# SPECTRAL OBSERVATIONS OF AB AUR

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ABSTRACT. Results of spectral observations of the Herbig Ae/Be type star AB Aur carried out for 2008 – 2009 in SHAO were presented. The absorption component of the $H_\alpha$ line has a negative variable displacement on different dates, reaching -300 km/s. To this absorption component superimposed an emission peak, which is rather unstable and can disappear completely on time scales 3-4 day. We also studied profiles of the $H_\beta$ line and found behavior completely similar to that of $H_\alpha$. The line HeI $\lambda$5876 AA has a composite structure with dominant one red and blue component. Profiles of presented lines and its spectral parameters shows variability from night to night.

Moreover we have also presented results of researches UV spectrograms of the star on the IUE archive data base. On this data we have measured intensities of 15 absorption lines. Our measurements allow us to catty out a monitoring of spectral parameters of the lines for 3, 6 days, and for 14 years. It was showed that since quick time variability from day-to day can be referred only for some group of lines, for 14 years observations in practice intensities of all spectral lines is showed variability with deviation larger 3 $\sigma$ level. We have discovered variability with period 6 day both for 6 day and more long time data. It was showed that some lines of different elements shows different character of variability. In some case variations of lines are in similar phase, in anti-phase and free forms with each other. We supposed that the basic variability in atmosphere  Aur occurs in the bottom layers of an environment, in nearby areas to the surface of the star where matter accretion velocity reaches up to 300 km/s.

**Key words**: stars: emission line stars, optic and UV spectroscopy, individual: AB Aur.

## 1. Introduction

AB Aur (HD 31293, $d$ = 150 pc; A0 Ve, van den Ancer et al., 1997) is one of the popular Herbig Ae/Be stars, with a mass of 2.4$\pm$0.2$M\odot$ and age of 4$\pm$1 Myr (de Warf et al. 2003). The star is surrounded by a 450 AU gas and dust disk (Mannings and Sargent 1997) viewed at $i = 76°$ (Miroshnichenko et al. 1997). Profiles of spectral lines $H_\alpha$ and h and k MgII shows conspicuous signs of strong stellar winds, like P Cyg and chromospheric activity, like e.g., the presence of C IV and Si IV resonance lines, emission in Ca II K and infrared triplet, and HeI $\lambda$5876 Å lines (Catala et al. 1986). Catala et al.(1997) find that the photospheric lines have variable profiles on a time scale of a few hours.

AB Aur has been the subject of several synoptic observing programs documenting periodic modulation of a strong stellar wind (Praderie et al. 1986, Catala et al. 1987, 1997), including species up to CIV (Catala 1988) and NV (Bouret et al.1997). An analysis of the Mg II blue wing velocity versus time shows that the variability can be fitted with a sine curve period 45 hr, which Praderie et al.(1986) have interpret as rotation modulation period.

First part of our spectral researches in the optical range was presented in Ismailov and Khalilov (2010), where we have showed that the blue wing of hydrogen Balmer lines $H_\alpha$ and $H_\beta$ is varied from night to night. Weak emission with component displacement -300 km/s is superimposed to the blue wing of these lines. In this report results of new researches in optical range and short-term day-by day, and 14 year variability of photospheric lines in UV range were presented.

## 2. Observations and results.

### *2.1. Visual range*

Our observations of 2008–2009 was carried out using echelle spectrometer and 530 × 580 CCD with spectral resolution ∼ 0.2 Å in spectral range $\lambda\lambda$4400 – 6700 ÅÅ. For these spectrograms mean error for equivalent widths $W_\lambda$ is at 5%, and in radial velocity Vr at $\pm$2 km/s. Following spectral parameters - $W_\lambda$, residual intensity $R_\lambda$, wide of lines at the half intensity (FWHM) and radial velocities Vr of lines had been measured.

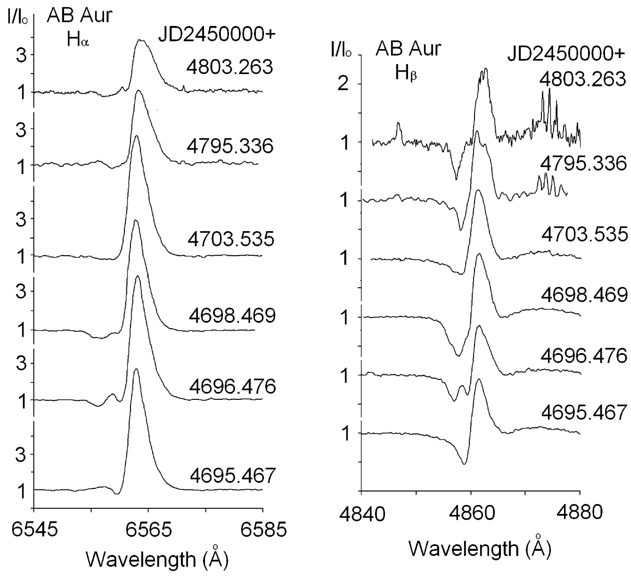


Figure 1: Profiles of emission lines $H_\alpha$ and $H_\beta$ for 2008 observations.

