EAST EUROPEAN JOURNAL OF PHYSICS. **2.** 38-42 (2025)
DOI:10.26565/2312-4334-2025-2-04 ISSN 2312-4334

PHOTOMETRIC FLICKERING OF THE CH Cyg IN 2018

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Received January 10, 2025; revised March 4, 2025; accepted March 17, 2025

Photometric observations of the CH Cyg symbiotic star were conducted using the Zeiss 600 telescope at the ShAO (Shamakhy Astrophysical Observatory) between 06.07.2018 and 16.09.2018 over the course of 17 nights with the V-filter. The light curve for this star was constructed based on our observations and data from the AAVSO (American Association of Variable Star Observers) database. To analyze the nature of the variability, we performed statistical spectral Fourier analysis utilizing the Scargle method. Our findings align perfectly with those of the AAVSO. The star's light has increased during the observation period up to 2 stars size – from 8.5^m to 6.5^m. Continuous observations have shown that short-term flickering of the star occurs during the night up to 0.2-0.45 magnitude. We suppose that the cause of these flickering is the increase in the flow rate of matter from the Red Giant star to the surface of the White Dwarf in the period close to the periastron.
Keywords: *Symbiotic star; CH Cyg; Photometric variable; Flickering; Power spectrum*, *Observation; CDD photometry*
PACS: 97.80.−d; 97.80 Fk; 97.80.Gm; 97.80.hn

1. INTRODUCTION

Symbiotic stars are interacting binary systems surrounded by cover. They consist of advanced Red Giant and hot component – White Dwarf. The material source of the cloud is Red Giant which loses its substance by star wind and pulsation, the energy source is the hot White Dwarf.

CH Cyg (HD 182917) is the brightest and closest one among the symbiotic stars. The distance to this symbiotic star is about 244 parsecs according to data of Hippacros [1]. Its visual star size increased up to $V=5.5^m$ on 1982-1983 and decreased down to minimum of $V=10.5^m$ in 1996. The brightness of the start in a still condition is mainly 7^m. Photometric observation of CH Cyg for more than 130 years is available, and it was studied comprehensively [2]. For long time CH Cyg was known as a single giant star pulsating in 100 days period in a little amplitude. Previous to 1963, CH Cyg showed no variable behavior and was actually used as a M6III spectral type calibrator. Since 1963 after activation strong emission lines of blue continuum and hydrogen were seen. Since that time CH Cyg was accepted as a symbiotic star – binary of M7 cold giant and accreting White Dwarf [3]. At that time, the spectrum of CH Cyg resembled a symbiotic star. This phenomenon was observed again in 1965. Since then, there have been several such outbursts of different durations: 1967−1970, 1977−1986, 1992−1995, 1998−1999, 2011-2012 and 2017-2018.

CH Cyg is one of the rare symbiotics flashing in minute time scale [4]. Flickering disappears, blue continuum gets stronger and radiation lines are getting larger when jets are observed. Flickering reflects large spectral stochastic changes of brightness in several minutes time scale up to 0.01^m to 1^m magnitude. Flickering activity has been observed only in 10 symbiotic stars: RS Oph, T GrB, MWC 560, V2116 Oph, CH Cyg, RT Cru, o Cet, V407 Cyg, V648 Car and EF Aql.

5-20 minutes of flickering has been observed in the spectrum of the symbiotic star of CH Cyg in the optical region profiles of emission lines and in the spectrophotometric parameters [5].

Here we present photometric observations of the flickering of CH Cyg in 2018.

2. OBSERVATIONS AND RESULTS

Observations of CH Cyg star have been carried out in ZEISS-600 telescope of Shamakhy Astrophysics Observatory during 72 days between 06.07.2018 – 16.09.2018 and 17 nights. The telescope was fitted with CCD photo receiver of 4096x4096 pixel (1 pix= 9mic) size and with 17 arcmin of efficient visual area of photometer [6].

The data reduction was done using MaxIm DL following standard procedures for aperture photometry. A few comparison stars from the list of Henden and Munari have been used, bearing in mind that V2365 Cyg (SAO 31628) is an eclipsing binary [7, 8].

TYC 3551-1725-1 was selected as the comparison star, and V2365 Cyg (SAO 31628) was used as the check star. To investigate the nature of the faster variations, continuous observations with high time resolution were carried out over several nights using a single filter (V).

Table 1 presents the observation list, including the observation date, the number of images taken, the exposure duration, the total observation period, as well as the average, maximum, and minimum brightness values, along with the maximum variations observed.

