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SPECTRAL VARIABILITY OF THE SUPERGIANT HD 187982

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In this report we have presented the results of spectral observations of the supergiant star HD 187982 (SpA1 Iab) for 2016-2018.Our measurements for 2017 data showed that variability for hydrogen lines higher than the other spectral lines. In this report we have presented results of studies of the time variability of the $H\alpha$ line parameters.In JD 24557971.340 an ejection of matter from the star with velocity of 7-12 km/s was observed, and after this, smooth increase in the equivalent width was found. All independently observed processes unambiguously indicate that the stellar wind near the supergiant sometimes throws out portions, i.e. outflow of the matter does not always occurred as stationary.

Keywords: supergiant-stars–spectral variability– atmofpheres–stellar wind–indivisual: HD 187982

1. INTRODUCTION

The bright supergiants of the OBA spectral class play an important role in the evolution of the galaxy and its chemical composition. These stars show variability in both spectrum and brightness on a time scale from several days to several tens of days. Despite numerous studies in this area, to date there are few works devoted to the study of A-supergiants. These stars occupy the region of the HR diagram where evolution is faster and therefore there are few such stars.

Stellar winds are a characteristic feature of such stars. Moreover, the stellar wind indicators in A supergiants are much weaker than in OB supergiants. In addition, from a few works it is known that the structure of the stellar wind of A-supergiants, for some unknown reason, differs from other types of supergiants [1]. This paper traces the nature of the variability of one of the bright supergiants.

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The star HD 187982 (SpA1-A2Iab,$\alpha_{2000} = 19^h52^m02^s, \delta_{2000} = +24°59'32"$) is a bright A supergiant and is brightest stars of the cluster Vul OB4. Despite the fact that individual parameters of the star are given in different catalogs and review papers on A supergiants, there has been no detailed study of the optical spectrum for variability. The spectrum of the star contains the spectral lines Hα,$H\gamma$, MgII (4481 Å), and FeII (4924 Å, 5018 Å, 5169 Å) [1–4]. The following parameters of the star were obtained - the radial velocities of the center of mass RV = -2.9 km/s [5], $T_{eff} = 9300K$, log g = 1.60 [6], vsini = 54 km/s [7]. According to different authors data, significantly different values of trigonometric parallaxes are obtained (Table1). This makes it difficult to determine the exact distance, and thus the exact physical parameters of the star.

Table 1. Trigonometric parallaxes of the star on the literature data.

No	plx (mas)	reference
1	1.83 ± 0.76	1997A&A...323L..49P
2	0.4667 ± 0.0853	2018yCat.1345....0G
3	5.3 ± 7.2	1995GCTP..C......0V
4	1.93 ± 0.39	2007A&A...474..653V
5	0.6566 ± 0.1339	https://gea.esac.esa.int/archive/

2. OBSERVATIONS

Our observations were carried out on a 2 m telescope of ShAO using a fiber echelle spectrograph ShAFES with a spectral resolution R = 28000 in the spectral range λ3800-8000 Å. The liquid nitrogen cooled CCD STA4150A was used. A detailed description of the complex is given in [8].

Table 2 lists the observation log for the star HD 187982. The object was observed in three different seasons of 2016-2018. The longest observation season was obtained in 2017 with 14 observation nights for about 80 days.

The spectrograms were processed using the DECH 20 softwere and its latest modifications, which was developed at the SAO RAS by Galazutdinov [9]. Spectrophotometric parameters (equivalent widths EW, depths R_λ) and radial velocities RV were measured, and profiles of different lines were plotted. The measurement errors for radial velocities are no more than ± 1 km/s, for the parameters EW ∼ 3-4% and $R_\lambda \sim 0.5\%$, respectively. A more detailed description of the material processing technique is described in our works [8, 10]. A total of 24 nights of observations were obtained, in which each night 2 spectrograms of

Table 2. Short log of observation of the star HD 187982.

Observation dates	JD 2400000+	Days in the run	N	S/N	texp (sec)
2016 June 16 –August 25	57562.359 - 57626.453	7	14	200	1100
2017 July 7–September 25	57946.337- 58014.276	14	30	250	900
2018 June 28–August 16	58298.258- 58347.363	3	23	230	750

the star and the standard were obtained. In 2016 and 2018. only 7 and 3 nights of observations were obtained, respectively. Therefore, in this report, we present the results of studies of the spectrophotometric parameters and profiles of the hydrogen Hα lines based on the data of 14 nights of observations in 2017.

3. RESULTS

In the Table 1 was shown the results of measurements of the spectral parameters of the α line for different years of observations. From left to right, columns show the spectrum number, date in JD, line depth, equivalent width and heliocentric radial velocity.

