HIGH VELOCITY ABSORPTION IN THE SPECTRA OF CH CYG IN 2017

Kh. M. Mikailov [a*], ***R. T. Mammadov*** [b], ***I. A. Alakbarov*** [a], ***O. V. Khalilov*** [a]

[a] *Shamakhy Astrophysical Observatory named after Nasireddin Tusi of the Azerbaijan National Academy of Sciences*

[b] *Batabat Astrophysical Observatory of Nakhchivan branch of ANAS*

Components of extensive high velocity absorption are observed in the hydrogen lines Hβ,Hγ, Hδ and He I λ 5876 Åof the symbiotic star CH Cyg. The spectral material was obtained for 2017 with the spectral resolution R=2800, in the 2 m telescope of Shao bu using the Fibre echelle spectrograph (ShAFES) . In the blue wing the displacement of the absorbtion components have reached up to -3000 km/s. The width of the line was riched 800-1000 km/s and the residual intencity - 0.2 - 0.6. It is supposed that the high velocity absorption is the occured due to ejection of matter from the white dwarf's equatorial part.

Keywords: Symbiotic stars–CH Cyg–Jet-high velocity absorption

1. INTRODUCTION

According to the modern imaginations symbiotic stars are binary systems comprising of a mutually reacting red Giant (RG) and white dwarf (WD) (sometimes comprising of three stars). Continuous substance flow is released from the RG and as a result of accretion a disc is generated around the WD. Alteration of velocity and power of accretion leads to change of the brightness of star both in visible region and in the ultraviolet region by $1 \div 3$ star size. In such type of objects high velocity release of substance is observed and this leads to the weight loss of the star.

One of the most discussed matter in the study of weight loss is collimated flows and jets emerged in phylogenetic stars. From this perspective symbiotic stars are the best laboratories to study the generation and phylogenesis of these

* E-mail: mikailov.kh@gmail.com

type of flows in the spectrally identified binary systems. Existence of strong aspheric, locally identified clouds around most of these stars is known already [1] and highly collimated jets have been identified in several symbiotic stars so far.

CH Cyg collimated bipolar substance flow was found in CH Cyg symbiotic star for the first time in the radio region. At least 3 different jet events have been recorded on 1984-1985, 1994-1995 and 1996-1997 [2], [3], [4]. Every jet event was related to optical activeness period and in all three cases generation of jets was followed by rapid collapse of brightness. Observations show that there are strong collimated flows in perpendicular to the sight direction with the velocity of 800 km/s 1" towards to north-east from the star [5].The typic size of jets in CH Cyg star is about 1400 au, cosmic velocity is 700 km/h [6]. Jets have been observed in the X-ray region as well [7]. Jets- high velocity substance release - in the optic region are noticed by observation of large and deep absorption components in profiles of HI and HeI lines. Absorption components were observed with the velocity of $-700 \div -2500$ km/s [8], [9], [10]. Astrophysical jets are observed almost in all type of accreting binary systems. Jets in symbiotics are mainly related with flickering in optical region. CH Cyg is one of the most dramatical source of jets among symbiotics. Its optical monitoring can help us to understand the jet structure.

In this paper we introduce information about high velocity absorption components generated in the profiles of HI and HeI lines based on echelle spectra achieved in 2017 in Shamakhy observatory.

2. OBSERVATION.

80 echelle spectra of CH Cyg star have been achieved within 36 nights in the 2 meters telescope of Shamakhy Astrophysical Observatory in May-November interval in 2017. The telescope is fitted with ShAFES – Shamakhy Fibre Echelle Spectrograph and CCD camera cooled by liquid nitrogen [11]. Spectral identification $R = \lambda/\Delta\lambda = 28000$, spectral diapason 3800-8000Å, Chip 4096x4096, pixel size $15 \times 15\mu m$.

Wavelength calibration achieved with Sky and Th–Ar hollow cathode comparison. The spectra were reduced using the software package new version of DECH [12] program folder. Processing of Extraction of all spectra have been done with IRAF mask.

In this paper we worked on spectra of 6 nights only, where strong and fast absorption components were highly visible. The list of spectra has been given in table2. Catalogue list of spectra, date of achievement, universal time zone, exposition time and the number of spectra achieved during the night have been introduced in the table.