Cite as: Kh.M. Mikailov, R.T. Mammadov, East Eur. J. Phys. 2, 38 (2025), https://doi.org/10.26565/2312-4334-2025-2-04

Table 1. Journal of observations.

date-obs	exposures	obs. duration (minute)	Vave	V_{min}	V_{max}	ΔV
06.07.2018	5x10s	1.16	7.579	7.591	7.568	0.023
09.07.2018	15x5s	2.51	7.488	7.507	7.466	0.041
10.07.2018	59x3s	10	7.463	7.546	7.379	0.167
11.07.2018	79x3s	9+3*	7.301	7.388	7.269	0.119
14.07.2018	10x3s	2.36	7.187	7.211	7.17	0.041
18.07.2018	60x2s,15x3s	13	7.145	7.275	7.056	0.219
19.07.2018	700x3s,30x5s	148	7.012	7.143	6.846	0.297
06.08.2018	450x1s,15x2s, 11x3s	79	6.574	6.714	6.411	0.303
07.08.2018	120x2s	20.5	6.564	6.61	6.493	0.117
16.08.2018	174x1.5s, 150x2s	37+42*	6.623	6.796	6.424	0.372
22.08.2018	50x2s, 15x3s	10	6.669	6.727	6.589	0.138
30.08.2018	60x2s	8	6.777	6.808	6.74	0.068
03.09.2018	70x2s	17	6.471	6.626	6.358	0.268
06.09.2018	20x1.5s, 130x1s, 200x1s	43+27*	6.674	6.91	6.447	0.463
07.09.2018	160x1s	24	6.889	6.961	6.828	0.133
15.09.2018	100x1s	14	7.214	7.336	7.082	0.254
16.09.2018	950x2s, 500x2s	87+79*	7.199	7.336	7.087	0.249

*- observations have been conducted in the two sequential time intervals.

Observations have been conducted continuously within several nights. The most lasting observations have been conducted in 19-07-2018 – 148 minutes, 06-08-2018 – 79 minutes and 16-09-2018 – 87 and 79 minutes. Continuity of observations in the other nights have been: 10 minutes in 10/11-07-2018 and 22-08-2018, 13-14 minutes in 18-07-2018 and 15-09-2018, 20 minutes in 07-08-2018, 37 and 42 minutes in 16-08-2018.

Light curve in V filter has been given in the figure-1 based on our observations and AAVSO (American Association of Variable Star Observers) database. As it is reflected in the figure, our results accord with the AAVSO results. CH Cyg star was active during observation period and increased its brightness from 7.56^m to 6.47^m.

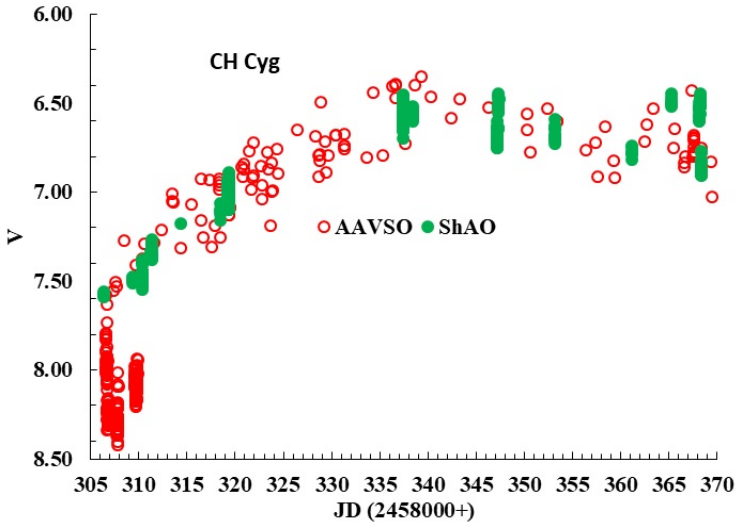

Figure.1. Comparison of the Light Curves of the CH Cyg Symbiotic Star for the period from 06-07-2018 ÷ 16-09-2018. ○-AAVSO, ●-ShAO.

3. FLICKERING

Photometric flickering of CH Cyg was identified by Wallerstein for the first time [9] and then have been comprehensively studied by various authors [10,11,12,13]. Flickering was not observed in 2010-2013, was observed again starting from 2014 [11].

