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Research Article

Spectral Variability of the Symbiotic Star CH Cyg

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Abstract: On July 15, 2015, the second telescope of the Shamakhi Astrophysical Observatory (ShAO) was used to collect 14 echelle spectra of the symbiotic star CH Cyg over the course of six hours of nocturnal exposures. Along the profiles of the lines Hα and Hβ, the intensity of line HeI λ5876 Å fluctuates simultaneously with variations in the intensity ratios of the blue and red emission components. The HeI λ5876 Å line's center intensities and corresponding widths correlate with information from the blue emission component of the lines. There are certain correlations between the radial velocities of the absorption DNaI and the emission line Hα.

Keywords: Symbiotic Star, Line Profile, Line Intensity, Radial Velocity.

1. INTRODUCTION

The advantageous star CH Cyg is bizarre and varies significantly from other conventional advantageous stars based on its ghostly and photometric behavior within the "calm" and dynamic stages, as well as based on the unveiled sets of periods for the system's outspread speeds and light bends. Following the appearance of symbiotic behavior, the photometric history of the star is shown as active phases (a sequence of flashes: 1969–1970; 1977–1986; 1992–95 and 1998–1999), interrupted by "silent" intervals of varying lengths. From many minutes (flashing amid the dynamic stage) to hundreds of days (throb and revolution of M ruddy giant), and indeed 10 of a long time, changes within the CH Cyg light bend take place on different time periods (orbital moving of the components within the framework). Beginning around 2010, the star's brightness in the rays of U progressively grows until it reaches a value of around 7^m–8^m by the end of 2014. The striking spectral and photometric variability that took place in 2014–2015, along with the synchronized rise in the star's brightness in the U and V rays, prove beyond a shadow of a doubt that CH Cyg has entered its subsequent active phase [2-9]. In the active phase of the star, flickers, which are defined as a dramatic rise in brightness over a time period of few minutes to many hours with an amplitude of 0.1^m to 0.5^m, emerge in CH Cyg's optical brightness.

The interaction among the parallel framework and the near-stellar matter causes exceptionally complicated kinematics to make within the near-stellar medium amid the dynamic stages of the advantageous framework. Diverse sorts of changes within the profiles of the hydrogen Balmer lines are one way that the variable of the growth and outflow administration of matter uncovers itself. Therefore, despite thorough spectrum investigations throughout all of the CH Cyg star's active phases, there is still no single explanation that can fully account for the majority of the observable evidence [see, for example, 3, 10-12].

On the night of July 15, 2015, spectral measurements of CH Cyg were made using the

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Shamakhy Astrophysical Observatory's second telescope. Parts of the findings from these observations are described in [13, 14]. The HeI λ5876 Å lines and the NaI D1 and D2 doublet in the CH Cyg spectrum are described in detail in this work, along with a comparison to the findings of previous studies on the Hα and Hβ lines based on the same spectra [13, 14].

2. SPECTRAL OBSERVATIONS PROCEDURE

The spectra of CH Cyg within the wavelength run λλ 4700-6800 ÅÅ were gotten for one night (15.07.2015) within the Cassegrain center of the 2nd telescope of the ShAO. An Echelle spectrometer was used, assembled based on a all inclusive astrospectrograph (UAGS), employing a CCD camera of 580×530 pixels with a scattering of 10.5 Å /mm at H_α (ghastly determination R = 14,000 [15]. The observations were carried out continuously for 6 hours with an exposure of 20 minutes for each spectrum. A total of 14 Echelle spectra were obtained. Observations and processing of Echelle spectra were carried out using the DECH–20 software package developed at the SAO RAS [16].

3. OBSERVATION RESULTS

From all of the available spectra, the profiles of the lines HeI λ5876 Å, NaI D1, and NaI D2 were built, and the equivalent widths and radial velocities of the lines were determined from these profiles. Figures 1a and 1b display the profiles of the lines HeI λ5876 Å and NaI D1 and D2 in the CH Cyg star's one-night spectral analysis.

