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PHOTOMETRIC ACTIVITY OF THE SYMBIOTIC STAR CH CYG DURING 2008–2011

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Abstract. We present results of $UBVR_{\rm C}$ observations of the symbiotic star CH Cyg before and after optical and X-ray bursts in 2009 at various timescales. Rapid variability was found only during a strong burst ($U \sim 9.5$ mag) in 2009 October, while during the low state, prior to ($U \sim 11$ mag) and after ($U \sim 9.4$ mag) the burst rapid variability was not detected.

Key words: stars: binaries: symbiotic: individual (CH Cyg) – stars: flare, oscillations

1. INTRODUCTION

CH Cyg is a bright ($V \approx 8$ mag) well-known symbiotic star, which shows unpredictable brightness variations on time-scales from minutes to years with amplitudes from ~ 0.1 mag to a few magnitudes. CH Cyg is active in different spectral ranges: from X-rays to radio.

Leahy & Taylor (1987) detected X-ray radiation from the star with maxima located in the soft X-ray (< 2 keV) and hard (> 10 keV) energies. CH Cyg is also a well known source of a collimated bipolar mass outflow, detected in the radio (e.g., Taylor et al. 1986; Crocker at al. 2001). The characteristic size of the jets was about 1400 au, and their space velocity was ~ 700 km/s. Recently, CH Cyg jets were detected also in X-rays (e.g., Galloway & Sokoloski 2004; Karovska et al. 2007).

Interferometric image of CH Cyg showed two components of the system with a separation of $0.042''$ (Mikolajewska et al. 2010). Hinkle (2009) derive the orbital period of the binary as 15.6 yr with the component masses 0.7 $M_\odot$ and 2 $M_\odot$ for the primary and the secondary, respectively.

2. OBSERVATIONS

Our $UBVR_{\rm C}$ CCD observations were taken with a SBIG ST10-XME camera mounted in the Newtonian focus of the 0.5 m (f/5) reflector in Stará Lesná Observatory. Photoelectric UBV observations were obtained with the 0.6 m (f/12.5) reflectors at the Skalnate Pleso and Crimean observatories.

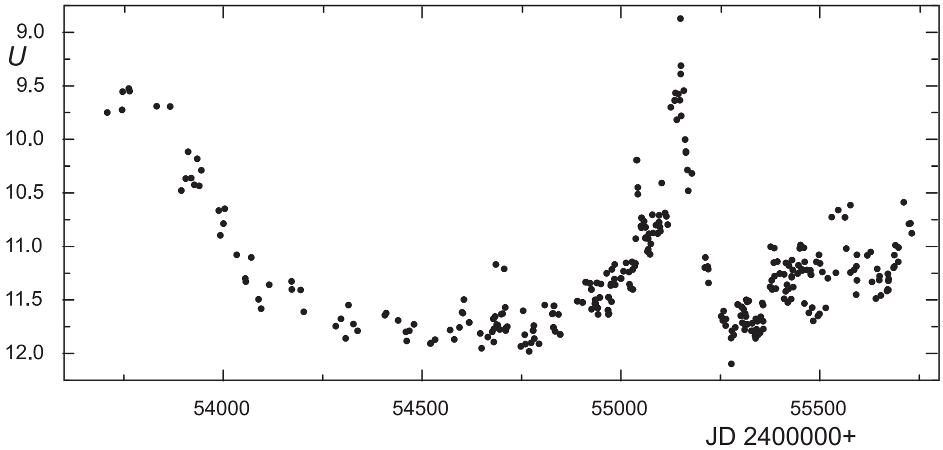

Fig. 1. *U* light curve of CH Cyg from 2006 to present.

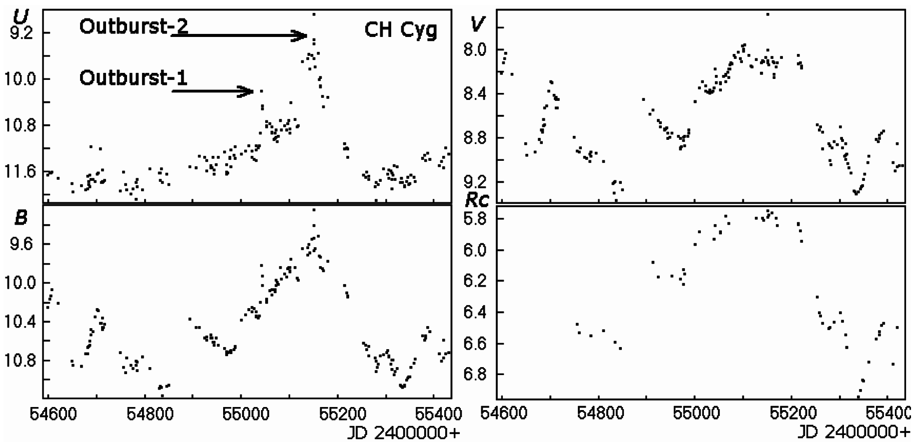

Fig. 2. $UBVR_{\rm C}$ light curves of CH Cyg from 2008 to present.

In this paper we analyse the photometric behavior of CH Cyg during 240 nights in the time interval between 2008 May and 2011 June.

3. LONG-TIME VARIABILITY

During 2006 June – December the brightness of the system faded by ~ 2 mag and persisted at a low level of $U \sim 11$ mag up to now (Figure 1). However, during this low level CH Cyg showed a few bursts lasting days or weeks. After the sudden fall in brightness in 2006, Wallerstein et al. (2010) found a pulsation period of ~ 1410 d, and also a shorter one of 95 d.