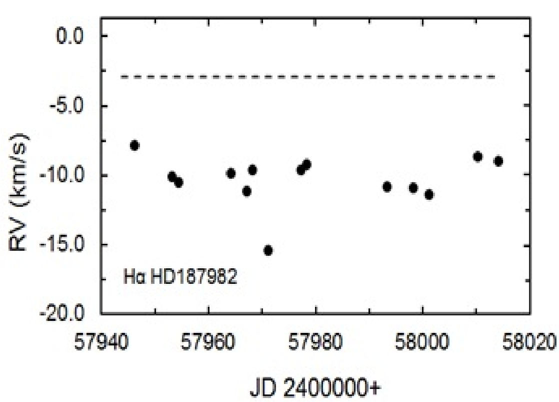

Fig. 1. Radial velocity variations in 2017 of the line $H\alpha$. For the date JD 2457971.340 some displacement with amplitude ~7 km/s is observed. Dashed line is show the mass center velocity of the star..

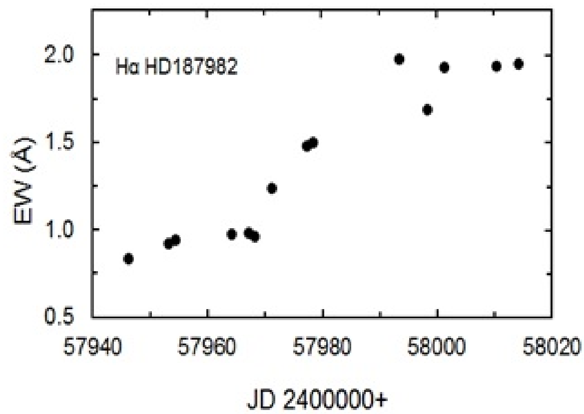

Fig. 2. Time variations of equivalent widths EW of the absorption line Hα in 2017.

In the Figure 1. the time variation of the heliocentric radial velocities of the α line is presented. As you can see, on the night of JD 24557971.340, a significant displacement of RV by about -12 km/s relative to the star's mass center velocity and a gradual return to its usual position was observed. Starting from the same night, a gradual increase in EW is observed until the end of the season (Fig.2). The shift to the blue part occurs with a characteristic time of about 9 days. At the same time, a slow drift of the RV parameter with a characteristic time of about 24-29 days is observed.

In our spectra, the Hα line is observed in the form of absorption; weak emission components are superimposed on the photospheric wings. Often, the blue emission component is practically not detected, while the red component shows the change in intensity over different dates. Figure 3 shows the $H\alpha$ line profiles according to the 2017 observational data. The numbers indicated on the spectra correspond to the numbers of the spectrum in Table 1. As can be seen from Fig 3., emission components on the wings of the α line gradually became noticeable in profile 14. This is the same date JD 24557971.340 at which a sudden blue shift of the RV and a smooth increase in the EW parameter were detected. Further, the emission components are gradually increased.

We averaged the line profile over 14 observation nights and determined the root mean square deviation from the mean in intensity at each wavelength along the line (Figure 3). This method makes it possible to determine the wavelength at which the intensity is varied in the spectral line. In the middle profile of the line, the blue and red components of the emission in the α line correspond to

Table 3. Results of measurements of the line $H\alpha$

№	2400000+	R_λ	EW (Å)	RV(km/s)
1	57562.359	0.46	2.0	-7.7
2	57567.363	0.47	2.2	-9.7
3	57615.311	0.37	2.2	-17.3
4	57621.425	0.35	2.1	-15.9
5	57622.460	0.35	2.1	-21.7
6	57623.254	0.29	1.4	-20.0
7	57626.453	0.36	2.2	-17.7
8	57946.337	0.22	0.8	-7.9
9	57953.309	0.24	0.9	-10.2
10	57954.417	0.24	0.9	-10.5
11	57964.365	0.24	1.0	-9.9
12	57967.243	0.26	1.0	-11.2
13	57968.266	0.26	1.0	-9.6
14	57971.340	0.26	1.2	-15.5
15	57977.392	0.31	1.5	-9.7
16	57978.367	0.31	1.5	-9.2
17	57993.366	0.37	2.0	-10.9
18	57998.345	0.37	1.7	-11.0
19	58001.329	0.38	1.9	-11.5
20	58010.316	0.40	1.9	-8.7
21	58014.276	0.43	1.9	-9.1
22	58298.258	0.39	1.9	-20.3
23	58318.410	0.43	2.2	-18.9
24	58347.363	0.32	1.6	-4.7

velocities of –65.6 km/s and +76.5 km/s, and the top of the absorption peak is –13.5 km/s. At the same time, the greatest variation in the line was obtained on the red wing at the velocity of +45.4 km/s.

