OUTBURST ACTIVITY IN MAGNETIC CATACLYSMIC VARIABLES BY CAM AND QQ VUL

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Flare properties in magnetic cataclysmic variables BY Cam and QQ Vul are determined based on the observations obtained at AZT-11 and the Shain mirror telescope of the Crimean Astrophysical Observatory. The UBVRI AZT-11 photometry demonstrates a wide range of color properties of these events. There are significant differences between the flare amplitudes in BY Cam and QQ Vul. The correlation coefficient between the flare amplitude and smoothed brightness variations of QQ Vul is of about 0.83. Similar dependence for the flares of BY Cam is not detected. Some values of the cross-correlation "brightness-polarization" are as large as 0.7. There are no significant differences between the colors of observed flares, as for instance, one could expect for possible "accretion" and "red dwarf" flares.

INTRODUCTION

Magnetic cataclysmic variables are the close binary systems, which consist of a red dwarf filling its Roche lobe, and of a strongly magnetized white dwarf with a surface field of about tens to hundreds MGs (Meggitt, Wickramasinghe, 1984). In the AM Her objects, or "polars", the magnetic field of the white dwarf is sufficiently strong to prevent formation of the accretion disk which is present in non-magnetic or weakly-magnetic cataclysmic variables. In these systems, the gas motion is determined by the balance between the magnetic pressure and ram plus thermal pressure (Mukai, 1988). When the magnetic pressure becomes larger than the ram one, the matter of the ballistic stream starts to be coupled by magnetic field to fall along the field lines to the white dwarf's surface. The extension of the standard model of polars and its observational consequences have been discussed by Andronov (1987a). If we suggest a dipole geometry of the magnetic field, then the active regions on the white dwarf surface lies near magnetic poles. In the ballistic stream, a matter is fragmented by Rayleigh–Taylor instability on to the large diamagnetic blobs with sizes of about 10^9 cm (Hameury, King, Lasota, 1986; Beardmore, Osborne, 1997; Shakhovskoy *et al.*, 1999). Accretion of most massive blobs can produce the outbursts in such systems. The types of instability of accretion structure have been discussed by Andronov (1987b).

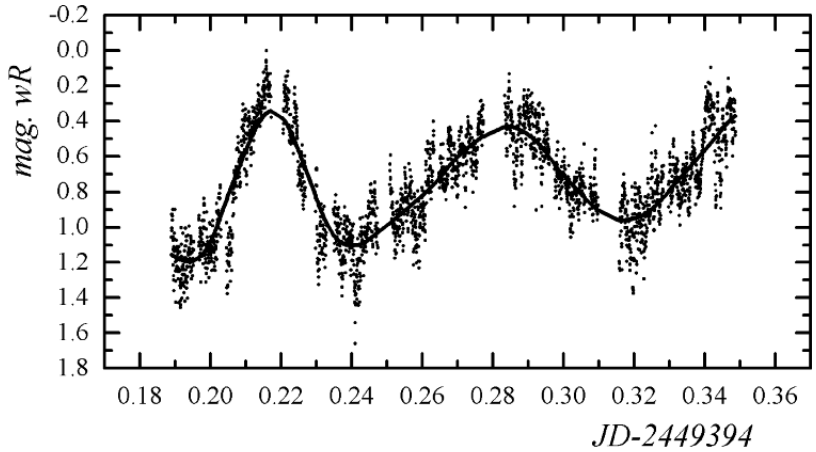

Figure 1: Smoothing by the "running parabolae method" of the orbital variability of BY Cam

