CIRCUMSTELLAR ACTIVITY OF THE HERBIG AE STAR HD163296

M.A. Pogodin[1], M.M. Guimaraes[2], S.H.P.Alencar[2], W.J.B.Corradi[2], S.L.A.Vieira[3]

[1] Pulkovo Observatory, St.Petersburg 196140, Russia, *pogodin@gao.spb.ru*
[2] UFMG, Belo Horizonte 30123-970, MG, Brazil
[3] Centro Univeritario UNA, Belo Horizonte 30455-590, MG, Brazil

ABSTRACT. We present new results of a high-resolution spectroscopic investigation of the young Ae Herbig star HD 163296. Nineteen spectra of this object had been obtained on May 8 - 10, 2002 at the ESO with the FEROS echelle spectrometer installed at the 1.52m telescope. Striking profile variability has been found in a number of lines originating in the stellar wind. Analysis of the variability revealed manifestation of a layered spatial structure of the wind zone containing layers of preferable generation of local inhomogeneities in the outflowing gas. Correlation between different spectral parameters corresponding to infall and outflow gaseous streams evidence in favour of the physical interdependence between the accretion and the mass loss processes in the circumstellar envelope.

Key words: Stars: pre-main sequence: circumstellar matter; stars: individual: HD 163296

1. Introduction

The emission line star HD 163296 (B9Ve-A2Ve) was first classified as a young Herbig Ae/Be star by Finkenzeller & Mundt (1984). Afterwards it became a subject of detailed study. The spectrum of the star demonstrates signatures of an intense stellar wind. High-resolution spectroscopic investigations have shown a complex picture of the variability observed in numerous circumstellar (CS) lines. It was interpreted in terms of the long-lived spatial inhomogeneities rotating in the CS envelope (Baade & Stahl 1989, Catala et al. 1989, Pogodin 1994, Beskrovnaya, Pogodin et al. 1998). The study presented here was aimed at further investigation of CS peculiarities of HD 163296 using new data obtained with a high-resolution echelle spectrometer.

2. Observations

Nineteen high-resolution (R=48000) spectra of HD 163296 were obtained on May 8-10, 2002 with the FEROS echelle spectrometer installed at the 1.52m telescope of ESO (La Silla, Chile).

Collection of all spectra is presented in the Table. The signal-to noise ratio (S/N) at the continuum level for all spectra was from 100 to 200 depending on spectral region.

Table 1: The UT of mid-exposure.

May 8	May 9	May 10
$02^h\ 57^m\ 08^s$	$02^h\ 58^m\ 53^s$	$02^h\ 30^m\ 58^s$
$04^h\ 33^m\ 08^s$	$03^h\ 57^m\ 57^s$	$03^h\ 54^m\ 41^s$
$08^h\ 25^m\ 36^s$	$05^h\ 08^m\ 17^s$	$05^h\ 26^m\ 15^s$
$09^h\ 09^m\ 20^s$	$06^h\ 23^m\ 35^s$	$06^h\ 40^m\ 46^s$
$10^h\ 31^m\ 51^s$	$07^h\ 54^m\ 45^s$	$08^h\ 11^m\ 51^s$
	$09^h\ 09^m\ 08^s$	$09^h\ 21^m\ 19^s$
	$10^h\ 10^m\ 15^s$	$10^h\ 20^m\ 00^s$

3. Results

The results of our investigation are illustrated in Figs.1-6. The radial velocity scale used in the graphs is given in the reference frame connected with the star. The synthetic photospheric profiles calculated with the use of the Piskunov's code SYNTH+ROTATE (Piskunov 1992) are also presented for comparison. The atmospheric model parameters (Teff = 9400^{o}K, $\log g = 4.1$, Fe/H = 0.5, $V \sin i = 130$ km/s) were taken from Guimaraes et al. (2006).

The analysis of the obtained results allowed us to draw the following conclusions:

1. During the first observing night (May 8) the Balmer lines display emission profiles with the blue wing overlapped by several local absorptions (Fig.1, *left*). In the following nights these features were decreasing in deepness, and the profiles became double-peaked (Fig1, *right*).

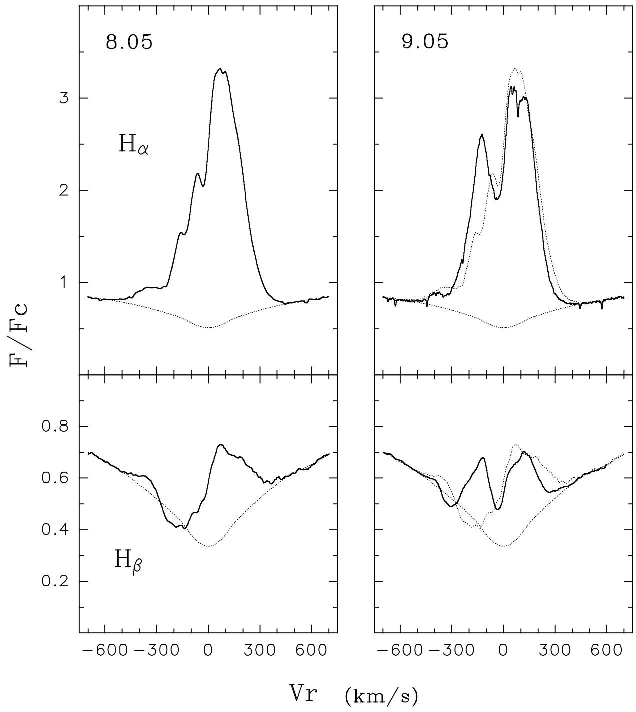

Figure 1: Normalized Hα and Hβ profiles obtained at the beginning of night on May 8 and May 9.