The analysis of these parameters showed that they are shows a short time variability from night to night which characteristic time one day. Moreover a variability of the structure of line profiles also we have derived. In the Fig.1 line profiles of $H_\alpha$, $H_\beta$ and in Fig.2 profiles of the lines He I $\lambda$5876 Å, $D_1$, $D_2$ NaI for CCD spectrograms obtained in 2008 was presented. For JD2454696.476 we can clear see increasing of the emission peak on blue wings of lines $H_\alpha$ and $H_\beta$. During observations 2454695, 2444696, 2444698 we have discovered continuously an appearance and disappearance of this blue emission component in blue wings of lines $H_\alpha$ and $H_\beta$.

As one can see in Fig.2, the line He I $\lambda$5876 Å has a composite structure with dominant one red and blue component. Profiles of presented lines and its spectral parameters shows variability from night to night.

For August - December 2008 we have received only 6 pairs of spectrograms of the star. It has been shown, that the absorption component of the line has negative variable displacement in the different days, reaching up to -300 km/s.

*2.2. UV spectrum.*

The UV spectrum of the star has been investigated on the spectrograms taken from IUE archive data. It has been used 57 SWP and 46 LWP type spectrograms. Spectral resolution is at 6 Å. For avoiding the account of interstellar reddening in spectral lines, and also additional mistakes because of heterogeneity of the received spectrograms we applied a classical method of processing of spectrograms in which measurement is made in relative units: after setting of a level

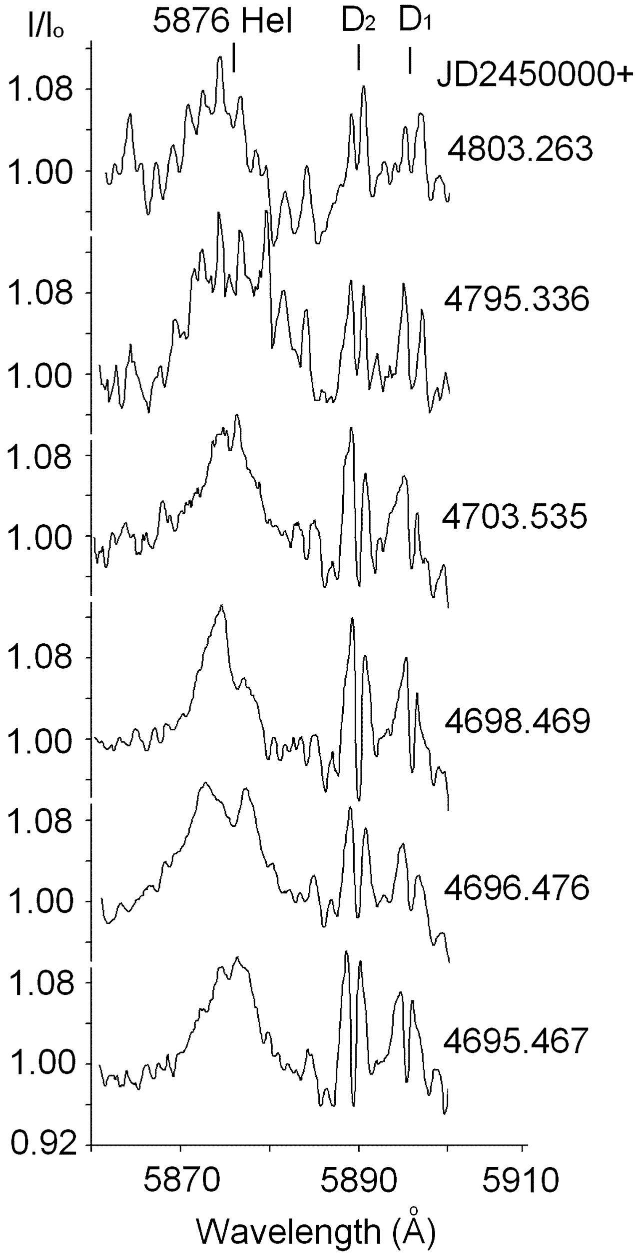


Figure 2: Profiles of He $\lambda$5876 Å and $D_1, D_2$ lines for 2008 observations.