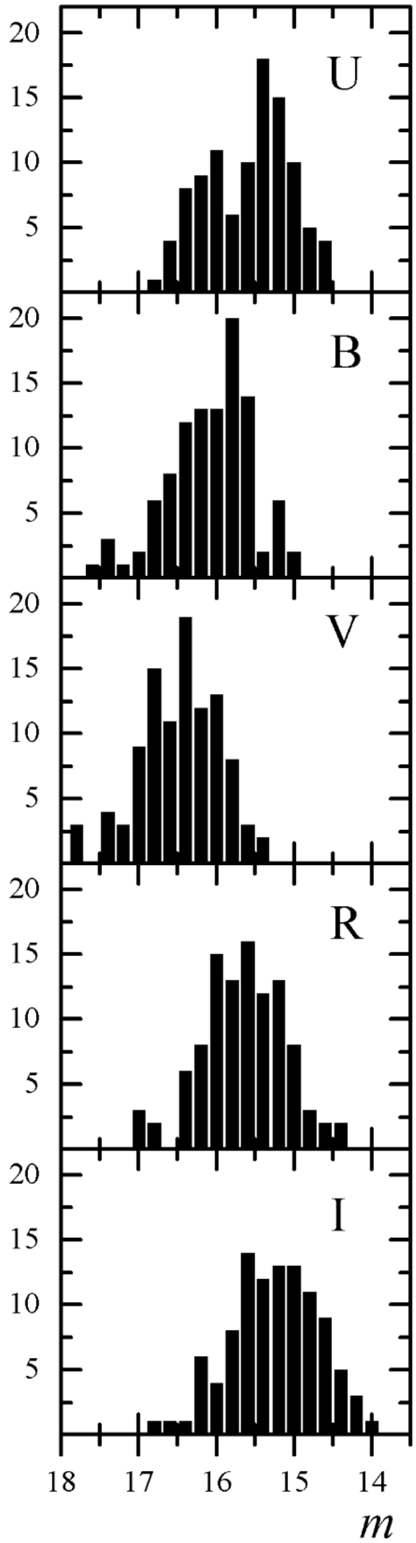

Figure 2: Distribution of the magnitudes of outbursts in UBVRI colours

OUTBURST ACTIVITY OF POLARS

On the photometric curves of polars, one can observe many outbursts, which have relative amplitudes of about $0\overset{m}{.}1-0\overset{m}{.}5$. They are explained as a product of an accretion of the massive and dense blobs in the gaseous stream onto the white dwarf's surface. Such structures will easier penetrate through magnitosphere and a significant part of the blobs do not fall with generating the accretion shock. These blobs fall directly onto the white dwarf's surface and, if the optical width exceeds ≈ 1, they can produce soft X-ray radiation with a nearly blackbody spectrum (Frank, King, Lasota, 1988). Secondary star in polars (red dwarf) also can be a source of blue outbursts likewise in the UV Ceti – type stars. Blobs, which are accreted with generating an accretion column near magnetic poles, are the sources of an infrared cyclotron radiation, hard X-ray bremsstrahlung radiation and a soft X-ray blackbody radiation re–radiated from the white dwarf's surface (Lamb, Masters, 1979).

So, one can observe 3 different types of outbursts:

1) Blobs accreting through shock wave with blue reflected component and infrared cyclotron spectra;

2) Blue outbursts from blobs, which are accreted directly into the white dwarf's photosphere;

3) Blue UV Ceti type outbursts from the red dwarf.

The first type can be surely distinguished among other types. But the distinction of the accretion and red dwarf's outbursts is much more difficult. In this latter case, only the Doppler tomography can resolve this problem. But some red dwarf's outbursts have a power which is much higher than that of the accretion outbursts. As an example, there is the unprecedented red dwarf's outburst in AM Her, which was observed by Shakhovskoy *et al.* (1993). This blue outburst had an amplitude of about 2^m and a duration of about 50 minutes. So, using multicolor observations, one can resolve only cyclotron outbursts and most powerful red dwarf's ones.

OBSERVATIONS

To study the outburst activity of polars, we have used high time resolution observations of two objects BY Cam and QQ Vul in the wide R filter (0.5–0.75 micron) obtained at the 2.6-m Shain mirror telescope and UBVRI observations obtained at the 1.25-m AZT-11 telescope (Shakhovskoy *et al.*, 1998).

Before measuring the outbursts amplitudes, we had removed orbital variability by using the method of "running parabolae" (Andronov, 1997). This method was applied to study separate outbursts clearly seen at the light curve. The statistical study of characteristics of the "shot" noise produced by overlapping outbursts for these objects was done by Shakhovskoy *et al.* (1999). It was based on the method (Andronov, 1994) using the autocorrelation functions biased by a trend removal and by a finite length.

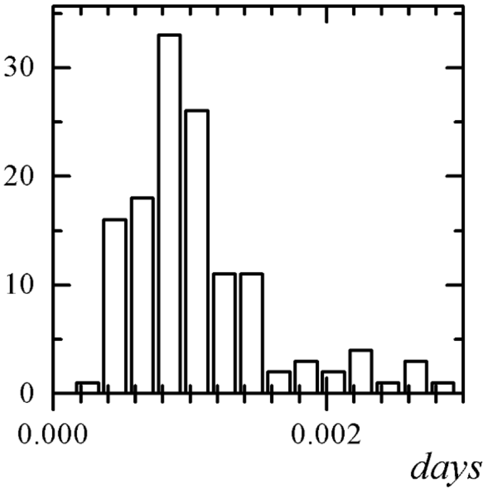

Figure 3: Distribution of the duration of the outbursts

We have determined the values of duration and true magnitudes of 239 outbursts for BY Cam and 56 ones for QQ Vul. Their durations lie in diapason 35 and 120 sec (see Fig. 1). These values correspond to a characteristic blob lengths of about 4–12 R_{wd}, despite the width of such "spaghetti" (Panek, 1980) is of about 1–2 km. There are no significant correlations between the brightness of system during outburst and the state of activity and circular polarization for BY Cam and QQ Vul. Hence, such accretion rate fluctuations can not provide significant polarization variability. This indicates that the accretion region's structure in these systems is complicated and the accretion may take place onto more than one magnetic poles.

Using the multicolour photometry, we had found that the majority of outbursts have two-component spectra with infrared and ultraviolet components (see Fig. 2). Red and infrared emission are explained by a cyclotron radiation of blobs, which penetrate through the shock wave and are cooling in strong magnetic fields above the white dwarf's surface. The ultraviolet component is probably explained by a blackbody re–emitted radiation from the white dwarf's surface, because the bremsstrahlung radiation at these wavelengths is very weak one.

DISCUSSION

The majority of outbursts observed in polars may be explained by accretion processes. As it was shown by Shakhovskoy *et al.* (1993), sometimes blue outbursts are observed in polars, which can be explained by a red dwarf's activity likewise in the UV Ceti–type stars. The resolving of the red dwarf outbursts can be possible, if the amplitude and duration of outburst exceed significantly the values which are typical for accretion events. But, as it is noted by Bonnet-Bidaud *et al.* (2000), possibly one may observe many low–amplitude outbursts of the red dwarf, which characteristics are very similar to the accretion ones, making their identification to be difficult. The energy distribution in the outburst's spectra does not give us a sure answer about their nature, because the most dense blobs, which can be accreted directly onto the white dwarf's surface, also produce blue outbursts. In the future we plan to apply a Doppler tomography of polars for resolving the outburst's locations.

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