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SPECTRAL VARIABILITY OF THE LINES HeI 5876, D NaI Si II and [OI]Ae/Be HERBIG TYPE STAR HD 179218

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Abstract. The results of spectral observations of the Herbig Ae/Be type star HD 179218 are presented, and as well a significant variation in the lines of He I, Si II, D NaI, [OI] has been observed. The parameters of many spectral lines show small variations in amplitude and a characteristic time of 10-20 days. Possible mechanisms of the variability are discussed, too. In addition, the parameters of many spectral lines shows variations with smaller amplitude and with a characteristic time of 10-20 days. Possible mechanisms of the observed variability of the star are discussed.

Keywords: *stars, variables, Herbig Ae/Be– stars, circumstellar matter – stars, individual – HD179218 .*

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1. Introduction

The HerbigAe/Be type stars (HAeBe) are pre-main sequence (PMS) objects of intermediate mass 2-10 M⊙ and are considered to be the progenitors of Vega type stars, which are surrounded with a residual protoplanetary disks. Spectral monitoring of individual objects has shown that in the spectra of these stars are observed variable emission and absorption lines (Praderie *et al.*, 1986; Pogodin, 1994; Rodgers *et al.*, 2002; Mora *et al*., 2004). The same features are also characteristic of classical T Tauri stars (CTTS) (Johns & Basri, 1995; Schisano *et al*,. 2009). It is known that emission lines, as well as some absorption lines in young stars, are formed in the circumstellar disks or in the envelopes of the stars. Such circumstellar matter can often participate in accretion, polar outflows, winds and other forms of disk interaction with the central star. Tracking the variation in the observed spectral lines makes it possible to perform diagnostics of the physical processes that are occurring in the stellar atmosphere and in the circumstellar environment. In young stars, in particularly, these processes can directly affect the formation of the planets and their evolution. Consequently, one of the important problems in the study of the early evolutionary stage of stars is the study of the characteristics of the circumstellar structure and the processes of interaction of the central star with the surrounding matter.

HD 179218 (MWC 614, Sp B9-A2) is an isolated HAeBe type star. Despite the fact that the star is relatively bright comparatively to other HAe stars, it has been studied less. It became the subject of active research after including in the catalog of Pogodin (1994). The circumstellar surroundings of the star were studied by IR photometry and speckle interferometry by Millan-Gabet et al. (2001), Prizkal et al. (1997), which did not reveal closely spaced components. Spectral studies of the star were performed by Miroshnichenko et al. and in more detail, Kozlova, Kozlova and Alexeev (Miroshnichenko *et al*., 1998; Kozlova, 2004; Kozlova & Alekseev, 2017).

According to the classification of Meeus et al. (Meeus*et al*., 2001), the spectral energy distribution (SED) of the star belongs to group I, i.e. starting with the infrared band K and further there is an excess of radiation excited in the dust. The profile of the line Hα is consisting of a stable single-peak structure (Mendigutıa *et al*., 2012). The star may has a close companion, about 2.5 arcsec apart (Wheelwright *et al*., 2010). Fedele et al (Fedele *et al*., 2008) showed that the star has two dust rings at distances of 1 AU and 20 AU, and the space between from 1 to 6 AU from the star filled with gas. The magnetic field of the star was measured by Hubrig et al. (Hubrig *et al*., 2009) where they have got about 51 ± 30 G on the data 2008.

The purpose of this paper is to carry out monitoring of the spectral variability of the star on spectral lines obtained in the visual range of spectrum.

2. Experiment

Spectral observations of the star were performed at the Cassegrain focus of the 2 m Karl Zayss telescope of Shamakhi Astrophysical Observatory (ShAO) of Azerbaijan National Academy of Sciences by an echelle spectrometer constructed on the base of the spectrograph UAGS (Ismailov *et al*., 2013). A CCD with 530x580 elements was used as a light detector, since observations were performed in the range λ 4700-6700 Å. The spectral resolution was R = 14000. Reduction and calibration of the spectrograms was performed in the DECH programs (Galazutdinov, 1992). The method of observations and data processing was described in more detail (Ismailov *et al.*, 2013).

