CIRCUMSTELLAR SPECTRAL VARIATIONS OF THE STAR HD 190073

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We have presented the results of spectral observations of the Herbig Ae star V1295 Aql, carried out in 2015-2017 at the 2 m telescope of the ShAO of ANAS. In 2015, a change in the radial velocities and equivalent widths of the emission component of the Hα and Hβ lines was detected with a characteristic time of about 40 days. The main variations in the profiles are observed on the wings of the hydrogen lines. In different years, there is a change in the activity of the star. We assume that the discovered phenomenon indicates the existence of a stable formation in the circumstellar space of the star HD 190073. A possible heterogeneity in the circumstellar disk may be the result of the existence of an asymmetric structure caused by the destroyed disk in a result of planet formation processes.

Keywords: pre-main sequence stars: spectral variations: circumstellar matter: emission lines: Ae stars: individual V1295 Aql.

1. INTRODUCTION

Herbig Ae/Be (HAeBe) stars are the intermediate-mass (~2–10 $M_\odot$) pre-main sequence counterparts of T Tauri stars (TTSs). Classically defined, they are spectral type B-A, show emission lines in their spectra, placed in obscured regions, and illuminate surrounding nebulosity [1]. The spectroscopic monitoring of some sources [2–4] revealed that the spectra of HAeBe objects are not only characterized by the presence of emission lines, but also by the complex variations observed in both the emission and absorption features. This variability is also characteristic of T-Tauri stars [5, 6].

V1295 Aql (HD190073, MWC325, A2IIIe – B9IIep+sh) is a very remarkable early-type object with rich emission lines in the visible spectrum. HD190073 was variously classified as a peculiar Bep star [7] or as an evolved post-main sequence

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A giant [8]. Recently HD190073 has gained recognition as a young Herbig Ae/Be star [9, 10]. In spite of being situated in the constellation of Aquila rather far from well-known regions of star formation, it displays a large far-IR excess due to thermal radiation of cool circumstellar (CS) dust [11]. The energy distribution of HD190073 in this spectral region is similar to that of well-known Herbig Ae stars, like AB Aur, HD163296 and HD31648 [12].

Alicia et al. [13] identified stellar parameters for V1295 Aql. The star has a magnetic field, ∼100 G, which has been detected and confirmed by many authors over several years [14–16]. As described in [13] from MIKE spectra Vr = -1.2 ± 1.3 km s^{-1} and v sin i = 3.19 ± 2.45 km s^{-1}. Effective temperature is Teff = 9250 ± 250 K, Mass is M=2.9 ± $0.5 M_{\odot}$, radius is R= 3.6 ± $0.5 M_{\odot}$. Variability was observed, indicating a change in the star's magnetic field structure.

In this work we have presented some results of monitoring of the hydrogen Hα and Hβ lines variation of the Ae type star V1295 Aql.

2. OBSERVATIONS

The spectra were taken in 2015–2017 in the Cassegrain focus of the 2-m telescope of Shamakhy Astrophysical Observatory of Azerbaijan National Academy of Sciences. We have used two spectrographs. First of them MUAGS was used in combination of CCD 530×580. Spectral resolution is R∼14000 in the range λ 4700-6700 Å. This system was used in 2015. Second spectrograph ShAPES works with CCD 4K×4K, spectral resolution is R∼28000 in wavelength range λ3700-8000Å [17]. The mean signal-to-noise level is S/N = 100 in the region of the Hα line, and S/N = 10-20 in the region of the Hβ line. Wavelength calibration was based on the sky spectrum. We used the DECH20T software to perform all the image reduction tasks and subsequent measurements of the spectra.

We acquired a total of 35 pairs of spectrograms of the star for 2015-2017 years. The errors of the measured equivalent widths and intensities were equal to 5% and about 1%, respectively. The mean error of position measurements in the spectra of standard stars was 1–2 km/s.

The Hα line In figure 1. we have presented the time variability of bisector radial velocity, FWHM and equivalent wide of the Hα emission line in 2015-2017. As seen from figure there are seasonal variability in all parameters. Equivalent width of Hα line increases during 3 years and changes from 18 Åto 34 Å. FWHM of Hα line gets the value of 4.0±0.5 Å, radial velocity of the line shows decrease and increase on this timescale and changes from 15.21 km s^{-1} to 47.73 km s^{-1}.