As observed in Figure 1a, there are significant variations to the center intensity of the HeI λ5876 Å line profiles over a period of roughly 20 minutes that are almost coincident with changes to the Ib/Ir ratios of the Hα and Hβ lines. As mentioned in, the variation in the intensity of the blue emission

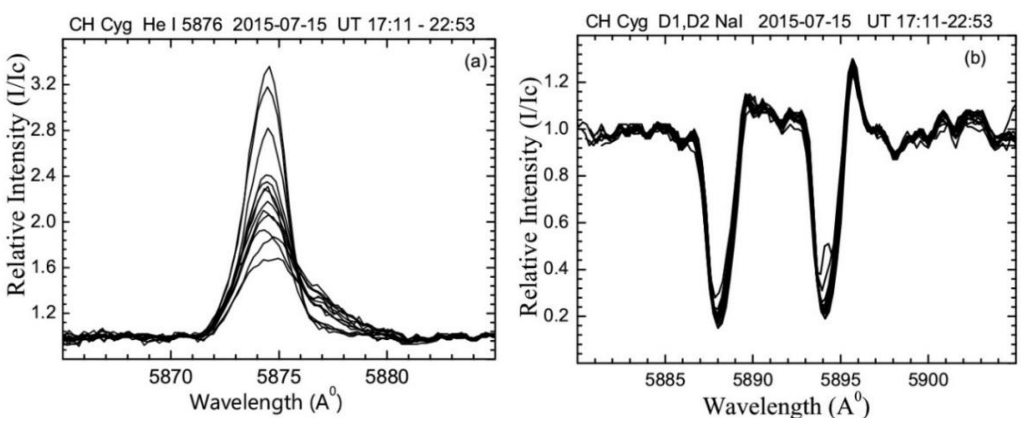

Fig. 1. (a, b). Profiles of HeI λ5876 and NaI D1.2 lines in the spectra of the symbiotic star CH Cyg observed for one night (2015-07-05 UT 17:11 – 22:53).

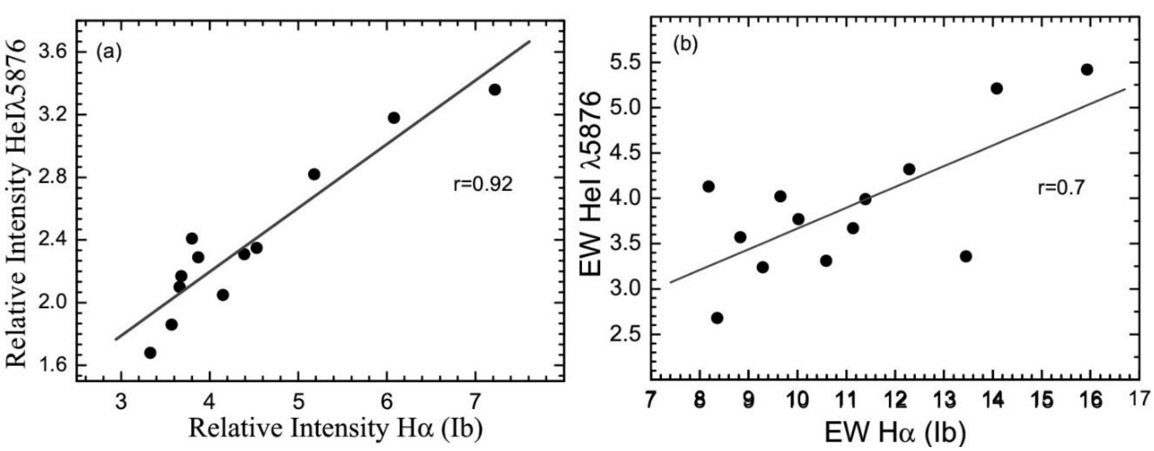

Fig. 2. (a, b). Dependences of the profile parameters of the blue component of the Hα lines on HeI 5876

