ACTIVIVE PHENOMENA OBSERVED IN ATMOSPHERIC LINES OF THE HERBIG AE STAR HD163296

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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 high-resolution echelle spectrometer (R=48000) installed at the 1.52m telescope. We have revealed a variability in a number of atmospheric lines of some ionized metals. This variability correlates with spectral parameters connected with the accretion process. In the night on May 8 a correlation of the atmospheric activity with the intensity of the outflowing matter was also observed. An interpretation of these phenomena is considered in the framework of several model.

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

1. Introduction

A study of active phenomena in the Herbig Ae star HD 163296 was carried out using new data obtained with the high-resolution FEROS echelle-spectrometer installed at the 1.52m telescope of ESO (La Silla, Chile). Nineteen spectra of the object have been registered on 8 - 10 May, 2002.

We addressed the following questions: a) spatial structure of the stellar wind; b) existence of interrelation between the accretion onto the star and the matter outflow, and c) existence of atmospheric activity in HD 163296.

The first stage of our investigation was devoted to solving the first two problem. The results of this investigation was published in Pogodin et al. (2007), where the used instrument was described and the collection of all spectra was presented. Nineteen high-resolution (R=48000) spectra have been obtained on May 8-10, 2002 with the echelle-spectrometer FEROS installed at the 1.52m telescope ESO (La Silla, Chile).

As it has been concluded in Pogodin et al. (2007): a) the model of the disk stellar wind is the most appropriate for HD 163296; b) it is likely, that the stellar wind zone contains layers of preferential generation of dense outflowing gas, and c) noticeable correlation exists between processes of accretion and stellar wind.

The study presented here was aimed at an investigation of active phenomena observed in atmospheric lines of HD 163296.

2. Results

Fig. 1 displays a fragment of the spectrum of HD 163296 containing a number of atmospheric lines. The synthetic spectrum is also given for comparison, which was calculated using the SYNTH+ROTATE code (Piskunov 1992) and model parameters taken from Guimaraes et al. (2006): $T_{eff} = 9400$ K, $\log g = 4.1$, [Fe/H] = 0.5, and $V \sin i = 130\,\mathrm{km\,s^{-1}}$.

Some blends are in good agreement with the model fit, but several lines of ionized metals demonstrate notable discrepacies. Moreover, depth and velocity positions of these lines at minimum intensity were different in different dates (bottom box of Fig. 1).

In contrast to the absorption line HeI 4471, originating in the accreted flow and demonstrating in all cases only positive positional shift, the ionized metal lines were shifted toward both negative and positive radial velocities.

Therefore, a source of these variations cannot be placed directly in the infalling gas. It cannot be situated in the stellar wind either, because of rather small radial velocity shefts of MgII, TiII anf FeII lines in comparison with velocities observed in the wind. According to Pogodin et al. (2007), all features, originating in the outflowing gas, are observed at $V_r <$ -25 km s^{-1} (Fig. 3 in Pogodin et al., 2007), and the wind cannot be responsible for distorting atmospheric line profiles at smaller negative velocities.

We tried to investigate a character of the variability observed in the metal lines and constructed the residual spectra by subtraction of the mean spectrum from each individual one (Fig. 2).

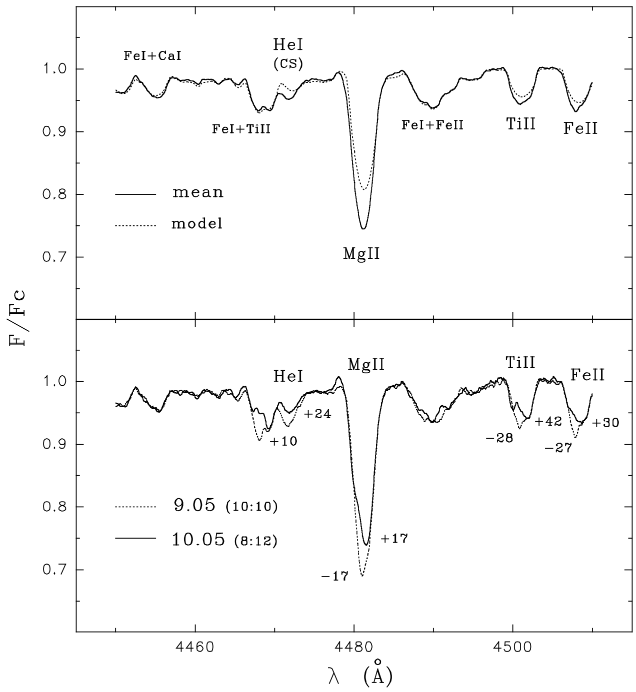

Figure 1: **Top:** Atmospheric lines in the spectrum of HD 163296 in comparison with the synthetic spectrum. **Bottom:** Variability of atmospheric lines of ionized metals.