Fig 2. presents normalized profile and the time variability of equivalent wide, bisector radial velocity and FWHM of the Hα emission line observed in the spectrum of HD 190073 in 2015. As can be seen from fig.1 the Hα line profile consists

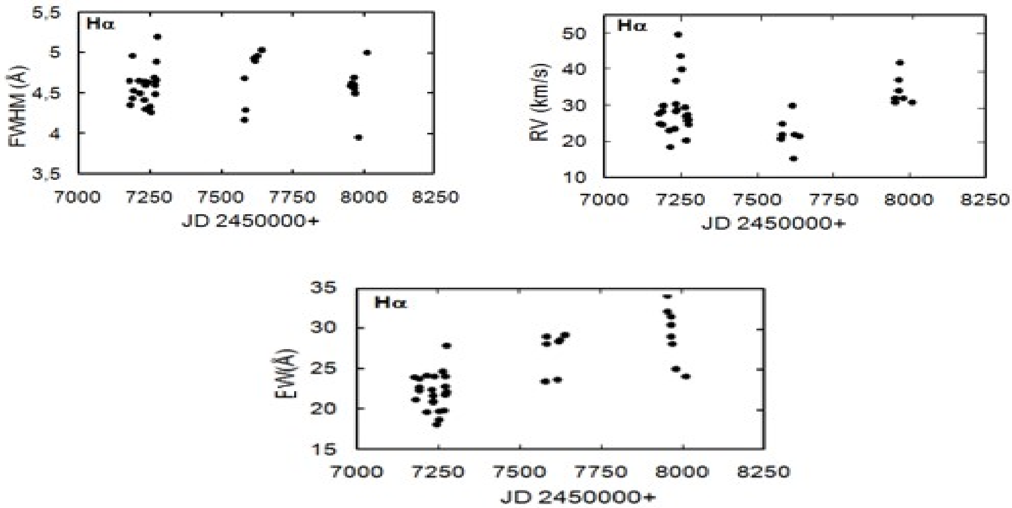

Fig. 1. The time variability of bisector radial velocity (right top panel), FWHM (left top panel) and equivalent wide (bottom) of the Hα emission line in 2015-2017.

of an emission peak, in which two separate components are barely distinguished at the top. The blue wing of the line is widest than the red. On the blue wing there is a wide and shallow absorption. The asymmetry in the profile shows that there is both accretion and outflow of matter on the circumstellar disk. Figure

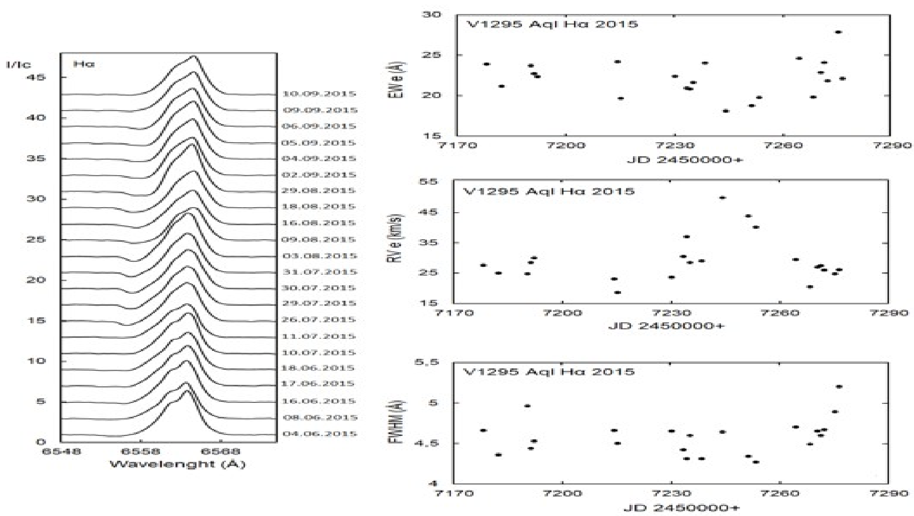

Fig. 2. Normalized profile and the time variability of equivalent wide, bisector radial velocity and FWHM of the Hα emission line observed in the spectrum of HD 190073 in 2015.

2 shows the change in the values of the parameters RV, EW and FWHM versus time. As can be seen, with relatively stable values of EW 22 Åwith root mean square (rms) ± 2 Å, we found a significant variation in the bisector radial velocity of the emission component of the Hα line ant mean value +29 with rms ± 7 km/s. The parameter FWHM also has a scatter around the average 4.56 ± 0.29 Å.

In the Figure 2 it is evident that, starting with JD 2457230, the RV shows a red shift to a maximum in JD 2457244, and then a slow return to the previous level, having reached it approximately in JD 2457275. In this case, the values of EW and FWHM are in minimum. This shows that during about 45 days a certain movement of matter and a change in intensity in radiation occurred in the star's disk.