Our observations also coincided to flickering time of the star. Nigh observations showed that several minutes lasting little amplitude of flickering occurs in the symbiotic star of CH Cyg. Light curves of several nights reflecting flickering in V filter of CH Cyg star are given in the figure 2. As it is reflected in the figure 2, character and amplitude of flickering was different from night to night.

Maximum change of brightness was 0.16^m for 7 minutes in 10-07-2018, 0.12^m for 5 minutes in 11-07-2018, 0.22^m for 10 minutes in 18-07-2018, 0.3^m for 35 minutes in 19-07-2018, 0.3^m for 39 minutes in 06-08-2018, 0.21^m for 17 minutes in 16-08-2018, in the first half of observation, 0.27^m for 39 minutes in the second half of observation, the amplitude of flickering during the night was 0.36^m. It was 0.14^m for 03 minutes in 22-08-2018, 0.14^m for 24 minutes in the first half of observation in 06-09-2018^m, 0.16^m for 26 minutes in the second half of the observation, amplitude of flickering was 0.45^m during the night. 0.22^m for 3 minutes in the first half of observation in 15-09-2018, 0.26^m for 8 minutes in the second half of observation, 0.14^m for 17 minutes in 16-09-2018 for the first half and maximum amplitude of flickering was 0.25^m.

Thus, changes in V brightness of CH Cyg symbiotic star with 0.1 m - 0.45 m amplitude in 1-30 minutes interval and 0.05 m - 0.06 m amplitude of changes happened in 10-30 seconds interval.

