Inside the Stars, IAU Colloquium 137
ASP Conference Series, Vol. 40, 1993
Werner W. Weiss and Annie Baglin (eds.)

SHORT-TERM SPECTRAL VARIABILITY IN THE HERBIG Ae STAR AB AUR: PRELIMINARY ANALYSIS OF CHROMOSPHERIC LINES [1].

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INTRODUCTION

The Herbig Ae stars are PMS objects of intermediate mass. Their location in the H-R diagram indicates that they are in the radiative phase of their quasi-static contraction toward the main sequence, i.e. that they do not possess outer convective zones, according to the standard stellar evolution theory (Iben, 1965; Gilliland, 1986). In spite of the expected absence of subphotospheric convective envelopes, these stars show remarkable signs of activity: emission in the Mg II h and k lines, presence of the C IV resonance lines at 1550 A and He I 5875.7 A line, Ca II IR triplet in emission, etc... Considering that stellar activity, witnessed by the same type of indicators in other parts of the H-R diagram, is generally attributed to dynamo magnetic fields and/or acoustic waves generated in the convection zone, these active phenomena are quite paradoxical in the Herbig Ae stars.

The main question concerns the origin of their activity: is this activity linked to phenomena occurring within the stars, like e.g. dynamo–generated magnetic fields, or to an external agent, like e.g. a boundary layer between an accretion disk and the stellar surface? We already have some indirect clues that the activity of the Herbig Ae stars might be of magnetic origin (Praderie et al., 1986; Catala et al. 1986) observed a rotational modulation of lines formed in the wind of AB Aur, prototype of the Herbig Ae stars. By analogy with the solar wind, they proposed that the modulation might be due to the corotation of azimuthal structures in the wind, controlled by a surface magnetic field.

However, the link between the stellar wind modulation and a structured magnetic field is far from being firmly established. In particular, we have no clear indication that the source of the modulation is near the stellar surface, since the lines for which such a modulation has been observed are formed far in the wind. Are we seeing a corotating structure linked to the stellar surface by a magnetic field, or some other type of variable phenomenon occurring in the

[1] Based on observations obtained with the "Bernard Lyot" telescope, at Pic du Midi Observatory, France.

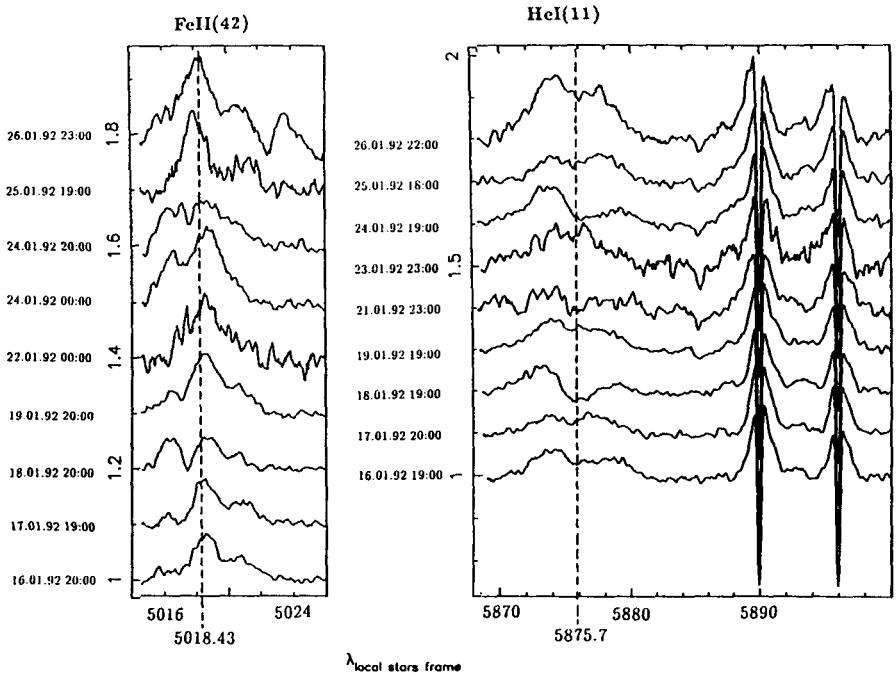

FIGURE I Profiles of the He I and Fe II lines

wind itself, like e.g. inhomogeneities passing periodically on the line of sight?

To answer this question, we have searched for the same type of modulation in a line which is formed closer to the stellar surface, at the base of the wind. From previous line profile analysis, we know that a chromosphere is present at the base of AB Aur's wind (Catala et Kunasz, 1987; Catala, 1988). The He I 5875.7 A line, quasi-absent in main sequence A-type stars and photospheric in earlier MS stars, is obviously of chromospheric origin in AB Aur.