component is the major cause of the change in the Ib/Ir ratio [13, 14]. Therefore, it can be inferred indirectly that the Hel λ5876 Å and Ib emission lines' intensities shift about at the same time. The Hel λ5876 Å line's relative intensity was 1.93 at the start of the observations; at the conclusion, it had climbed by around twice and was at a value of 3.36. The blue component of the Hα and Hel λ5876 Å lines' profile characteristics exhibit strong correlations. Correlation values of 0.92 and 0.70, respectively, are found between the relative intensities and equivalent widths of these lines (see Figure 2a and 2b). The antiphase is when the Hel λ5876 Å line's center intensity and half-width alter (Figure 3a and 3b).

The NaI D1 and D2 lines, particularly NaI D1, have a profile of type P Cyg, as seen in Figure 1b. The outspread speed of the emanation component of the line NaI D1 is close to the speed of the ruddy component (Vre) of the emanation lines Hα and Hβ, and the spiral speed of the assimilation component of the line NaI D1 generally compares to the outspread speed of the blue component (Vbe) of the outflow lines Hα and Hβ (roughly -100 km/s) [14].

Although the absorption core exhibits significant fluctuation, particularly in the NaI D1 line, the residual intensity of the NaI D1 and D2 lines do not exhibit abrupt shifts. For the observation period, the emission component NaI D1 does not exhibit fluctuation. A second absorption component shows at the NaI D1 line on one spectrum (UT 22:37) with a speed of 68 km/s, which is comparable to the Hα line's core absorption rate [14]. On this spectrum, the HeI λ5876 line's intensity reaches a maximum.

4. DISCUSSION

We found the dependences of the escalated of the HeI λ5876 emanation line, the proportionate width of the blue outflow component, and the leftover escalated of the high-speed retention components on the Ib/Ir proportions of the twofold profiles of the emanation Hα and Hβ lines utilizing spectra from one night for a time interim of approximately 6 hours.

Outspread speeds of the outflow line Hα and the D NaI assimilation line have a few association, as seen in Figure 4. This shows up to infer that sodium lines create in a especially hot and thick gas within the line's creation zone. Such circumstances are achieved in exceptionally minor segments of the disk or wind, but the root of the emanation line creation is much bigger, for illustration, see [17].

It appears that the white dwarf's activity levels and orbital location have a significant impact on the profiles' shapes and intensity ratios of the emission lines. The phase that corresponds to our spectral measurements was computed for the orbital period of 5689.2 days using the ephemeris from [18]: φ= 0.028.

JD (periastre)=2445681 (±192) + 5689.2 (±47.0) x E

where JD –Julian date and E is an integer number of cycles. The hot component was virtually periastric at the time of our spectral measurements. It may be