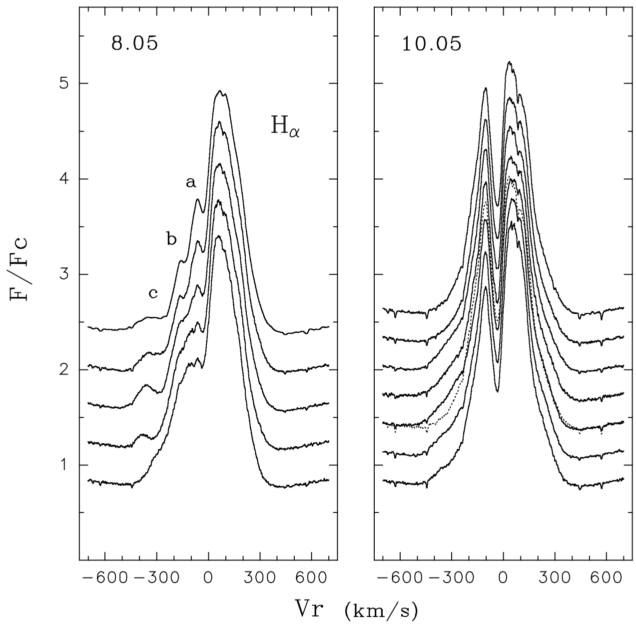

Figure 2: Rapid variability of Hα profile observed on May 8 and May 10. Time increases from top to bottom.

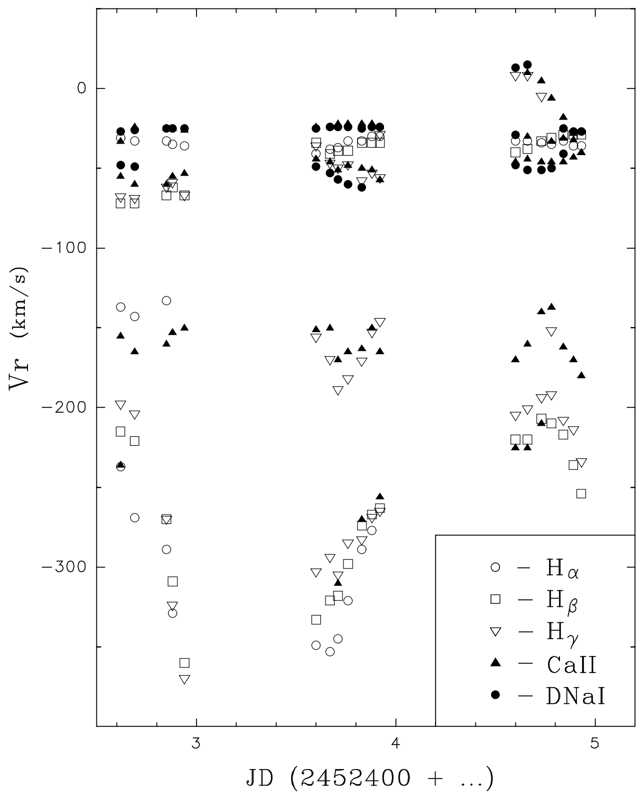

Figure 3: The temporal run of radial velocities of all local absorptions originating in the stellar wind and observed in different lines.

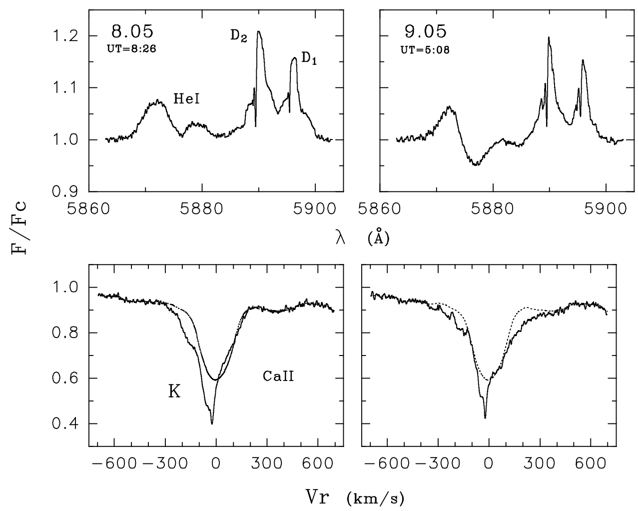

Figure 4: Typical profiles of the HeI, DNaI and CaII K lines in the spectrum of HD 163296.