Table 1. Log of Spectral observations of CH Cyg in 2017

Spectrum number in the catalogue	Observation date(day.month.year)	UT	Exp(s)	number of spectra spectra
KF1376-77.fit	17.07.2017	18:40:33	1500	2
KF1412-13.fit	18.07.2017	21:46:01	1500	2
KF1689-91.fit	08.08.2017	23:58:10	1200	3
KF1692-93.fit	09.08.2017	19:03:03	1200	2
KF1686-87.fit	28.08.2017	20:28:42	1200	2
KF2173-75.fit	18.09.2017	22:40:06	1800	3

3. RESULTS OF MEASUREMENTS

Profiles of Hβ Hγ, HδFig. 1a) and HeI 5876 Ålines (Fig. 1 b) of Balmer series of Hydrogen atom based on spectra of CH Cyg achieved for 6 nights have been introduced in the figure1. High velocity of absorptions is observed in all Balmer lines (from Hα to Hδ). As it is seen from the figure except 18 July high velocity of large absorption components have been observed in the blue side of HI and HeI lines in the other 5 spectra. The absorption components demonstrated different velocities $-1200 \div -2500$ km/s from the spectrum to spectrum. Absorption components are better visible in Hβline. But visibility of absorption components in Hγ and Hδgets more difficult due to overlap of the emission spectrum with absorption components. For example 4320, 4306 and 4313 lines of [FeII] in Hγline, 4068 and 4076 lines of [SII] in Hδline.

It gets very difficult to identify high velocity of absorption components in the blue side of HeI 5876 Åline due to dominance of molecular lanes of the red giant. High velocity of absorption components are highly visible only in the spectra achieved in 18 September and 28 August (Fig.1).

As it is seen from the Fig.1, structure of profiles of absorption components of all 3 Balmer lines are completely similar. But equivalent width and deepness of the line is greater in the Hβ line (see table 2). Equivalent width, deepness and ray velocities of high velocity absorption components of Hβ, Hγ, Hδ and HeI 5876 Ålines for cleaned spectra have been measured. Results of measurements have been presented in the table2.

As it is presented in the table 2, equivalent width of absorption components of Hβ, Hγ, Hδ and HeI 5876 Ålines get values in the interval of 9.18 $\div$4.55 Å, 7.23$\div$2.77 Å, 5.22 $\div$ 2.46 Åand 4.31 $\div$ 3.2 Årespectively and the deepness gets values of 0.75 $\div$ 0.39, 0.70 $\div$ 0.26 and 0.33 $\div$ 0.18 respectively.