As can be seen from Fig.2 radial velocities show seasonal changes within ± 15 km/s. According to the data of 2015, we identified the above variability of radial velocities (Fig. 2). The same variation we can see in the parameters EW (±5 Å) and FWHM (±1 Å). Moreover, the mean values of the mentioned parameters are demonstrated variation from year to year. Similar type variations we have discovered in the line Hβ. Figure 3. shows normalized profile and the time variability

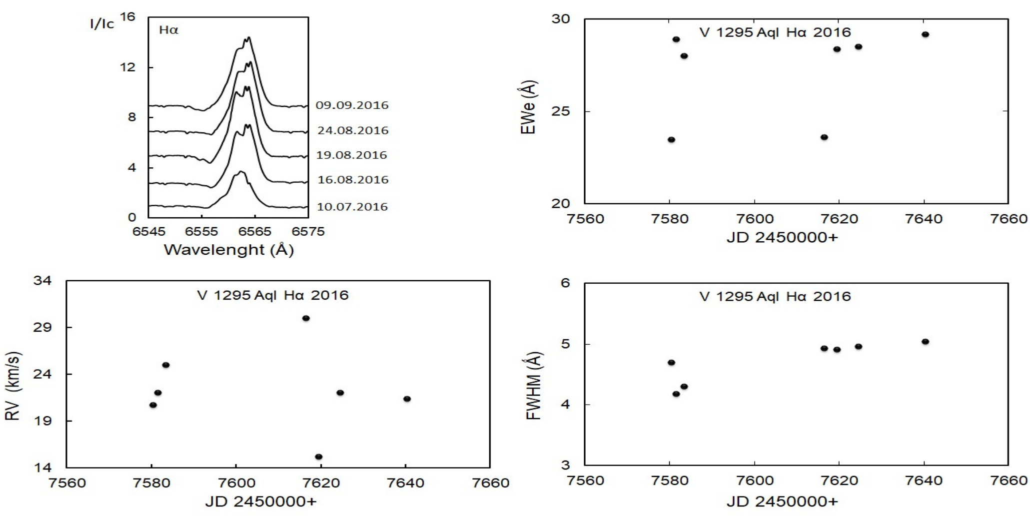

Fig. 3. Normalized profile and the time variability of equivalent wide, radial velocity in halve-widths level and FWHM of the Hα emission line observed in the spectrum of HD 190073 in 2016.

of equivalent wide, bisector radial velocity and FWHM of the Hα emission line observed in the spectrum of HD 190073 in 2016. In 2016 profile of Hα emission line obviously separated into two peaks. And it shows itself in the parameter of the line.

As is shown in Fig.4, in 2017 parameters of the Hα line shows the similar variability as in 2015. We can see increase and decrease in the value of radial velocity and decrease in the equivalent wide (from 34 Åto 24Å).

As can be seen from the data of 2017 (fig.4), we observed a similar variability in radial velocities of the emission component of the Hα line, which was obtained in 2015. EW is changing from 34 Åto 24 Å. Here, the duration of the event is about 50 days in the changes from the maximum to the minimum in equivalent widths, and about 40 days in the values of radial velocities. Such a feature in the change in the line parameters is a sign of a long-lived stable part in a circumstellar environment. We assume that such a component can be formed by additional components or a planet that rotates in a Keplerian orbit.

About one additional detail which is observed in the profile of the line Hα: in 2015 and in 2017, the profile of emission component of the Hα line has a single peak. In 2015, the spectral resolution is lower than in 2016 and 2017. But in 2017, we also find a line profile with barely distinguished peaks. Perhaps such a profile is observed simultaneously in the case when there is a significant change in the line parameters within 40-50 days.