Table 1 showed the log of observations, where presented the names of the spectrum, the Gregorian and Julian dates, the signal accumulation time and the signal-to-noise ratio in the region of the line Hα. Observations were carried out for the season May-September 2015. In total, 28 pairs of spectrograms were obtained for 28 nights of observations. For each night the spectra of standard stars HR 7300 and HR 7734 were obtained to control instrument stability and position measurements. The equivalent widths EW, the bisector radial velocities V_{bis}, the radial velocities at the peak of the line Vp, the half-widths FWHM (full width at half maximum), the central depths R_{λ} (intensities) of lines HeI λ5876 Å, D1, D2 NaI, SiII λ6347, 6371 Å, [OI] λ 6300, 6363 Å.

3. Results and discussion

Line HeI 5876

This section has dedicated to results of the analysis for the helium line. Figure 1 shows the spectral region containing the lines He I λ5876 Å and the sodium doublet D1, D2 NaI.

As shown in figure 1, this line has blue and red emission components separated by a central absorption.This is the line in which only a saddle-like two peak emission profile is observed. The average half-width of the absorption is 1.5 Å with a scatter of up to 1.0 Å. The total width of the line is more than 20 Å at the continuum level. As shown, the profile of the He I line λ5876 Å Keeps stably the structure from night to night and, does not show any noticeable variations. The average value of the shift of the emission peaks in the He I line of 5876 Å corresponds to approximately -150 and +150 km/s, for the blue and red components, respectively.

Table 1. The log of observations of the star HD 179218

Spektr	Date	JD 2450000+	t (sec)	S|N
ks 6096-97	31.05.2015	7174.3138	1800	94
ks 6103-04	02.06.2015	7176.3444	1800	89
ks 6113-14	04.06.2015	7178.3034	1800	103
ks 6150-51	08.06.20015	7182.3042	2100	90
ks 6154-55	16.06.2015	7190.2681	2100	93
ks 6204-05	17.06.2015	7191.3021	2000	89
ks 6220-21	18.06.2015	7192.2757	1800	99
ks 6233-34	20.06.2015	7194.3174	1800	91
ks 6275-76	21.06.2015	7195.2604	1800	97
ks 6286-87	24.06.2015	7198.2736	1800	91
ks 6328-29	27.06.2015	7201.3125	1500	96
ks 6343-44	29.06.2015	7203.2667	1800	98
ks 6369-70	30.06.2015	7204.3042	1500	87
ks 6387-88	09.07.2015	7213.3222	1500	98
ks 6424-25	10.07.2015	7214.3278	1500	99
ks 6437-38	11.07.2015	7215.2778	1500	98
ks 6448	11.07.2015	7215.2958	1500	90
ks 6449	12.07.2015	7216.2938	1500	87
ks 6460	23.07.2015	7227.3139	1500	86
ks 6491	26.07.2015	7230.2590	600	97
ks 6528-29	29.07.2015	7233.2625	1500	94
ks 6585-86	30.07.2015	7234.2882	1500	98
ks 6602-03	31.07.2015	7235.2681	1500	101
ks 6614-15	01.08.2015	7236.3104	1500	100
ks 6635-36	03.08.2015	7238.35	1500	102
ks 6716-17	09.08.2015	7244.2451	1800	99
ks 6815-16	16.08.2015	7251.2715	1500	109
ks 6831-32	18.08.2015	7253.2618	1800	108

The radial velocities of individual emission peaks show a variability of about an average value 50 km/s. The central absorption is displaced about +20 km/s.

Figure 2 presents diagrams of variations in the equivalent widths of the central absorption of EWa, the radial velocities of the absorption vertex Vp, the ratio of the equivalent widths of the blue component to the red EW1/EW2, and the half-width of the FWHM absorption in the line HeI 5876. As shown, the parameters of the absorption component of the line HeI 5876 show a certain variation while parameters of the hydrogen lines are decreased: EWa tends to increase, Vp is shifted to the red part of the spectrum by about 20 km/s, the ratio EW1/EW2 is increased by 5-7 times, and the parameter FWHM is also increased. A decrease in the FWHM of the absorption is observed between two waves of parameter reduction.

