# SEARCH FOR ROTATIONAL MODULATION IN PRE-MAIN SEQUENCE HERBIG Ae/Be STARS*

C. Catala, J. Czarny, P. Felenbok
Observatoire de Paris, Section de Meudon

1 - Introduction: The Herbig Ae/Be stars (Herbig, 1960; Finkenzeller and Mundt, 1984) are widely believed to be intermediate mass (2-5 $M_{\odot}$) pre-main sequence stars. In the past few years, a big effort has been made to model their outer layers, and it has been shown that they possess stellar winds and extended chromospheres (Catala et al., 1984; Catala et al., 1986a; Catala and Kunasz, 1987).

Periodic variations have been reported in the Ca II K line and in the Mg II h and k lines for one of these stars, AB Aur (Praderie et al., 1986; Catala et al., 1986b). A 32 hour period has been found for the Ca II K variations, whereas the period is of 45 hours for the Mg II h and k variations. These variations have been interpreted as a rotational modulation. A qualitative model of the wind has been built, in which fast and slow streams alternatively cross the line of sight. In this model, the radial differential rotation of the star's extended atmosphere explains the period difference mentioned above : the Ca II K line is formed in a compact region at the base of the wind, where the structures due to the inhomogeneous wind are stable, and is therefore modulated with the star's rotation period ; on the other hand, the blue edge of the Mg II resonance lines is formed further away in the wind, in a region where the streams have merged, and is therefore modulated with the rotation period of the extended atmosphere in this region.

The stream structure discovered in the wind of AB Aur is obviously attached to the stellar photosphere, and therefore related to azimuthal inhomogeneities at the star's surface, like for instance the alternation of regions of closed and open magnetic loops. The observed rotational modulation of lines formed in the wind of AB Aur constitutes evidence for the existence of activity in this star.

The question that must be addressed now is whether the other Herbig Ae/Be stars show the same rotational modulation phenomenon.Since the rotation periods of these stars are typically of the order of 30-40 hours, this observational programme requires ground-based multi-site

(*) communication presented by F. Praderie



G. Cayrel de Strobel and M. Spite (eds.), The Impact of Very High S/N Spectroscopy on Stellar Physics, 105–108.

or space-based observations. The present paper describes two ground-based multi-site campaigns that have been carried out in 1986.

## 2 - Observations and discussion :

2-1 - HD250550: The Hα line of this star ($m_v$=9.1, A0) shows long term variations (Catala et al., 1986a), and a vsini of 110 km $s^{-1}$ was estimated by Finkenzeller (1985).

We observed this star in February 1986, with the Coudé spectrograph of the 3.6 m Canada-France-Hawaii telescope (CFHT), the Cassegrain spectrograph of the 2.5 m "Isaak Newton" telescope (Canary Islands), and the fiber-fed "Isis" spectrograph (see Felenbok and Guérin, these proceedings) on the 1.93 m telescope at Observatoire de Haute-Provence (OHP). The aim was to obtain a series of Ca II K line profiles with the best time coverage possible, in order to find short term variations and to determine an eventual period for these variations. Unfortunately, the weather was not good enough to reach this goal. However, the few spectra we obtained are sufficient to show that the Ca II K line is spectacularly variable on a very short time scale. In particular, two spectra obtained at CFHT within two hours exhibit strong variations in the Ca II K line profile (see Fig.1).

We therefore conclude that HD 250550 is an excellent candidate for a search for rotational modulation in the Ca II K line.

2-2 - BD+46°3471: The vsini of this Herbig star ($m_v$=10.1, A4) is estimated to about 150 km $s^{-1}$ (Finkenzeller, 1985).

A multi-site observation campaign has been carried out on the Hα line of this star in July 1986, involving the "Hamilton" Coudé spectrograph on the 120 inch telescope at Lick Observatory, and the fiber-fed "Isis" spectrograph on the 1.93 m OHP telescope. The Ca II K line was not chosen, because it was impossible to obtain a reasonable S/N ratio in this line for this magnitude at OHP. Due to the small longitude difference between the two sites, the time coverage was not optimal, but still sufficient to detect an eventual rotational modulation. We obtained 27 spectra at Lick observatory and 16 at OHP. The total duration of the campaign was 5 days.

We detected variations in the Hα line, which appears purely in emission. Fig. 2 shows the two most different spectra of the series. We looked for a period in the variations of the blue wing (where they are the most intense), using the technique described in Catala et al. (1986b), but with no success. This indicates that the observed variations are not simply related to the star's rotation.

This result can be interpreted in several ways. First, it is possible that BD+46°3471 is not active, in which case the activity phenomenon would not be general among Herbig Ae/Be stars. We would still have to explain the origin of the detected variability. Another possibility is that the activity of Herbig Ae/Be stars is cyclic, and we have observed BD+46°3471 in a quiet phase. Finally, the Hα line can be

https://doi.org/10.1017/S0074180900034859 Published online by Cambridge University Press

formed far from the stellar photosphere (Catala and Kunasz, 1987), and considering a model similar to the one built far the case of AB Aur (Praderie et al., 1986; Catala et al., 1986b), it is possible that no structure related to the rotation is present in its region of formation, even if the star is active.

New observations, in particular in the Ca II K line, should provide answers to these questions.