of the spectral continuum the central depths (residual - intensity) $R_\lambda = 1 - I/I_0$ and half widths (($\Delta\lambda_{1/2}$ - FWHM) of lines were determined. There, $I$ - an absolute intensity at top of the line, $I_0$ - an absolute intensity of line at the level of continuum. In such measurements the mainly error in intensity of the line arises because of wrong carrying out of a level of the spectral continuum. Therefore, we carried out procedure of setting of the spectral continuum level very carefully, achieving a constancy of carrying out of a continuum through stable points of the spectrum. On the standard stars measurements mean deviations are

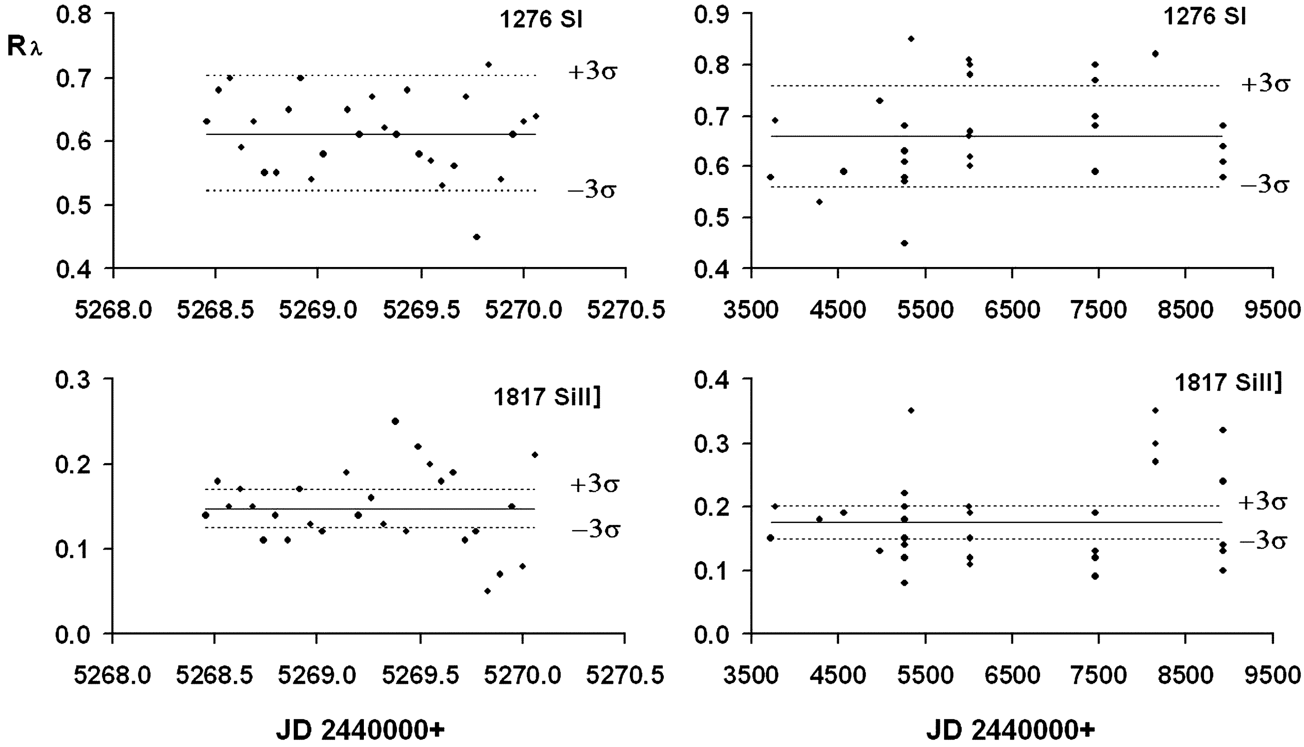


Figure 3: An example of time variability diagrams the residual intensity for 3 day monitoring (left panel) and 14 year (right panel) monitoring for lines Si I 1276 and Si II] 1817.