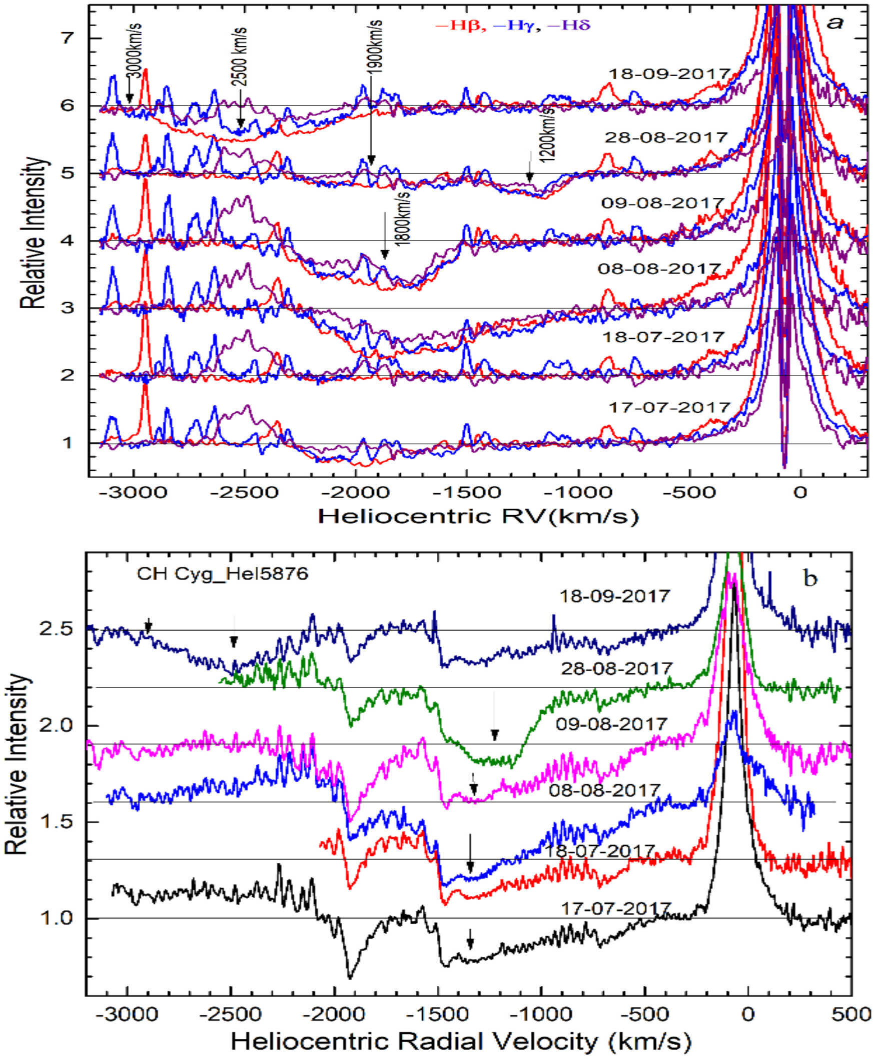

Fig. 1. Demonstration of high velocity of absorptions in CH Cyg. a- Hβ, Hγ, Hδregions, b – HeI 5876 Åregion.

In Fig.1 profiles of absorption components of Hβ and HeI 5876 lines in the ray scale to compare their structure. As it is seen from the figure the structures of absorption components of Hβ and HeI 5876 Ålines are very similar in the other 4 nights' spectra except 08th of July. But their deepness are very different. Deepness of the Hβlines was about 2,7 times greater than HeI line deepness on 08 and 09 July. Emission was observed in the blue wing of the absorption on 8th of July. They same time, the ray velocity of the absorption component of HeI 5876 Åline for deepness on the same day was totally different – 1400km/s, 500 km/s less than

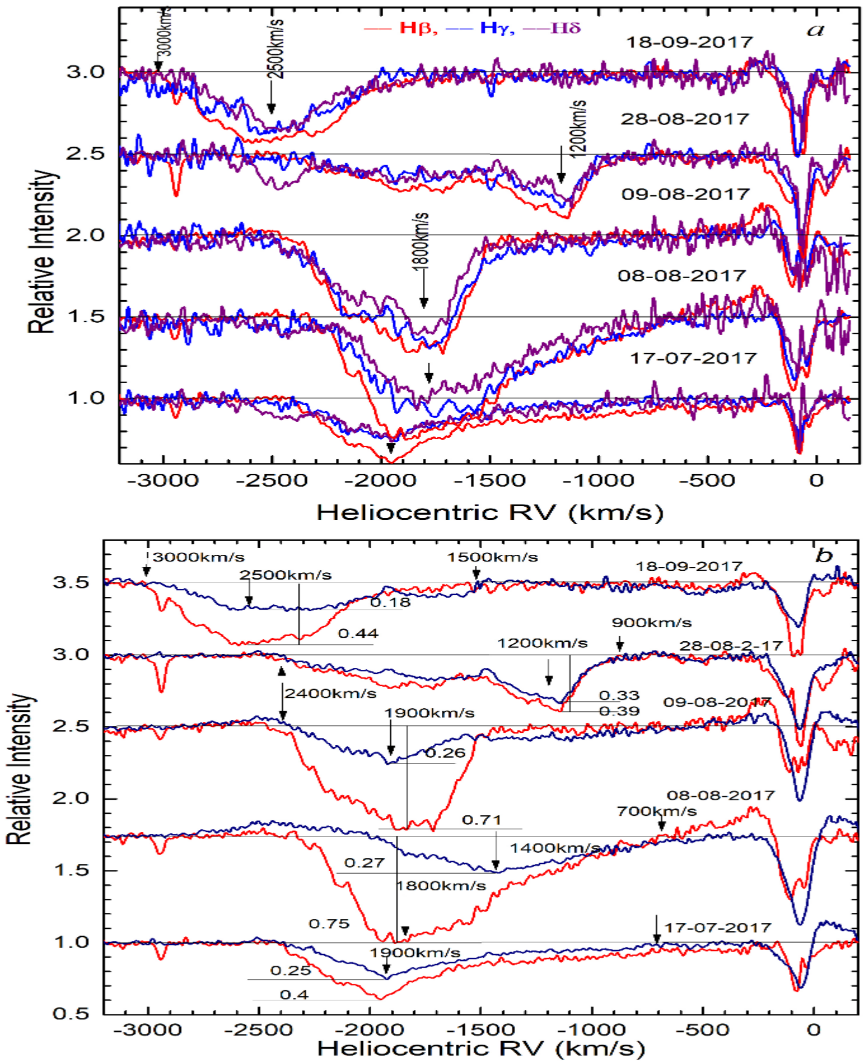

Fig. 2. . Demonstration of high velocity of absorptions after cleaning the CH Cyg symbiotic star from emission and molecular lanes. a - profiles of Hβ, Hγ, Hδ absorption components,b -profiles of absorption components of H$\beta$and HeI 5876 lines.