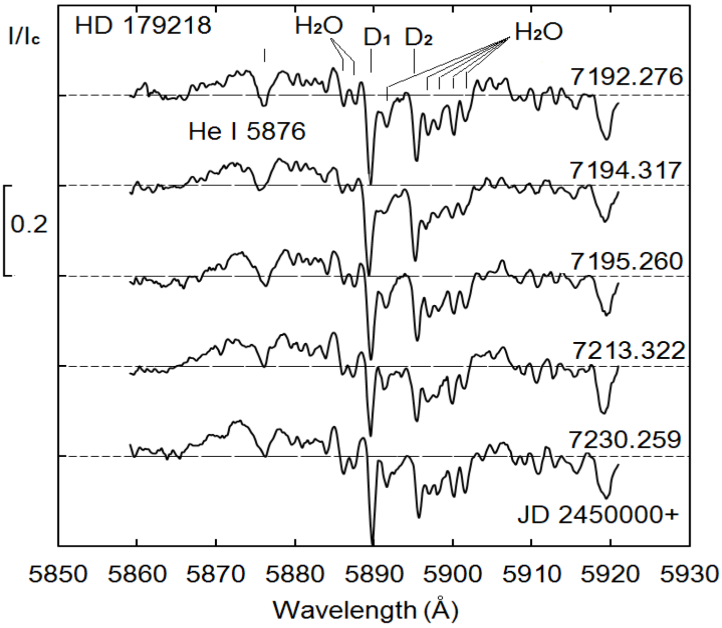

Fig. 1. A spectral range of spectra containing lines of HeI 5876 Å and doublet D1, D2 NaI. Individual sky (atmospheric) lines are indicated

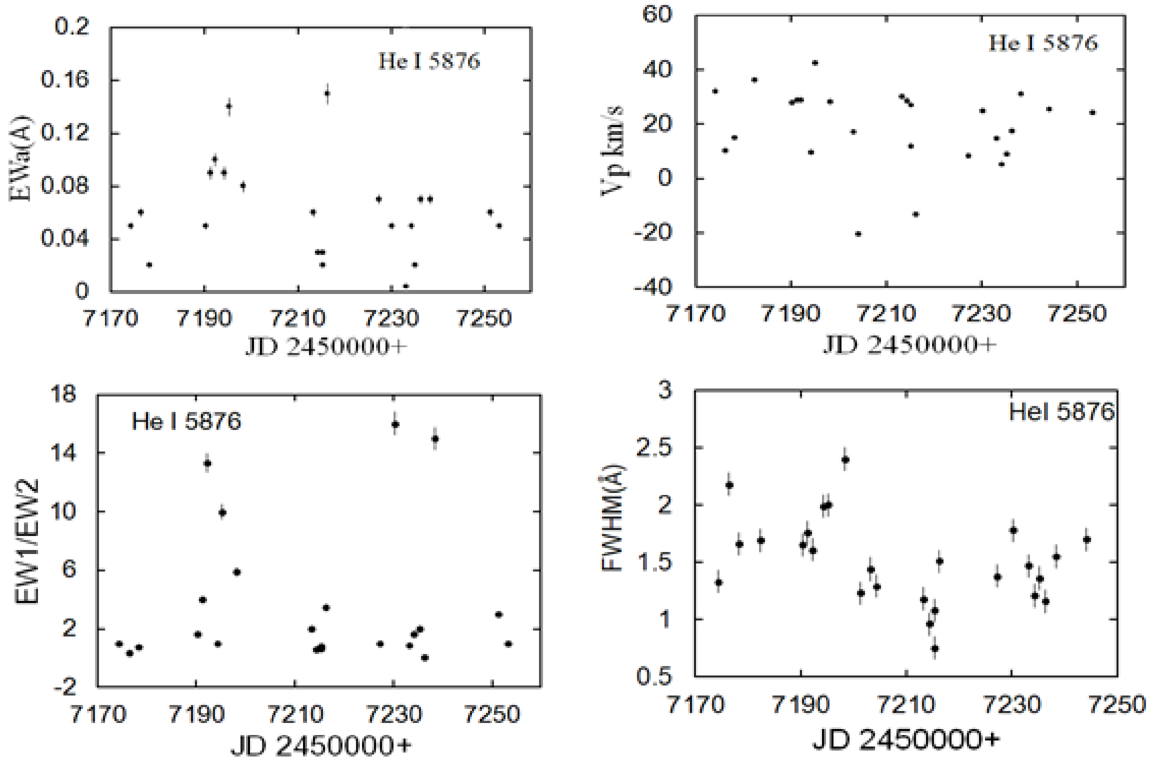

Fig. 2. The time variation of the spectral parameters of the He I line (λ5876 Å) In Fig. 8, the top panels are from left to right EWa-equivalent width of the absorption component, Vp is the radial velocity of the absorption peak, lower panels - EW1/EW2 are the ratio of the equivalent widths of the blue emission component to red and the FWHM of the absorption component

Lines D NaI

Figure 1 shows that the profiles of the D1, D2 NaI lines represent narrow blue-wing absorption lines in which they will have a weak emission (inverse P Cyg). Such structure is a sign of matter accretion. Interestingly, the profiles of these lines have an emission component on the red wings (Kozlova, 2004). This indicates that the matter outflow and its accretion can be observed in these lines in different seasons. This may depends on the orientation of the direction of motion of the circumstellar gas to the observer.

