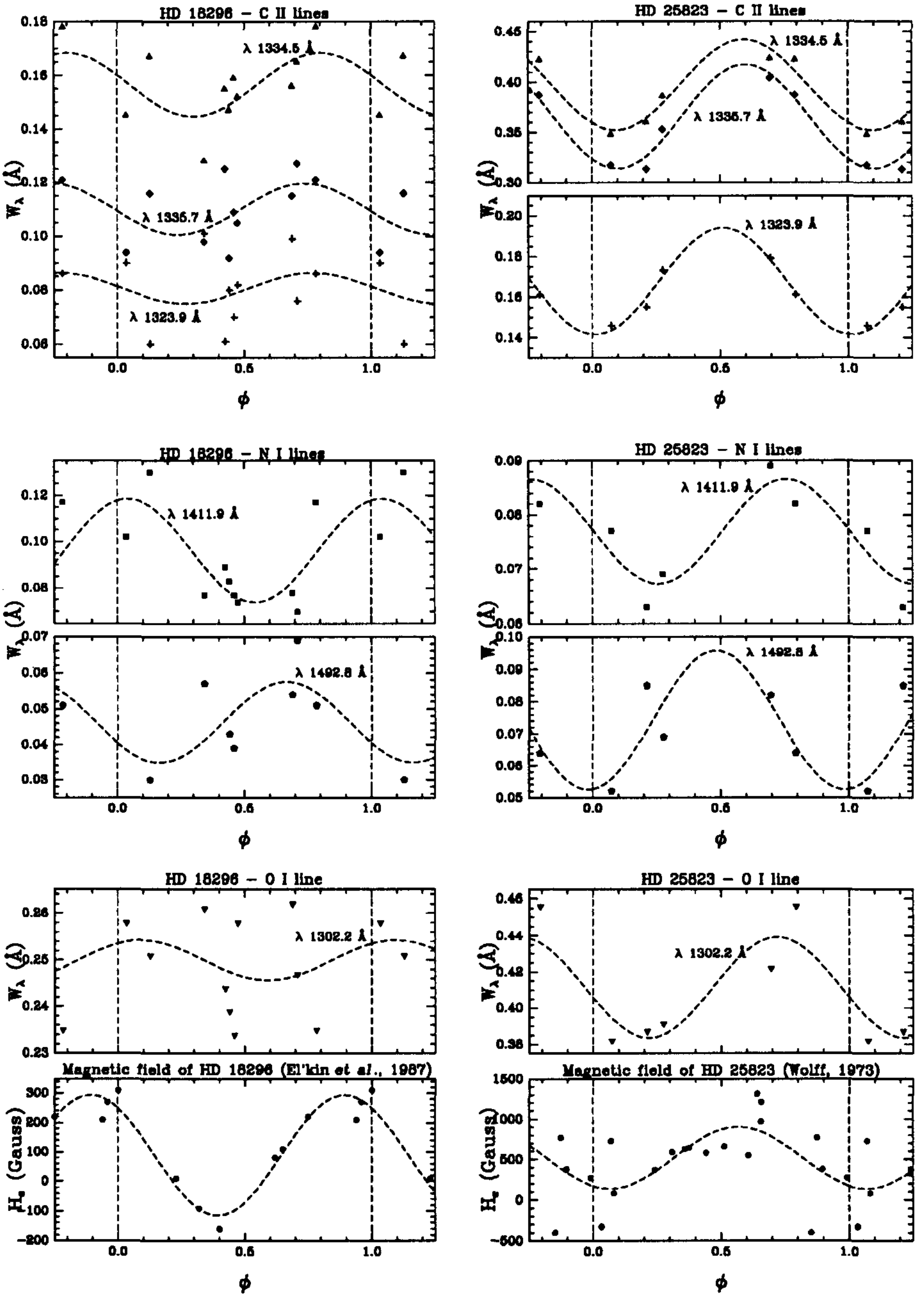

Fig. 1 Variations of the equivalent widths of C II, N I, and O I lines for HD 18296 (left) and HD 25823 (right) together with the magnetic field of these stars.

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4 CONCLUSION

A detailed comparison of the observed variations with theoretical predictions from the diffusion theory would require a more precise description of the magnetic geometry of the stars. It is also necessary to improve the computation of radiative forces on the different ions of C, N, and O.

TABLE II Variations of the equivalent widths and phase of maximum for the lines shown on Fig. 1

		Line variation	Pseudo-continuum variation	ϕ_{max}
		HD 18296		
C II	1323.9	51%	13%	0.77
	1334.5	32%	13%	0.80
	1335.7	31%	13%	0.74
N I	1411.9	67%	12%	0.04
	1492.8	80%	11%	0.67
O I	1302.2	11%	11%	0.09
Magnetic field				0.89
		HD 25823		
C II	1323.9	20%	4%	0.51
	1334.5	19%	4%	0.59
	1335.7	26%	4%	0.60
N I	1411.9	34%	2%	0.76
	1492.8	47%	2%	0.48
O I	1302.2	18%	4%	0.72
Magnetic field				0.57

However, following the analysis of Roby and Lambert (1990), the elements C and O diffuse downwards (explaining their general underabundance). On the contrary, N could be pushed upwards, at least in stars hotter than $T_{eff} = 10,000$ K. According to Michaud *et al.* (1981), the horizontal diffusion mechanism accumulate elements which are pushed downwards (resp. upwards) in the regions where the magnetic field is vertical (resp. horizontal).

When the effective magnetic field is maximum (for example around phase 0.57 for HD 25823), one can assume that the visible stellar hemisphere contains a polar region. Therefore the observed variations for carbon and oxygen imply that the horizontal diffusion may be the dominant mechanism.

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