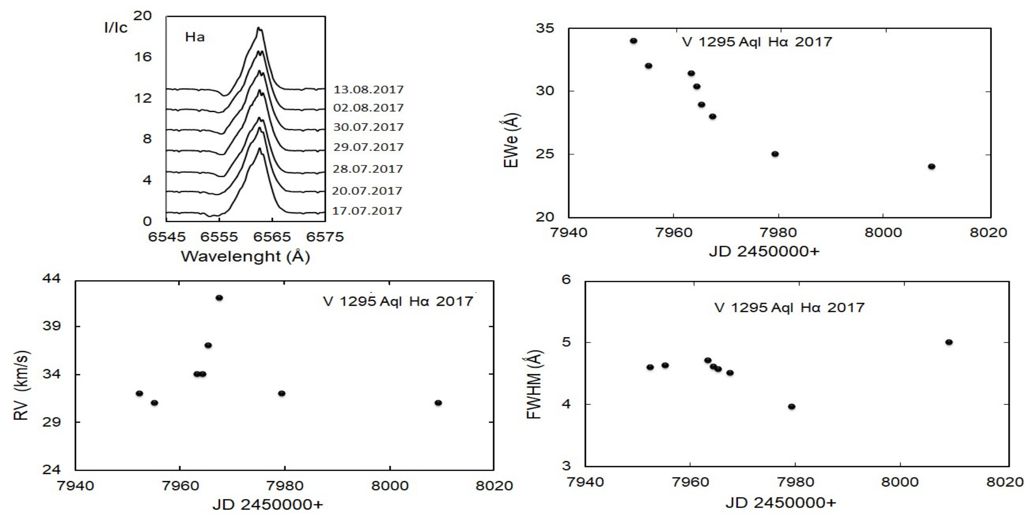

Fig. 4. Normalized profile and the time variability of equivalent wide, radial velocity in halve-widths level and FWHM of the Hα emission line observed in the spectrum of HD 190073 in 2017.

Hβline

Variability in the parameters of the Hβ line is of the same nature as in the Hα line. Significant seasonal variations in radial velocities and equivalent widths are observed (Fig.5). In 2015, radial velocities, equivalent widths and half-widths of the emission component of the line Hβ show significant changes at the same moment when active changes in radial velocities are observed in the Hα line. In the Hβ line, the characteristic duration time of process is about 60 days. This even was presented in the Fig.6 and Fig.7. As can be seen from the figure, in

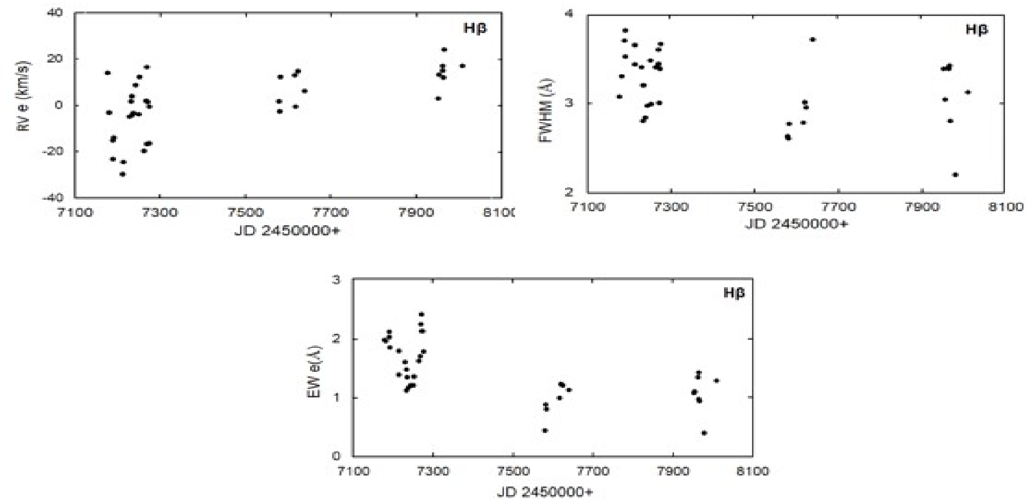

Fig. 5. The time variability of bisector RV (right top panel), EW (left top panel) and FWHM (bottom) of the Hβ emission line in 2015-2017.

2017, the same effect in the Hβ line is observed that took place in the Hα line in 2015 in time, these events occur synchronously and with approximately the same duration.

3. CONCLUSION

Thus, our spectral monitoring for 2015-2017 showed that there are active seasonal variations in the spectral lines of hydrogen Hα and Hβ. Such seasonal changes are accompanied by a change in the structure of the profiles of these emission components.

The most important result obtained in this work is the detection of a continuous smooth change in radial velocities, equivalent widths and half-widths of the emission components of hydrogen lines, in 2015 and in 2017. The characteristic duration time of this event is about 40-50 days. First, a redshift of the bisector velocity of the emission components is observed, and at the same time, a smooth decrease in the line intensity is occurs.