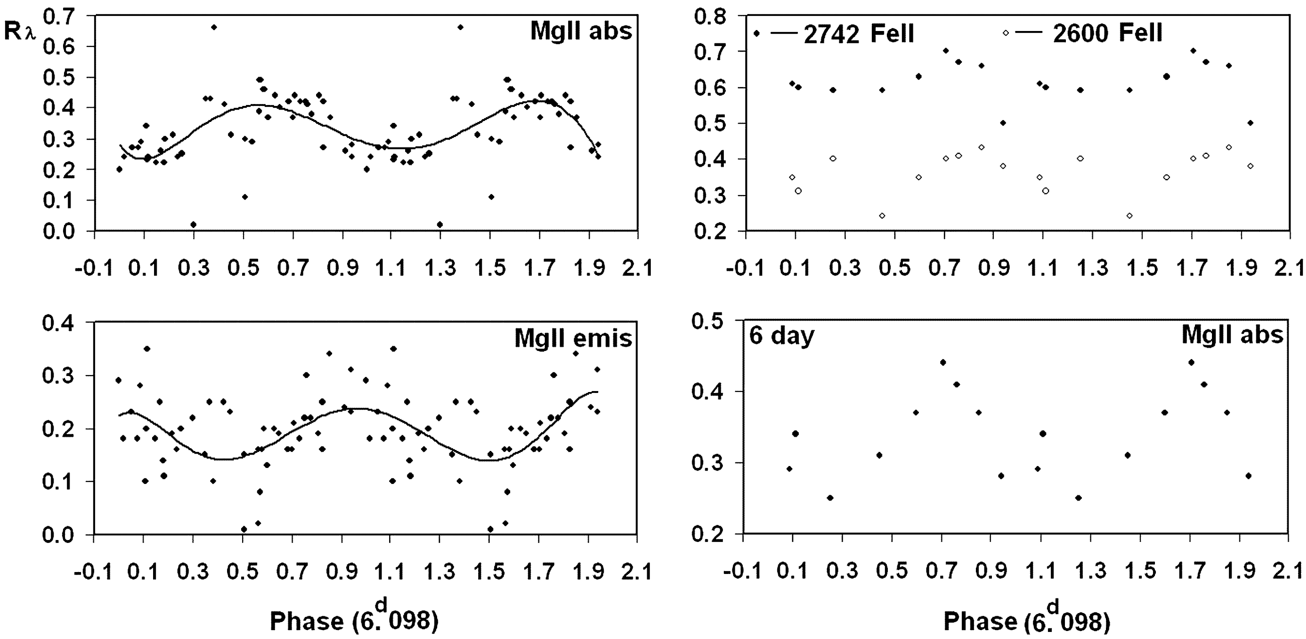


Figure 4: Phase diagrams for lines Mg II$\lambda$ 2800 Å absorption and emission components (left panel), and only for 6 day monitoring of lines Fe II $\lambda$2742, 2600 ÅÅ and Mg II $\lambda$2800 Å absorption lines.

in intensity at 5 %, and in half widths at 15-20 %.

We have divided all observations to three contiguous sequences: I - monitoring for 3 day (JD2445268-2445270, all -27 points), II - monitoring for 6 day (JD 2446010-2446016, all - 16 points), and III - monitoring for 14 years (1978-1992, all - 57 points). We have measured photospheric absorption spectrum for more than 15 different lines in SWP and at 10 lines in LWP spectrograms. Doublet h and k Mg II $\lambda 2795, 2802$ ÅÅ, is not resolved and we had measured absorption and emission components separately as line Mg II $\lambda 2800$ Å.

We have discovered that in the short term series, as I and II, residual intensities of some photospheric lines with needs a high temperature excitation, as C IV 1549, He II 1640, Si IV 1403, Si III 1533 etc. are not shows variability in the 3 $\sigma$ level. Some group of lines, as S III] 1817, $H_2$ 1435, C III] 1915 etc., in series I and II shows active variability. But all lines shows variability in the large time interval for 14 years.

In the Fig.3 residual intensities versus time for I and III series for lines SI 1276 and Si II] 1817 have presented. The short time series do not shows any variability in level 3 $\sigma$ for line S I 1276, since for series III both of lines shows variability higher $3\sigma$ level.

For lines Mg II $\lambda 2800$ Å nightly parameters $R_\lambda$ were used for the period search, resulting in a massive containing 46 points spread over 14 year interval of the observation We use the Scargle (1982) periodogram method as recommended by Horne and Balinas (1986) to search for periods. The greatest peak in a power spectrum is observed at frequency $\nu = 0.1641 \pm 0.0002 d^{-1}$, that corresponds to the period 6.098±0.005 days.

In Fig.4 variability of intensities $R_\lambda$ versus phase of period $P = 6.098$ for lines were presented.

## 3. Conclusions.

On results of this work it is possible to make the following conclusion:

1. The basic variability in atmosphere Aur occurs in the bottom layers of an environment, in nearby areas to the surface of the star where matter accretion velocity reaches up to 300 km/s.

2. We have observed variations of emission component in the blue wing of lines $H_\alpha$ and $H_\beta$ from day to day with continuously an appearance and disappearance for 3-4 day. Maximal displacement for this unstable emission component is -300 km/s.

3. For day to day short time observations shows that there are some group of absorption lines, as CIV1549, HeII1640, Si IV 1403, Si III 1533 etc. which are not vary of intensities in the $3\sigma$ level. Group of lines, as S III] 1817, $H_2$ 1435, C III] 1915 etc., in short time series shows active variability. For a long time all absorption lines shows variability with larger $3\sigma$ level.

4. Some group of absorption lines including Mg II $\lambda 2800$, FeII , etc. shows variability with period 6.098 days.

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