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LONG-TERM OPTICAL OBSERVATIONS OF THE BE/X-RAY BINARY SYSTEM V0332+53

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The Be/X-ray binary V0332+53 has an orbital period of 34.25 d with an eccentricity of 0.31 (Stella et al. 1985). The optical counterpart of this system, BQ Cam, is an O8-9Ve star at a distance of about 7 kpc, showing Hα line emission (Negueruela et al. 1999). This emission is related to the circumstellar disk around the optical star.

Three optical brightening of BQ Cam have been detected. Two of them were reported by Goranskij (2001), one was in 1983 and the other was in 1989. The third one was reported by Goranskij and Barsukova (2004) in the beginning of 2004. About 300 days later, Swank et al. (2004) informed the first All Sky Monitor detection (on the Rossi X-Ray Timing Explorer (RXTE)) of the November 2004 X-ray outburst. The previous two optical brightenings were also accompanied by X-ray outbursts.

Recently, Krimm et al. (2008) reported a new X-ray activity starting at MJD 54 756 detected by Swift/BAT[1] hard X-ray transient monitor. Hsiao et al. (2008) obtained an optical spectrum at MJD 54 761 in which the Hα emission line showed P-Cygni profile with FWHM $\sim$12 Å.

We have been monitoring the binary system V0332+53 since 2004 using the 45 cm ROTSEIIId telescope (Robotic Optical Transient Experiment)[2] and RTT150 (Russian-Turkish 1.5 m Telescope)[3] located at Bakırlıtepe, Antalya, Turkey. ROTSEIII telescopes which operate without filters were described in detail by Akerlof et al. (2003). Details on the reduction of the data were described in Baykal et al. (2005) and Kızıloğlu et al. (2005). The reference stars for differential photometry were listed in a previous study of Baykal et al. (2005).

In our previous study (Baykal et al. 2005), we presented part of the optical light curve during the giant 2004 X-ray outburst. In this study we report on the long-term variability of the Be/X-ray binary system V0332+53 up to the present date. The differential optical light curve and X-ray light curve of Be/X-ray binary system V0332+53 are shown in Fig. 1. X-ray light curve was obtained from RXTE/ASM web site[4].

A fading of 0.2 mag occurs in the light of BQ Cam after MJD 53 400. On the onset of the fading trend, the Type II X-ray outburst comes to an end. The X-ray activity ends accompanied by the fading of magnitudes. The fading in the light curve of BQ Cam

[1] http://swift.gsfc.nasa.gov/docs/swift/results/
[2] http://www.rotse.net
[3] http://www.tug.tubitak.gov.tr
[4] http://xte.mit.edu

could be due to a decrease in the density or in the size of the circumstellar disk. After MJD 53 600 the system brightened again but did not reach its previous value observed before the giant 2004 X-ray activity until about MJD 54 700.

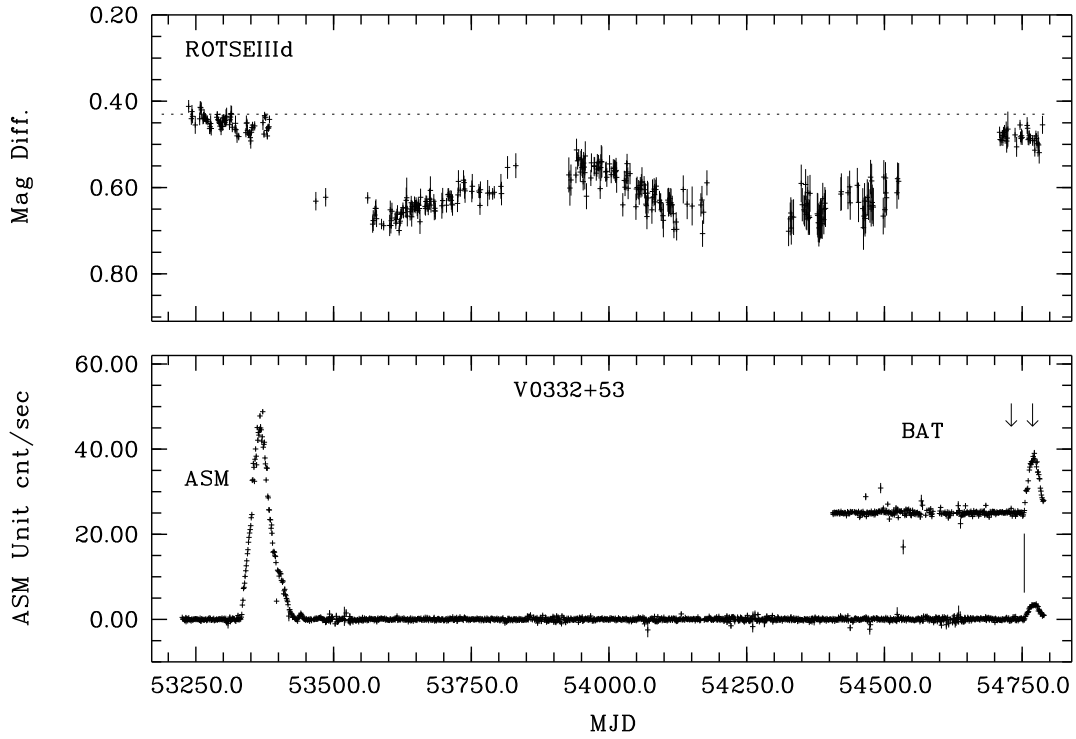

Figure 1. ROTSEIIId daily averaged differential light curve (upper panel) and X-ray light curve (lower panel) of the Be/X-ray system V0332+53 (MJD = JD − 2400000.5). Daily averages of RXTE/ASM 5.0-15.0 keV band light curve and 15-50 keV SWIFT/BAT light curve (properly scaled and shifted) are shown. Vertical line represents PAP and arrows denote spectroscopic observation times.