According to the data of work [13], the rotation period Prot of the star was obtained about 32 $\pm$25 days, which is in satisfactory agreement with the char-

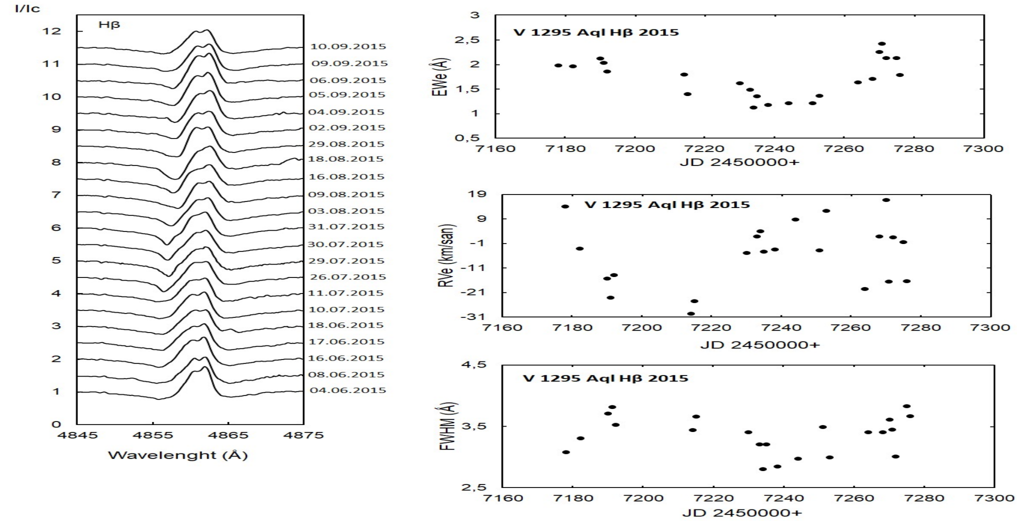

Fig. 6. Normalized profile and the time variability of EW, RV and FWHM of the Hβ emission line observed in the spectrum of HD 190073 in 2015.

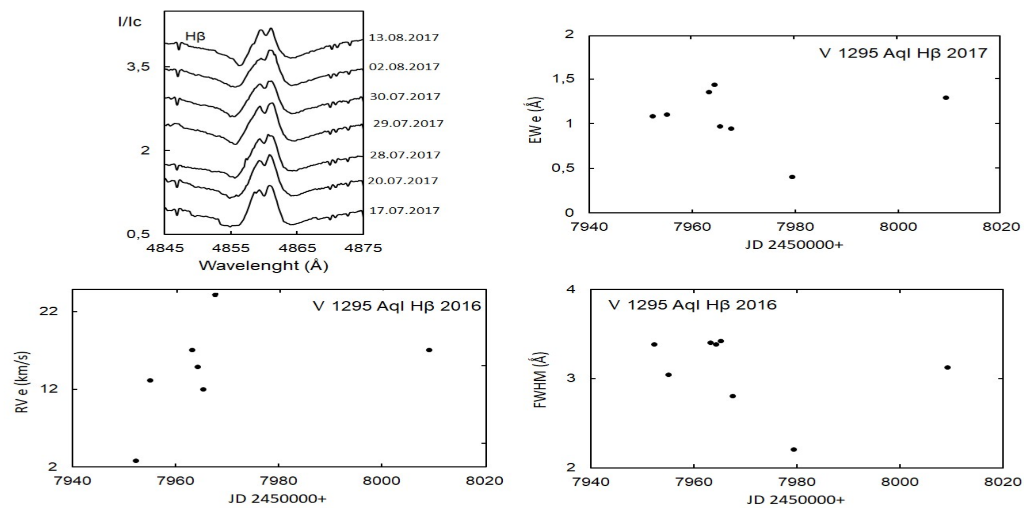

Fig. 7. Normalized profile and the time variability of EW, bisectorial RV and FWHM of the Hβ emission line observed in the spectrum of HD 190073 in 2017.

acteristic time obtained in our observations during active processes. Fortunately, our 2015 data were obtained in a fairly close step time resolution and allows us to determine the characteristic time of an active event with an accuracy of several days. If we take the value of the rotation period of the star about 40±5 days, then with a known radius of the star 3.6 ±0.5 $R_\odot$ [16], for the rotation velocity of the star we can get 4.6 km/s. Knowing the vsini as equal to 3.2 km/s [1], we can determine the angle of inclination of the axis of rotation, as $45° \pm 6°$. This value of the angle of inclination is little larger than the angle presented in work [1].

The discovered by us event was observed for two case - in 2015 and 2017. This event is an active change in the spectral parameters with a characteristic time of 40±5 days in the hydrogen lines of Hα and Hβ. We assume that the discovered phenomenon indicates the existence of a stable formation in the circumstellar space of the star HD 190073. A possible heterogeneity in the circumstellar disk may be the result of the existence of an asymmetric structure caused by the destroyed disk in a result of planet formation processes.

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