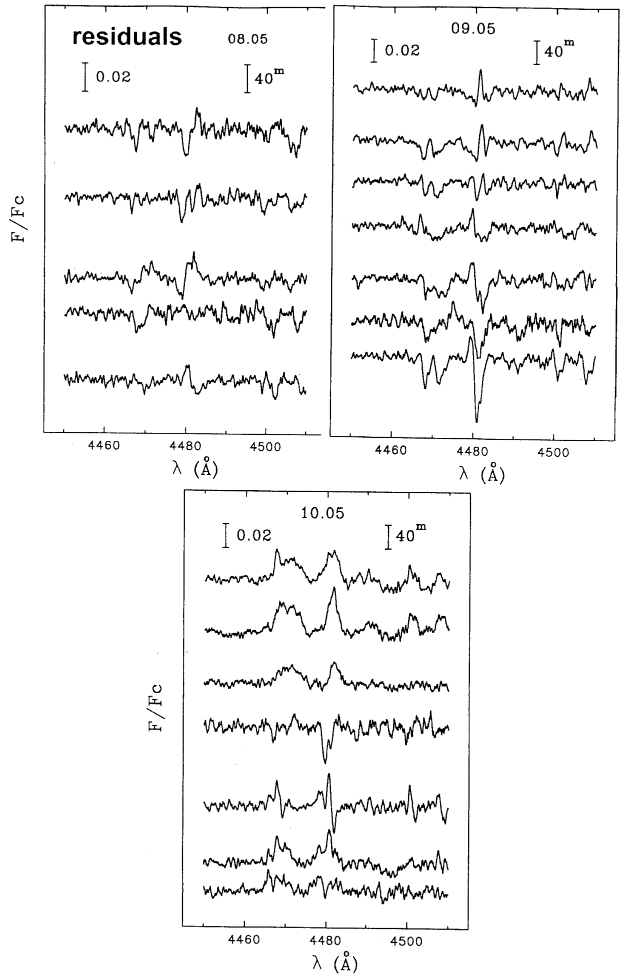

Figure 2: Residual spectra in the region of atmospheric lines. Shift between neighboring spectra is proportional to the time interval between expositions (time increases from top to bottom).

One can see that the character of variability is rather complex. Sometimes the neighboring spectra are rather similar, sometimes the changes are very significant and rapid.

In late 80's Baade & Stahl (1989) revealed a short-term variability of some atmospheric lines in the spectrum of HD 163296. They tried to establish periodicity of these variations, but had no success and assumed that a multi-harmonious non-radial pulsations (NRP) could take place in the stellar atmosphere. But actually, the question on a nature of the variations remains an unresolved one.

We tried to find a possible relation between the activity, observed in atmospheric lines and the processes in the circumstellar (CS) matter: accretion and stellar wind. With this aim, we chose several parameters, connected with these three processes, which could serve as their quantitative characteristics. These parameters are as follows: a) intensity in the red wing of the HeI 5876 line profile at radial velocity, corresponding to its maximum (or minimum) is a characteristic of the rate of accretion onto the star and designated as "HeI(red)"; b) the same intensity, but in the red wing of the CaII K line profile after subtracting the synthetic atmosphere component – "CaII(CS,red)"; c) the same as b), but for the blue wing, as a parameter, connected with the rate of gas outflow – "CaII(CS,blue"; d) another parameter of the rate of wind – the asymmetry index of the emission Hα profile "Q(Hα", determined as the relation of (EW_+ - EW_-) and (EW_+ + EW_-), where EW_+ = EW ($V_r > 0$) and EW_+ = EW ($V_r < 0$). This index Q is zero for a symmetric profile and becomes close to 1 for a classical PCyg II-type profile with a deep blue absorption.

The bisector radial velocity of an atmospheric line at the 0.7 F_c level (V_r) was accepted as a characteristic of the atmospheric activity.

Fig. 3 presents the temporal run of radial velocities of atmospheric lines MgII 4481 and FeII 4508 in comparison with temporal variations of the Q index for the Hα line (upper boxes). One can see, that a correlation between these parameters and the Q index was observed only during the first night (on May 8). This fact is well illustrated by the diagram in the bottom box, constructed using data, obtained for the MgII line. Points for different nights, marked by different symbols, are divided into three separate groups.