We presented optical spectroscopic observations obtained before (at MJD 54 730) and during (at MJD 54 768) the new X-ray activity reported by Krimm et al. (2008). The spectroscopic observations were performed with the RTT150 telescope using the medium resolution spectrometer TFOSC (TÜBİTAK Faint Object Spectrometer and Camera). The camera is equipped with a 2048 × 2048, 15μ pixel Fairchild 447BI CCD. We used grism G8 (spectral range 5800-8300 Å) with average dispersion of ∼1.1 Å pixel^{-1}. The reduction and analysis of spectra were made by using MIDAS[5] and its packages: Longslit context and ALICE.

The observed Hα line profiles (Fig. 2) were single-peaked and almost symmetric. Measurements of Hα emission lines were made by fitting a Gaussian profile. For each spectrum the measured value of the equivalent width (EW) and full width at half maximum (FWHM) are given in Table 1. The EW and FWHM values for the present two Hα emission profiles are almost the same. The calculated EW value of ∼ 4.4 Åfor both profiles is less than the measured value of 10 Åwhich was obtained by Masetti et al. (2005) at MJD 53 377. It should be noted that the Be disk was denser at that time. According to

[5]http://www.eso.org/projects/esomidas/

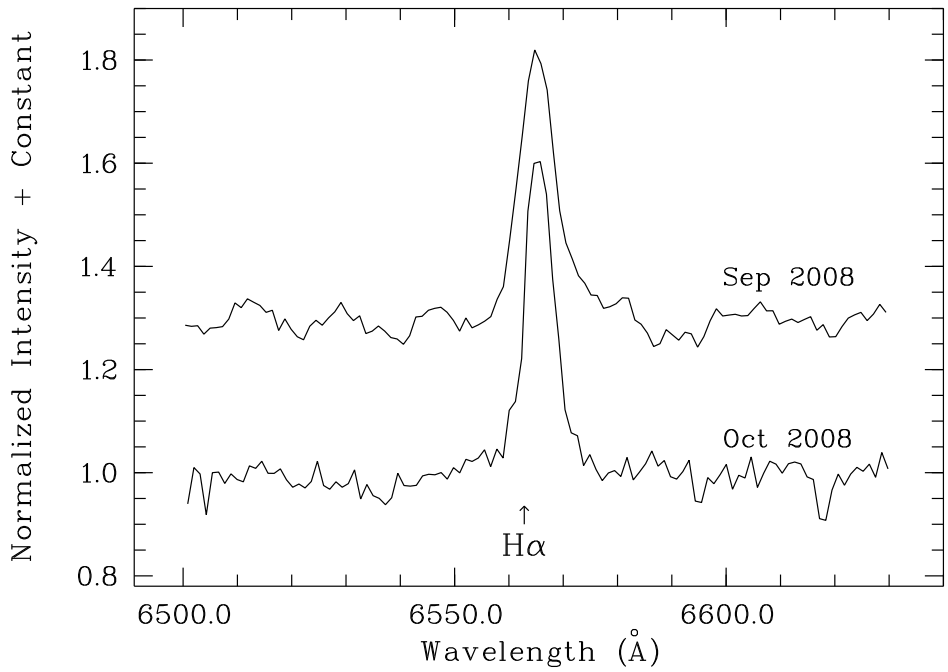

Figure 2. Hα profiles observed on Sep 21 and Oct 29, 2008, before and during the X-ray activity.

the present data, the disk is less dense and the system has almost reached the previous brightness observed before the giant X-ray flare.

The present EW values are found to be similar to the ones observed during the fading of infrared magnitudes of Negueruela et al. (1999). We did not confirm the result of Hsiao et al. (2008) since our detection showed single peaked Hα emission line (obtained 7 days later than their observations). In addition to this, the present FWHM was weaker by a factor of 2.

The Hα emission lines were found to be red-shifted by $\sim$140 km/s which were larger than that of Corbet et al. (1986), who found a blue-shift of $\sim$65 km/s in Hα line and related this to V/R variability seen in Be type stars. In the present study, quite symmetric Hα line profiles do not represent a perturbation in the disk. Because of the low inclination of this system, it is also possible that no variability is seen.

Okazaki and Negueruela (2001) pointed out the possibility of disc truncation by the neutron star which was not close to the mean critical Roche Lobe radius at periastron for the binary system V0332+53 since this system showed no Type I X-ray outburst for a long period of time. According to them, to have a temporary Type I X-ray outbursts, Be disk should be strongly disturbed. But, the Hα emission line profile obtained during the 2008 Type I X-ray outburst does not show any variability which would indicate a disturbed disk. The line is quite symmetric.

We suggest that brightening of the disk after MJD 54 700 may be due to the precession

Table 1. Hα line profiles.

Date	MJD	EW (Å)	FWHM (Å)
Sep 21, 2008	54730.0796	4.44 ± 0.13	7.89 ± 2.05
Oct 29, 2008	54768.8644	4.37 ± 0.15	6.57 ± 1.52

of the disk. When the disk is toward the periastron the material in the outer part of the disk falls on to the neutron star giving rise to the observed 2008 X-ray outburst. The new 2008 X-ray outburst coincides with the periastron passage (PAP) time of the neutron star (Type I outburst). We used the orbital period of 34.67 days and PAP time of 53367 given by Zhang et al. (2005).

We continue monitoring the system.

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