Hβline. On 28th of July absorption components demonstrated binary structure. Components demonstrated -1900 km/s and -1200 km/s velocity. Velocity in the blue wing of absorption component on 18^{th} of September reached to -3000 km/s.

4. DISCUSSION.

Jet is estimated only in the systems which are reasonably accreted from the red giant by disc. Existence of the disc leads to strong and short-term flickering of hot component and this case absorption component is also seen in the profiles of emission lines. But flickering is observed in only few objects [13].

Collimated substance flows (jets) have been observed in at least 10 of 200 symbiotic stars [14]. Jets are temporary in the symbiotic stars because they are related to activeness of the hot component [15].

Hot star of CH Cyg symbiotic system was in periastron in 1999 and 2015. In these years high velocity of absorption components have been observed in the blue side of HI and HeI 5876 Ålines [8, 9]. Because white dwarf is moving in the elliptic orbit, it gets very closer to the red giant in periastron. For that reason, more substance flows onto the white dwarf from the red giant when it is in periastron and near to periastron. And it leads to activation of the hot component, increasement of brightness in about $1^m \div 1.5^m$ mag and flickering. As a result of this jet shaped substance releases occurs from the poles and equatorial part of the white dwarf. It is noticed by observation of high velocity of large absorption components in the spectrum. Absorption jets have been observed in our spectra in 2017. 2 years passed from the time when the start was periastron to our observations. The orbital period of the star is about 16 years. For these 2 years the star didn't move away from the periastron so much. That's why it can be accepted that, continuation of high velocity jets is related to getting the star closer to the periastron.

High velocity of absorptions are weaker in the Hα line than Hβ line. This is connected with either the position of jets in the direction of observer's sights or radiation of the giant star in the red region and filling Hα line blue side absorptions [16]. That's why high velocity of absorptions are weak in Hα line.

High velocity of star winds also cause generation of large absorption lines in the blue wing of the emission lines. P Cyg profiles have been observed in our observations in the line of HeI 5876 of spectra. Position and location of absorption lines depend on the velocity of star wind. But star wind cannot cause absorption components at such a high velocity (about several 1000 km/s).

Observations at radio and x-ray region show that large scale substance releases lasts for long time in the direction of pole. On the other hand, due to acceptance of CH Cyg as a weakened binary star, observation of high velocity (up to -3000 km/s) of large absorption components in the blue side of HI and HeI lines is explained with occurrence of substance jets in orbit flatness of the equatorial part [8]. Being different of bipolar substance flows, jets observed in 1998-2000 are quite similar to the jets in Be stars. 250 days after high velocity substance jets started in CH Cyg, in the 1^{st} of October 1999 two nebulas have been identified detached from the central star in 100 a.u. distance based on images achieved in Habble telescope [17]. Flow of substance with the velocity of 1000 km/s can get this distance in 250 days.

Despite multiple facts of observation there are still unclarified problems related to generation of jets: 1. At which phase is the red giant's 756 days of pulsation while the hot star is in periastron if CH Cyg is accepted as a binary system, 2. The location of the third star moving in the inner orbit in 756 days period if CH Cyg is accepted to be triple system. Multiple observations required again to bring clarity to these questions.

5. CONCLUSION.

Components of extensive high velocity absorption are observed in the hydrogen lines Hβ,Hγ, Hδ and HeI λ 5876 Åof the symbiotic star CH Cyg. The spectral material was obtained for 2017 with the spectral resolution R=28000, in the 2 m telescope of ShAO by using the Fibre echelle spectrograph (ShAFES) In the blue wing the displacement of the absorbtion components have reached up to -3000 km/s. The width of the line was riched 800-1000 km/s and the residual intencity - 0.2 – 0.6. It is supposed that the high velocity absorption is the occured due to ejection of matter from the white dwarf's equatorial part.