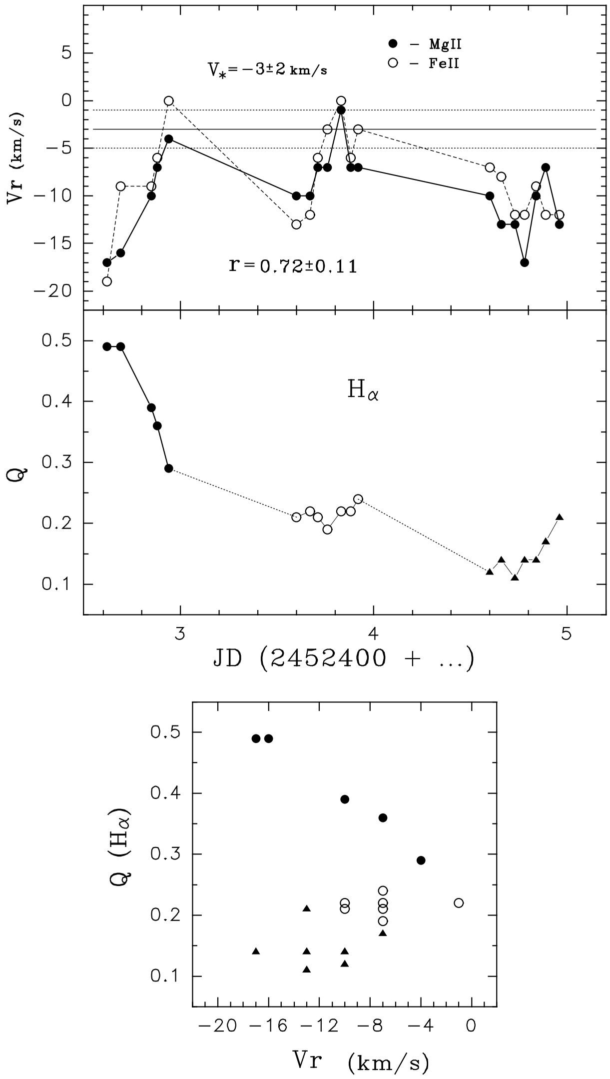

Figure 3: Correlation between the radial velocities of atmospheric lines and the index Q(Hα), characterising the rate of stellar wind (all designations are explained in the text).

A quite different relation is observed between the radial velocity of the MgII 4481 line and two parameters, chosen as characteristics of the accrertion process. One can see, that points in the diagrams, corresponding to different nights, are not separated into different groups, but form a common single dependence with noticeable correlation coefficient, which is very similar for these two parameters. This fact allows us to assume, that a real physical relation exists between the atmospheric activity and the process of accretion onto the star.

We assume, that a cause of this relation can be processes in the internal part of the accretion disk, partly screening the sellar limb, provided the disk is situated close to the star.

We cannot also exclude a possibility, that the accreted streams, exciting equatorial region of the stellar surface, stimulate the observed atmospheric activity.

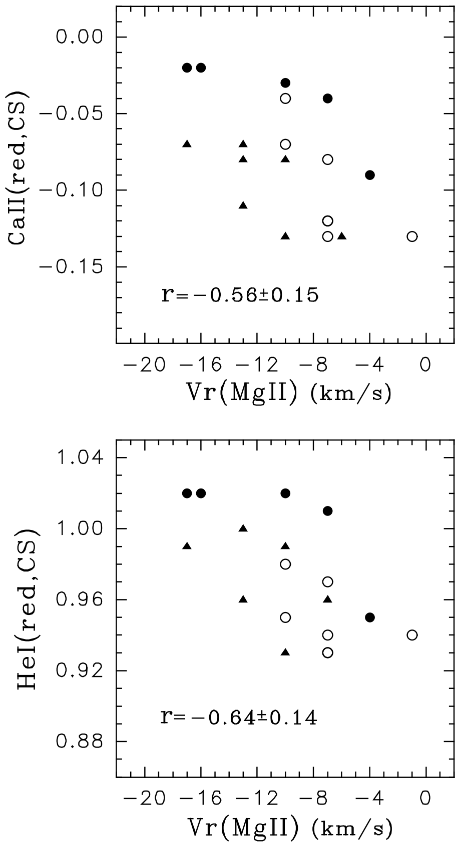

Figure 4: Correlation between the radial velocity of the atmospheric MgII line and parameters, characterising the rate of accretion (all designations are the same as in Fig. 3).

Forthcoming collecting the observational data as well as a development of theoretical models will allow to construct a rigorous theory of this interrelation.

Acknoledgements. M.Pogodin would like to remark that his contribution to this work was sponsored by the Program of the Presidium of the RAS No 4, OFN RAS Rrogram No 10104, RFBR (grant No 07-02-00535a) and Sci.Schole No 6110.2008.2. Brasilian co-authors aknowledge support from FAREMIG (EDT-1883/03 and CEX-96/04). We also thank Dr.Herman Hensberge for help with the reduction of FEROS data.

References

Baade D., Stahl O.: 1989, *A&A* **209**, 268.

Guimaraes M.M., Alencar S.H.P., Corradi W.J.B., Vieira S.L.A.: 2006, *A&A*, **457**, 581.

Piskunov N.E.: 1992, *Stellar Magnetism*, 92.

Pogodin M.A., Guimaraes M.M., Alencar S.H.P., Corradi W.J.B., Vieira S.L.A.: 2007, *Odessa Astron. Publ.*, **20**, 182.