Figure 3 shows diagrams of time variations for the parameters of D1, D2 NaI lines. As shown, the radial velocities of the peak of lines Vp show generally a radial velocity of -15 km/s with a mean scatter ± 10 km/s. The shift of the radial velocity of the peak Vp to the blue part of the spectrum is observed with a decrease in the intensity of the hydrogen lines.

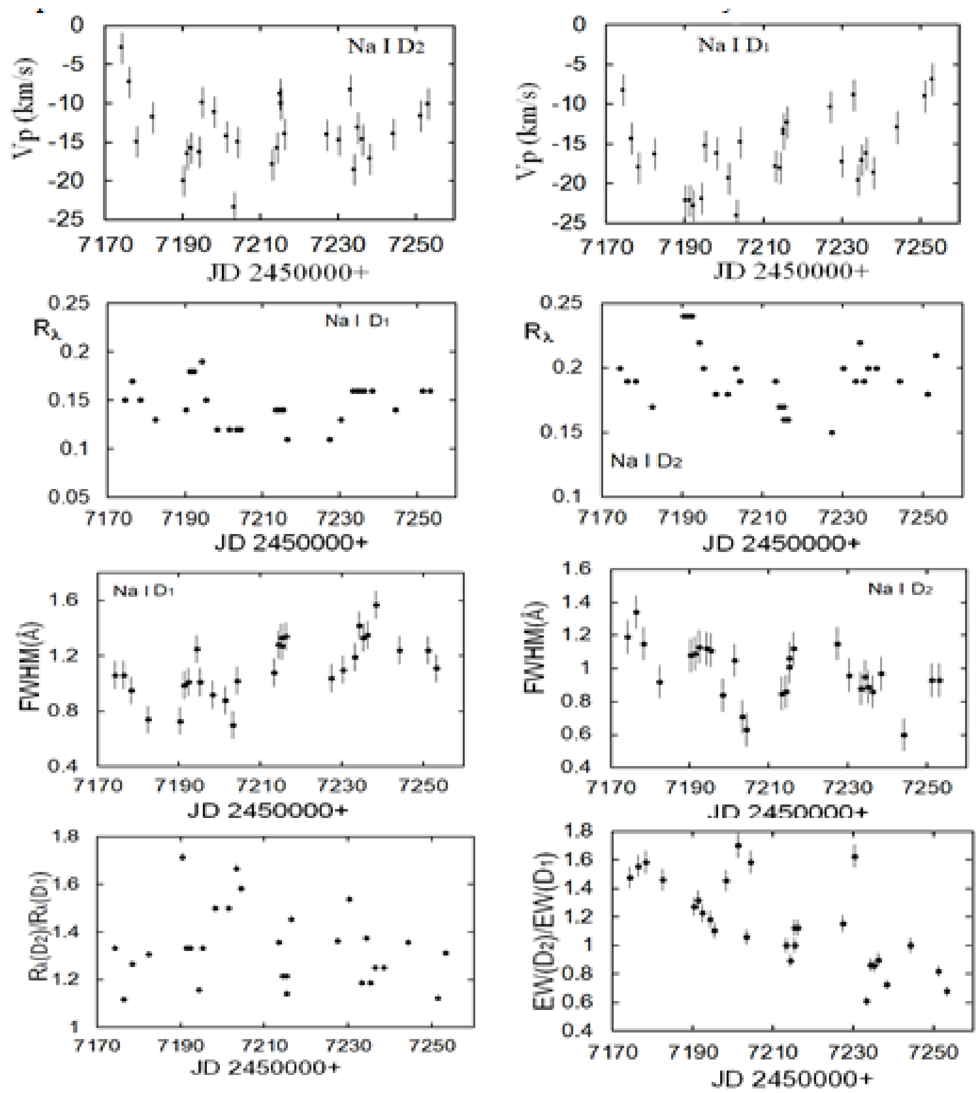

Fig. 3. Variation of parameters of D1, D2 NaI lines for the whole observation season in 2015. The first line of the panels is the radial velocities of the line peak, the second line is the line intensity R_λ, the third line is the FWHM of the lines, the fourth line is the ratio of intensities (left) and equivalent widths on (right)

The intensities R_λ of the D1, D2 NaI lines show a wavy-like variation with small amplitude. A similar character of the variations is also shown by the FWHM of lines.