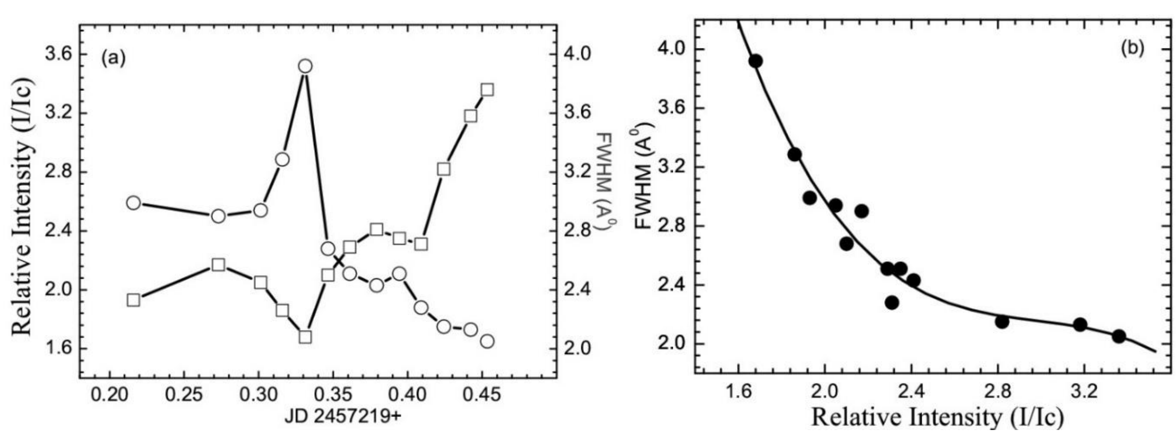

Fig. 3. (a, b). The change in the central intensity (y–axis scale on the left scale) and the half–width (y-axis scale on the right scale) - (a) and the dependence between the central intensity of the half-width - (b) - line HeI λ5876 on a time scale of regarding 6 hours during the night in the spectrum of the symbiotic star CH Cyg.

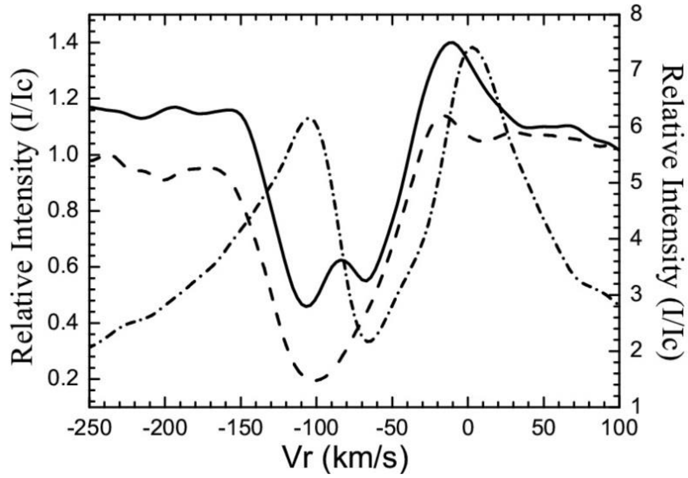

Fig. 4. Profiles of the lines NaI D1 (solid line), NaI D2 (dashed line) - scale on the y axis on the left scale and the emission line Hα (dashed line) - scale on the y axis on the right scale, according to the spectrum obtained in 2015-07-05 (UT 22:37).

believed that the hot star in 2014-2015 was situated close to the periaster due to the enormous size of the orbital period. The mass exchange process is activated when the system components have reached their maximum convergence, and this is followed by a large increase in spectral variability.

Rapid photometric variability was seen in the active phase of the symbiotic star CH Cyg system in 2014-2015 with amplitudes of $0.^m1$-$0.^m3$ and ~$0.^m5$ over typical times of 7–15 minutes and 4 hours, respectively [6,7]. Combining the aforementioned observational data, it can be said that the CH Cyg system exhibits fast photometric variability (flickering) in 2014-2015 and in earlier active phases, with characteristic timings that are similar to those of spectral variability. Evidently, the star's optical brightness is flickering in conjunction with the quick spectral shifts we have observed in the CH Cyg spectrum.

5. CONCLUSION

1. It was discovered that Hα and Hβ simultaneously occur with variations in the Ib/Ir ratios of the emission lines' blue emission component.
    a. variations in the line HeI λ5876 's intensity. The HeI λ5876 line's center intensities and comparable widths correlate with information from the H lines' blue emission component.
    b. changes in the corresponding lengths of the Hα and Hβ lines' blue emission components.
    c. the intensity of the Hβ line's blue wing's high-speed broad absorption components. During the observations, the intensity of the absorption components increased for 2.5 hours when the Ib/Ir ratio decreased, then decreased for the following 3 hours when the Ib/Ir ratio increased.
2. The outspread speed of the emanation component of the line NaI D1 is close to the speed of the ruddy component (Vre) of the emanation lines Hα and Hβ, and the spiral speed of the assimilation component of the line NaI D1 generally compares to the outspread speed of the blue component (Vbe) of the outflow lines Hα and Hβ (roughly -100 km/s) [14].
3. Our quick spectral variations in the CH Cyg spectrum are likely caused by the star's optical brightness flickering, which is typical of the active phase of the system.