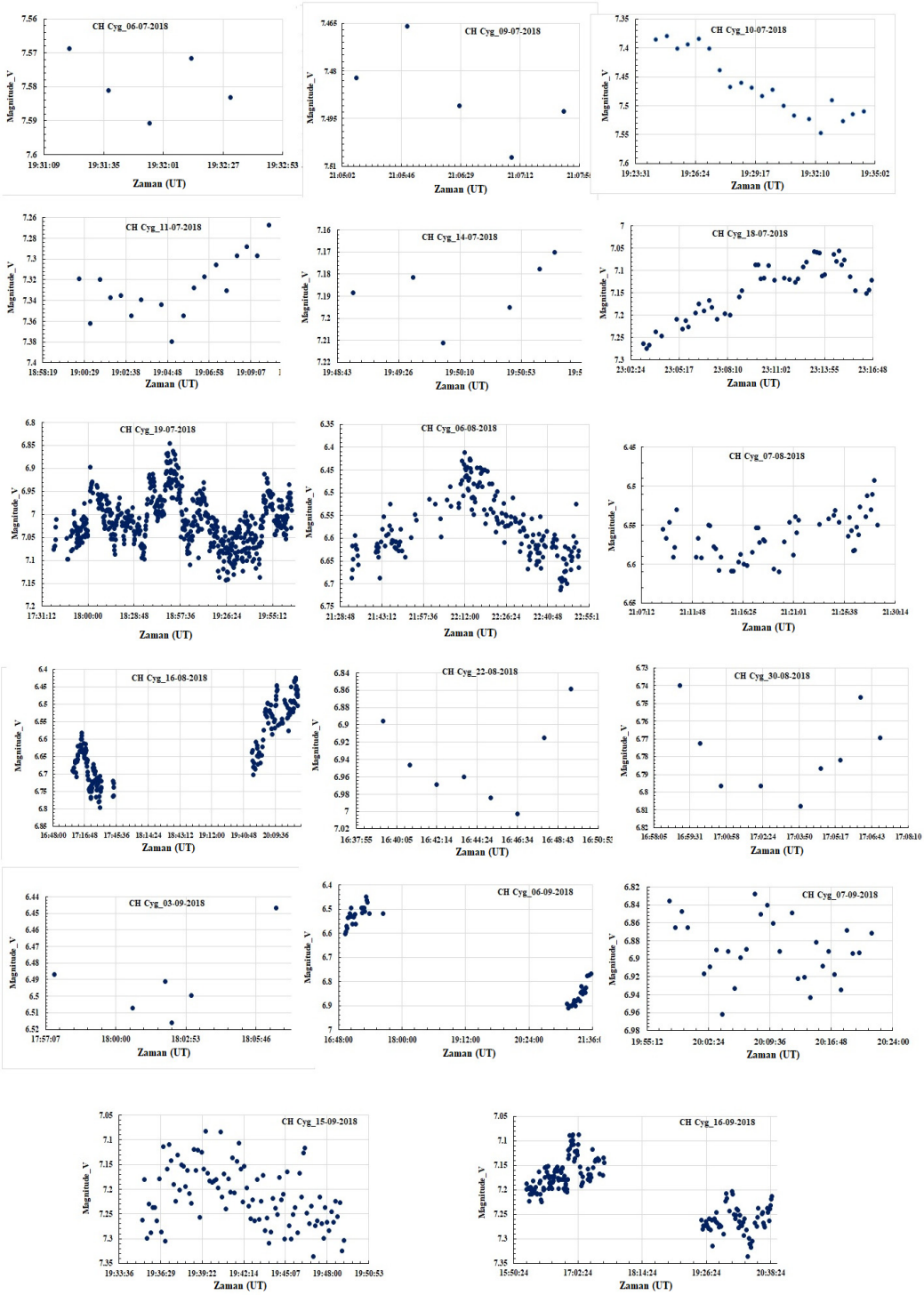

Figure 2. Flickering of CH Cyg in V bands.

4. PERIODICITY

Investigating the periodicity of flickering in the CH Cyg symbiotic star is challenging because our observations did not cover a sufficiently long time period, except for a few nights. However, as shown in Figure 2, some periodic variations were observed on certain nights. To explore the periodicity on a minute timescale, we applied spectral Fourier analysis using the Scargle method to the results of all our observations. As an example, the power spectra for the V-band on 06-08-2018, 16-08-2018, and 07-09-2018 are presented in figure 3.

In the figure 4 phase diagrams of brightness in V filter for the dates of 06-08-2018, 16-08-2018 and 07-09-2018 are given. Short time changes in brightness of CH Cyg star in V filter in dates of 06-08-2018 (79 minutes of observation) and 16-08-2018 (200 minutes) demonstrated close periodic values – 67 minutes and 65 minutes. Period of flickering was 12 minutes in 07-09-2018.

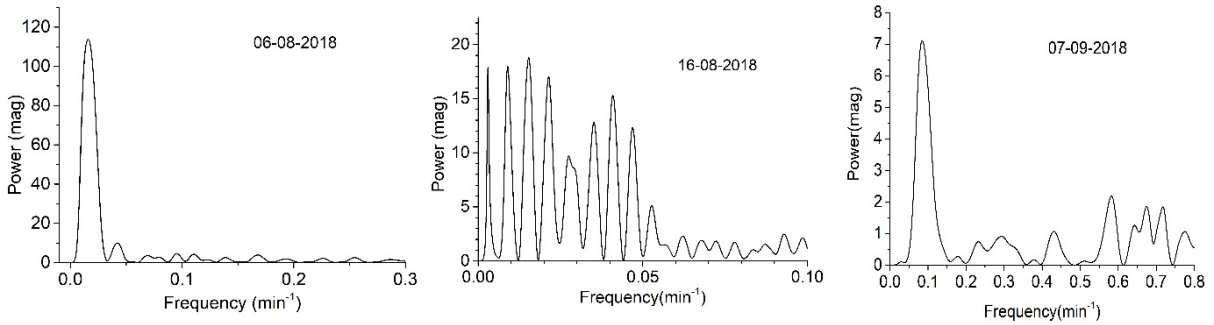

Figure 3. Power spectrum within 0-0.3, 0-0.1, 0-0.8 frequency intervals according to value of V data massive. The highest peak within the power spectrum accords with the value of frequency 0.0149, 0.0153, 0.0846 in the dates of 06-08-2018, 16-08-2018, 07-09-2018. Periods respectively are 67 minutes, 65 minutes and 12 minutes.

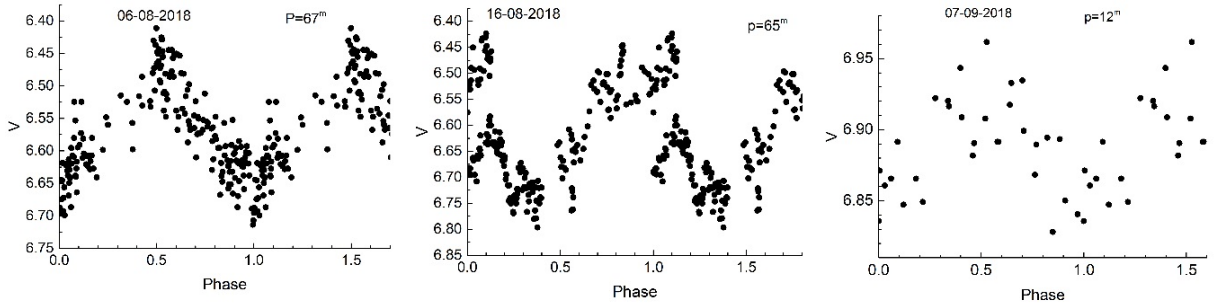

Figure 4. Phase diagrams for brightness of the start CH Cyg in V filter.