Table 2. Log of Spectral observations of CH Cyg in 2017

Spectrum number in the catalogue	Observation date(day.month.year)	UT	Exp(s)	number of spectra
KF1376-77.fit	17.07.2017	18:40:33	1500	2
KF1412-13.fit	18.07.2017	21:46:01	1500	2
KF1689-91.fit	08.08.2017	23:58:10	1200	3
KF1692-93.fit	09.08.2017	19:03:03	1200	2
KF1686-87.fit	28.08.2017	20:28:42	1200	2
KF2173-75.fit	18.09.2017	22:40:06	1800	3

REFERENCES

1. Corradi, R.L.M.; Brandi, E.; Ferrer, O.E.; Schwarz, H.E., A narrowband imaging survey of symbiotic stars, Astron. and Astrophys., 1999, v.343, p.841-846

2. Taylor, A. R.; Seaquist, E. R.; Mattei, J. A., A radio outburst and jet from the symbiotic star CH CYG, Nature, 1986, 319, 38

3. Karovska, M.; Carilli, C. L.; Mattei, J. A., Possible Jet Formation in the Symbiotic System CH Cyg,, Journal AAVSO, 1998, vol. 26, no. 2, p. 97-100

4. Crocker, M. M.; Davis, R. J.; Eyres, S. P. S.; Bode, M. F.; Taylor, A. R.; Skopal, A.; Kenny, H. T., The symbiotic star CH Cygni - I. Non-thermal bipolar jets, M.N.R.A.S., 2001, vol.326, Is. 2, pp. 781-787.

5. Solf J., 1987, Optical confirmation and high-resolution spectroscopy of the radio jet from the symbiotic star CH Cygni , Astron. and Astrophys., v. 180, no. 1-2, p. 207-212

6. Karovska, M.; Gaetz, T.J.; Carilli, C. L.; Hack, W.; Raymond, J.C.; Lee, N.P., A Precessing Jet in the CH Cyg Symbiotic System, Astrophys. J. Let., 2010, vol.710, Is.2, pp. L132-L136

7. Galloway D., Sokoloski J. L. An X-Ray Jet from a White Dwarf: Detection of the Collimated Outflow from CH Cygni with Chandra, ApJ, 2004, vol. 613, p.61.

8. Iijima, T., Naito, H., and Narusawa, S., High-velocity equatorial mass ejections and some other spectroscopic phenomena of the symbiotic star CH Cygni in an active stage, Astronomy & Astrophysics, 2018, V.622, A45, p.2-15

9. Mikayilov, Kh. M.; Rustamov, B. N.; Alakbarov, I. A.; Rustamova, A. B., Rapid Spectral Variability of the Symbiotic Star CH Cyg During One Night, ASPC, 2017, v.510, p.170-174

10. www.ta3.sk/conferences/75AI2018/talks/B12.pdf

11. Mikayilov Kh.M., Musayev F.A., Alakbarov I.A., Rustamov B.N., Khalilov O.V., Astronomıcal Journal of Azerbaıjan, SHaFES: Shamakhy Fibre Echelle Spectrograph, 2017, Vol.12, No.1, p4-27

12. www.gazinur.com/DECH-software.htm

13. Sokoloski, J. L.; Bildsten, Lars; Ho, Wynn C. G, A search for rapid photometric variability in symbiotic binaries, MNRAS., 2001, Vol. 326, Is. 2, pp.553-577.

14. Brocksopp, C., Sokoloski, J.L., Kaiser,C., Richards, A.M., Muxlow, T.W.B., Seymour, N., A radio jet in the prototypical symbiotic star Z And?, M.N.R.A.S., 2004, v.347,p 430–436.

15. Tomov, Toma; Munari, Ulisse; Marrese, Paola Maria, Bipolar jets from the symbiotic star Hen 3-1341 in outburst, Astronomy and Astrophysics, 2000, v.354, p.L25-L28

16. Schmid, H. M.; Kaufer, A.; Camenzind, M.; Rivinius, Th.; Stahl, O.; Szeifert, T.; Tubbesing, S.; Wolf, B., Spectroscopic monitoring of the jet in the symbiotic star MWC 560. I. Spectroscopic properties, general outflow structure and system parameters, Astron. and Astrophys., 2001, v.377, p.206-240

17. Corradi, R.L.M.; Munari, U.; Livio, M.; Mampaso, A.; Gonçalves, D.R.; Schwarz, H.E., The Large-Scale Ionized Outflow of CH Cygni, Astrophys. J., 2001, v.560, pp. 912-918