6. CONFLICT OF INTEREST

The authors declare no conflict of interest.

7. REFERENCES

1. J. Mikołajewska, Y. Balega, K. Hofmann, and G. Weigelt. First spatial resolution of the stellar components of the interacting binary CH Cygni. *Monthly Notices of the Royal Astronomical Society* 403: 21–25 (2010).
2. A. Skopal. *ARAS Eruptive Stars Information Letter 13* (01): 31-01 (2015).

3. F. Rspaev, L. Kondratyeva, and E. Aimuratov. CH Cygni: New Brightening in 2014. Commissions 27 and 42 of the IAU information bulletin on variable stars. *Information Bulletin on Variable Stars* 6117: 121–124 (2017).
4. A. Skopal. *ARAS Eruptive Stars Information Letter* 11: 17-11, 10 (2014).
5. A. Skopal. *ARAS Eruptive Stars Information Letter* 14 (02): 28-02, (2015a).
6. S. Shugarov, A. Sekeras, A. Skopal, and G. Komissarova. Investigation of a rapid photometric variability of the symbiotic system CH Cyg during its current 2014-15 active phase. *Physics of Evolved Stars 2015*, *8-12 Jun, France* 71: 67 (2015a).
7. S. Shugarov, A. Skopal, M. Sekeras, G. Komissarova, and M. Wolf. Rapid Photometric Variability Of The Symbiotic System CH Cyg During 2008-15. *EAS Publications Series* 71-72: 107–108 (2015).
8. A. Skopal. *ARAS Eruptive Stars Information Letter* 16 (04): 08-05 (2015b).
9. A. Skopal. *ARAS Eruptive Stars Information Letter* 17 (05): 19-07 (2015c).
10. T. Tomov, D. Kolev, U. Munari, and A. Antov. Time-resolved high-resolution spectroscopy of CH Cygni: evidence for a magnetic propeller state in 1994. *Monthly Notices of the Royal Astronomical Society* 278: 542–550 (1996).
11. M. Burmeister, and L. Leedjarv. Spectroscopy of the symbiotic binary CH Cygni from 1996 to 2007. *Astronomy and Astrophysics* 504: 171–180 (2009).
12. S.P.S. Eyres, M.F. Bode, A. Skopal, M.M. Crocker, R.J. Davis, A.R. Taylor, M. Teodorani, L. Errico, A.A. Vittone, and V.G. Elkin. The symbiotic star CH Cygni – II. The ejecta from the 1998–2000 active phase. *Monthly Notices of the Royal Astronomical Society* 335: 526-538 (2002).
13. K.M. Mikailov**,** B.N. Rustamov, I.A. Alakbarov, and A.B. Rustamova. Rapid Hα variability in CH Cyg during of night. *Azerbaijani Astronomical Journal* 10 (3): 25–30 (2015).
14. K.M. Mikayilov, B.N. Rustamov, I.A. Alakbarov, and A.B. Rustamova. The rapid spectral variability of the symbiotic star CH Cyg during one-night. *San Francisco: Astronomical Society of the Pacific* 510: 170-173 (2017).
15. K.M. Mikailov, V.M. Khalilov, and I.A. Alekberov. Cassegrain focus echelle spectrometer of the 2-m telescope at the Shamakhy Astrophysical Observatory. *Tsirkulyar ShAO* 109: 21–29 (2005).
16. G.A. Galazutdinov. *Preprint of the Special Astrophysical Observatory* 92: (1992).
17. A. Natta, V.P. Grinin, and L.V. Tambovtseva. An Interesting Episode of Accretion Activity in UX Orionis. *The Astrophysical Journal* 542: 421-427 (2000).
18. K.H. Hinkle, F.C. Fekel, and R. Joyce. Infrared Spectroscopy of Symbiotic Stars. VII. Binary Orbit and Long Secondary Period Variability of CH Cygni. *The Astrophysical Journal* 692: 1360–1373 (2009).