OBSERVATIONS

The MUSICOS echelle spectrograph (Baudrand and Böhm, 1992) covers the whole visible domain, in two exposures (390–540, and 540–890 nm). In January 1992 we monitored AB Aur with this instrument at the 2m Bernard Lyot Telescope (Pic du Midi, France) at high resolution (R=38000). Nine spectra were obtained in both wavelength domains during 11 nights. We observed remarkable variations of several spectral lines, like the He I 5875.7 A (multiplet 11) and the Fe II 4923.9 A, 5018.4 A and 5169.0 A lines (multiplet 42). Both groups of lines show intense emission profiles which are strongly variable with a timescale shorter than one day (Fig. I)!

https://doi.org/10.1017/S0252921100018613 Published online by Cambridge University Press

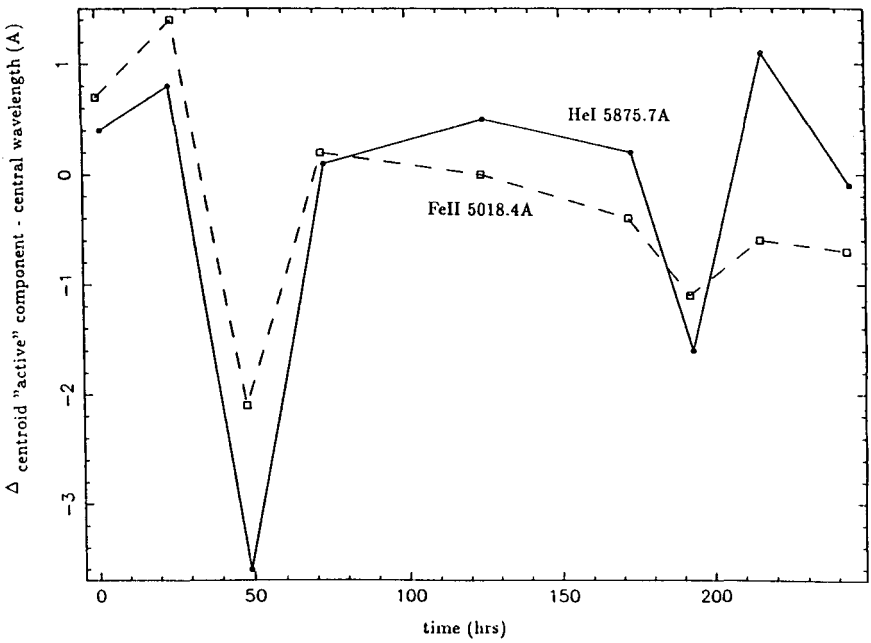

FIGURE II Covariation of He I and Fe II lines. Plotted is the wavelength shift of the active component centroid of each line against time.

ROTATIONAL MODULATION?

As a possible interpretation of these variations, we propose that the line profiles consist of a "variable" emission component superimposed on a "quiet" profile, also including emission; the variable component, which varies both in intensity and position, may be due to an active region which is corotating with the star.

For the HeI 5875.7A line, we determined an "asymmetry parameter", defined as $A = F_a \times \Delta\lambda_a$, where F_a is the integrated flux in the active component, and $\Delta\lambda_a$ is the wavelength shift of the active component centroid with respect to the line center in the stellar rest frame. The variations of A are compatible with a sinusoidal modulation with period P=37hrs, which may correspond to the star's rotation period (vsini about 90 kms^{-1}), although we do not have enough data to decide whether the observed variations are truely periodic. More observations are needed to verify this hypothesis.

COVARIATION OF HE I AND FE II LINES

The different shapes of the He I and Fe II lines suggest that they are formed in different regions. However, the variations of fluxes and centroids of the "variable" component of both groups of lines (He I and Fe II triplets) are strongly correlated (Fig. II)!

Therefore, if the observed variability is due to rotational modulation, the co-variation of these lines formed in different regions indicates that the same

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azimuthal structuration exists in these regions, and that the chromosphere is globally structured.

CONCLUSION

The correlation of the variations of the chromospheric He I and Fe II lines and their modulation by the star's rotation, if confirmed by further analysis, would indicate the presence of a globally structured chromosphere.

The regions of formation of these lines are probably very close to the photosphere, and thus the source of the structure responsible for the observed variations seems to be at the stellar surface, rather than further out in the wind.

These results are only preliminary. If confirmed, they will provide a further clue for a magnetically structured atmosphere in AB Aur.

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