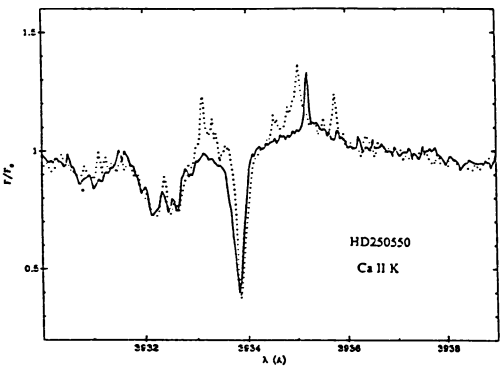


*Fig. 1: Two spectra of the Ca II line obtained at CFHT. The dotted spectrum has been observed 140 minutes after the other one. The spectacular short-term variability of this line is obvious. The blue edge of the main absorption component varies by 10 km.s$^{-1}$, while the spectral resolution is 7 km.s$^{-1}$.*

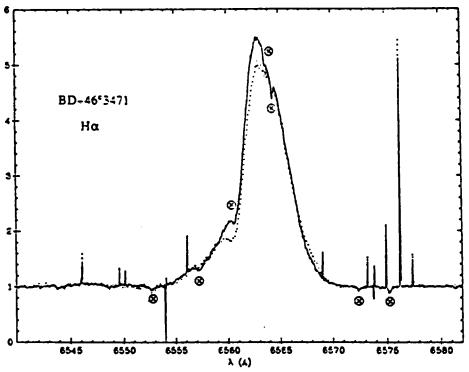


*Fig. 2: These 2 Hα profiles obtained during the Lick-OHP campaign shows the most important variation in the observed series. Telluric absorption lines are indicated by crossed circles. The other sharp features are due to blind columns of the CCD. Although the variability of the Hα profile is obvious (9% at the top of the emission component, 16% in the blue wing), no periodicity was found in the variations.*

3 - Conclusion: The two multi-site observation campaigns described in this paper have brought some new insight into the problem of the activity of Herbig Ae/Be stars. Apart from AB Aur, which clearly shows rotational modulation of its wind, we now have a second excellent candidate for this kind of phenomenon, HD250550, and an "ambiguous" case, BD+46°3471.

Let us mention here that a third possible case of rotational modulation has been detected with IUE : preliminary results of an IUE observation campaign on HD163296 show a possible 32 hr period in the Mg II h and k line variations. We have not presented these results here, because they are not based on high S/N observations.

The problem of the origin of this activity of the Herbig Ae/Be

https://doi.org/10.1017/S0074180900034859 Published online by Cambridge University Press

stars is still open. By analogy with the solar wind, one might think that the magnetic field is responsible for the wind structuration. However, in these stars where the presence of a magnetic field has not been established, other mechanisms could be at work.

Acknowledgements: The multi-site campaigns described above require a lot of efforts and involve many people. Many thanks are due to P.S. Thé, H.R.E. Tjin-A-Djié, A. Talavera, M. Dreux and J. Guérin, who took an active part in the observation of HD250550, and to U. Finkenzeller, J. Guérin, M. Dreux and T. Fauconnier who participated in the observation of BD+46°3471. Finally, we thank F. Praderie who originated the study of activity in Herbig Ae/Be stars, and who presented this paper at the conference.

Références:

Catala, C., Kunasz, P., Praderie, F.: 1984, *Astron. Astrophys.* 134,402
Catala, C., Czarny, J., Felenbok, P., Praderie, F.: 1986a, *Astron. Astrophys.* 154,103
Catala, C., Felenbok, P., Czarny, J., Talavera, A., Boesgaard, A.M.: 1986b, *Astrophys. J.* 308,791
Catala, C., Kunasz, P.B.: 1987, *Astron. Astrophys.* 174,158
Finkenzeller, U., Mundt, R.: 1984, *Astron. Astrophys. Suppl.* 55,109
Finkenzeller, U.: 1985, *Astron. Astrophys.* 151,340
Herbig, G.H.: 1960, *Astrophys. J. Suppl.* 4,337
Praderie, F., Simon, T., Catala, C., Boesgaard, A.M.: 1986, *Astrophys. J.* 303,311.

**DISCUSSION**

**BAADE** You mentioned possible evidence from IUE spectra for rotational modulation of line profiles in HD 163296. Otmar Stahl and I just observed several optical lines of the same star at high spectral and time resolution as well as low noise. The profile variability we are seeing in all lines selected appears to be of the same type as in OB stars where it is caused by nonradial pulsations. If this possibility is borne out by a more thorough analysis, it may
a) shed some light on the interaction between different types of variabilities seen in pre-main sequence stars, and
b) help to identify the (as yet unknown) driving mechanism of NRPs in OB stars. The latter potential derives from the fact that HD 163296 is classified as A0, i.e. has a Teff where NRPs have not so far been seen in MS or slightly evoled stars. This might support the view that there is a core excitation mechanism and it could, e.g., already be active in HD 163296 because the star's core is farther evolved than its envelope is.

**PRADERIE** I would not be surprised that such a star shows non radial pulsation. We face a problem with the hydrodynamics of the interior, whether we want to give account of non radial pulsation or of the non-axisymmetric wind, modulated by rotation, that we detect. I would like to know the period of your non radial pulsation.