The characteristic time of variations is about 10-20 days in individual waves. The last line of the panels below shows the variation in the intensity ratios and the equivalent widths of the lines D2 to D1. As shown, the intensities and equivalent widths of these lines are varied usually from night to night. This is especially right for equivalent widths of the line, which are continuously decreasing with time.

Si II lines

The lines Si II λ6347, 6371 Å were observed in the absorption without signs of the presence of the emission components. The mean value of FWHM of the lines Si II λ6347, 6371 Å was obtained 2.37 ± 0.05 Å with the mean-square deviation from the mean value ± 0.37 Å and ± 0.50 Å, respectively.

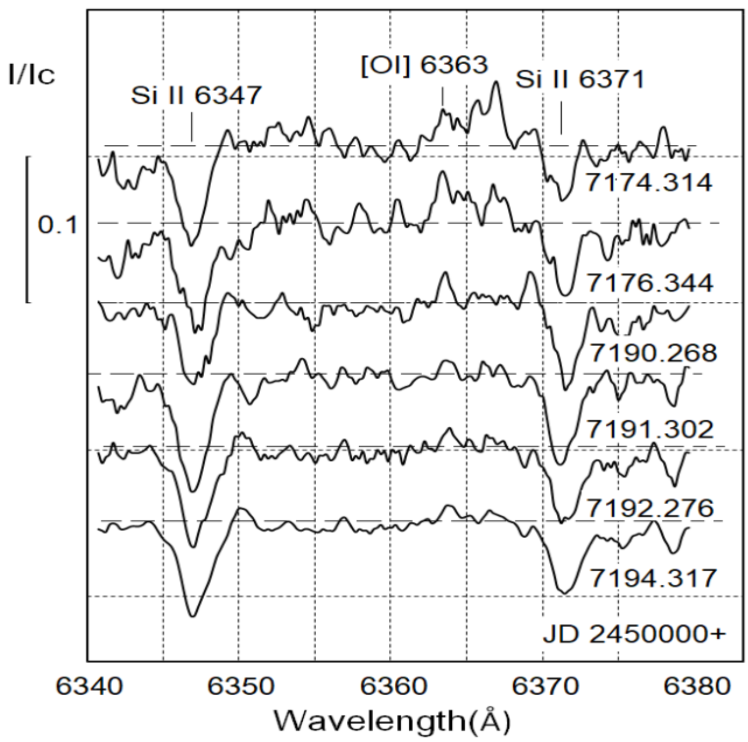

Fig.4. The segment of the spectrum of star HD 179218 containing lines Si II λ6347, 6371 Å, and [OI] λ 6363 Å. Intermittent lines indicate the continuum level

In the Fig. 4 it was shown fragments of the star's spectrum section containing Si II lines of λ6347, 6371 Å, as well as the [OI] λ 6363 Å line. As shown in Fig 4., the general structure of Si II line profiles varies considerably from night to night. This is also seen from the variation in the parameters of the spectral lines. Fig. 4 presents as example diagrams of the dependence of the radial velocities and equivalent widths of the Si II λ6347 Å line, as well as the ratio of the half-widths of the mentioned silicon lines. The average value of the radial velocity of these lines has positive values of +12 and +18 km/s with a scatter of 7-8 km/s at the mean. The values of the equivalent widths show a significant variation after the first wave of variations observed in the parameters of the hydrogen lines. The ratio of the half-widths of the lines also shows a smooth variation, reaching a maximum between the first and second minima. In addition, the forbidden lines [OI] λ6300, 6363 Å are observed in a weak form in the spectrum of the star.