5. DISCUSSION

Red Giants are stars that have reached the necessary temperature for helium fusion in their cores. White Dwarfs, on the other hand, are stars nearing the end of their life cycle and are highly compressed. These stars are so dense that, despite having nearly the same mass as the Sun, their size is comparable to that of Earth. Due to their immense density, being 200000 times heavier than Earth, they exert a very strong gravitational pull. As a result, they can accumulate large amounts of matter from the companion cold giant, and in most symbiotic systems, an accretion disc forms around the White Dwarf.[16]. This happens due to rotation of binary system. As a result of the rotation of the binary system, the substance flowing from the Red Giant bends and falls on the White Dwarf due to its strong gravity. By causing matter to rotate, it forms a disk around the White Dwarf.

White Dwarfs have such a strong gravitational field that they can pull matter from the other star in a symbiotic system. This process is known as Roche Lobe Overflow. It occurs when a star expands to a point where its ability to retain its outer layers diminishes, causing its size to exceed the Roche limit. As a result, the excess material flows onto the binary system, forming a disc. Occasionally, this accretion leads to the formation of an ionized gas cloud around the hot component.

Source of flickering in optical region in symbiotic stars are known to be a disc [15]. Researchers consider that flickering disappears when accretion disc destroyed [11] or magnetic propeller gets activated [10]. Faster changes were observed during flickering of stars. Changes in fluxes in U filter were 10-30% within several minutes. CH Cyg is unique changing star and demonstrates complex alterations of different character in the light curve and large diapason of spectrum. Observed long lasting alterations (variating in 10 years) are caused by orbital movements or increasement of the dust cover. Several alterations of 95-100 days are related to pulsation of the giant [16]. Short term flickering activity relates to accretion disc. Increasement of activity of flickering since 2014 can be related to acceleration of processes in the disc as a result of increasement in amount of substance absorbed from the Red Giant while White Dwarf moves through periastron in CH Cyg symbiotic system.

6. CONCLUSION

The results of the analysis of observations in the V filter for the CH Cyg symbiotic star, made with the "Zeiss-600" telescope at the ShAO from 06.07.2018 to 16.09.2018 (over a period of 72 days and 17 nights), are as follows:

The star's brightness increased by about 2 magnitudes during the observation period, rising from 8.5^m to 6.5^m.

Continuous observations revealed that short-term flickerings in the star's brightness occur, ranging from 0.2 to 0.45 magnitudes. These flickering are likely caused by an increase in the rate of material flow from the Red Giant to the White Dwarf near periastron.

Periodic variations of 67, 65, and 12 minutes were observed for the fluctuations on different nights.

We sincerely thank the observers worldwide who contributed variable star observations to the **AAVSO** (American Association of Variable Star Observers) International Database, which were used in this research.

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ФОТОМЕТРИЧНЕ МЕРЕХТІННЯ CH CYG У 2018 РОЦІ

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Фотометричні спостереження симбіотичної зірки CH Cyg проводилися на телескопі Zeiss 600 в ШАО (Шамахинська Астрофізична Обсерваторія) в інтервалі 06.07.2018-16.09.2018 протягом 17 ночей з використанням V-фільтра. Криву блиску цієї зірки було встановлено на основі наших спостережень і баз даних AAVSO. Для вивчення характеру зміни ми застосували статистичний спектральний аналіз Фур'є за методом Скаргла. Наші результати повністю відповідають результатам AAVSO. Світло зірки збільшилося за період спостережень до розміру 2 зірки – з 8,5 до 6,5. Безперервні спостереження показали, що вночі відбуваються короткочасні мерехтіння зірки до 0,2-0,45 зоряної величини. Ми припускаємо, що причиною цих мерехтінь є збільшення швидкості потоку речовини від зірки червоного гіганта до поверхні білого карлика в період, близький до периастрона.

Ключові слова: *симбіотична зірка; CH Cyg; фотометрична змінна; мерехтіння; спектр потужності, спостереження; CDD фотометрія*