4. DISCUSSION AND CONCLUSIONS

So, in this work, we considered the time variation in the spectrophotometric parameters of the $H\alpha$ line, as well as in the profile variation according to the data of spectral observations in 2016-2018. It was shown that the variation in the parameters of the $H\alpha$ line occurs smoothly, with a characteristic time of 25-29

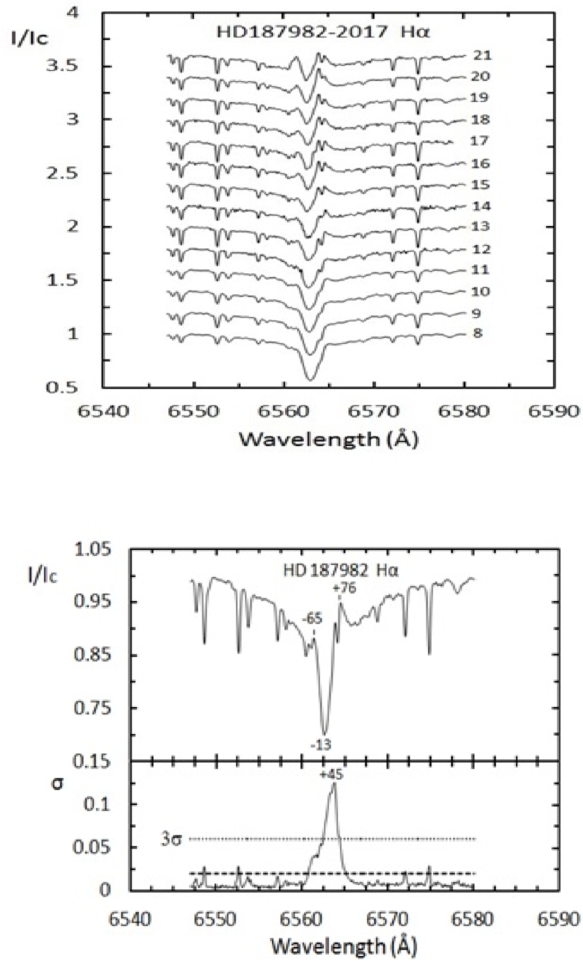

Fig. 3. Profiles of the Hα line in 2017 season.

days. The α line shows displacement the radial velocity relative to the star mass center at -10 km/s (Fig. 1). This rate is in good agreement with the shift of the deep absorption peak of the Hα line.

On the night of JD 2457971.340, a sudden blue displacement of the velocity at -12 km/s was detected, and further, returning to its original position. On the same date, an increase in the equivalent line width and its smooth increase until the end of the observation season were found. Simultaneously with these phenomena, at the indicated date and further, appearance of emission components of the α line are observed, which become stronger at the end of the observation season.

These variations indicate that the stellar wind around the star is not stationary, but at times occurs in the form of ejections from the star's surface. This leads to an increase in emitting atoms and an increase in EW. The enhancement of the intensities of the emission components on the blue and red wings of the line shows that the suddenly ejected mass accumulates in the circumstellar environment and creates a gaseous disk that over time can gradually dissipate or return to the star's surface.

As can be seen from Table1, completely different values of the star parallaxes were obtained from the literature. The latest data from the Gaia DR2 archive gives a value of 0.6566 ± 0.1339 mas, which gives a distance of 1522 ± 300 pc. The closest measurement is obtained in the second reference 0.4667 ± 0.0853 mas, which is equivalent to a distance of 2142 ± 200 pc. If we take the Gaia DR2 data as a more accurate value, then using the standard expression for the absolute luminosity of the star, we can get

$$Mv = m + 5 - 5logr - Av = 5.57 + 5 - 53.182 - 2.04 = -7.38\,mag,$$

When bolometric correction is $mBC = -0.45$ mag, for bolometric absolute magnitude $M_{vbol} = -7.83$ mag Then for luminocity we can get

$$\mathrm{L = L \odot 10^{0.4(Mb\odot - Mvbol)} = 106659\ L\odot \approx 10^6\ L\odot}$$

and for the radius of the star

$$\mathrm{R = R \odot 10^3 (\ T \odot /T) = 400R\odot}$$

The parameters obtained here shows that, possible the star HD 187982 is one of the brightest A type supergiants.

5. ACKNOWLEDGEMENTS

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