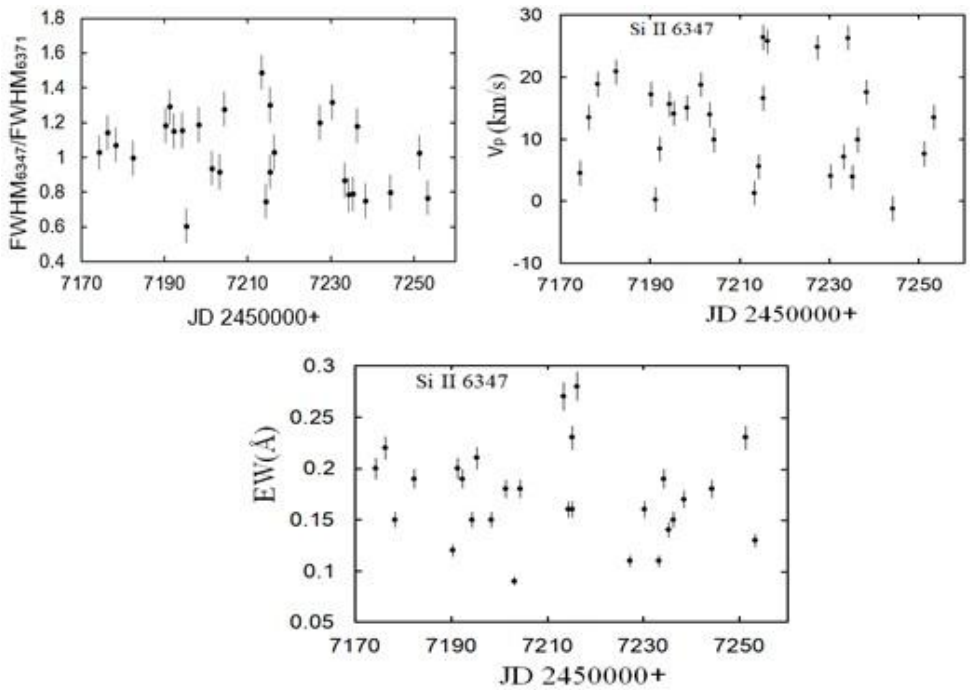

Fig.5. Temporal variations in the parameters of the Si II lines λ6347, 6371 Å. The top panels from left to right are the ratio of half-widths FWHM (6347/6371), RV-radial velocities, and below EW-equivalent line widths of Si II λ 6347 Å

4. Conclusion

The speed of rotation of HD 179218 is 60 km / s (Bernacca & Perinotto, 1970), and the value υsini = 72 ± 5 km / s (Guimaraes *et al.*, 2006). The angle of inclination to the axis of rotation of the star is about 40 ° (Dent *et al.*, 2005). If we consider the observable minimum characteristic time equal to 10 days, then the rotation speed of the star is obtained υ = 112 ± 8 km / s and the star radius - about 22 R □ . This is not reasonable and differs significantly from the data of (Alecian *et al.*, 2008) (4.8 R □). Even greater discrepancy is obtained for the radius if we take the angle i = 20 ° as suggested by (Leinert *et al.*, 2004). This means that the observed cycle of about 10 days can not be a period of axial rotation of the star. Recall that the characteristic time of 10 days is obtained from the variation in the radial velocities of the peak of the dominant emission component and the intensity of the line. Therefore, it should be assumed that it arises in the outer parts of the disk. However, if the observed 10-day activity is related to the axial rotation of the disk, it can be assumed that such a variation could occur at the boundary between the accretion and outflow streams. Then one of the assumptions of the cause of the observed variations in the emission lines of the star may be the existence of a stellar magnetosphere. In favor of the possibility of the existence of magnetospheric accretion, the star is also proposed in the work of (Mendigutıa *et al.*,2017). The dispersion of velocities and different lines indicates that lines with a higher ionization potential can form in the accretion zone. The main indicator of the existence of the magnetosphere of a star is the magnitude of the magnetic field. In classical T Tauri stars, for which the presence of the magnetosphere is assumed, the magnitude of the magnetic field is several kilograms (Bouvier *et al*., 2007; Mendigutía *et al*., 2011). However, the result of measured magnetic field of star HD 179218 shows the existence of a weak magnetic field (Hubrig *et al.*, 2009).

It is also possible that a star can be a spectral-double or multiple system. In fact, it is difficult to explain the observed wave-like variation of the radial velocities and other parameters of the Hα line. The dependence of the brightness V on the color index V-I has two separate distributions (Kozlova & Alekseev, 2017). This fact is accepted by the authors in favor of the duality of a star. The time of our observations from May to September 2015 corresponds to the minimum of the 4000-day cycle of variability found in (Kozlova & Alekseev, 2017). Therefore, the observed features of the variation in the spectrum of a star in the Hα line can be related to the moment of the star's stay at the minimum of the 4000-day cycle. Then, obtained results may be a kind of unique event and can be observed only in the minima of the 4000-day cycle. Our observations show that it is necessary to perform a more dense series of photometric and spectral observations of the star in order to elucidate these questions.

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