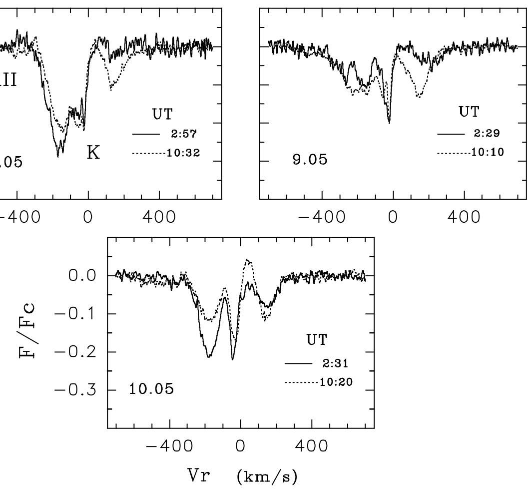

Figure 5: Typical residual profiles of the CaII K line in the spectrum of HD 163296, obtained by subtracting the photospheric component from the entire profile and demonstrating clearly separated CS profile components.

Fig.2 demonstrates the rapid Hα variability observed during a night. One can see that the lifetime of separate local features are of several hours. Such character of variations is typical for a stellar wind containing spatial inhomogeneities.

2. The analysis of radial velocity temporal runs of all local absorptions originating in the outflowing matter and observed in different lines shows that at least four variable components can be separated with larger amplitude of variations seen in a component with larger negative velocity (Fig.3). The duration of the observing run was not long enough to conclude with certainty on periodicity. But it is much longer than the expected lifetime of separate local absorptions. Therefore, the observed variability is hardly to be a result of rotational modulation by single long-lived azimuthal inhomogeneities. It is more likely to be a consequence of a layered spatial structure of the stellar wind, which can contain layers of preferential generation of dense outflowing gas. Such structure can be connected with a specific configuration of the global magnetic field in the region of interaction between the star and the accretion disk which must control the mass loss process (Pogodin et al., 2005).

3. The HeI line (at 5876 Å) profile displays a two-component structure with a blue emission peak and the very variable red part which is observed sometimes in absorption and sometimes in emission (Fig.4, *top*). These components are connected with different CS regions: the base of the stellar wind and the accretion flow, correspondingly. The optical depth of the wind is much smaller than one of the infalling gas, and, in contrast to the accreted matter, the wind is transparent

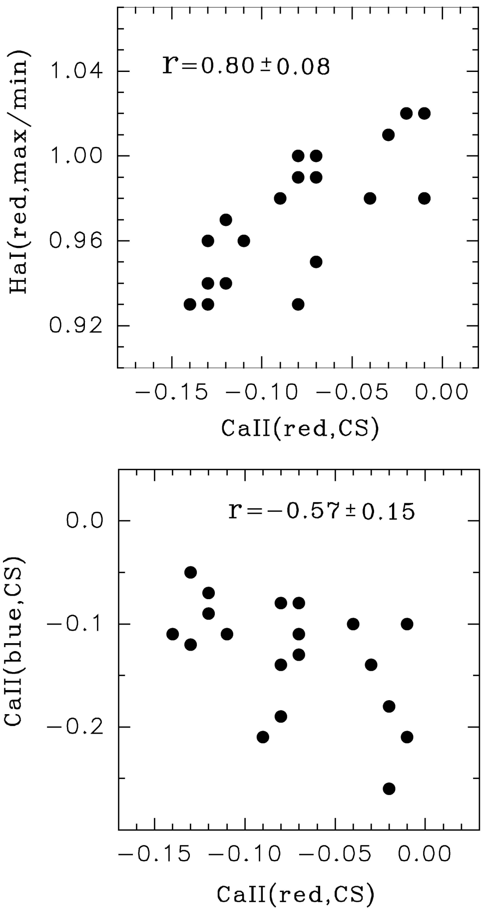

Figure 6: Correlation between the intensity in the visual extremum of the red local feature of the HeI profile and of the red absorption in the residual CaII K profile (*top*). The lower graph illustrates the correlation between the intensity of the blue (at Vr = -140 km/s) and the red (at Vr = +140 km/s) CS absorption in the residual CaII K profiles.

in the HeI line.

3. These two CS features are also displayed in the resonance CaII K line (Fig.4, *bottom*). Fig.5 illustrates typical CaII K residual profiles obtained by subtracting the photospheric component from the entire profile. The blue absorption, corresponding to the outflowing gas, and the red local feature, forming in the infalling matter are clearly separated. Additionally, a central narrow absorptions originating in the remote wind is also observed. In contrast to the HeI line, the stellar wind base is not transparent in the CaII K line.

4. Fig.6 (*top*) shows the well-defined correlation (r = 0.85±0.08) between intensities in the red local features in the CaII K and HeI λ5876 Å profiles, that confirms their common origin in the accretion flow. An appreciable correlation (r = -0.57±0.15) has been also found between the intensity in the blue (Vr = -140 km/s) and the red (Vr = +140

km/s) wings of the CS CaII K line profile. This indicates a possible connection between the accretion process and the mass loss in the envelope of HD 163296.

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