Since the end of 2008 until the outburst in 2009 October observations in the *U* band showed a gradual growth in brightness. On 2009 July 25 Mukai et al. (2009a) registered very powerful X-ray flash in the range $2-10$ keV. Our simultaneous photometric observations showed only a small brightening in *U* by 0.25 mag

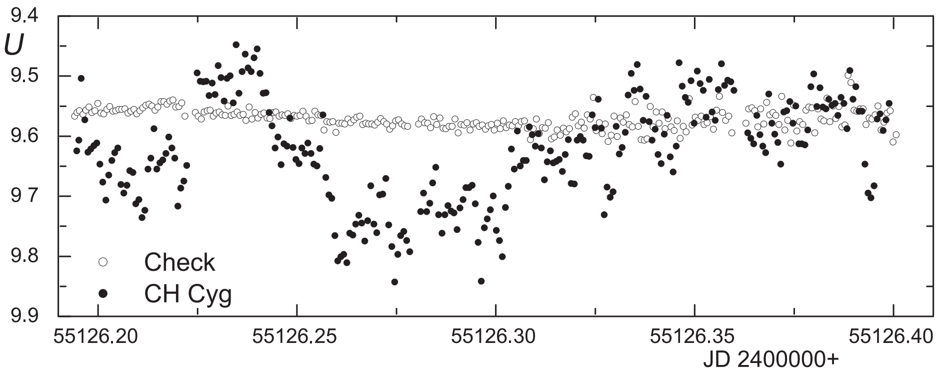

Fig. 3. High-time-resolution photometry of CH Cyg during its 2009 burst measured on 2009 October 21.

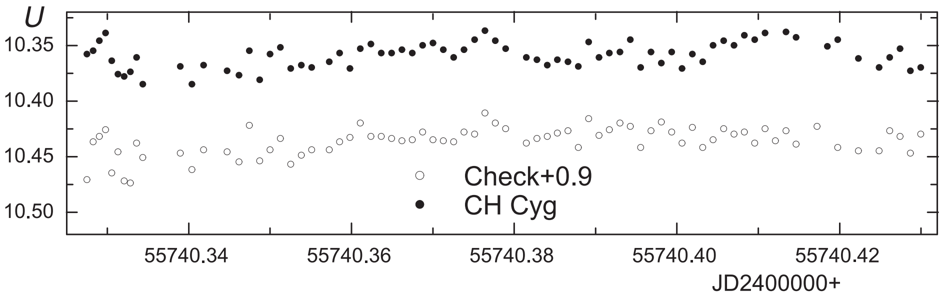

Fig. 4. High-time-resolution photometry of CH Cyg after the burst, on 2011 June 26.

(Skopal, Shugarov & Chochol 2009). However, the optical afterglow of the hard X-ray flare was detected later, on July 28.099 UT, when CH Cyg brightened by about 1 mag (see Figure 2). Assuming two-day time delay of the optical afterglow suggests particle density of about 10^7 cm^{-3} in the emitting region ionized by the X-ray photons. However an exact position of the X-ray maximum is not known.

Approximately two months later, at the end of 2009 September, our observations showed another strong burst in the U light curve of CH Cyg. From 2009 September 25 to October 21 the star brightened from $U = 10.9$ to $U = 9.7$. However, the slope of the brightening is unknown, because of the lack of data. Then CH Cyg persisted at a bright stage at $U \sim 9.6$ mag to 2009 November 23, i.e. for 33 days. Further observations indicated a fading in the brightness up to $U \sim 11.1$ mag, as given by our measurements on 2010 January 15 and 16 (Skopal, Shugarov & Chochol 2010).

According to the X-ray monitoring of CH Cyg (Mukai et al. 2009a,b), the hard 2–10 keV emission correlates with that measured in the U passband. This correlation could qualitatively be caused by a sudden mass outflow from the accretor leading to energy dissipation throughout a shocked extremely hot plasma. A fraction of the hard X-ray photons from the hot plasma can ionize the circumstellar medium, which converts their energy through the recombination process to the nebular radiation in the optical passband. As a result, an increase of brightness in the U band is observed with a delay corresponding to the recombination time.

The delay thus allow us to estimate the concentration of electrons ionized by the X-ray photons in the emitting region. An inactive phase of brightness continues to date (see Figure 1).

4. RAPID VARIABILITY

It is well-known that CH Cyg exhibits fast changes of brightness with a small amplitude around 0.01–0.1 mag (Wallerstein 1968). The amplitude of flickering was 0.03–0.04 mag in UBV (Sokoloski et al. 2010) on the timescale of a few minutes between 2010 January – March.

Figure 3 shows fast variability of CH Cyg during the 2009 strong burst (outburst-2 in Figure 2). At this time (2009 October), in the U band the amplitude reaches 0.3 mag, while in the V band fast variability of brightness was not observed. This variability is probably caused by the instability of a hot accretion disk.

During the inactive phase, in 2011 June, we found no fast variability in U and V bands (see Figure 4).

5. FUTURE PROPOSAL

We continue monitoring of this system, mainly in the U band, where the brightness variation is the most pronounced. In case of a new outburst, we will analyze a correlation and time shifts between the optical and X-ray light curves.

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